Bangor University

DOCTOR OF PHILOSOPHY

Bilingual Semantics: Intra- and inter-sense mapping in the case of two languages

Evans, Gwennant Mai

Award date:
2021

Awarding institution:
Bangor University

Link to publication

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal ?

Take down policy
If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Download date: 27. Jul. 2024

Bilingual Semantics: Intra- and inter-sense mapping in the case of two languages

Semanteg Ddwyieithog: Mapio mewn- a rhyng-synnwyr mewn achos o ddwy iaith

Gwennant Mai Evans

Thesis submitted to the School of Psychology, Bangor University in partial fulfilment of the requirements for the degree of Doctor of Philosophy

Traethawd ymchwil a gyflwynwyd i'r Ysgol Seicoleg, Prifysgol Bangor i gyflawni'r gofynion ar gyfer gradd Doethur mewn Athroniaeth yn rhannol

September 2020 / *Medi 2020*

I hereby declare that this thesis is the results of my own investigations, except where otherwise stated. All other sources are acknowledged by bibliographic references. This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree unless, as agreed by the University, for approved dual awards.

Yr wyf drwy hyn yn datgan mai canlyniad fy ymchwil fy hun yw'r thesis hwn, ac eithrio lle nodir yn wahanol. Caiff ffynonellau eraill eu cydnabod gan droednodiadau yn rhoi cyfeiriadau eglur. Nid yw sylwedd y gwaith hwn wedi cael ei dderbyn o'r blaen ar gyfer unrhyw radd, ac nid yw'n cael ei gyflwyno ar yr un pryd mewn ymgeisiaeth am unrhyw radd oni bai ei fod, fel y cytunwyd gan y Brifysgol, am gymwysterau deuol cymeradwy.

Acknowledgments

Undertaking this PhD has been one of the best experiences of my life and I am indebted to many. Firstly, I would like to thank my supervisor Dr Manon Jones who has truly been wonderful. I feel so fortunate to have been given this opportunity. Your continued support has made my experience unforgettable and has enabled me to present a thesis that I am truly proud of.

I would also like to say a big thank you to my second supervisor Dr Awel Vaughan-Evans who has supported me not only with the PhD but with all my academic endeavors. You encouraged me to always strive for the highest standard which has made me a much more confident and competent person.

It would not have been possible to complete this thesis without the support of the BULET ARIAN lab. Therefore, I would like to thank Prof. Guillaume Thierry and all the members who have come and gone over the years for their valuable support and feedback in designing and conducting my experiments. I have made some amazing friends in the lab, Ciara, Jen and Yang, thank you for hours of fun, for listening to my many complaints, and for all the hours spent helping me cap up.

To my family who have supported me throughout the PhD - even though they have no idea what I study - thank you for the support and for completing countless norming studies without question. Finally, a big thank you to Danial for suffering four years of complaints and for cheering me up even on the worst of days. Thank you for always believing that I could do this and encouraged me to keep going despite all challenges.

Cydnabyddiaethau

Mae ymgymryd â'r PhD hwn wedi bod yn un o brofiadau gorau fy mywyd ac mae fy nyled yn fawr i sawl un. Yn gyntaf, hoffwn ddiolch i'm goruchwyliwr Dr Manon Jones sydd wedi bod yn wirioneddol wych. Dw i'n teimlo mor ffodus fy mod i wedi derbyn y cyfle yma. Mae’r gefnogaeth barhaus wedi gwneud fy mhrofiad yn un bythgofiadwy ac wedi fy ngalluogi i gyflwyno traethawd yr wyf wirioneddol yn falch ohono.

Hoffwn hefyd diolch o waelod calon i'm hail oruchwyliwr Dr Awel Vaughan-Evans sydd wedi fy nghefnogi nid yn unig gyda’r PhD ond â’n holl waith academaidd. Fe wnest fy annog i ymdrechu am y safon uchaf pob amser sydd wedi fy ngwneud yn berson llawer mwy hyderus a chymwys.

Ni fyddai wedi bod yn bosibl cwblhau'r traethawd ymchwil hwn heb gefnogaeth y labordy BULET ARIAN. Felly, hoffwn ddiolch yn fawr i Prof. Guillaume Thierry a'r holl aelodau sydd wedi mynd a dod dros y blynyddoedd am eu cydweithrediad a'u hadborth wrth ddylunio a chynnal fy arbrofion. Rwyf wedi gwneud ffrindiau anhygoel yn y lab, Ciara, Jen a Yang, diolch i chi am oriau o hwyl, am ddidda fy nghwynion, ac am yr holl oriau a dreuliwyd yn fy helpu i gapio i fyny.

I fy nheulu sydd wedi fy nghefnogi trwy gydol y PhD - er nad oes ganddyn nhw syniad beth rydw i'n ei astudio - diolch am y cefnogaeth ac am gwblhau cant a mil o astudiaethau normio heb gwestiynu (llawer). Yn olaf, diolch o galon i Danial am ddioddef pedair blynedd o gwynoion, ac am chodi fy nghalon hyd yn oed ar y dyddiau gwaethaf. Diolch am dy ffydd yn fy ngallu i wnued hyn ac fy annog i ddal ati er gwaetha pob her.

Summary

Despite large strides in our understanding of bilingual language processing at the lexical and syntactic level, including activation in L1/L2 and co-activation of languages (RHM, Kroll and Stewart, 1994; BIA - Dijkstra & Van Heuven & Grainger, 1998; BIA+, Dijkstra & Van Heuven, 2002), relatively little is known about the structure and activation of bilingual semantics. Current models provide at best a sketchy account of how the two languages compare and potentially interact at the level of meaning (The Sense Model, Finkbeiner et al, 2004; The distributed Feature Model, de Groot, 1992), and it is imperative that more empirical work is done to ascertain a more detailed picture of bilingual semantics (Multilink, Dijkstra et al, 2018). The empirical work presented in this thesis therefore aims to examine whether stronger conceptual links in the L1 afford less processing effort to achieve intra-sense conceptual mapping than in L2 (Part 1), and whether the bilingual inter-sense mapping includes co-activations of meaning (Part 2). Crucially, we use sentence processing throughout in a bid to provide an account of bilingual semantics beyond the lexical level.

Part 1 includes three experiments, in which we examine bilingual intra-sense mapping using two manipulations. First, we compare bilinguals' sensitivity to sentence meaning at the level of sense violation, using sensible and anomalous sentences. We find greater sensitivity to anomaly in the L1 at the level of online semantic processing, and evidence of delayed semantic processing in the L2. Second, we examine access to meaning in the more subtle case of literal vs. figurative language processing. We find evidence of direct access to metaphor in both the L1 and L2. Interestingly, however, our findings and interpretation centre on the suggestion that ease of access to a figurative

meaning is driven not by L1 status, but rather the statistical probability of encountering a metaphor in Welsh rather than English. Our results suggest that conceptual access and sentence processing is more efficient in the L1 than in the L2, but that the frequency with which certain stylistics are encountered in a given language may also influence literal vs. figurative language processing.

Part 2 examined whether the non-operational language is implicitly co-activated on a semantic level, even when the meaning is idiosyncratic to one language, suggestive of interactivity in bilinguals' semantic interpretations between the two languages. To this end, we examined whether online semantic access to L1-specific representations (Welsh idiomatic expressions) is possible when presented in the idiom-incongruent language (English). We found that the Welsh specific meaning of these idioms was available at this level of processing, suggestive of co-activation of semantic representations.

Taken together, our findings suggest that although semantic processing is overall less effortful in the L1, deriving meaning in the L2 is also highly efficient. In a similar manner to the L1, the L2 has direct access to figurative language and benefits from the facilitation of experience. In addition, the L2 may directly access L1-specific concepts, implicating a highly interactive semantic system in proficient bilinguals.

Crynodeb

Er gwaethaf camau breision yn ein dealltwriaeth o brosesu iaith ddwyieithog ar y lefel eiriadurol a chystrawennol, gan gynnwys actifadu yn L1 / L2 a chyd-actifiant ieithoedd (RHM, Kroll a Stewart, 1994; BIA - Dijkstra & Van Heuven & Grainger, 1998; BIA + , Dijkstra & Van Heuven, 2002), ychydig iawn a wyddwn am strwythur ac actifiant semanteg mewn unigolion dwyieithog Mae modelau cyfredol yn darparu cyfrif bras ar y gorau o sut mae'r ddwy iaith yn cymharu, ac o bosibl yn rhyngweithio, ar lefel ystyr (The Sense Model, Finkbeiner et al, 2004; The Distributed Feature Model, de Groot, 1992). Mae'n hanfodol felly, bod mwy o waith empeiraidd yn cael ei gynnal er mwyn ein galluogi I lunio darlun manylach o semanteg dwyieithog (Multilink, Dijkstra et al, 2018). Nod y gwaith empirig a gyflwynir yn y traethawd ymchwil hwn felly, yw archwilio os yw cysylltiadau cysyniadol cryfach yn L1 yn arwain at lai o ymdrech prosesu i gyflawni mapio cysyniadol drwy-synnwyr nag yn L2 (Rhan 1), ac os yw mapio rhyng-synnwyr dwyieithog yn cynnwys cyd-actifiant ar lefel ystyr (Rhan 2). Mae’n bwysig nodi ein bod yn defnyddio prosesu brawddegau drwyddi draw mewn ymgais i ddarparu cyfrif o semanteg dwyieithog y tu hwnt i'r lefel eirfaol.

Mae rhan 1 yn cynnwys tri arbrawf sydd yn archwilio mapio mewn-synnwyr dwyieithog gan ddefnyddio dwy driniaeth arbrofol. Yn gyntaf, rydym yn cymharu sensitifrwydd siaradwyr dwyieithog i ystyr brawddeg ar lefel sydd yn torri synnwyr, gan ddefnyddio brawddegau synhwyrol ac anomoliaidd. Rydym yn canfod mwy o sensitifrwydd i anomali yn L1 ar lefel prosesu semantig ar-lein, a chanfod oediad ym mhrosesu semantig yn L2. Yn ail, rydym yn archwilio mynediad at ystyr yn achos mwy cynnil gan gymharu prosesu iaith llythrennol yn erbyn ffigurol. Rydym yn dod o hyd i

dystiolaeth o fynediad uniongyrchol i drosiad yn L1 a L2. Yn ddiddorol, fodd bynnag, mae ein canfyddiadau a'n dehongliad yn canolbwyntio ar yr awgrym bod rhwyddineb mynediad at ystyr ffigurol yn cael ei yrru nid gan statws L1, ond yn hytrach y tebygolrwydd ystadegol o ddod ar draws trosiad yn Gymraeg yn hytrach na Saesneg. Mae ein canlyniadau'n awgrymu bod mynediad cysyniadol a phrosesu brawddegau yn fwy effeithlon yn L1 nag yn L2, ond y gall amlder o ddod ar draws arddulliau penodol mewn iaith benodol hefyd ddylanwadu ar brosesu iaith lythrennol yn erbyn ffigurol.

Archwiliodd Rhan 2 os yw’r iaith anweithredol wedi’i chyd-actifio’n ymhlyg ar lefel semantig, hyd yn oed pan fo’r ystyr yn idiosyncratig i un iaith, sy’n awgrymu rhyngweithiad rhwng ystyron semantig dwyieithog rhwng y ddwy iaith. I gyflawni hyn, gwnaethom archwilio os yw mynediad semantig ar-lein i gynrychioliadau L1-benodol (ymadroddion idiomatig Cymraeg) yn bosibl pan gaiff ei gyflwyno yn yr iaith idiom-anghydweddol (Saesneg). Canfuom fod ystyr benodol Gymraeg yr idiomau hyn ar gael ar y lefel hon o brosesu, sy'n awgrymu cyd-actifadu cynrychioliadau semantig.

Ar y cyfan, mae ein canfyddiadau'n awgrymu, er bod prosesu semantig yn llai ymdrechgar ar y cyfan yn L1, mae cael ystyr yn L2 hefyd yn effeithlon iawn. Yn yr un modd â'r L1, mae gan L2 fynediad uniongyrchol i iaith ffigurol a caiff ei hwyluso gan profiad. Yn ogystal, gall L2 gyrchu cysyniadau L1-benodol yn uniongyrchol, sydd yn awgrymu fod y system semantig yn ryngweithiol iawn mewn pobl ddwyieithog hyfedr.

Table of Content

Chapter 1. Literature Review and Thesis Aims **24**

1.0 Chapter Overview 25

1.1 Highlighting the basic differences between monolingual and bilingual semantics 25

1.2 Psycholinguistic Models of Bilingualism 28

1.2.1 The Revised Hierarchical Model (RHM) 28

1.2.2 The BIA and BIA+ models 31

1.2.3 The Sense Model 35

1.2.4 The Distributed Feature Model 37

1.2.5 Multilink 40

1.2.6 Interim Conclusion and Outstanding Questions 42

1.3 PART 1 ~ Intra-Sense mapping in bilinguals 44

1.3.1 Semantic processing in sentence contexts 45

1.3.2 Literal and figurative language 48

1.4 PART 2 ~ Inter Sense mapping in bilinguals 52

1.4.1 Language co-activation 53

1.4.2 Idiomatic expressions 57

Chapter Summary 58

Chapter 2. Methodological Considerations **60**

2.0 Chapter Overview 61

2.1 Participants: The Welsh-English bilingual population 61

2.1.1 Age of Acquisition 62

2.2 Self-report measures 64

2.3 Electrophysiological recording 65

2.3.1 Event related potential (ERP) components 67

2.3.2 N400 68

2.3.3 P600 70

2.3.4 Methodological considerations of extant ERP studies 71
2.4 Norming of literal and metaphorical stimuli 76
2.4.1 Aims of the current norming study 77
2.4.2 Methods 78
2.4.2.1 Participants 78
2.4.2.2 Method and Results 79
2.4.2.3 Words 80
4.2.2.4 Sentence Data 81
4.2.2.5 Cloze Probability 83
2.4.3 Modifications to sentences based on scale scores and cloze probability data 84
2.4.3.1 Scale Data 84
2.4.3.2 Cloze Probability 85
2.4.4 Discussion 86
2.4.5 Modifying the sentences for the ERP experiments: Lessons from the norming data 87
2.5 Chapter Summary 88

Chapter 3. Bilinguals making sense: Earlier online access to semantics in the L1 during sentence comprehension. 90
Abstract 91
Introduction 92
The current study 96
Experiment 1a 97
Method 97
Participants 97
Stimuli 97
Procedure 99
Electrophysiological Recording 101

Results and discussion 102
Behavioral Data 200
Event Related Potentials 104
N400 104
P600 106
Experiment 1b 109
Method 109
Participants 109
Materials, Design and Procedure 110
Results & Discussion 111
N400 111
P600 112
General Discussion 115
Online semantic processing of sentence anomaly in L1 and L2 116
Online semantic processing of sentence metaphoricity in L1 and L2 119
Conclusions 121

Chapter 4. Bilinguals making sense (II): Online semantic processing of figurative meaning may depend on language context, not bilinguals' L1 status 123
Abstract 124
Introduction 125
Methods 127
Participants 127
Materials, Design and Procedure 127
Results 128
N400 128
P600 129
Discussion 130
Direct access to figurative language 131

Properties belonging to the Welsh language may facilitate metaphor processing 134
Conclusions 141

Chapter 5. Inter-sense mapping in bilinguals 144
Chapter Overview 145
Introduction 146
Methods 151
Participants 151
Bilingual Group 151
Monolingual Group 152
Stimuli 152
Norming 153
Procedure 155
Electrophysiological Recording 156
Results 157
Behavioral Results 157
ERP Results 159
N400 159
P600 161
Discussion 162
Conclusion 164

Chapter 6: General Discussion 166
6.0 Chapter overview 167
6.1 Part 1: Intra-Sense mapping in the L1 and L2 167
6.1.1 Online semantic processing of sentence anomaly in the L1 and L2 168
6.1.2 Mapping multiple conceptual representations in the L1 and L2 171
6.1.3 Interim conclusions on bilingual intra-sense mapping 173

6.1.4 A schematic of intra-sense mapping in bilinguals 174
6.2 Part 2: Inter-sense mapping in bilinguals 176
6.2.1 A schematic of intra-sense mapping in bilinguals 179
6.3 Thesis Limitations 180
6.3.1 Data quality and analysis 180
6.3.2 Experimental stimuli 182
6.3.3 Participant selection 183
6.3 Directions for future work 186
6.3.1 Intra-sense mapping 186
6.4.2 Inter-sense mapping 187
6.4 Final Remarks 188

References **365**

Appendix A: Language History Questionnaire used in experimental chapters 408

Appendix B: Multi Group Ethnic Identity Measure used in experimental chapters 415

Appendix C: Experimental stimuli used in chapter 2 norming study 417

Appendix D: Procedures used in chapter 2 norming study 434

Appendix E: Experimental stimuli used in chapters 3 & 4 443

Appendix F: Experimental stimuli used in chapter 4 460

Appendix G: Illustration of metaphor detection in Welsh across experiments 1a, 1b and 2 467

Tabl Cynnwys

Pennod 1. Adolygiad o’r Lenyddiaeth ac Amcanion y Traethawd Ymchwil 191

1.0 Trosolwg o'r Bennod 192

1.1 Amlygu’r gwahaniaethau sylfaenol rhwng semanteg uniaith a dwyieithog 192

1.2 Modelau Seicieithyddol Dwyieithrwydd 195

1.2.1 Revised Hierarchical Model (RHM) 196

1.2.2 Y modelau BIA a BIA + 199

1.2.3 Y Sense Model 203

1.2.4 Y Distributed Feature Model 205

1.2.5 Multilink 208

1.2.6 Casgliad Dros Dro a Chwestiynau Amlwg 210

1.3 RHAN 1 ~ Mapio Mewn-Synnwyr mewn pobl ddwyieithog 212

1.3.1 Prosesu semantig mewn cyd-destun brawddeg 213

1.3.2 Iaith lythrennol a ffigurol 216

1.4 RHAN 2 ~ Mapio rhyng-synnwyr mewn pobl ddwyieithog 220

1.4.1 Cyd-actifadu iaith 221

1.4.2 Ymadroddion idiomatig 225

Crynodeb o'r Bennod 227

Pennod 2. Ystyriaethau Methodolegol 229

2.0 Trosolwg o'r Bennod 230

2.1 Cyfranogwyr: y boblogaeth ddwyieithog Gymraeg-Saesneg 230

2.1.1 Oedran caffaeliad 231

2.2 Mesurau hunan-adroddol 233

2.3 Cofnodi electroffisiolegol 234

2.3.1 Cydrannau ERP 237

2.3.2 N400 237

2.3.3 P600 239

2.3.4 Ystyriaethau methodolegol astudiaethau ERP 241
2.4 Normio ysgogiadau llythrennol a throsiadol 246
2.4.1 Nodau'r astudiaeth normio gyfredol 247
2.4.2 Dulliau 248
2.4.2.1 Cyfranogwyr 248
2.4.2.2 Dull a Chanlyniadau 249
2.4.2.3 Geiriau 249
4.2.2.4 Data brawddeg 251
4.2.2.5 Cloze probability 253
2.4.3 Addasiadau i frawddegau yn seiliedig ar sgoriau graddfa a data ‘cloze probability’ 254
2.4.3.1 Data Graddfa 254
2.4.3.2 Cloze probability 255
2.4.4 Trafodaeth 256
2.4.5 Addasu'r brawddegau ar gyfer arbrofion ERP: Gwersi o'r data normio 257
2.5 Crynodeb o'r Bennod 259

Pennod 3. Dwyieithrwyr yn gwneud synnwyr: Mynediad cynharach ar-lein i semanteg yn L1 yn ystod amgyffred brawddegau. 261
Crynodeb 262
Cyflwyniad 263
Yr astudiaeth gyfredol 267
Arbrawf 1a 268
Dull 268
Cyfranogwyr 268
Ysgogiadau 269
Gweithdrefn 271
Cofnodi Electroffisiolegol 272
Canlyniadau a thrafodaeth 273
Data Ymddygiadol 273

Canlyniadau ERP 275
N400 276
P600 277
Arbrawf 1b 281
Dull 281
Cyfranogwyr 281
Deunyddiau, Dylunio a Threfn 282
Canlyniadau a Thrafodaeth 283
N400 283
P600 284
Trafodaeth Gyffredinol 287
Prosesu semantig ar-lein o anghysondeb brawddegau yn L1 a L2 288
Prosesu semantig ar-lein o frawddeg trosiadol yn L1 a L2 291
Casgliadau 293

Pennod 4. Dwyieithrwyr yn gwneud synnwyr (II): Gall prosesu semantig ar-lein o ystyr ffigurol ddibynnu ar gyd-destun iaith, nid statws L1 295
Crynodeb 296
Cyflwyniad 297
Dulliau 299
Cyfranogwyr 299
Deunyddiau, Dylunio a Threfn 300
Canlyniadau 300
N400 300
P600 301
Trafodaeth 302
Mynediad uniongyrchol i iaith ffigurol 303
Gall priodweddau sy'n perthyn i'r Gymraeg hwyluso prosesu trosiad 307
Casgliadau 314

Pennod 5. Rhan 2: Mapio rhyng-synnwyr mewn pobl ddwyieithog **316**
Trosolwg o'r Bennod 317
Cyflwyniad 319
Dulliau 324
Cyfranogwyr 324
Grŵp Dwyieithog 324
Grŵp uniaith 325
Ysgogiadau 325
Normio 327
Gweithdrefn 328
Cofnodi Electroffisiolegol 329
Canlyniadau 330
Canlyniadau Ymddygiadol 330
Canlyniadau ERP 332
N400 332
P600 334
Trafodaeth 335
Casgliadau 338

Pennod 6: Trafodaeth Gyffredinol **340**
6.0 Trosolwg o'r bennod 341
6.1 Rhan 1: Mapio Mewn-Synnwyr yn L1 a L2 341
6.1.1 Prosesu semantig ar-lein o anghysondeb brawddegau yn L1 a L2` 342
6.1.2 Mapio nifer o gynrychioliadau cysyniadol yn L1 a L2 345
6.1.3 Casgliadau dros dro ar fapio dwyieithog o fewn synnwyr 347
6.1.5 Sgematig o fapio mewn synnwyr mewn pobl ddwyieithog 348
6.2 Rhan 2: Mapio rhyng-synnwyr mewn pobl ddwyieithog 350
6.2.1 Sgematig o fapio mewn synnwyr mewn pobl ddwyieithog 353
6.3 Cyfyngiadau’r treuthawd 345

6.3.1 Ansawdd a dadansoddiad y data 355
6.3.2 Ysgogiadau arbrofol 356
6.3.3 Detholiad cyfranogwyr 357
6.3 Cyfarwyddiadau ar gyfer ymchwil yn y dyfodol 360
6.3.1 Mapio o fewn synnwyr 361
6.4.2 Mapio rhyng-synnwyr 362
6.4 Sylwadau Terfynol 363

Cyfeirnodau 365

Atodiad A: Holiadur Hanes Iaith a ddefnyddiwyd yn y penodau arbrofol 408

Atodiad B: *Mesur Hunaniaeth Ethnig Aml-Grŵp a ddefnyddiwyd yn y penodau arbrofol* 415

Atodiad C: Ysgogiadau arbrofol a ddefnyddir yn astudiaeth normio pennod 2 417

Atodiad D: Gweithdrefnau a ddefnyddir yn astudiaeth normio pennod 2 343

Atodiad E: Ysgogiadau arbrofol a ddefnyddir ym mhenodau 3 a 4 443

Atodiad F: Ysgogiadau arbrofol a ddefnyddir ym mhennod 4 460

Atodiad G: Darlun o ganfod trosiad yn Gymraeg ar draws arbrofion 1a, 1b a 2 467

Chapter 1

Literature Review and Thesis Aims

1.0 Chapter overview

This chapter will review current models of bilingual semantics, including associated empirical findings. This section will, therefore, necessarily focus largely on word-level representations. The chapter then moves on to the primary aims, which are to elucidate, (1) the intra-sense mapping (within languages), and (2) the inter sense-mapping (between languages) of concepts in the more complex yet naturalistic context of sentence processing. The chapter ends by outlining the thesis aims, addressing outstanding theoretical questions concerning semantic representations in the bilingual brain.

1.1 Highlighting the basic differences between monolingual and bilingual semantics

Producing a single defining feature for most concepts can be challenging (Wittgenstein, 1953). In fact, the classic theory of semantics describes a semantic concept as a definition that is built from a combination of smaller, simpler concepts. That is to say, a single word may be directly associated with many defining features. The word *dog* for example is associated with a given shape, motion, smell, sound, colour, feel, fur length, and features such as wears a collar. However, an added complexity is encountered when irregularities incompatible with this information occur; i.e., when encountering a new dog of a different color, size, shape, fur, or sound. The individual must thus be sensitive to the weight given to each feature on various occasions, whilst retaining the ability to derive the core representation of dog. In addition, the defining semantic features of the word dog will overlap significantly with those of the word *cat*. Consequently,

stronger associations will exist between these concepts than concepts with fewer overlapping features such as *dog – table*, and even fewer between *dog – lemon* (Yee, Jones, McRae, 2018). These overlapping features are said to produce a taxonomic relationship that group concepts into semantic categories based on shared overlapping properties (i.e., animals, furniture, fruit). These concepts that share common features are said to be taxonomically similar and thus belong to the same category; dog and cat or dog and bear share a taxonomic relationship and belong to the category of mammals (Mirman, Landrigan, & Britt, 2017).

However, concepts can also overlap significantly whilst belonging to entirely different categories. For example, *dog* and *leash* share a thematic link whilst one may belong to the category of animal and the other to the category of tools. These concepts do, however, occur frequently within the same events or scenario (i.e., walking a dog). The distributional hypothesis (Firth, 1957; Harris,1958; 1970) assumes that words that frequently occur within similar context will have similar, overlapping meanings. Under this account the linguistic contexts in which a word is encountered becomes an important feature of its conceptual representation, and the extent to which words share a common context determines the extent of conceptual overlap (Rotaru, Vigliocco, Frank, 2018). The words *dog* and *cat* for example frequently occur in similar linguistic context (i.e., in the context of animal, pet, furry, house) suggesting that their meanings overlap significantly. Distributional relations are typically more important for manipulatable objects such as tools whereas taxonomic relations are more important for more natural objects such as animals (Bonthoux and Kalénine, 2007; Kalénine et al., 2009)

This basic tenet of semantic organization and acquisition has been elaborated upon in the latter prototype theory (Rosch, 1975) and radial structure theory (Lakoff, 1987), which proposes that words have a conventional or core definition with radial-like structures that become extended and mapped. In the case of polysemy (words that have several meanings that share semantic features) core definitions become extended via metaphor (Gathercole, Stadthagen-Gonzalez, Perez-Tattam, Yava, 2016; Lakoff & Johnson, 1980). For example, the core definition of *sister* is 'female sibling', but by metaphorical extension it can also refer to a nun, as the relationship between nuns simulates that of female siblings.

In the case of bilingualism, the difficulty of producing a single defining feature for a given concept is compounded by the fact that no two languages share the exact same semantic characteristics (Jarvis and Pavlenko, 2008; Malt et al., 2015; Gathercole & Moawad, 2010). Whilst translation-equivalent terms in either language can overlap fully and are shared across languages, in many instances, there is no such equivalence, only approximation. For example, a word in one language can have more than one translation equivalent in the other language (e.g., the Spanish term *dedo* is translated as both *finger* and *toe* in English), or a category in one language can be absent from the other language (e.g., the English word *nut* has no equivalent in Spanish; Gathercole, Stadthagen-Gonzalez, Perez-Tattam, Yavas, 2016). Moreover, polysemous words can have a number of meanings and additional language-specific meanings, whilst homophones and homographs share a word form but have multiple unrelated meanings that may not be shared across languages (Francis, 2018). Added to this, recent neurophysiological evidence suggests that bilingualism and the way languages code information, gives rise to

altered conceptual understanding in either language – so-called linguistic relativity – in which object categorisation (e.g. Boutonnet, Athanasopoulos & Thierry, 2012), the perception of movement (Athanasopoulos, Bylund, Montero-Melis, Damjanovic, Schartner, Kibbe, Riches, & Thierry, 2015), and understanding culturally-salient information (Ellis, Kuipers, Thierry, Lovett, Turnbull, & Jones, 2015; Ellis, Thierry, Vaughan-Evans, & Jones, 2017) differs between the L1 and the L2.

The semantic system must then be sophisticated enough to accommodate these multiple meaning mappings in order that bilinguals may effortlessly access meaning in either of their languages. However, the structure of these mappings and their interrelationship is still debated among researchers.

1.2 Psycholinguistic Models of Bilingualism

Several models now attempt to describe, to varying degrees, both bilinguals' lexico-semantic and semantic organisation and access. These models will be reviewed here, along with supporting empirical findings. Whilst the first two models reviewed: The Revised Hierarchical Model (RHM) and The Bilingual Interactive Activation Model (and its BIA+ successor) do not differentiate conceptual representations for the L1 and the L2 *per se*, they are to a large extent the backbone of bilingual theorizing in the last two decades and a valuable counterpoint to models focusing more exclusively on bilingual lexico-semantic differentiation.

1.2.1 The Revised Hierarchical Model (RHM)

The RHM (Kroll and Stewart, 1994) is composed of lexical and conceptual representational layers (including two separate lexica for the L1 and L2), and is most commonly used to describe word production and translation in bilinguals. Both languages are assumed to access common conceptual representations, stored in a single conceptual store.

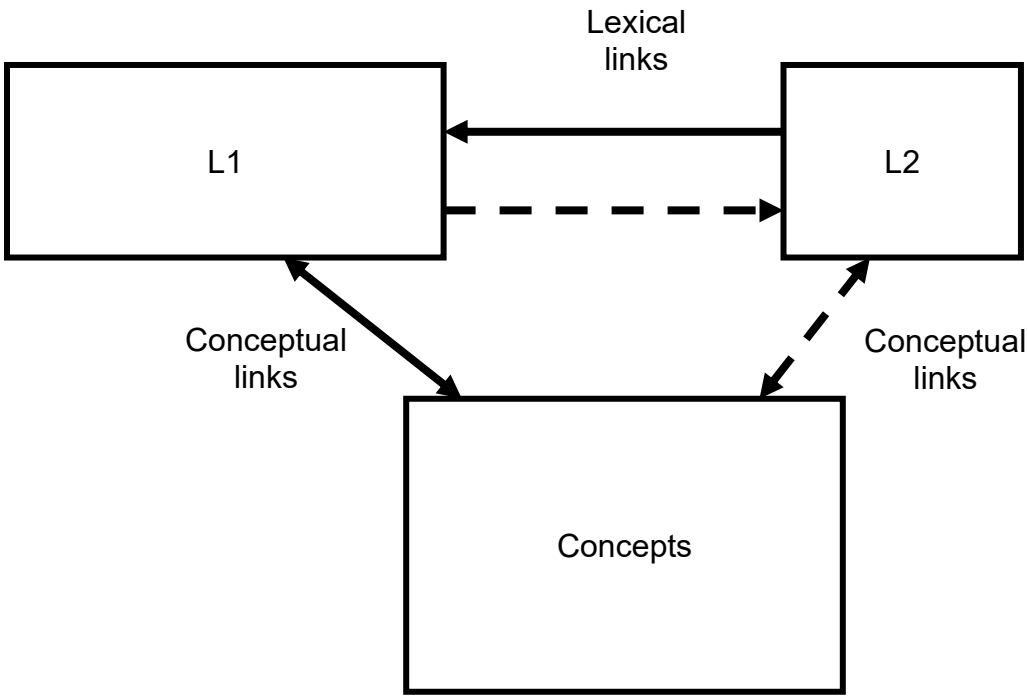


Figure 1. The Revised Hierarchical Model adapted from Kroll & Stewart (1994) pp.158

As well as describing L1-L2 lexical links and lexico-semantic connections, it also serves as a developmental model, describing the trajectory from novice to a proficient speaker (van Hell & Tanner, 2012). Whilst the model is not computationally implemented, it assumes excitatory links between the two lexica, such that activation of a

word in one language (e.g., *horse* in English) will activate its translation equivalent in the other language (e.g., *ceffyl* in Welsh). The strength of links between lexica are assumed to vary according to proficiency. Bilinguals typically acquire the second language within classroom settings in middle or late childhood (Van Hell & Tanner, 2012; Brysbaert & Duyck, 2010), by which time strong connections between conceptual representations and the L1 lexicon are already established (Kroll and Stuart, 1994). Thus, in the novice the L1 has direct access to semantic meaning whilst L2 has little or no direct access to meaning (Van Hell & Tanner, 2012). In such cases, L1-L2 lexical links are assumed to be stronger than L2-conceptual links, indicative of L2 learning via translation (Kroll & Stewart, 1994; Kroll, van Hell, Tokowicz & Green, 2010). For example, a native speaker of Spanish would initially learn the L2 English word *house* by direct mapping onto its L1 equivalent *casa* (Heredia, 1997). With greater proficiency, bidirectional links between the L2 lexicon and the semantic store are established and strengthened, allowing direct access to concepts via the L2 (Kroll and Stewart, 1994; Kroll, van Hell, Tokowicz & Green, 2010). Thus, experience enables the L2 lexicon to become more independent and less reliant on the L1 (Heredia, 1997) and access to conceptual representations changes from the lexically mediated route to the conceptually mediated route. Crucially, however, an L1-L2 asymmetry continues to exist: The bilingual naturally has more experience in the L1, leading to a larger and richer L1 lexicon, with continued stronger lexico-semantic links. This L1 dominance thus survives irrespective of L1-L2 fluency (Kroll & Stuart, 1994).

Evidence in support of the RHM stems from translation tasks (L1-L2 and L2-L1) that manipulate the semantic context of translation list (i.e., one mixed semantic list and

another was semantically categorised – all fruits, all animals for example). Translation in the L1 - L2 direction was affected by semantic context; translation was slower for words in semantically categorised lists than for same words in the mixed list. This effect was not observed in the L2-L1 direction. These findings provide support for the assumption that L1-L2 translation involves concept mediation whilst L2-L1 does not.

However, the RHM has been widely criticised in recent years for the limited evidence in support of the existence of independent lexicons and language-selective access (Brysbaert & Duyck, 2010). In fact, there is considerable evidence to suggest the opposite; that is, suggesting non-selective language access in bilinguals (Brysbaert and Duyck, 2010; Dijkstra, 2005; Schwartz & Kroll, 2006; Thierry & Wu, 2007; van Hell & de Groot, 2008; Dijkstra, Timmermans, & Schriefers, 2000; Van Heuven, Schriefers, Dijkstra & Hagoort, 2008). Perhaps a more salient criticism particularly for the current thesis, is that the model assumes a unitary semantic store, with a (mis)assumption of absolute parity in bilinguals' conceptual representations (Bysbaert & Duyck, 2010; Tokowicz and Kroll, 2007). The oversimplified account of processing provided by the model poses significant problems for implementation.

1.2.2 The BIA and BIA+ models

The bilingual interactive activation and its successor, the BIA+ (Dijkstra & Van Heuven, 2002; Grainger & Dijkstra, 1992; Dijkstra & Van Heuven, 1998) are computational accounts of bilingual word recognition, and assumes non-selective access and activation of shared lexical items at the orthographic, phonological and semantic

representational levels. Consequently, exposure to a word in one language allows spreading activation of related words in another, evident on all sub-lexical and lexical levels in a non-selective fashion.

Although lexical activation is non-selective, activation of each representation is influenced by its resting level activation which is highly correlated with its frequency of use. A word or representation that has a high resting level activation (close to zero) will have a high frequency of use and will become quickly activated. A word or representation that has a low resting level activation (larger than zero) will have low frequency of use and will be activated more slowly. For the bilingual, whose proficiency and use differ between languages, resting level activation for the L1 will typically be higher than that of the L2 causing delayed activation on all levels. This causes cross-linguistic influences from the L1 to the L2 to be larger than from the L2 to the L1; referred to as the temporal delay assumption which has since been supported by neurocognitive studies (van Heuven & Dijkstra, 2010).

The models also assume that language-specific nodes exist to assign language membership to words, allowing the individual to inhibit the non-operational language. Whilst the BIA model assumes a fully interactive system in which information activated by these nodes is fed back to mediate lexical access in a top-down fashion, the BIA+ assumes that information is not fed-back to the lexical level as the activation of language nodes occurs post-lexically in a bottom-up fashion. Additionally, the BIA make no assumptions regarding the activation of words based on expectations, whilst the BIA+

concedes that task demands and linguistic context influences the expectancy of the target word.

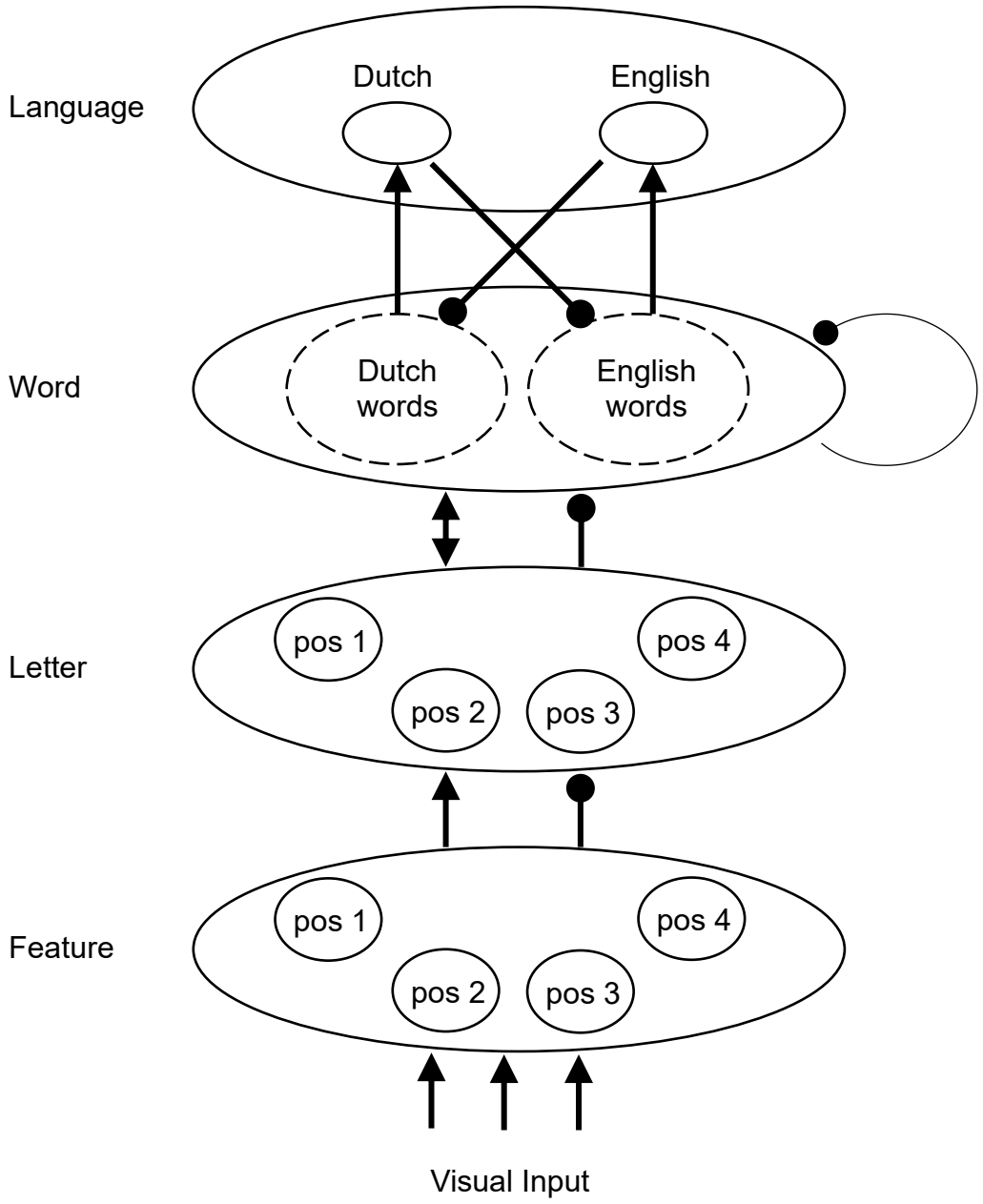


Figure 2. The Bilingual Interactive Activation (BIA) model for bilingual word recognition adapted from van Heuven, Dijkstra, and Grainger (1998), pp. 475.

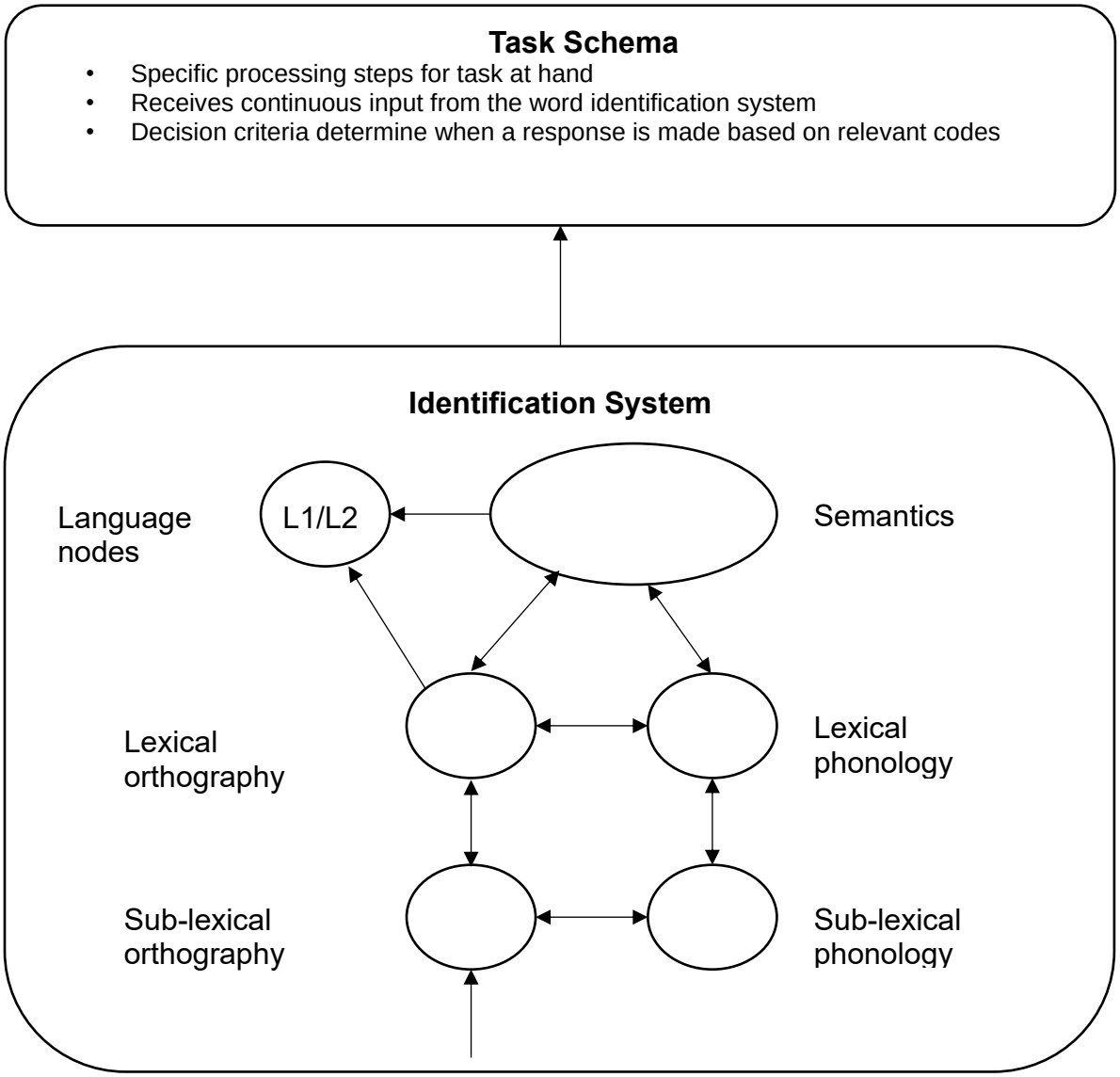


Figure 3. The BIA+ model for bilingual word recognition adapted from Dijkstra & van Heuven (2002).

Considered together, the RHM and the BIA models provide a detailed account of lexical activation, L1-L2 connections, and lexico-semantic connections, including qualitative changes in bilinguals' linguistic development. However, both models assume L1 and L2 access to a common semantic store, which is not differentiated on the basis of unique senses in the L1-L2, nor the functional organisation of these senses.

1.2.3 The Sense Model

The Sense Model (Finkbeiner, Forster, Nicol & Nakamura, 2004), attempts to provide a more nuanced account of bilingual semantic processing than that provided by the RHM or the BIA models. The Sense model assumes (Chen, Zhou, Gao, & Dunlap, 2013), first and foremost, that most words –irrespective of bilingualism– are polysemous: each word has several meanings and is connected to multiple semantic senses. For example, the word *hammer* is associated with several meanings including the noun *a tool*, or the verb *the act of hitting a nail*, *the act of violently striking an object*, including in a more figurative sense, *working hard and persistently*, or *criticizing relentlessly*. Each sense is represented separately in the semantic system (Chen, Zhou, Gao, & Dunlap, 2013; Basnight-Brown & Altarriba, 2007).

The Sense Model assumes that the conceptual store consists of both shared, overlapping senses, and language-specific, non-overlapping senses (Brysbaert & Duyck, 2010; Finkbeiner, Forster, Nicol & Nakamura, 2004). Translation equivalents in two languages are not simple one-to-one mappings; depending upon the language of

operation, each language may have access to a different range of senses (Brysbaert & Duyck, 2010). Across languages, each word typically shares a dominant common core sense but differs in the remaining senses (Wang & Forster, 2010). The English word *black* and its Japanese equivalent *kuroi* share the dominant sense *colour* (see Figure 4). However, beyond this core sense, the Japanese equivalent *kuroi* may be used to describe an *evil-minded individual*, whist the English word may represent *humour* or *depression*. Furthermore, each language has its own constraints on the meaning of words. For example, *big sister* is acceptable in English, whilst *large sister* is not (Brysbaert & Duyck, 2010).

Whilst bilinguals are typically more proficient and familiar with the range of semantic representations in the L1, they may not be similarly familiar with all senses associated with a certain word in the L2 (Finkbeiner, Forster, Nicol & Nakamura, 2004; Chen, Zhou, Gao, & Dunlap, 2013). Consequently, L1 words are connected to a greater and richer number of senses than words in the L2 in which only core representations are typically learned (Luo, Cheung, Bel, Li, Chen, & Mo, 2013). The Sense Model proposes that asymmetries found in lexical and semantic decision tasks are due to the number of senses activated by a prime, with many-sense targets increasing activation (Finkbeiner, Forster, Nicol & Nakamura, 2004). If the overlapping senses between the prime and target are limited, activation is limited, and priming will be ineffective. Thus, an L1 target will not be effectively activated by an L2 prime because of the limited proportion of senses available in the L2. Contrastingly, in the L1-L2 direction, the rich number of primes available to the L1 will pre-active their overlapping L2 senses.

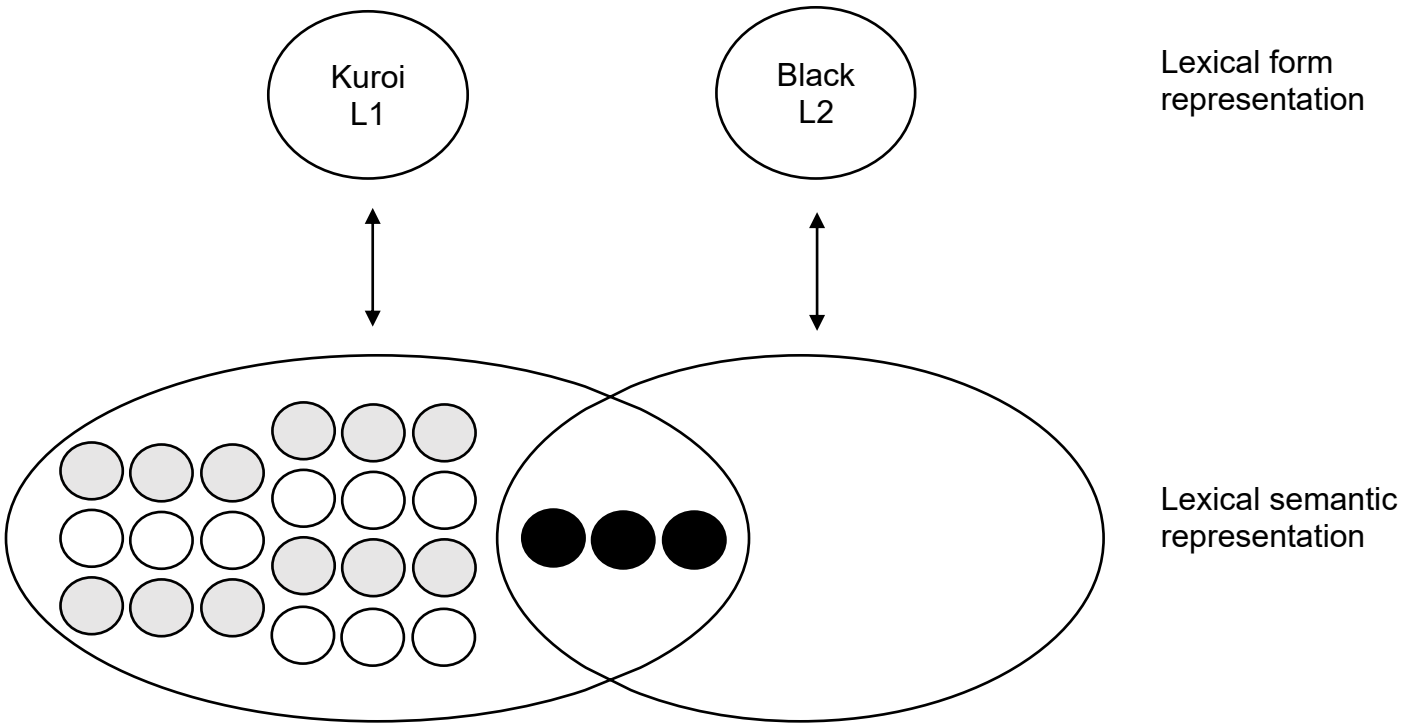


Figure 4: The Sense Model adapted from Finkbeiner, Forster, Nicol & Nakamura, (2004)

1.2.4 The Distributed Feature Model (de Groot, 1992)

The Distributed Feature Model (de Groot, 1992; De Groot, 1995; De Groot, Dannenburg, & Van Hell, 1994; Van Hell, 2019; Van Hell & De Groot, 1998) proposes that the degree to which representations in a given language are overlapping or unique depends on the word's lexical category. For example, concrete nouns and cognates are assumed to be similar across languages, with translation equivalents sharing all nodes of conceptual representations, whereas abstract nouns and noncognates are assumed to be

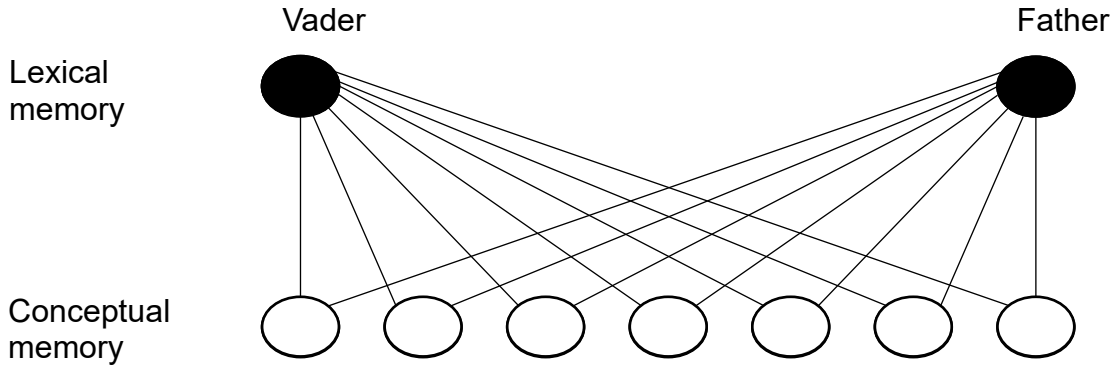
more language specific with only a sub-set of conceptual nodes shared by translation equivalents (see Figure 5).

The model assumes that translation in fluent bilinguals for concrete words occurs via both the lexical route (T1) and conceptually mediated route (T2) whereas abstract words are translated only via the lexical route (T1; see Figure 6). In non-fluent bilinguals on the other hand, translation occurs via word association, implying that during second language learning, the route by which translation occurs eventually switches from the word association route to the conceptually mediated route (De Groot, 1992), also reminiscent of the switch proposed by the RHM (van Hell & Tanner, 2012).

Ease of translation according to the DFM is determined by the degree of overlap between translation equivalents. A larger number of conceptual nodes associated with a specific concept will lead to greater spreading of semantic activation resulting in more rapid translation. Thus, speed of access to semantic representations will influence translation performance. This allows us to predict the time it will take to recognise whether words are correct translation equivalents or to translate from one language to another.

For cognates and concrete nouns, recognition of translation equivalents has been found to be faster than that of abstract nouns and non-cognates in translation production, translation recognition, lexical decision, and word association tasks (De Groot, 1992De Groot, 1995; De Groot et al., 1994; Van Hell, 2019Van Hell & De Groot, 1998). Moreover, translation performance is influenced by the number of translations a word may have; recognition is slower for those with multiple translations than for those with a

single translation (Tokowicz, 2000). This suggests that bilinguals can have both identical and non-identical concepts for words leading to varying degrees of overlapping meanings (Kroll & Tokowicz, 2005). For example, the word *play* is a broad term that can mean playing a *sport*, *board game* or *instrument*. Its Spanish translation *jugar* is only used to refer to playing a sport or board game whilst *tocar* is used to refer to playing an instrument. Moreover, in colloquial Welsh an instrument is *played*, whilst in formal Welsh an instrument is *sung*. According to the DFM each meaning will be represented by a different node, thus, *play*, *juga* and *tocar* will only partially overlap. The degree of overlap will depend on the bilingual's level of proficiency and context of acquisition (e.g., Dufour & Kroll, 1995; Finkbeiner,2003; Jiang, 2000; Silverberg & Samuel, 2003).



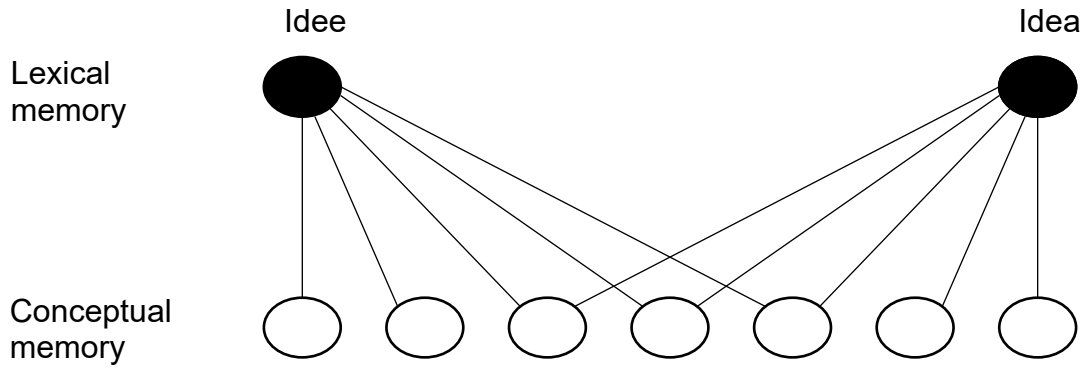


Figure 5. Structure of distributed conceptual representations in bilingual memory adapted from De Groot (1992).

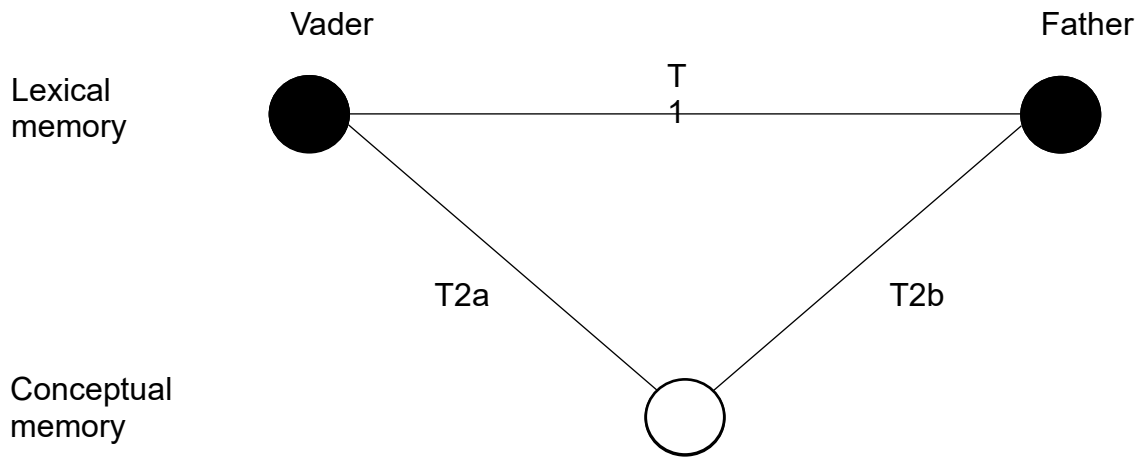


Figure 6. Representation of bilingual memory adapted from De Groot, 1992.

1.2.5 Multilink

The Multilink model (Dijkstra, Wahl, Buytenhuijs, Van Halem, Al-Jibouri, De Corte, & Rekke, 2018), is a computational model that seeks to integrate current models of bilingualism and the various aspects of bilingualism they currently describe, including word retrieval, production and translation, lexical-semantic processing, language activation, word frequency and task decision systems. Incorporating assumptions of both the BIA+ and the RHM models, the model itself is called ‘Multilink’ owing to the large number of connections between representations that are required in constructing a comprehensive model of word retrieval. Its structure comprises an integrated lexicon

arguing against the separation of the bilinguals two languages. Upon visual stimulus presentation lexical-orthographic representations are activated consequently activating corresponding phonological, semantic and language membership representations. In line with the BIA model these stores are highly interactive with bidirectional activation.

Current empirical evidence in support of this model comes from stimulation studies. A strength of computational models is that they allow for the comparison of the model's components with empirical data, and more importantly, determine how well the model explains empirical findings (Van Heuven & Wen, 2019). One such example is the model's explanation of word translation. The authors simulated an experiment by Chistoffels et al (2006) who found faster translation in the L1 - L2 direction (forward translation) than in the L2-L1 direction (backward translation); effects were larger when proficiency was lower. The experiment was replicated with some minor changes to the experimental design (see Pruijn et al, in preperation; Dijkstra, Wahl, Buytenhuijs, Van Halem, Al-Jibouri, De Corte, & Rekke, 2018) and faster translation was again found in the forward direction (L1 - L2). Multilink also simulated the forward translation direction effect. These results may be explained by stronger links to concepts in the L1 or by stronger L1 – L2 direct word links. However, these findings diverge considerably from the assumptions and evidence in support for the RHM (Kroll & Stewart, 1994), who predicts stronger links from the L1 - L2 than vice versa. Evidence in support of the RHM (as well as many other word recognition and production studies) stem from the masked priming paradigm therefore the model's ability to capture these asymmetries using this method is a crucial test of any model. Thus, although the Multilink offers great advancement in the development of a comprehensive model of bilingual word

recognition and translation, it is not yet fully developed to be universal (Van Heuven & Wen, 2019).

Another key issues that require specification in its second implementation is the activation between conceptual representations that share partially overlapping lexico-semantic links in either language. At present the model describes semantic representations as simple holistic units. Both the influence of language context (as specified in the advancement of the BIA to the BIA+; Dijkstra & Van Heuven, 2002; Van Hell, 2019) and the spreading of activation between semantic representations and the processing of language dependent vs independent semantic features are currently left unconsidered. A second implementation of Multilink will investigate activation between conceptual representations, as well as partially non-overlapping lexico-semantic mappings in the L1 and L2 (Dijkstra, Wahl, Buytenhuijs, Halem, Al-Jibouri, De Korte, Rekke, 2018).

1.2.6 Interim Conclusion and Outstanding Questions

The models outlined above provide a comprehensive account of bilingual word recognition and production, perhaps particularly at the level of lexical activation and L1-L2 translation (Kroll & Stewart, 1994); Dijstra & Van Heuven, 2002; Dijkstra & Van Heuven, 1998; Finkbeiner, Forster, Nicol & Nakamura, 2004); De Groot, 1992). However, each model's account of the bilingual semantic structure varies considerably. The BIA/BIA+ and RHM models conceptualise the semantic system as a unitary store, and whilst the BIA models do not specify privileged access to semantics for either

language, the RHM at least specifies stronger lexico-semantic links in the L1. The Sense Model attempts to account for the translation non-equivalence between languages (de Groot, 2011; Pavlenko, 2009) by specifying shared and unique lexico-semantic links for the L1 and the L2. A greater number of semantic items belong to the native language, which results in greater spreading and activation of conceptual features. The DFM similarly distinguishes shared and unique L1-L2 senses, but also assumes greater conceptual overlap for concrete words over abstract words.

Current theorizing therefore extends to the acknowledgement and implementation of shared and unique lexico-semantic mapping for the L1 and L2, and a description of the word types that likely fall into either category. But a number of tantalising theoretical questions remain concerning the functional structure of the bilingual semantic system and the implications of this structure for language processing.

For the purposes of this thesis, we categorise these questions into those concerning bilinguals *intra*-sense mapping, i.e., within the L1 and the L2, and *inter*-sense mapping, i.e., between the L1 and L2. The intra-sense questions arise from repeated observations that the L1 lexicon is typically considered 'larger' (Kroll & de Groot, 1997) and 'richer' (Finkbeiner, Forster, Nicol & Nakamura, 2004) than the L2 lexicon, since lexico-semantic links are typically instantiated from birth or at least an early age (Kuhn, Wiloughby, Wilbourn, Vernon-Feagans & Blair, 2014). Therefore, we ask: Are there processing characteristics or advantages in the L1, owing to its size and stronger lexico-semantic links? In L1, is the mapping between senses conducted with less processing effort, owing to the greater level of linguistic experience, leading to stronger and richer

inter-conceptual links? The inter-sense mapping questions arise from a body of evidence (reviewed below) examining implicit co-activation of language. We ask, at the conceptual level: Are senses unique to one language accessed only in that language, or can they also be access in the other language? And if so, can we find evidence of immediate (online semantic) access to these unique senses in the other – 'incorrect' – language, suggestive of a fully interactive lexico-semantic system in bilinguals?

The remaining sections of this chapter deal in turn with the specific intra- and inter-sense mapping questions dealt with in this thesis.

1.3 PART 1 ~ Intra-Sense mapping in bilinguals

If greater experience in the L1 leads to a larger and richer lexicon, a testable hypothesis of this bilingual feature is whether it then leads to less processing effort in a) accessing meaning *per se*, and b) mapping multiple conceptual representations in order to derive meaning with less processing effort.

In order to test these hypotheses, Experiments 1a, 1b and 2 examine the evidence for an L1 advantage in (a) processing sentence anomaly, i.e., identifying meaningful over nonsensical sentences, and (b) processing figurative meanings in sentences, i.e., a metaphorical interpretation that requires multiple conceptual mappings in order to derive meaning (explained further in section 1.3.3 below). These questions were addressed in the context of sentence processing, as opposed to individual words processing, primarily in order to more easily manipulate meaning whilst keeping target words identical across

different sentence types, but also to examine bilingual semantics in a more naturalistic language context. I will now review literature pertaining to semantic processing in a sentence context.

1.3.1 Semantic processing in sentence contexts

Readers / listeners are proposed to anticipate upcoming words as a sentence unfolds, enabled by various syntactic and pragmatic constraints, and ultimately leading to ease of semantic processing and integration as the word appears (Foucart, Martin, Moreno & Costa, 2014; Pickering & Garrod, 2007; Wicha, Morena & Kutas, 2004; DeLong et al, 2005; Neely, 1977). Such predictive processes therefore enable rapid comprehension of continuous text and speech (Pickering & Garrod, 2007). In cognitive neuroscience, a large body of literature attests to contextual word prediction, as revealed in N400 modulation in event related potential (ERP) paradigms (described further in Chapter 2, but briefly, negativity at ~400 ms post stimulus onset increases as a function of difficulty in integrating an upcoming word with the previous linguistic context (Kutas & Federmier, 2011; Lau, Phillips, Poppel, 2008; Wlotko & Federmier, 2015).

In bilingualism, models currently focus on individual word processing, and linguistic context is as yet under represented (van Hell, 2019), we know that that it exerts considerable influence on bilinguals' linguistic functioning, often biasing the language system to recognise and produce words in a language-specific way (Egan, Oppenheim, Moll, Saville, & Jones, 2019; Bultena, Dijkstra, & van Hell, 2014; Schwanenflugel & Shoben, 1985; Foucart, Martin, Moreno, & Costa, 2014; Schwartz & Van Hell, 2012;

Van Hell & De Groot, 2008), Schwartz & Kroll, 2006); Duyck et al, 2007). Moreover, an emerging body of evidence suggests that predictive processes may not operate similarly across languages; findings suggest that predictive processes are utilized to a greater degree, or at least more efficiently in the L1. For example, Martin et al. (2013) presented English monolinguals and late Spanish-English bilinguals with sentences in which the final word was either highly predictable or not. Whilst the monolingual group showed a classic N400 effect, with a more negative wave for unpredictable words, the bilingual group showed no N400 difference across conditions, which the authors interpret as a weaker capacity for predicting the upcoming word as a consequence of delayed linguistic processing in the L2 relative to the L1.

Consistent with these findings, bilinguals' semantic expectancy violations are found to be delayed and more pronounced in the L2 (Ardal, Donald, Meuter, & Muldrew, 1990; Kutas & Kluender, 1994; Weber-Fox & Neville, 1996), suggesting that bilinguals are slower to appreciate that a word does not fit with the sentence context (Moreno & Kutas, 2005) possibly due to greater semantic integration difficulties (Hahne & Friederici, 2001). To test whether fluency (Ardal, Donald, Meuter, & Muldrew, 1990) or age of exposure (Webber-Fox & Neville, 1996) may modulate this effect, Moreno & Kutas (2005) presented Spanish-English bilinguals, who were either late or early L2 learners, with semantically acceptable and unacceptable English and Spanish sentences. Semantic violations elicited greater N400 effects relative to semantically congruent items regardless of language dominance. The congruency effect however, produced a delayed N400 effect in the less proficient language for both groups, suggesting faster L1 processing even in highly proficient, early bilinguals.

Although these findings suggest a processing asymmetry between semantically congruous and incongruous sentences in the L2, the processing of semantically meaningful sentences have also been found to be more effortful in the non-native compared to the native language (Hahne, 2001; Hahne & Friederici, 2001). Hahne & Friederici (2001) found greater positivity in the P600 time window (a positive going ERP component indicating sentence re-analysis; see methodological chapter for review) to both semantically meaningful and anomalous sentences in non-native compared to native speakers. These results suggest that regardless of sensibility, processing in the second language required additional effort suggesting more effortful conceptual access in the non-native language relative to the native language.

Thus, the processing of a non-native language appears to follow a different time course and comprehension process relative to the native language and to monolingual speakers (Moreno, Rodriguez-Fornells, & Laine, 2008). Why might this be? One possible explanation is that more frequent exposure to certain lexical strings in the L1 leads to greater activation of these contingencies on subsequent exposures, similar to the transitional probabilities described in models of language learning (e.g., Elman, 1990; Dell & Chang, 2014). Greater activation of specific lexical strings would then presumably enable the individual to make efficient predictions concerning upcoming words. Less frequent exposure to specific strings in the L2 would results in less activation, with less scope for the prediction of upcoming words. Under this account, accessing semantic representations online may be relatively inefficient or delayed in the L2.

In Part 1 of this thesis, we therefore examine whether online detection of semantic violation in sentences is more efficient in the L1 than in the L2. A second major goal is to examine potential differences in the efficiency with which bilinguals map conceptual representations during sentence processing. To this end, we used literal and figurative sentences, for which the sentence meaning can be derived directly, or indirectly, respectively. Figurative language therefore presents a context in which the sentence is meaningful, but accessing meaning is less straightforward than is the case for literal language. In the next section, I will summarise the considerable literature on metaphor before I describe how literal and metaphorical language were specifically used in our experiments.

1.3.2 Literal and figurative language

An intense focus on literal language in research belies the fact that everyday language is littered with nonliteral expressions (Citron, Cacciari, Kucarski, Beck, Conrad, & Jacobs, 2016) when in fact, approximately six metaphorical expressions are used per minute (Pollio, Barlow, Fine, & Polio, 1977). Metaphor, as a form of figurative language, occurs when a word is applied to an object or action to which it is not literally applicable, which requires the comprehender to go beyond conventional word meaning and map two or more concepts to each other via representations common to both (Citron et al, 2016; Landau, Keefer, and Meier, 2010; Rapp, Leube, Erb, Grodd, Kircher, 2004).). For example, in the statement: *From the lonely heart came a cry*, the literal meaning is nonsensical, since a heart cannot cry. Nevertheless, the statement becomes meaningful

when these concepts are considered according to their overlapping properties, such as *emotion, communicate unhappiness*, etc. (Lai, Curran, and Menn, 2009; Rapp, Leube, Erb, Grodd, Kircher, 2004). Contrast this metaphorical statement with the literal statement: *From the lonely baby came a cry*, in which *baby* and *cry* can be straightforwardly (literally) mapped to one another. Thus, metaphoric language requires individuals to connect two seemingly unrelated concepts on the basis of their overlapping features (Bambini, Bertini, Schaeken, Stella a Russo, 2016; Cardillo et al, 2010; Lai, Curran, & Menn, 2009; Rapp, Leube, Erb, Grodd, Kircher, 2004; Pynte, Besson, Robichon, & Poli, 1996). Thus, metaphors can potentially throw light on the complex relationship between the lexical and semantic layers of representation (Bolognesi, 2016).

Given the relative complexity of figurative language, a common assumption, also supported by empirical evidence, is that literal meaning is accessed first and rejected, before the figurative meaning is considered (Citron et al, 2016; Gibbs, & Colston, 2006; Glucksberg, 2003). Whilst metaphorical language indeed often incurs longer reaction times in sentence comprehension tasks, other findings suggest that metaphorical meaning is accessed as readily as literal meaning (Bambini et al, 2016; Glucksberg, 2003), so long as there are comparable levels of semantic saliency (cf. the graded salience hypothesis, Giora, 1997; De Grauwe et al, 2010; Glucksberg, 2003). Frequency of use is also found to determine whether or not metaphorical meaning is accessed without recourse to the initial rejection of literal meaning. Conventional metaphors such as *ideas are food / food for thought* are accessed on a par with literal language, whereas novel metaphors such as *theories are fathers / the father of a theory* require online construction of disparate conceptual links and therefore more processing effort (Lai, Curan & Menn, 2009; Rataj,

2014; Rataj, Przekoracka-Krawczyk, & Lubbe, 2018). It is thought that with frequent use, a new general sense is acquired, which can be accessed directly, in addition to the original specific sense (Lai, Curran & Menn, 2009). This direct access occurs when metaphors become lexicalised with frequent exposure and words become associated with both a literal and a metaphorical meaning (Geiger & Ward, 1999).

The ERP literature has yielded mixed support for indirect vs. direct metaphor access. Studies in support of the indirect model report asymmetric modulations of N400-P600 (Bambini et al, 2016; De Grauwe et al, 2010; Coulson & Van Petten, 2002). For example, de Grauwe et al (2010) found a relatively small, early N400 effect to familiar metaphors compared to literal sentences, suggesting that whilst the metaphorical meaning was accessed, larger modulation of the subsequent late positive component (LPC: 550-750ms) indicated conflict between the implausible literal interpretation and the plausible metaphorical meaning. Findings in support of the direct view, on the other hand, demonstrate larger N400 modulations to metaphorical sentences: *Those fighters are lions* than to literal sentences: *Those animals are lions* (Pynte, Besson Robichon and Poli, 1996), suggesting that whilst accessing metaphorical meaning is more effortful, it is nevertheless resolved during online semantic access and does not incur greater reanalysis processes (Coulson & Van Petten, 2007; Bambini et al, 2016). As with behavioural findings, frequency or 'conventionality' of the metaphor may also modulate online semantic access. Lai, Curran & Menn (2009) showed largest N400 amplitudes to anomalous sentences, novel metaphors, and conventional metaphors compared to literal sentences. In the later N400 window (440-560 ms), amplitudes elicited by the conventional metaphors converged with the amplitude of literal sentences, whilst novel

metaphors and anomalous sentences elicited continued N400 negativity. Thus, whilst even conventional metaphors require some additional and slightly later semantic processing compared to literal language, novel metaphors require considerable levels of effort, similar to that required in anomalous sentence processing.

To date, little is known of how figurative language is processed online in a second language. Yet metaphor may prove a very useful tool to examine how conceptual mapping is conducted in the first and second language. A recent ERP study investigated bilinguals' responses to novel metaphoric, conventional metaphoric, literal and anomalous word pairs in the first (Polish) and second language (English; Jankowiak, Rataj, & Naskrecki, 2017). The study found that late bilinguals responded to novel and conventional metaphors similarly in their second language (indexed by similar amplitudes of the late positive component). In the native language (within the same time window), the same bilinguals displayed continued processing effort only for novel metaphors. These findings imply that non-native processing involves a decrease in both automaticity and sensitivity to conventionality of metaphorical meanings. The method of word-pair investigations used however, are as previously discussed, unrepresentative of natural language processing (Egan, Oppenheim, Moll, Saville, & Jones, 2019; Bultena, Dijkstra, & van Hell, 2014; Schwanenflugel & Shoben, 1985; Foucart, Martin, Moreno, & Costa, 2014; Schwartz & Van Hell, 2012; Van Hell & De Groot (2008), Schwartz & Kroll (2006); Duyck et al (2007). To avoid biasing the individuals processing, here, we use contextualised metaphorical language by use of complete sentences.

In sum, current models of bilingualism focus on recognition and word production at the lexical level, and conceptual representations are generally described in terms of

lexico-semantic links. Part 1 of this thesis examines possible L1 and L2 differences in how bilinguals conduct intra-conceptual mapping, in a bid to reveal whether integration of multiple conceptual representations can be accomplished more easily in the L1 than in the L2. To this end, Experiments 1 a and b (Chapter 4) and Experiment 2 compare bilinguals L1 and L2 sentence processing for anomalous, literal and metaphorical language.

1.4 PART 2 ~ Inter Sense mapping in bilinguals

Whilst Part 1 of this thesis is concerned with bilingual conceptual mapping *within* the L1 and L2, Part 2 examines the evidence for co-activation of conceptual representations *between* languages. A large body of research now exists in support of the language non-selective view suggesting that bilinguals cannot inhibit words and syntactic structures in the unintended language, even within monolingual contexts (Kroll & De Groot, 2005;Thierry & Wu, 2004;2007; Schwartz & Van Hell, 2012; Gollan, Froster & Frost; Hoshino & Kroll, 2008; Starreveld, De Groot, Rossmark, & Van Hell, 2014; Schoonbaert, Duyck, Brysbaert, & Hartsuiker, 2009; Hartsuiker, Pickering, & Veltkamp, 2004; Vaughan-Evans, Kuipers, Thierry, Jones, 2014; Van Hell & Dijkstra, 2002). In Part 2, I ask whether such co-activation also occurs at the level of conceptual representation. In other words, is a sense that is unique to one language spontaneously co-active in the unintended language?

1.4.1 Language co-activation

The degree to which words overlap across languages varies considerably. Whilst some such as cognates (share both form and meaning) overlap significantly, others only partly overlap, such as interlingual homographs (share form but are not translation equivalents), and orthographic neighbours (the lexical form is similar to the target form). The question of whether bilinguals activate representations from a single language or both languages in parallel during language comprehension, has been of great interest to language researchers in recent years.

The language selective view postulates that bilinguals activate word candidates from the language of operation only (Macnamara & Kushnir, 1971). Accordingly, the mere presence of an overlapping translation is irrelevant to the processing of a given target; comparable to that of monolingual processing (Kroll & Tokowicz, 2005). For example, the English words *lip* or *apple* would be processed by a Dutch-English bilingual unambiguously without interference from their Dutch translation *lip* and *appel* (van Hell & de Groot, 2008). The evidence, however, suggests the contrary. Cognates are in fact recognized and processed faster than non-cognates when presented in both the native and non-native language (van Hell & Dijkstra, 2002; Costa et al., 2000; de Groot & Nas, 1991; de Groot et al., 2000; Dijkstra et al., 1998; Dijkstra et al., 1999).

The faster recognition of cognates suggests that word-level representations from both languages are activated in parallel (van Hell & de Groot, 2008). Thus, the language non-selective view holds that representations in both languages are activated simultaneously. The prevalence of evidence in support of the nonselective view is

considerable, rendering the language-selective view alone a misleading representation of language access in bilinguals (Dijkstra, van Jaarsveld, & Brinkle, 1998; Brysbaert, van Dyck, & van de Poel, 1999; Costa, Caramazza, & Sebastia´n-Galle´s, 2000; Costa, Miozzo, & Caramazza, 1999; de Groot, Delmaar, & Lupker, 2000; Dijkstra, Grainger, & van Heuven, 1999; Dijkstra, van Jaarsveld, & ten Brinke, 1998; Gollan, Forster, & Frost, 1997; Jared & Kroll, 2000; van Hell & Dijkstra, 2002; van Heuven, Dijkstra, & Grainger, 1998; Von Studnitz & Green, 2002).

The issue of whether words from the other language are spontaneously co-active when a bilingual operates in only one of their languages, is now well established at the lexical level. For example, behavioural evidence includes facilitation for word recognition when the target is a translation equivalent of a prime (*doctor'*– '*arts'* (*doctor* in Dutch) than when prime and target are semantically related (*doctor* - *nurse*) or unrelated (*doctor* - *fish*; Kroll and Sholl, 1992; Tzelgov and Eben-Ezra, 1992; Keatley et al., 1994). Moreover, reaction times in lexical-decision tasks are faster when the target (e.g., *money*) is an inter-lexical homograph of the French prime (e.g., *coin*, meaning *corner*, but also a unit of currency in English) compared with an unrelated French prime (e.g., '*feuille'*, meaning *leaf*; Beauvillain and Grainger, 1987). Thierry and Wu (2007) presented Chinese individuals with English word pairs, half of which shared a first syllable when translated to Chinese (e.g., the English words *train* and *ham* translate into '*huo che'* and '*huo tui'*). These trials elicited a priming effect, as indicated by a reduced N400 to the concealed Chinese character repetition, even though these trials elicited no such distinction on the behavioural level. Thus, Chinese-English bilinguals spontaneously co-activated Chinese translation equivalents, even in a monolingual English context.

In a later study the same authors investigated the influence of emotional valence on spontaneous cross-linguistic activation (Wu & Thierry, 2012). Using a similar paradigm of concealed Chinese sound repetition, participants were asked to judge the semantic relatedness of words that were positive, negative or neutral in their emotional valence. Whilst neutral and positive English words effectively primed their Chinese translation equivalents, no such effects were found for the negative valence words. Cross-linguistic activation in bilinguals is thus constrained by stimuli that may be disturbing semantically (such as *violence*) which act to supress full access to lexical-semantic representations. This suggests that semantic information plays an important role in cross-linguistic activation. Indeed, lexical selection does not comprise of orthography alone; if the system is fully interactive (McClelland & Rumelhart, 1981) then phonological, syntactic and semantic features will also determine activation.

Evidence also supports cross-language activation of *syntactic* information. In one of the first studies to explore coactivation of syntax, Hartsuiker, Pickering, & Veltkamp (2004) asked Spanish-English bilinguals to describe cards to other Spanish-English bilinguals in a dialogue game. Participants tended to use the same sentence form as the one previously heard to describe their card; English passive sentences were often used after hearing a Spanish passive sentence, providing evidence of cross-linguistic syntactic priming. More recently, Vaughan-Evans et al (2014) demonstrated using event related potentials that morphosyntactic rules specific to one language can be unconsciously transferred to the other language. Welsh-English bilinguals' N400 responses to nonwords, placed at the end of English sentences, were attenuated only when the non-word was both a legal phonological mutation in Welsh, and occurred in the

morphosyntactic context that would elicit a mutation in Welsh. Co-active representations at the lexical level conform with current bilingualism models reviewed above (e.g., Dijkstra & van Heuven, 2002), although such models are yet to fully implement or theorize the basis for syntactic coactivation.

In contrast, spontaneous activation of semantic senses is currently underexplored. In a fully interactive system, selection of lexical candidates is influenced by semantic information from surrounding contexts that are fed back to the orthographic level (BIA+ Dijkstra & van Heuven, 2002, and the inhibitory effects of interlingual homographs (Dijkstra et al., 1999; Libben and Titone, 2009) suggest that semantic information both languages can be active in parallel. To examine automatic access to semantic information in L1 and L2, Martin, Dering, Thomas & Thierry (2009) instructed Welsh-English bilinguals to make word length decisions in one language whilst ignoring distractor – manipulated according to semantic relatedness - with words from the other language. Priming was found in both languages, suggesting that meaning-level information was also active in both languages.

In Experiment 3 of this thesis, we examine co-activation of meaning in bilinguals' two languages using a monolingual sentence context. Thus, our study avoids inherent biases in presenting two languages simultaneously, and in assuming meaning equivalence across languages for single words. We also examine spontaneous co-activation of semantic senses in bilinguals by presenting *idiomatic language* – specific to one language – in bilinguals' other, 'idiom-incongruent' language.

1.4.2 Idiomatic expressions

Idiomatic expressions typically comprise a fixed string of words denoting a meaning that can be interpreted literally and figuratively; i.e., the popular English idiom *she was in hot water* implies being literally submerged in hot water and figuratively being in trouble (Carrol, Conklin, & Gyllstad 2016; Carol & Conklin, 2017; Beck & Weber, 2016). Recent evidence shows that the figurative meaning of well-known idioms is available before the literal meaning (Giora 1997; 2002; Libben & Titone,2008; Rommers, Dijkstra & Bastiaansen,2013; Siyanova-Chanturia, Conklin & Schmitt, 2011), and are highly lexicalized, existing as whole units in the lexicon (Ortony et al., 1978; Swinney and Cutler, 1979; Cacciari and Tabossi, 1988)

However, idiomatic language is often language specific. For example, the Welsh idiom *roedd y ddynes yn het* (‘*the woman was a hat’*) carries the meaning of ‘the woman was an idiot’ in Welsh, though it carries no sensible meaning in English. Idioms presented in the incongruent language may therefore a) be processed similarly as in the congruent language, if meaning is co-active, or b) present with a processing delay if meaning is only activated following online semantic processing (perhaps analogous to processing a novel or less familiar idiom; Carrol, Conklin & Gyllstad, 2016). Carrol and Conklin (2017) investigated how translated Chinese idioms are processed by native Chinese speakers when encountered in the L2 (English). Although recognition was slower than for those of literal meanings, native speakers of Chinese were able to recognize the L1 idiomatic form even when encountered in the L2. The authors therefore suggest that although the Chinese translated idioms activate L1 lexical representations, conceptual information associated with the idioms are not automatically activated.

However, it is currently unknown how native language idioms are processed during *semantic online* stages when encountered in the non-native language.

In Part two of the current thesis, we use event related potentials to investigate whether the 'unique' senses of each language are nevertheless fully interactive and activated with no discernable processing cost in the idiom-incongruent language. Or, whether processing delay signals that language-unique senses are activated in the incongruent language only following meaning activation in the congruent language. In Experiment 3 I will therefore compare Welsh-English bilinguals and English monolinguals processing English sentences manipulated to create a) sensible and b) anomalous sentences, forming baseline conditions against which we can compare processing of c) translated Welsh idioms.

1.5 Chapter Summary

In this chapter, I reviewed current models of bilingual semantic processing, their empirical underpinnings and how word-level representations are explained. The current thesis will extend current research efforts by focusing solely on sentence-level processing and will attempt to elucidate bilinguals' (1) the intra-sense mapping (within languages), and (2) inter-sense mapping (between languages). The following chapter outlines the experimental procedures, methodologies and considerations used in data collection.

Chapter 2

Methodological Considerations

Acknowledgements: Thank you to Awel Vaughan Evans and Yang Lee for providing guidance and support during my ERP training.

2.0 Chapter Overview

This chapter outlines the three primary methodological details of the thesis: 1) the target bilingual populations, and the various self-report measures used to determine each participants' language history, use and proficiency. 2) the rationale for using event-related potentials to address the research questions outlined in the previous chapter, including a brief review of the two components of interest (N400 & P600), and a discussion of how this method has previously been used in the study of figurative language. 3) I consider the natural properties of literal and figurative language, including inherent differences on a number of factors. For this purpose, I will present a norming study which was instrumental in informing our choice of experimental design in the ensuing experiments.

2.1 Participants: The Welsh-English bilingual population

Our population of bilinguals was drawn from the Welsh-English community of North Wales. I will now detail the demographic of this population.

Whilst Welsh is considered a minority language (Martin, Dering, Thomas, & Thierry, 2009), and according to the Welsh Language Census (Office for national Statistics, 2011) only 19% of the general population in Wales speak the language, its prevalence is much greater when looking at individual counties (65% in Gwynedd), and even more so within specific regions of North-West Wales (86% in Caernarfon for example). In terms of education, in the county of Gwynedd (from which our current

bilingual population is derived), the majority of schools are predominantly Welsh medium (84 Welsh; keeping with the county's Welsh language policy, Gwynedd Council, 2016) and the reminder either bilingual (12) or predominantly English (2; Welsh Government, 2019/20). In Welsh medium schools, tuition is mainly in Welsh, but English is introduced as a second language subject during the final period of foundation years (6-7 years of age), and there is an increased focus on the use of English as schooling progresses (Gwynedd Welsh in Education strategic plan 2017-2020, 2017). Thus, for native L1 Welsh-speaking bilinguals (receiving mainly Welsh at home), both the education system, the bilingual community, and the predominant English media means that most will reach an early and very high level of L2 English proficiency (Gathercole, 2007). The existence of large numbers of L1 and L2 Welsh/English speakers (but all with very high proficiency levels) means that examining how L1/L2 status affects figurative language processing was also possible. In the following section, I detail the means by we which we ascertained bilingual status and proficiency in either language.

2.1.2 Age of Acquisition

The nature of the bilingual population in Wales poses an interesting dilemma when it comes to categorising individuals based upon L2 age of acquisition. Research shows that bilinguals language skills are strongly related to linguistic experiences at home (Scheele, Leseman, & Mayo 2010) and greater exposure to Welsh results in structures and vocabulary being established earlier (Gathercole, 2007). Thus, when categorising bilinguals as simultaneous or sequential two factors must be taken into

account; 1) when exposure to a language begins and 2) the context in which language is acquired (De Houwer, 1990, 2009). For the specific bilingual population studies within the thesis, L2 acquisition begun during and after partial acquisition of the L1 in early childhood within educational settings. With this in mind, we have carefully considered how the context of second language acquisition (i.e., within the school environment) may serve to better distinguish the different Welsh acquisition experiences, with reduced emphasis on age boundaries.

Our bilingual populations acquired the second language at an early age (4.7 (experiment 1a), 3.8 (experiment 1b), 2.6 (experiment 2), 3.3 (experiment 3), and for this reason, we categorise our participants as early bilinguals. Furthermore, as both languages were not acquired in parallel from birth, we do not categorise this sample as simultaneous bilinguals even though the age of acquisition is very early in the case of experiment 2 for example (M = 2.7). Such an early age of acquisition in the L2 Welsh sample is not surprising for this sample given the Welsh language policy in Gwynedd aims to ensure exposure to Welsh during the earliest years of education (e.g., nursery and reception; Gwynedd Council, 2016; Gwynedd Council, 2017).

Furthermore, in an attempt to minimise interpretation differences between participants, the age of acquisition was discussed and explained to each individual participant (as suggested by de Bruin, 2019). Specifically, they were instructed to consider the language(s) they were exposed to from birth rather than the age at which language production began. The recruitment message also expressed our intention to

recruit individuals from Welsh only (or English only) homes, and those who reported being exposed to two languages from birth were discarded prior to the analysis.

2.2 Self-report measures

The language history questionnaire is a self-report measure designed to gather information regarding the participants' language background, including age of acquisition and the learning situation of each language. In addition, the measure enables collection of reading, writing, conversational and comprehension proficiency data for each language on a 10-point Likert scale (10=very proficient, 1=not proficient). Finally, participants are asked to indicate the percentage of time they use Welsh and English, and how often they read, write, speak, and watch TV and listen to radio and lectures in both languages again using a 10-point Likert scale (10=always, 1=never; see appendix A). Questions did not extend to language use of family members (such as parents) as those who reported being from bilingual homes were not included in the analysis.

The Multi-group Ethnic Identity Measure (MEIM; Phinney, 1992; Roberts, Phinney, Masse, Chen, Roberts, & Romero, 1999) is a 12-item measure of ethnic and cultural identity. Participants were asked to indicate their cultural identity (rather than ethnic identity) and answer questions regarding their engagement, sense of belonging and attachment to the community on a 4-point Likert scale ranging from 1=strongly disagree to 4=strongly agree. See appendix B.

These measures were used to validate our criteria of ‘L1 Welsh’ or ‘L2 Welsh’ for the experimental work collected in the empirical chapters of this thesis. Those who did not meet the criteria for the specific experiment wee disregarded prior to the data analysis. Both questionnaires were only available in English and were completed prior to the experimental procedure (10 minutes).

2.3 Electrophysiological recording

Electroencephalogram (EEG) is a non-invasive methodology used to detect electrical activity generated in the brain as a response to stimulus presentation, by placing electrodes upon the scalp. This activity is produced by two types of electrical movements; first, when energy travels along the body of a neuron from the beginning of the axon (the cell body) to the axon terminals and second, when neuronal neurotransmitters bind to the receptors of the postsynaptic cell membrane, known as postsynaptic potentials (Stemmer & Whitaker, 2008; Luck 2014). When a considerable amount of localised neuronal activity is recorded simultaneously, it is possible to sum the potential voltage by calculating the differences between the activity detected at each of the electrodes placed on the scalp and reference and ground electrodes. Such activity can be recorded in response to a particular stimulus or event; known as Event Related Potentials (ERPs).

The EEG system used to collect data for the current thesis was a 64-electrode cap (See figure 1) with an additional four electrodes measuring vertical and horizontal eye blinks and movements. These movements create electrical potentials that spread to the

surrounding area leading to artefacts in the EEG signal recorded by electrodes at the front of the head (Luck, 2014). Obtaining a recording of this signal thus allows mathematic correction of the data.

A connection was established between the scalp and the cap using an electro conductive gel. Once a connection was established the electrical activity was recorded, amplified and sampled at a rate of 1 data point per millisecond (1kHz). An online filter was applied using a band-pass filter set between 0.1 and 200 Hz. The data was later filtered offline using a low-pass zero-shift filter with a cut off frequency at 20Hz, and to reduce contamination effects from external sources and activities exceeding +_75Uv were automatically discarded. Ocular artefacts were mathematically modelled and corrected using an algorithm proposed by Gratton, Coles and Donchin (1983). A baseline correction was conducted to ensure no systematic differences between conditions prior to stimulus presentation. To efficiently reduce slow drift and noise in the data (Tanner, Norton, Morgan, Short & Luck, 2016) a baseline of '*a few hundred*' milliseconds (Alday, 2019; 20% of the overall epoch; Luck, 2014) is suggested; thus, in the current thesis, a baseline correction of -200 was used throughout. The recorded signal was then re-referenced to the global average to prevent electrical artefacts localized to each channel (including the CZ reference).

Activities related to specific stimulus-locked events were extracted from the continuous EEG of an epoch ranging from -200 to 1000ms post critical stimulus onset. These events were later averaged across both conditions and participants. Peaks of interest were the N400 and P600, and thus, I conducted separate data analyses of these

peaks. In the next section I will present and discuss the two peaks of interest in this thesis.

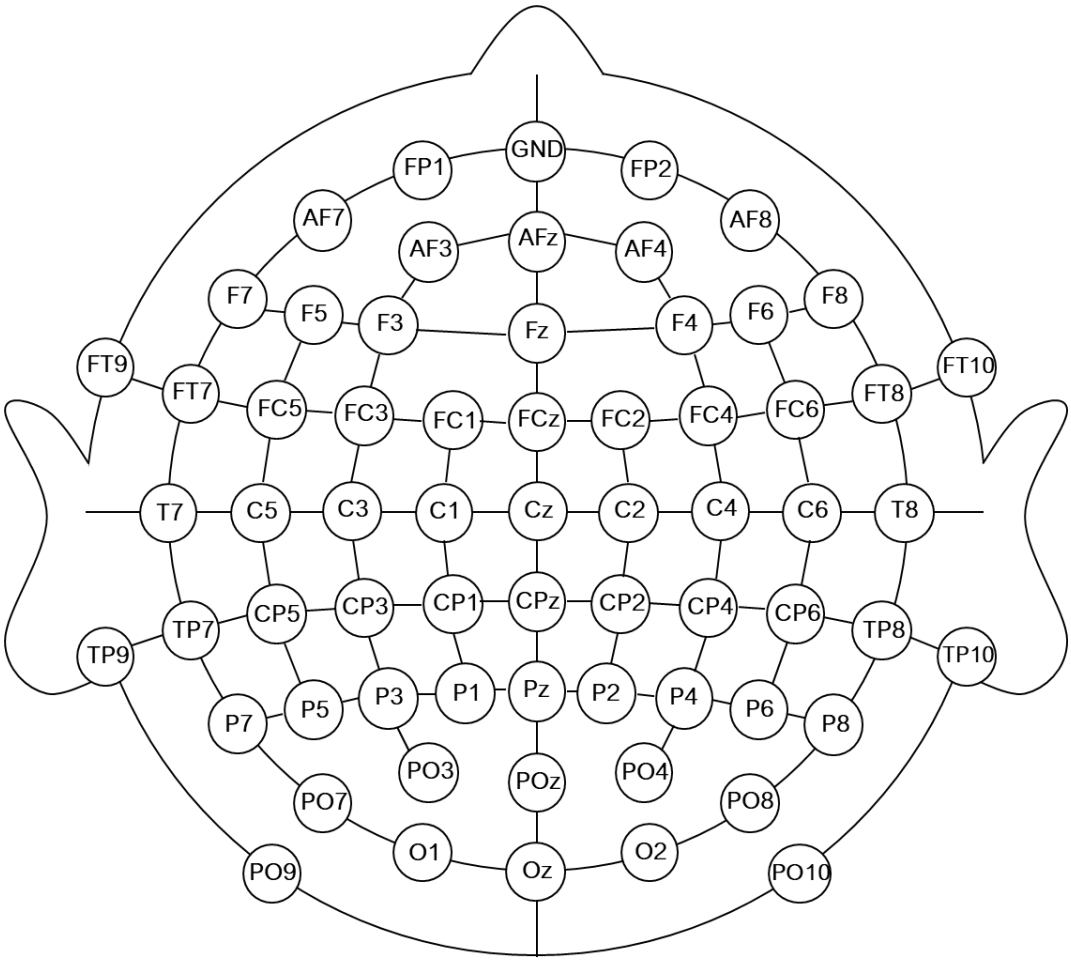


Figure 1. 64 channel electrode arrangement used in all investigations of the current thesis.

2.3.1 Event related potential (ERP) components

ERPs taking place throughout the 1000 millisecond epoch manifest as either positive or negative waves with specific latencies. These are referred to as ERP

components (Steinhauer, 2014). These components provide us with information regarding the nature of processing as it unfolds in time, with several components routinely being associated with language processing, including the P1 and N1. These components reflect early, low-level processing indexing perception and attentional responses to a stimulus (Luck, 2014), but our focus lies on two later components: the N400 and the P600.

2.3.2 N400: A very well-researched component in the ERP literature is the N400, which was first documented by Kutas & Hillyard (1980) and peaks between 300 – 500 ms over central-parietal electrode sites. Since its discovery, the component has been extensively used in language research, and is considered to index online semantic processing (Kutas & Federmier, 2011). Specifically, paradigms designed to elicit sentence anomaly or a generally unexpected word (with regards the sentence context), elicits a more negative-going wave at approximately 400 ms post stimulus onset. Using a sensible vs anomalous sentence paradigm, Kutas & Hillyard (1980) found that incongruous word endings *(I take coffee with cream and dog)* manifested a large, negative peak around 400 ms post stimulus onset of the unexpected target word *dog*, compared to congruent controls (*I shaved off my moustache and beard*) and improbable word endings (*he planted string beans in his car*) which produced intermediate amplitudes. These results suggest that the N400 is sensitive to semantic violations and as such an index of semantic integration. Further studies that demonstrate the component's sensitivity to word concreteness (Gomes et al. 1997) and frequency / repitition (Van Petten & Kutas, 1991; with concrete and familiar / high frequency words eliciting reduced N400 amplitudes) suggests that the

N400 component reflects the ease of retrieval of information associated with the lexical input from the long-term memory (Kutas & Federmeier, 2000)

Perhaps more important for the current thesis, the amplitude of the N400 is also highly correlated with word expectancy and cloze probability (the likelihood of the sentence being completed by a certain word as indicated by a sample of individual raters; Kutas & Federmier, 2011; Van Berkum, 2009; Brouwer et al, 2012). Specifically, studies have shown that readers and listeners use contextual information to predict upcoming words (Federmeier, 2007) and semantically appropriate sentences ending in low expected words (e.g., *she was stung by a wasp*) result in greater modulations relative to more expected endings (e.g., *she was stung by a bee*; Kutas & Hillyard, 1984; Luck & Kappenman, 2011). The situation is further compounded by the distinction between high and low cloze probability sentences. Some sentences are highly contextualized setting limits on the potential of upcoming words; e.g. the sentence *I take my coffee with milk and* would be highly expected to end with the word *sugar* whereas a completion for the sentence *I ate the* is far less predictable. An unexpected completion of the former and any completion of the later will require greater semantic integration and mapping reflected in greater N400 amplitudes.

Similarly, research suggest that non-literal language (including metaphor) elicit increased N400 amplitudes and thus suggesting that processing of non-literal language is more difficult to integrate semantically (see chapter 1, section 1.3.2 for overview of literature). Kutas and Federmeier (2011) however, explain that the N400 to figurative language unfold in a similar manner and with similar timing patterns as that of literal

language; specifically, they unfold similarly to literal language that require mapping and integration (e.g., *He used cough syrup as an intoxicant*) similar to that of a metaphorical sentence (e.g., *He knows that whisky is a strong intoxicant*).

The literal and non-literal sentences used in the current thesis were therefore designed to be equally low in plausibility and cloze probability to ensure that sentences differed only on their figurativeness levels. This will allow us to accurately describe how non-literal language is processed relative to literal language. I will return to this matter in greater depth later in the chapter.

2.3.3 P600: The P600 has a central-parietal topography, peaking between 500 – 800 ms post stimulus onset in a positive-going direction (van Herten, Kolk, & Chwilla, 2005). Increased positive amplitudes in this range are associated with greater reanalysis, typically in response to unconventional stimuli (Regel, Gunter, Friederici, 2011; Burkhardt, 2006). Thus, similar to the N400 component, modulations of the P600 have been observed in response to semantically anomalous sentences either subsequently or in the absence of an N400 effect (Brouwer, Fitz, & Hoeks, 2012; Hoeks et al, 2004). To arrive at a coherent meaning of semantic violations, the individual often requires additional and more effortful processing to resolve conflict and create an accurate mental representation of what is being communicated. Such processes consequently produce an increase in P600 amplitude.

In the current thesis, these two components can provide crucial information on the differences in time-course for literal and figurative sentence processing. Specifically, how figurative meanings may be differentially processed at the level of online semantic processing (N400) or during post-semantic, reanalysis stages of processing (P600). And how these differences change as a function of the sentence comprehension in the bilingual's L1 or L2. Thus, ERPs considered in conjunction with behavioural measures such as reaction times and accuracy provide a more comprehensive account of the processes that contribute to language comprehension (Kutas & Federmier, 2011). Moreover, whilst modulations of the N400 are often found to be distinct from behavioural measures (Kutas & Federmier, 2011), the P600 often correlates positively with reaction times (Brouwer, Fitz, & Hoeks, 2012).

We also took into consideration that controlled experiments (and ERP studies) are argued to be relatively low in validity due to their highly controlled environments (Coolican, 2009). Although, we could not change the controlled environment without compromising the quality of the ERPs, our use of context by way of full, complete sentences reflects natural language processing and reading to a greater extent than the more traditional word pair experiments (as suggested by Van Hell & de Groot, 2008) increasing the ecological validity of our experiments (Van Assche, Duyck, & Hartsuiker, 2016).

2.3.4 Methodological considerations of extant ERP studies

A handful of extant studies have used ERPs in order to examine how literal and non-literal language processes differ. In the N400 time window, figurative sentences are found to elicit larger amplitudes compared to literal language, indicative of more effortful semantic integration (Pynte et al, 1996; Coulson & Van Petten, 2002; Coulson & Van Petten, 2007; Tatter et al 2002; Lai et al, 2009). P600 amplitudes reveal inconsistent findings, however. Whilst figurative language generally elicits larger P600 responses, some studies report larger amplitudes to metaphor (De Grauwe, 2010), whilst others report reduced amplitudes (Arzouan, 2007). I have already reviewed the theoretical outcomes of these studies in Chapter 1, but my emphasis in this chapter is to examine the temporal windows and topographic sites of the existing ERP studies with a focus on metaphor comprehension. As shown in Table 1, the temporal sites and time windows selected in different studies vary considerably.

Table 1. Overview of metaphorical ERP studies including component time windows, distribution sites of main effects and main findings.

Authors	*Time window & distribution sites*	*Findings*
Bambini, Bertini, Schaeken, Stella, & Russo (2016)	• 320 – 440 ms: fronto-central, central & centro-parietal • 550 – 700 ms: parietal, parieto-occipital	• Greater N400 and P600 to metaphorical compared with literal
Yang, Bradley, Huq, Wu & Krawczyk (2013)	• 300 - 700 ms • 600 – 1200 ms • Quadrant analysis	• No N400 • Larger P600 amplitudes to Incongruent conditions (literal & metaphor) relative to congruent condition (literal & metaphor)

De Grauwe, Swain, Holcomb, Ditman, Kuperberg (2010)	• 325 – 400 ms • 400 – 500 ms • 550 – 750 ms • 750 – 900	• Early N400 to metaphor which converges with literal sentences by late N400. • N400 to anomalous relative to metaphorical & literal • Increased LPC to metaphor relative to literal
Rataj, Przekoracka-Krawczyk, & Lubbe (2018)	• 300 - 500 ms: central & parietal sites • 500 - 800 ms: parietal sites	• Increased N400 to novel metaphor relative to literal sentences • Reduced P6 to novel metaphor relative to anomalous sentences
Lai, Curran & Menn (2009)	• 320 - 400 ms: Central sites • 440 - 560 ms: Central sites	• Greater N400 amplitudes to anomalous, novel metaphor, and conventional metaphor compared with literal sentences. • Later, conventional metaphors converge with literal sentences.
Bambini, Canal, Resta, & Grimaldi (2019)	• 300-500: midline, frontal • 600-900: frontal	• Greater N400 and later sustained negativity to metaphorical compared with literal
Schneider, Rapp, Haeubinger, Ernst, Hamm, Fallgatter & Ehlis, (2014)	• 300 - 500 ms • Left fronto-central • (Based on Duncan et al, 2009)	• Greater N400 to metaphorical compared with literal
Pynte, Besson, Robichon, & Poli (1996)	• 300 - 600 ms: central • 600 – 1000 ms	• Greater N400 to metaphorical compared with literal • No differences in later time windows
Coulson & Van Petten (2007)	• 300 – 500 ms: Midline, dorsal, ventral • 600 – 900 ms: Midline, dorsal, ventral	• Greater N400 and later sustained negativity to metaphorical compared with literal

Given this inconsistency and a general absence of rationale in most of the studies cited, we base our electrode and time window selection for the current thesis on the established literature for each component rather than the metaphor literature. Thus, N400 electrode cites include fronto-central, central and central parietal (FC1 FCZ FC2, C1, CZ, C2, CP1, CPZ, CP2) and time windows include the typical N400 range (300-500) (Kutas

& Hillyard, 1980; 1984; Thierry & Wu, 2007; Kutas & Federmeier, 2000; Kuipers, van Koningsbruggen, Thierry, 2013; Lau, Phillips, Poppel, 2008; Holcombe, 1993; Barber, Donamayor, Kutas, & Munte, 2010; West & Holcomb, 2002). These sites and time windows also mostly overlap with the metaphor literature. For the P600, we similarly chose electrode sites (CP1 CPZ CP2 P1 PZ P2) and time window (500-800) associated with classic language effects; although it should be noted that this component is not as well established as the N400.

Studies examining cognitive responses to metaphor often fail to mention the extraneous variables that may influence the interpretation of differences in literal vs. metaphorical sentence processing. Differences include inherent differences between these types of language use, such as concreteness and frequency, for example (more concrete nouns and meanings, and higher frequency interpretation is more often characteristic of literal language; Cardillo et al., 2010). Several studies have therefore attempted to build normed sentence sets, in which literal and metaphorical sentences are matched as closely as possible (Cardillo, Schmidt, Kranjec, & Chatterjee, 2010; Nordmann & Jambozazova, 2017; Katz, Paivio, Marscark & Clark, 1988; Torreano, Cacciari, & Glucksberg, 2005). For example, in an attempt to address confounds associated with stimulus creation, Cardillo et al. (2010) developed a large set of metaphorical and literal sentences, upon which extensive measurements were collected, resulting in a final list of 560 sentences. At the word level, they collected information on concreteness, length and frequency using both online psycholinguistic databases and participant ratings. At the sentence level, they also collected subjective ratings on familiarity, naturalness, imageability, figurativeness and interpretability. Importantly, the authors note that inherent differences between literal

and metaphorical language on these measures is likely to confound interpretation of metaphor processing, leading to conflicting evidence. Whilst word-level inspection (comparison of means) indicated comparable ratings for sentence type on length, frequency and concreteness, important differences emerged at the sentence level. Specifically, literal sentences were deemed more familiar, natural, and imageable compared with metaphorical sentences. However, metaphorical sentences were deemed more figurative. No inferential statistics are reported, but the authors note that discrepancies in literal vs. metaphorical sentences are consistent with the characteristics of these sentence types and that over-modification would lead to non-representative items. They advocate the use of co-variates where such non-equivalence is apparent.

An additional factor that may affect sentence processing is the predictability of upcoming words (Chou, Huang, Lee & Lee, 2014). Predictability is empirically determined prior to experimental study using cloze probability, which is determined by calculating the percentage of participants who complete a given sentence with a particular word (Taylor, 1953). The cloze probability method is commonly used in ERP studies because predictability affects ease of semantic processing and the N400 amplitude is highly sensitive to this factor (Chou, huang, Lee & Lee, 2014). Specifically, a reduction in amplitude is observed when words are easily predicted/are high in close probability compared to an increased negativity for words that are difficult to predict/low cloze probability (van Berkum, Hagoort, & Brown, 1999; Kutas & Hillyard, 1980a, 1980b, 1984; Van Petten & Kutas, 1990, 1991).

In our construction of sentence sets suitable for the current research questions (and detailed further in the next section), we attempted to avoid these limitations and limit any effects of such confounds. We therefore constructed our sentences so that a) the same target word appeared in each condition (as per Cardillo et al 2010; 2012), b) sentences were identical with the exception of subject words (as per De Grauwe, 2010), c) not fully predictable (low in cloze probability; as per De Grauwe, 2010) and d) equated in terms of plausibility. We scrutinized literal sentences, in particular, to avoid fully predictable endings, thus ensuring comparable cloze probability and plausibility with metaphorical sentences. This should avoid bias between conditions, but also allow the N400 room for modulation, thus avoiding ceiling effects (cf. Ellis, Thierry, Vaughan-Evans, & Jones, 2017). Equivalence was sought for all sentential characteristics with the exception of figurativeness. This should allow us to interpret any findings according to literal and metaphorical processing alone and control for confounds found in the current literature. To these ends, we conducted a relatively large norming study prior to the ERP investigations (presented below). We present this work here, to show the general distribution of literal and metaphorical sentences on various psycholinguistic features (i.e., how our stimulus set compared to the results of Cardillo et al., 2010).

2.4 Norming of literal and metaphorical stimuli

Each sentence in our sets comprised a simple structure with a single subject, followed by a verb or a verb phrase. Each set comprised four sentences, which represented two of our experimental conditions (e.g., Culturally non-specific / literal

sentence; Culturally non-specific / metaphorical sentence; Culturally specific / literal sentence; Culturally specific / metaphorical sentence***; see table 2***). Thus, differences between literal and metaphorical sentences involved a change in subject (e.g., crash/relationship), but in all cases the verb / verb phrase remained identical across sentences, a procedure similar to that used by de Grauwe et al. (2010). Each sentence was also translated into Welsh in order to create the between-language factor. See appendix C for ful list of experimental sentences.

Table 2. Example of experimental stimuli. Note Welsh translation equivalents were also included.

Figurativeness	Cultural relevance	Sentence	Target
Literal	Culturally non-specific	The harmful crash left a	Wound
Metaphorical	Culturally non-specific	The harmful relationship left a	Wound
Literal	Culturally Specific	The red dragon's bite left a	Wound
Metaphorical	Culturally Specific	The red dragon's failure left a	Wound

2.4.1 Aims of the current norming study

Our main aim was to a) ensure that literal and metaphorical sentences were equivalent on cloze probability and plausibility, and b) more exploratively, we sought to discover how Welsh-English bilingual differentially rated in the L1 (Welsh) and L2

(English), and whether responses were further biased by sentence context (the cultural specificity of the content: aligning with the L1 but not the L2). Word-level measurement included length and frequency across conditions. Then, given that our ERP experiments focus on semantic integration at the sentence level, our primary aim was to obtain sentence-level ratings that were consistent with previous studies. Thus, we collected data on familiarity, imageability, figurativeness, and plausibility, as per Cardillo et al. (2010). Our aim was to see whether our sentences matched across conditions, or in the case that they did not match, that the direction of ratings matched previous findings. We also collected data on cloze probability, which followed the same rationale as sentence ratings. We determined beforehand that plausibility and cloze probability must be equivalent across literal and metaphorical sentences, and that non-equivalence would be followed up with revision of the sentences until equivalence was obtained.

Our main factor of interest was therefore differences in the Figurativeness of sentences (literal vs. metaphorical), and any interactions between figurativeness and other factors, and in particular figurativeness * language (English vs. Welsh). More exploratively, we also examined figurativeness * culture (non-specific vs. specific).

2.4.2 Methods

2.4.2.1 Participants

32 fluent Welsh-English bilinguals were recruited via opportunity sampling, for whom the self-reported native language was Welsh (26 females, 6 males; *M age* = 37, *SD*

= 15.55). Ethical approval was sought from the Bangor University Psychology ethics panel, and informed consent was obtained prior to testing.

2.4.2.2 Method and Results

An online survey was created using Google forms. Links to the survey along with electronic copies of the information and consent form were e-mailed to each participant. Before starting the survey, participants were asked to read the information sheet carefully and return a signed copy of the consent form to the experimenter. Participants were allocated to one of the lists detailed in Appendix D. Each version included 320 sentences, corresponding to every experimental sentence presented *either* in English or Welsh (i.e., a total of 160 sentences in English and 160 sentences in Welsh). Presentation of sentences was randomized. Although each participant only saw a quarter of all sentences (given the large volume of the total set), between group and mixed designs outcomes for norming literal/metaphorical sentences are found to be comparable with within-group designs (Libben & Titone, 2008; Titone & Connie, 1994; Nordmann & Jambazova, 2017).

General instructions were presented in both Welsh and English, but specific instructions within each rating procedure were presented in the language of the sentences presented in that procedure. E.g., If sentences presented in a particular block were in Welsh, then the instruction was also in Welsh.

***2.4.2.3 Words*.** Data on length and frequency were collected for the subject of each sentence (e.g., crash vs. relationship). Frequency (words per million; frequency counts of observations / occurances per million words) for English sentences was obtained via the CELEX database (Baayen, Piepenbrock, & Gulikers. 1995), and frequency of Welsh words was obtained using the Cronfa database (Ellis, O'Dochartaigh, Hicks, Morgan, & Laporte, 2001). For English words, frequency data was available for 93% from the Celex database (English non-specific, 97%; English specific, 89%). For Welsh words, raw frequency data (frequency counts of observations / occurrences within samples of Welsh text) was available for 88% from the Cronfa database (Welsh non-specific, 91%; Welsh specific 84%). A mean frequency score was calculated for each condition, together with standard deviations (see Table 3). Other than an effect of culture, in which culturally non-specific items were more frequent than specific items, no other effects emerged.

Table 3. Summaries of sentence length (total number of words and characters) and subject word frequency based on the Celex database.

Literal

	English-non-specific		*English-Specific*		*Welsh*-non-specific		*Welsh-Specific*	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Total words	6.43	1.12	6.7	1.39	5.98	1.08	6.16	1.41
Characters	31.45	6.04	35.36	6.47	31.61	5.99	35.48	6.20
Frequency	202.04	487.33	120.4	440.85	181.26	261.7	117.3	149.75

Metaphorical

	English-non-specific		*English-Specific*		*Welsh*-non-specific		*Welsh-Specific*	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Words	6.48	1.13	6.81	1.42	6.11	1.69	6.33	1.41
Characters	32.56	5.86	36.42	6.55	32.98	6.33	36.73	6.96
Frequency	257.94	678.18	157.8	628.43	228.84	303.0	154.6	237.59

2.4.2.4 Sentence data. Each of the 640 sentences (320 in each language) were rated for familiarity, plausibility, imageability, figurativeness and cloze probability (see Table 4 for means and SDs and appendix D for a full account of rating scales and cloze measures). Three participants were removed because of English education (2) and failure to understand the task requirements (1).

Table 4. Summary of Means and Standard Deviation scores for each of the four dependent variables in all eight conditions.

	Literal								*Metaphorical*							
	Eng-nonS		*Eng-Spec*		*Wel-nonS*		*Wel-Spec*		*Eng-nonS*		*Eng-Spec*		*Wel-nonS*		*Wel-Spec*	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Familiarity	2.83	0.59	2.76	0.49	2.67	0.5	2.21	0.69	2.46	0.66	2.37	0.56	2.11	0.58	2.24	0.61
Plausibility	3.13	0.54	3.1	0.46	2.94	0.53	2.89	0.7	2.64	0.65	2.65	0.63	2.46	0.58	2.55	0.64
Figurativeness	1.83	0.54	1.9	0.47	1.91	0.51	2.04	0.6	2.79	0.43	2.91	0.36	2.82	0.5	2.67	0.49
Imageability	3.19	0.59	3.02	0.46	2.86	0.54	2.9	0.7	2.6	0.6	2.55	0.54	2.29	0.55	2.53	0.6

Although categorical data are typically analysed using non-parametric test (e.g., Pearson chi-square test), as we have several outcome variables, the data set was analysed using a Multivariate analysis of variance (MANOVA; as suggested by Field, 2009). Results revealed a significant main effect of Figurativeness, in which literal sentences obtained higher ratings than metaphorical sentences on familiarity (M = 2.71 vs. M = 2.31; F = (1, 632) = 71.78, $p < .001$, ηp^2 =.10), imageability (M = 2.99 vs. M = 2.49; F = (1, 632) = 121.66, $p < .001$, ηp^2 = .16), and plausibility (M = 3.20 vs. M = 2.57; F = (1, 632) = 87.96, $p < .001$, ηp^2 = .122). On the 'figurativeness' rating scale, metaphorical sentences obtained higher ratings than literal sentences (M = 1.92 vs. M = 2.80; F = (1, 632) = 504.96, $p < .001$, ηp^2 = .003). A significant main effect of Language also emerged, in which English sentences obtained higher ratings than Welsh sentences on familiarity (M = 2.6 vs. M = 2.43; F = (1, 632) = 13.26, $p < .001$, ηp^2 = .02), imageability (M = 2.84 vs. M = 2.64; F = (1, 632) = 19.06, $p < .001$, ηp^2 = .03), and plausibility (M = 2.88 vs. M = 2.71; F = (1, 632) = 12.67, $p < .001$, ηp^2 = .02). There was no significant difference between languages for figurativeness (M = 2.36 vs. M = 2.36; F = (1, 632) = .00, p =.677.), and no main effect of Culture emerged (F = (1, 632) = .556, p = .456).

A three-way interaction was also observed between language, figurativeness, and culture (F = (1, 632) = 5.1, p = .024, ηp^2 = .008). In English, metaphorical sentences obtained higher figurativeness ratings across both culture-non-specific and -specific sentences. For Welsh, a similar pattern emerged but interestingly, metaphorical culture-specific sentences (i.e., specific to Wales) were rated as less figurative than culture-non-specific sentences.

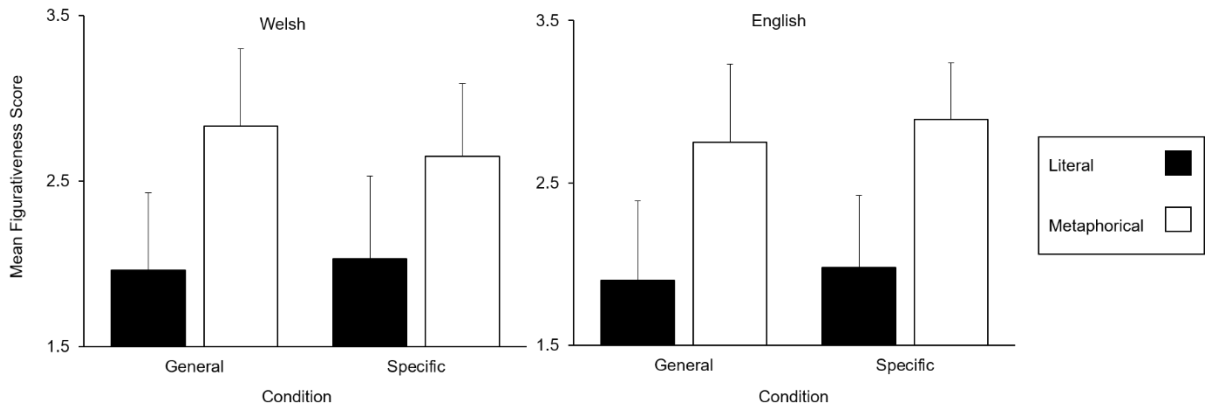


Figure 2. Three-way interaction between language, figurativeness and culture on the figurativeness scale. Standard error of the mean is represented by the error bars.

2.4.2.5 Cloze Probability. Responses that did not match the experimental stimulus were coded as 0 whereas matched responses were coded as 1.

Scores were averaged across all items generating a cloze probability score under the threshold of 40% (Coulson, Urbach and Kutas, 2006). Average cloze probability percentage for each condition can be found in Table 5. Overall probabilities are very low, as expected, but plausibility (presented again in Table 5 for ease for comparability) is at the higher end of the scale for all conditions, such that sentences were not considered particularly odd.

Table 5. Cloze probability percentage score for each condition (literal vs metaphorical; Welsh vs English; non-specific vs specific).

	Literal				*Metaphorical*			
	Eng-nonS	*Eng-Spec*	*Wel-nonS*	*Wel-Spec*	*Eng-nonS*	*Eng-Spec*	*Wel-nonS*	*Wel-Spec*

Cloze	13%	7%	9%	6%	4%	4%	3%	2%
Plausibility	3.13	3.1	2.94	2.89	2.64	2.65	2.46	2.55

2.4.3 Modifications to sentences based on scale scores and cloze probability data

2.4.3.1 Scale data. Based on the means data and inferential statistics presented above, we next identified potentially problematic sentences for modification. For scale data, we calculated difference scores for literal and metaphorical sentences on an item-by-item basis and identified any with a mean difference score > 1.5 points. This was done for each of the scales (familiarity, plausibility, imageability and figurativeness). Items identified with such large difference scores on two or more of these scales (e.g., both plausibility and familiarity) were highlighted for modification (a total of 5% of all sentence pairs: literal / metaphorical). To examine the effect of removing these items on condition means, we calculated new means based on the remaining 95% of sentences, presented in Table 6.

Table 6. Summary of ***new*** means and standard deviations after the removal of identified problematic items.

	Literal								*Metaphorical*							
	Eng-nonS		*Eng-Spec*		*Wel-nonS*		*Wel-Spec*		*Eng-nonS*		*Eng-Spec*		*Wel-nonS*		*Wel-Spec*	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Familiarity	2.81	0.59	2.72	0.48	2.67	0.5	2.49	0.65	2.48	0.63	2.40	0.55	2.23	0.57	2.29	0.62

Plausibility	3.10	0.53	3.07	0.46	2.93	0.53	2.81	0.67	2.69	0.61	2.68	0.61	2.47	0.58	2.61	0.63
Figurativeness	1.84	0.55	1.93	0.47	1.91	0.51	2.08	0.60	2.77	0.43	2.91	0.36	2.82	0.49	2.68	0.49
Imageability	3.16	0.59	3.00	0.46	2.85	0.54	2.81	0.68	2.63	0.59	2.58	0.52	2.30	0.55	2.56	0.61

These modified set was therefore better equated across conditions.

2.4.3.2 Cloze probability. Sentences were highlighted for concern when either the literal or the metaphorical version obtained cloze probability of > 40% and removed only in the event of an imbalance (> 40% in one condition and < 40% in the other condition). The resulting data can be seen in Table 7.

Table 7. Summaries of new cloze probability ratings for each condition following the removal of high probability sentences.

Literal				Metaphorical			
Eng-*nonS*	Eng-Spec	Wel-*nonS*	Wel-Spec	Eng-*nonS*	Eng-Spec	Wel-*nonS*	Wel-Spec
6%	5%	5%	3%	0%	3%	2%	1%

Again, removing these problematic items resulted in more equivalence across conditions. However, as our sentences were designed to be low in cloze probability a completion task may not accurately reflect the semantic acceptability of the sentence. Therefore, for our experimental stimuli we instead conducted an acceptability study with participants rating sentences on a scale of +2 (very acceptable) to -2 (not acceptable).

2.4.4 Discussion

Results of the current norming study suggest that literal and metaphorical sentences are non-equivalent on the key rating scales devised. Literal sentences were rated as more familiar, plausible and imageable than metaphorical sentences, in both English and Welsh. Literal sentences also tended to have a higher cloze-probability rating (cf. de Grauwe et al., 2010). Moreover, metaphorical sentences were rated as more figurative. These results are consistent with our a priori expectations and with findings from other studies with similar objectives (Cardillo et al., 2010; De Grauwe et al, 2010). We did, however, find somewhat surprising findings deriving from our more explorative examination of L1 (Welsh) and L2 (English) sentences (which, please recall, are translation equivalents). Specifically, English sentences obtained higher ratings of familiarity, plausibility and imageability than Welsh sentences. Although Welsh is participants' native language is it not uncommon for Welsh speakers to be raised in bilingual homes. Prior to the ERP experiments, we will screen all bilinguals using a language history questionnaire; to, for example, ensure that our Welsh-English bilingual sample is also more immersed in the Welsh than in the English language (cf. Experiment 1).

An interaction between figurativeness (literal vs. metaphorical) and language on figurativeness ratings also indicated that literal sentences in Welsh tended to be rated as more figurative than literal sentences in English, indicating that the gap between literal and metaphorical meaning is less in Welsh than in English. An interesting language-by-culture interaction also emerged with regards imageability ratings, in which non-specific sentences were rated as more imageable than specific sentences in English, but the

reverse pattern emerged in Welsh. This interaction attests to differences in language-culture alignment, as showing in previous work ratings (as per Ellis et al., 2015, 2017).

To conclude, the data reveals non-equivalence between literal and metaphorical sentences, but in ways that are broadly consistent with the existing literature (Cardillo et al., 2010; Nordmann & Jambazova, 2017; Lai, Curran & Menn, 2009). Whilst our conclusions are lent additional weight in being consistent with previous findings, we note that the small sample size and the restricted number of scale points in our measures may have been problematic (Nordmann & Jambazova, 2017; Lai, Curran & Menn, 2009; Keit, 2002; Durand, 2013; Leon, & Heo, 2009; Aguinas & Stone-Romero, 1997). A within-subjects design would also have been preferable (Normann and Jambazova (2017).

2.4.5 Modifying the sentences for the ERP experiments: Lessons from the norming data

Our norming study revealed natural variations in how literal and metaphorical language differ in terms of factors such as imageability, plausibility and figurativeness. However, for the purposes of experimental control and valid data in our empirical work, it is imperative that we strike the correct balance between sentences that are identifiably literal and metaphorical (and therefore somewhat respectful of the naturalistic differences identified), but also matched as closely as possible on all scales, in order not to introduce confounds into the data.

To this end, our sentence sets created for Experiments 1 and 2 in the following two empirical chapters follow the following criteria: First, we not only rotate target words

across all conditions (an essential stimulus control mechanism used in ERP work to avoid low-level differences such as saliency cascading to higher-level processes: The Hillyard Principle, Luck 2014), we also fully rotated *sentences* across conditions. That is, any given sentence (the fragment preceding a target word) presented as a metaphorical sentence in one condition would be presented as a literal sentence in another and vice versa. This will help to reduce inherent biases in the stimulus sets. Examples can be viewed in the next chapter.

Next, we decided to focus on literal vs. metaphorical sentences in the context of the L1 and L2. Thus, our final set of sentences for Experiment 1, comprised the factors Figurativeness (literal vs. metaphorical) and Language (English vs. Welsh). We also introduced a third factor, sentence anomaly (sensible, anomalous), as a baseline measure from which we could differentiate the effect of a gross semantic violation (anomaly) from a subtle difficulty in accessing meaning (metaphoricity). The Culture factor introduces an interesting further avenue for future work. However, with the introduction of anomalous sentences in experiment 1, the inclusion of this additional factor would have resulted in an experimental design far too complex as a starting point, and was therefore removed.

2.5 Chapter Summary

In this chapter I discussed the methodological considerations required to address the aims outlined in chapter 1. In the following chapters I discuss three empirical ERP studies used to investigate these aims.

Chapter 3

Part 1

Bilinguals making sense (I): Earlier online detection of anomaly in the L1 than in the L2 during sentence comprehension.

Acknowledgements: I would like to thank Yang Lee for her assistance fitting the EEG cap, and Manon Jones, Awel Vaughan-Evans and Guillaume Thierry for their valuable feedback in the creation of the experimental stimulus.

Abstract

Semantic concepts cannot be fully captured using a single defining feature, with significant implications for speakers of multiple languages, for whom a single feature maps to translation equivalents in each language. However, bilingual conceptual access is relatively underexplored, and current models provide conflicting accounts (Dijkstra, Wahl, Buytenhuijs, Halem, Al-Jibouri, De Korte, & Rekke, 2019; Van de Putte, De Baene, Brass, & Duyck, 2017). Here, we examined whether highly fluent Welsh-English bilinguals – with very high proficiency in the L2 – nevertheless showed less effortful access to conceptual information in the L1, measured via *violation* of meaning (anomaly) and *relative difficulty in extracting* meaning (figurativeness). In Experiment 1a, we presented semantically sensible and semantically anomalous sentences orthogonally with literal and metaphorical meaning, in the L1 Welsh, or the L2 English, whilst recording event-related potentials (ERPs). These bilinguals were better able to accurately judge whether or not a sentence 'made sense' when it was semantically anomalous, when it was literal and when presented in English. However, ERPs revealed greater sensitivity to sentence meaning (anomaly) in the L1 Welsh during a time frame associated with semantic processing. In Experiment 1b, we show that, when bilinguals read literal and metaphorical sentences, excluding semantically anomalous sentences, language figurativeness elicited differential semantic processing in the L1 but not in the L2. Taken together, our findings suggest that sentence meaning is available at an earlier time point in the L1, yet this sensitivity does not necessarily translate to better sentence verification.

Word meanings are notoriously considered to be ‘slippery customers’ (Labov, 1973), whose boundaries and features are ambiguous and context dependent. This problem is increased in the context of bilingualism – which is in itself a renowned ‘slippery customer’ as no two bilinguals are alike (Bak, 2016; De Bruin, 2019; De Luca, Rothman, Bialystock, & Pliatsikas, 2019) - in which multiple terms are assigned to partially overlapping concepts. For example, in Japanese and English, the translation-equivalents *kuroi* and *black* have overlapping senses (i.e., *colour*), as well as non-overlapping senses (e.g.,*black* in English indicates in humour, whereas *kuroi* is more strongly redolent of evil or guilty individuals; Finkbeiner, et al, 2004). Moreover, in the native language, bilinguals typically have access to more senses in relation to a single word than in the non-native language. Despite several decades of research examining access to lexical- and syntactic-level information in the bilingual brain (Dijkstra & van Heuven 1998; Kroll & Stewart, 1994; Thierry & Wu, 2007; Vaughan-Evans, Thierry, Kuipers, & Jones, 2014), access to meaning in each of a bilinguals’ languages is relatively underexplored (though recent models of bilingualism, e.g., Multilink, Dijkstra, Wahl, Buytenhuijs, Van Halem, Al-Jibouri, De Korte, & Rekke, 2019), will soon instantiate language-non-specific and -specific connections between senses in the case of bilinguals). Using neurocognitive methods, we examine whether a richer and stronger network of senses in the L1 gives rise to greater ease in sense mapping than in the sparser L2. Specifically, whether bilinguals more easily integrate individual concepts into the larger context during sentence reading.

In a given language, words (e.g., *hammer*) can often correspond to a single referent (*tool to break things/drive in nails*), but have secondary connotations derived

from the original meaning (e.g., a second literal interpretation in verb form: *to hammer*, and a metaphorical interpretation: *to be heavily criticized*), with the result that one lexical item has several partially overlapping meanings in the semantic system (Taylor, Devereux, Tyler, & 2011). Access to these alternative meanings is largely driven by sentence context and/or other contextually rich cues in which a word is presented (VanHell & DeGroot, 2008; Dijkstra, VanHell & Brenders, 2015; Payne, Lee & Federmeier, 2015). For example, *to drive in the nail, he used a* ***hammer*** vs. *he was as incalcitrant as a* ***hammer***. In both cases, as the sentence unfolds, incoming words are continuously mapped onto the global semantic meaning of the sentence, leading to an expectation of possible upcoming words. When an expected word is encountered, its meaning is therefore processed and integrated with ease, whereas unexpected or anomalous endings (e.g., *I take coffee with cream and dog*; Kutas & Hillyard, 1980) are more difficult to integrate (Fisher-Baum et al, 2014; Federmeier, 2007; Kutas & Van Petten, 1994; Federmeier & Laszlo, 2009; Kutas and Hillyard, 1980; Payne, Lee & Federmeier, 2015). In event related potential (ERP) research, ease of semantic integration is indexed by modulation of the N400 wave, (a negative-going ERP component sensitive to the process of meaning integration, peaking at around 400ms; Kutas & Hillyard, 1980; Kutas & Federmeier, 2011), in which less expected concepts elicit larger N400 negativity. Sentence context is also found to modulate word frequency effects: Words presented in isolation or at the beginning of a sentence elicit larger N400 effects compared to when the same word is presented at the end of a sentence (Van Hell, 2002; Moreno, Rodriguez-Fornells, & Laine, 2008; Van Petten & Kutas, 1990, 1991).

Sentence context can therefore augment or delay recognition of individual words, yet the juxtaposition of concepts – represented by nouns, or even verbs – in a sentence can also dramatically alter overall sentence meaning. This is perhaps best exemplified in the differences between literal and metaphorical interpretations of sentences. For example, the literal sentence *from the lonely baby came a cry* includes two concepts that can be directly mapped or linked (baby – cry). However, a small modification of this sentence, *from the lonely heart came a cry* includes two concepts (heart – cry) that can only be linked via a common concept (loneliness) to arrive at a metaphorical meaning (Bolognesi, 2016; De Grauwe, Swain, Holcomb, Ditman, & Kuperberg, 2010; Citron et al, 2016; Landau, Keefer, & Meier, 2010; Rapp, Leube, Erb, Grodd, & Kircher, 2004; Lai, Curran, & Menn, 2009; Rapp, Leube, Erb, Grodd, Kircher, & 2004; Pynte, Besson, Robichon, & Poli, 1996). A large body of literature has examined whether metaphorical meaning can be accessed directly, or whether it is accessed following rejection of the literal meaning (Grice, 1975; Searle, 1979; Gibbs & Gerrig 1989; Gibbs, 2002; Giora, 1997), and recent neurophysiological evidence suggests that metaphorical meaning is derived in parallel with literal meaning (de Grauwe et al., 2010; Iakimova, Passerieux, Laurent, & Hardy-Bayle, 2005). However, metaphors also elicit larger modulation of N400 amplitudes, indicative of more effortful semantic integration (Arzouan et al., 2007; Coulson and Van Petten, 2002, 2007; De Grauwe et al., 2010; Goldstein et al., 2012; Lai et al., 2009; Pynte et al., 1996), reflecting the extra effort involved in mapping indirectly related concepts.

Thus, an established literature shows that in monolingualism, sentence context modulates semantic access, by influencing word predictability and through the

juxtaposition of directly and indirectly related concepts. However, in bilingual language processing, semantic access is less well understood. Whilst traditional models of bilingualism typically describe the connections between lexical and semantic level representations (e.g., Kroll & Stewart, 1994; Dijkstra, Van Heuven, & Grainger, 1998), much less empirical data elucidates semantic sense connectivity within and between languages. Existing models do specify that bilinguals' semantic representations range from non-overlapping (i.e., exist only in one language) to almost-fully overlapping translation equivalents (e.g. *black* and *kuroi*), and suggest that a richer semantic network and temporal advantage exists in the L1 compared with the L2 (Finkbeiner, Forster, Nicol, & Nakamurs, 2004; De Groot, Kroll & Stuart, 1994; Hahne, 2001; Hahne & Friederici, 2001; Moreno & Kutas, 2005).

Despite the under specificity of these processes in current bilingual models, empirical evidence derived from event-related potentials suggests that meaning is more easily accessed in the L1 compared with the L2. In the non-native language, semantic violations produced larger and delayed N400 effects (Ardal, Donald, Meuter, & Muldrew, 1990; Kutas & Kluender, 1994; Weber-Fox & Neville, 1996), as well as larger P600 effects indicative of greater reliance on reanalysis (Hahne & Friederici, 2001). However, such effects are attenuated in the case of early acquisition and high proficiency (Moreno & Kutas, 2005). How and why these differences manifest across the time course of comprehension requires further investigations using tools that transcend plain semantic violations similar to those undertaken by studies examining semantic processing in the monolingual literature (Moreno, Rodriguez-Fomells, & Laine, 2008). One such approach

is to examine direct and indirect semantic mapping, for example in literal and metaphorical contexts.

The current study

Here, we used event related potentials (ERPs) to examine whether Welsh-English bilinguals who are highly proficient in both languages nevertheless show less effortful semantic access in the L1 compared with the L2 during sentence reading. In Experiment 1a, bilinguals read semantically sensible or anomalous sentences crossed with literal and metaphorical meanings. Translation equivalents of these sentences were presented in each of their languages. Recall that the literature suggests that access to metaphorical meanings requires indirect mapping of concepts, whereas access to literal meanings occurs via direct sense mapping. Thus, metaphoricity provides an interesting test case for how easily senses can be integrated in each language. We thus predicted, on the basis of previous findings, that bilinguals would more easily detect anomaly in the native language, manifest in less pronounced N400 effect to sensible senses in the L1 than in the L2 (Ardal, Donald, Meuter, & Muldrew, 1990; Kutas & Kluender, 1994; Weber-Fox & Neville, 1996; Moreno & Kutas, 2005). We also predicted, on the assumption that the L1 comprises a richer array of senses (Finkbeiner et al, 2004), that bilinguals would more easily integrate metaphorical meaning in the native language, manifest in a smaller N400 difference between literal and metaphorical sentences in the L1 than in the L2. To preview our findings, bilinguals were indeed more sensitive to semantic anomaly in the L1 than in the L2, but processing in the L2 was more delayed than anticipated (manifesting in the P600 component). We found no online effects of figurativeness. In

Experiment 1b, we therefore examined online L1 and L2 semantic processing in the context of literal and metaphorical sentences *only*, excluding the potentially overwhelming factor of sentence anomaly.

Experiment 1a

Method

Participants

Twenty native Welsh-English bilinguals (3 males, 17 females; *M* age = 23.5, *SD* = 6.08) were included in the final analysis. A further four participants were excluded due to low data quality. Ethical approval was obtained from the Bangor University ethics committee. Participants were recruited via snowball and opportunity sampling using Social Media, Bangor University notice boards, library notice boards (University and community libraries), Bangor University email groups (staff and students). Participants provided informed consent and were compensated financially or with course credits (Bangor University Psychology students – approximately 30%) for their participation.

A Language History Questionnaire (see appendix A) administered prior to the experiment assessed L1 and L2 proficiency and experience in Welsh and English. All participants acquired Welsh from birth and English at an early age (*M* = 4.7, *SD* = 2.22), and reported more daily use of Welsh than English (*M* = 74%, *SD* = 0.22; *M* = 26%, *SD* = 0.19). Self-ratings on indices of reading, writing, speaking and comprehension on a scale of 1 (not very literate) to 10 (very literate) were high for both Welsh and English (*M* = 9.78, *SD* = 0.38; *M* = 8.33, *SD* = 0.46). The Multigroup Ethnic Identity Measure (MEIM; Phinney, 1992; Roberts, Phinney, Masse, Chen, Roberts & Romero, 1999; see appendix

B), which measures cultural belonging on a scale of 1 (indifferent) to 4 (strong sense of belonging) revealed strong cultural Welsh identity (*M* = 3.79, SE = 0.1).

Stimuli

A total of 80 Welsh and 80 English translation equivalent sentence sets were constructed. As translating stimulus may present both semantic and syntactical confusion, English and Welsh versions of each sentence was constructed simultaneously.

A norming study was conducted in which English monolingual participants rated each English sentence on their figurativeness and semantically acceptability of sentence final word on a scale of -2 (very literal; very unacceptable) to +2 (very figurative; very acceptable). A small proportion of items (18.75%) were adapted and re-normed to ensure equivalence across stimuli on target word acceptability (literal sensible *M* = 0.14, *SD* = 0.51; literal anomalous *M* = 0.12, *SD* = 0.47; metaphorical sensible *M* = -0.3, *SD* = 0.61; metaphorical anomalous *M* = -0.29, *SD* = 0.61) and non-equivalence on sentence figurativeness (literal sensible *M* = -1.08, *SD* = 0.53; literal anomalous *M* = 0.58, *SD* = 0.19; metaphorical sensible *M* = 0.5, *SD* = 0.72; metaphorical anomalous *M* = 0.83, *SD* = 0.56). In both languages, each sentence set comprised four sentences in which sentence figurativeness and sensibility were manipulated: Sets therefore comprised a literal sensible sentence, a metaphorical sensible sentence, a literal anomalous sentence, and a metaphorical anomalous sentence. The two literal sentences (sensible and anomalous) were identical up to the point of the target final word. The two metaphorical sentences (sensible and anomalous) were also identical to the point of the target final word – and minimally adapted from the literal sentence in order to minimize variance within the

sentence set. Within a given set, the target words for sensible sentences were identical and the target words for anomalous sentences were identical. Target words were then fully rotated across sets, such that the ending for sensible sentences would also appear for anomalous sentences. Sentences were further counterbalanced so that each participant saw either the literal or metaphorical version of each sentence in only one language. All sentences comprised a simple grammatical structure (a single subject, followed by a verb phrase) and an example is provided in Table 8. See appendix E for full list of experimental sentences.

Table 8. Experimental design and example of a sentence set.

Sensibility	Figurativeness	Sentence	Target Word
Sensible	Literal	Her awkwardly placed stool made her	stumble
Sensible	Metaphorical	Her awkwardly placed words made her	stumble
Anomalous	Literal	Her awkwardly placed stool made her	whip
Anomalous	Metaphorical	Her awkwardly placed words made her	whip

* Translation equivalents were also presented in Welsh.

Procedure

Sentences were presented in white 18-point font on a black background. Participants were initially presented with the first half of the sentence as continuous text, which was self-paced, and the rest of the sentence was presented word by word (presentation time: 500ms; ISI: 250ms). Participants then responded to the question ‘Does the sentence make sense?’ at the end of each trial, using a binary keyboard

response (y/n), which was counterbalanced. Participants were instructed to concentrate on the (semantic) meaning of the sentence not the grammatical structure, and were given verbal examples prior to the practice block. General instructions were presented bilingually and further instructions within each experimental block were in line with the language of the sentences (i.e., Welsh instructions accompanied Welsh sentences, and English instructions accompanied English sentences).

Prior to the experimental block, participants completed six practice trials. The experiment consisted of eight experimental blocks comprising 40 trials each. Sentences were pseudorandomized such that only one sentence from each set was presented within each block. To reduce contamination from the unattended language, language was blocked and counterbalanced across participants. For example, participant 1 saw 4 Welsh blocks followed by 4 English blocks, whilst participant 2 saw 4 English blocks followed by 4 Welsh blocks).

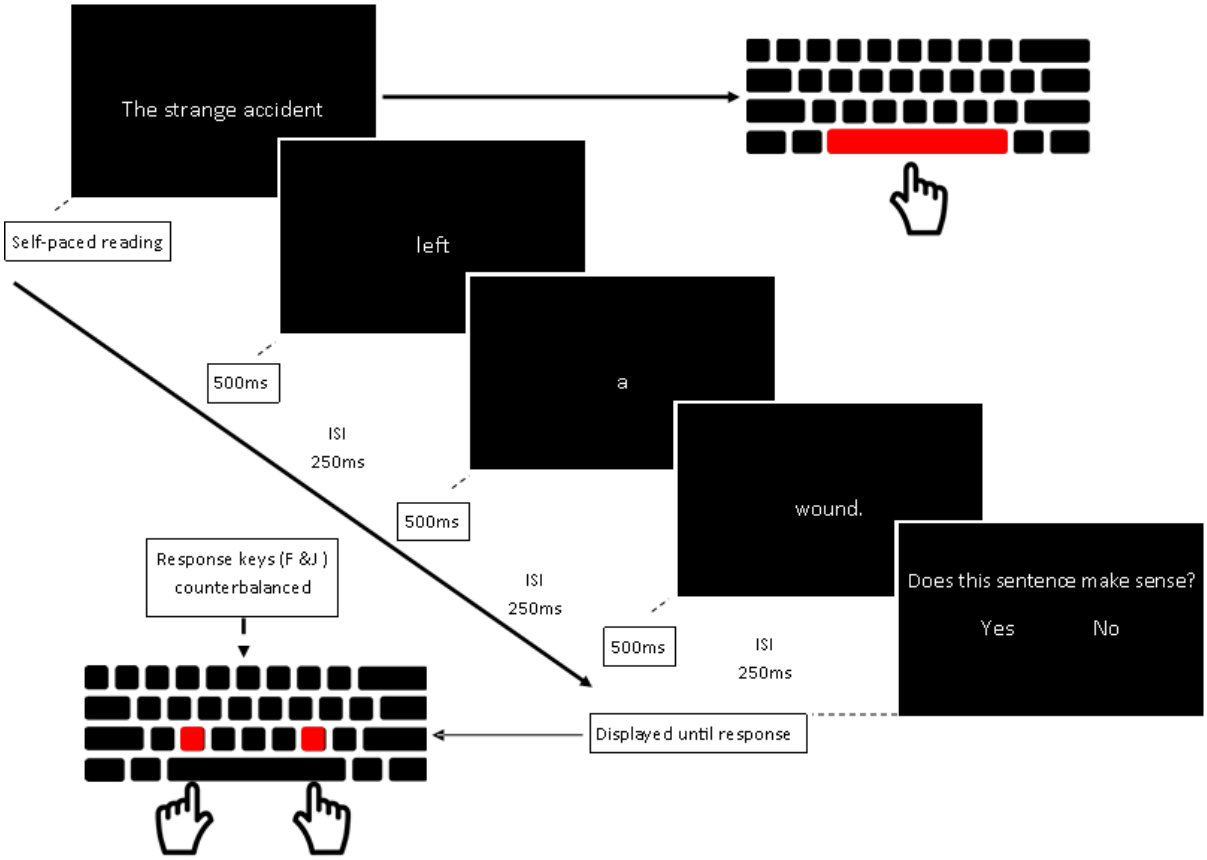


Figure 9. Schematic of the experimental procedure.

Electrophysiological recording

Electrophysiological data was recorded using 64 electrodes placed upon the scalp recording at a rate of 1 kHz, referenced to the Cz electrode. Filtering occurred both online using a band-pass filter between 0.1 and 200Hz, and offline using a low-pass zero-shift filter cut off at 20Hz. Eye artefacts were mathematically modelled and corrected. Remaining artefacts were removed manually using NeuroScan 4.4 software. Epochs ranging from -200 to 1000 ms post target word presentation were extracted with a minimum of 30 epochs per condition for each participant. Activities exceeding ±75Uv were automatically discarded. A baseline correction procedure was conducted.

Results & Discussion

Behavioral data

Accuracy data and reaction times were modelled as a function of one between-groups factor: Language (English, Welsh), and two within-subjects factors: Sensibility (sensible, anomalous), and Figurativeness (literal, metaphorical). All three factors were centered for the analyses. Accuracy data was submitted to a generalized mixed-effects model (*glmer* function in lme4 package; Bates, Mächler, Bolker, & Walker, 2014), in which we modelled the maximal random effect including participant and items intercepts and slopes (Barr, Levy, Scheepers, & Tily, 2013), systematically trimming the random effects (removing interactions) if the model at first did not converge. A fixed effect of Language, Figurativeness and Sensibility occurred, such that English sentences elicited better accuracy than Welsh sentences (b = -0.28, SE = 0.12, z = -2.33, p = 0.02), literal sentences elicited better accuracy than metaphorical sentences (b = -0.46, SE = 0.06, z = -6.70, p < .001), and anomalous sentences elicited better accuracy than sensible sentences (b = -0.90, SE = 0.06, z = -14.63, p < .001). A Figurativeness*Sensibility interaction also emerged (b = -0.89, SE = 0.12, z = -7.25, p < .001), in which for sensible sentences, literal sentences were more accurately detected than metaphorical sentences, whereas for anomalous sentences, figurativeness did not affect accuracy. No other effects emerged (p > .05). Reaction time data was log transformed for normality and submitted to a linear mixed effects model (lmer function in lme4), again with maximal random effects trimmed for model convergence. A main effect of language emerged, in which bilinguals were faster to respond in English than in Welsh (b = 90.55, SE = 27.81, t = 3.25, p = .001)

and an interaction between language and figurativeness moreover showed that in English, participants were faster to respond to literal than metaphorical sentences, but response times to both literal and metaphorical sentences were comparable in Welsh (b = -69.86, SE = 34.47, t = -2.02, p = .04). No other effects emerged (p > .05).

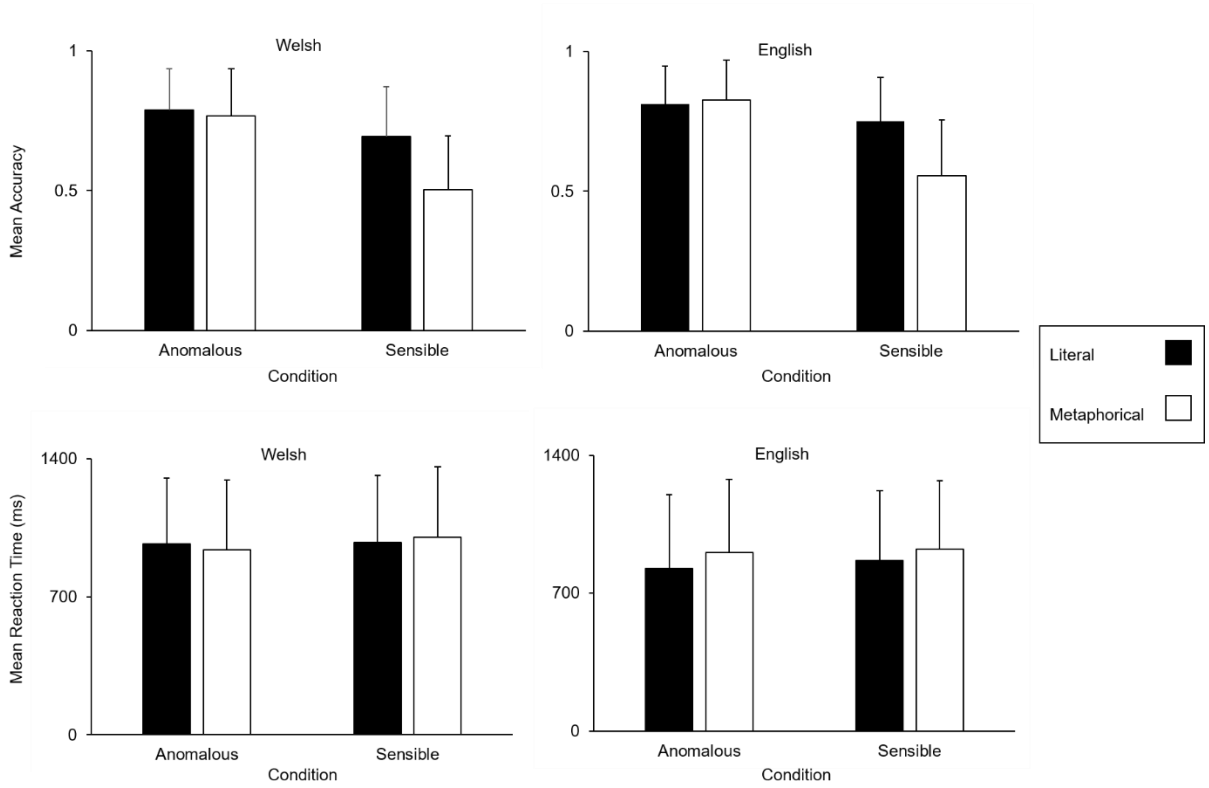


Figure 10. Mean accuracy of correct responses and mean reaction times for Welsh and English sensible/anomalous sentences with literal/metaphorical meanings. Error bars represent the standard errors.

To summarize the behavioral results, participants showed better accuracy for detecting anomalous sentences, indicating that participants perceived these sentences to be semantically anomalous. They also showed better accuracy for sentences with literal meanings, than the more ambiguous case of metaphorical meanings. Participants were

therefore sensitive to literal vs. metaphorical meaning, and somewhat surprisingly, they were more accurate in the L2 English than in the L1 Welsh. Reaction times provided converging evidence for better behavioral performance in the L2: In the L2, participants' responses were generally quicker and literal sentences moreover incurred a quicker response than metaphorical sentences. No comparable literal vs. metaphorical RT differences emerged in the L1, however.

Event related potentials

The main analysis comprised a 3-way repeated measures ANOVA with the independent factors, language (Welsh, English) figurativeness (literal, metaphorical) and sensibility (sensible, anomalous). A second analysis then examined the interaction effect of language and figurativeness for sensible sentences only, given the negligible difference between 'literal' and 'metaphorical' sentences in the anomalous condition.

N400. ERP amplitudes over 6 electrode sites (FC1 FC2 FCZ C1 C2 CZ CP1 CP2 CPZ) typically yielding modulation of the N400 (Kutas & Hillyard, 1980; 1984; Thierry & Wu, 2007; Kutas & Federmeier, 2000; Kuiper, van Koningsbruggen, Thierry, 2013; Lau, Phillips, Poppel, 2008; Barber, Donamayor, Kuta, & Munte, 2010; West & Holcomb, 2002) were analysed. In the 300-500ms time window, two main effects of language (F (1, 19) = 6.15, p = .023, η_p^2 = .24) and sensibility (F (1, 19) = 14.48, p =.001, η_p^2 =.43) revealed reduced mean N400 amplitudes in response to L2 English sentences (M = .04, SE =.38, compared with L1 Welsh sentences: M =-.48, SE =.33) and sensible sentences (M =.27, SE=.33, compared with anomalous: M =-.17, SE =.01) sentences,

respectively. There was no main effect of figurativeness (p = .39). A near significant two-way interaction between language and sensibility (F (1, 19) = 3.715, p =.06, η_p^2 =.164) revealed that, in Welsh, sensible sentences elicited smaller N400 effects (M = --24, SE =.33) compared with anomalous sentences (M = -.72, SE = 33) whilst in English, sensible and anomalous sentences elicited comparable N400 effects (M = .09, SE = .41 and M =.-.017, SE = 334). No other significant interactions were observed (p > .05). Please see *Figure 11*.

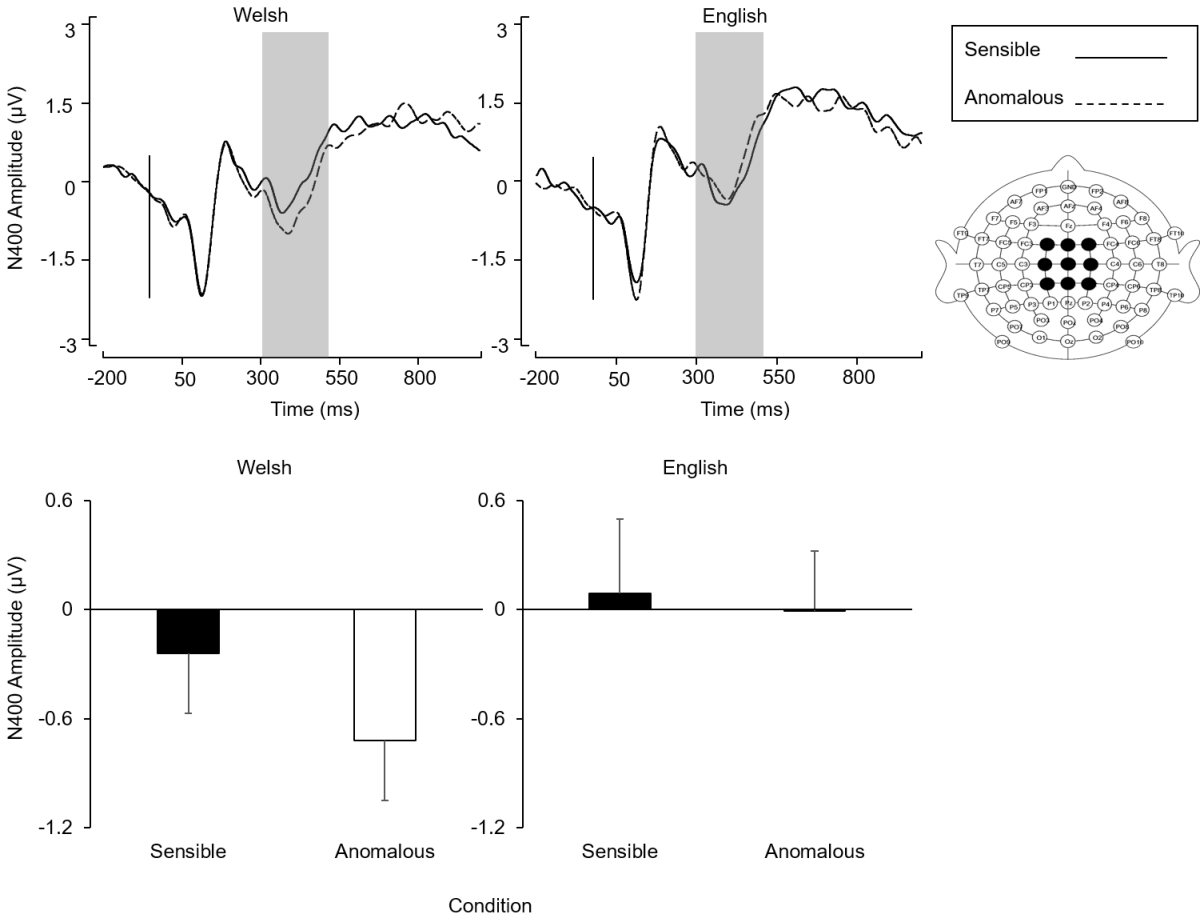


Figure 11. Mean amplitude (µV) of the N400 effect for Welsh and English sensible and anomalous sentences. Error bars represent the standard errors.

P600. We then analyzed P600 amplitudes over 6 Centro-parietal electrodes (CP1 CP2 CPZ P1 P2 PZ) in the 500-800ms time window (Tanner, Grey, Van Hell, 2017; Tanner et al., 2014). Results revealed a significant main effect of language (F (1, 19) = 21.22, p <.001, η_p^2 = .25) in which greater P6 amplitude to English (M = .3.3, SE = .302) compared to Welsh sentences (M = 2.27, SE = .220) emerged. No main effects of figurativeness or sensibility (p = .79), or significant interactions were observed (p > .05).

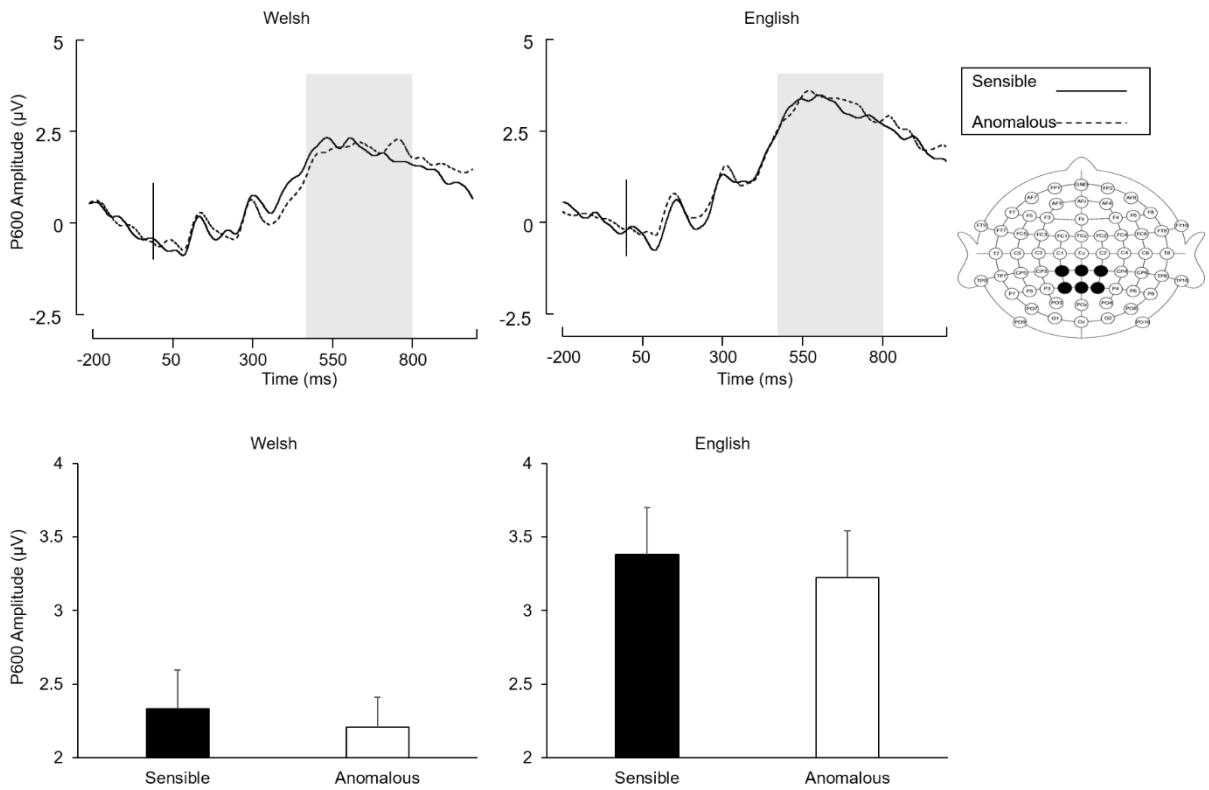


Figure 12. Mean amplitude (µV) of the P600 effect for Welsh and English sensible/anomalous sentences with literal/metaphorical meanings. Error bars represent the standard errors.

To summarize the results of Experiment 1a, we found that this highly proficient group of Welsh-English bilinguals show greater overall behavioral accuracy and faster reaction times in their second language, English rather than the native language, Welsh. In other words, bilinguals show better L2 performance in terms of their explicit responses to sentence meaning; the opposite of our original prediction. However, if we examine the earliest point of semantic integration during sentence reading, at approximately 400 ms post target word onset, we find evidence of online semantic processing – indicated by detection of sensible vs. anomalous sentences – in the native language, which is absent in the second language - indicated by a lack of divergence between sensible and anomalous sentences in both time windows. Thus, a dissociation appears to occur between our explicit and implicit measures, whereby bilinguals show earlier sensitivity to sentence meaning in the L1, which is absent in the L2 (at least online). Note that this does not suggest comprehension of meaning, only that a semantic search occurs at an earlier time point in the L1 relative to the L2. However, this tendency does not translate into better L1 behavioral performance as participants were faster and more accurate in the L2, suggesting meaning in the L2 was also retrieved, albeit during later stages of processing.

We consider factors known to moderately correlate with accuracy such as participant self-confidence (Kleitman, & Stankov, 2007; Harvey, 1997; Keren, 1991; Stankov, 1999) and whether confidence in the L1 may have influenced explicit responses. According to the Welsh Government (2018) only 68% of Welsh speakers feel confident speaking Welsh, and 21% of fluent speakers are concerned about how well they speak the language. However, research shows that those who speak Welsh at home and are educated primarily in Welsh are confident in their speaking, reading and writing abilities

and report making very few mistakes in Welsh (Morris, 2014), consistent with the finding that confidence is strongly correlated with fluency (Welsh Government, 2018). As our bilingual sample were from Welsh only homes, we suggest this explanation is unlikely; an explicit measure of these factors would have allowed to determine the extent of these influences more accurately.

Our implicit measure of semantic processing on the other hand, is consistent with an account in which conceptual information can be more easily integrated in the native language, even in highly proficient bilinguals (Ardal, Donald, Meuter, & Muldrew, 1990; Kutas & Kluender, 1994; Weber-Fox & Neville, 1996; Hahne & Friederici, 2001; Moreno & Kutas, 2005). We leave further discussion, including how to reconcile our findings derived from implicit and explicit measures to the general discussion, and now focus on bilingual processing of literal vs. metaphorical sentences.

Despite participants' clear sensitivity to figurative meaning, evidenced in overall behavioral accuracy and RTs, we found no evidence in this experiment that bilinguals distinguish literal and metaphorical meanings at an implicit level, nor was figurativeness modulated by language. This is contra previous findings in the monolingual literature (Arzouan et al., 2007a, b; Coulson and Van Petten, 2002, 2007; De Grauwe et al., 2010; Goldstein et al., 2012; Lai et al., 2009; Pynte et al., 1996; Tartter et al., 2002), and our predictions, in which we anticipated that metaphorical meanings would be more readily accessible in the L1.

We propose that our inclusion of anomalous sentences in Experiment 1a – though informative in revealing L1-L2 differences in semantic processing for sense – was responsible for the null result on our figurativeness factor. Specifically, participants were

likely primed to detect sentence anomaly, potentially rendering differences in meaning between literal and metaphorical sentences less salient, and therefore reducing differences in N400 between these levels of the figurativeness factor. In order to test this hypothesis, we conducted a second experiment, almost identical to the first but now including only sensible items (omitting all anomalous items). This necessitated inclusion of a different behavioral task detailed in the next section.

Experiment 1b

In experiment 1b we once again examined whether bilinguals are better able to rapidly map conceptual-level information in the L1, leading to easier comprehension of metaphorical language than in the L2. To this end, a new sample of Welsh-English bilinguals read Welsh and English sentences manipulated for literal and metaphorical meaning. We predicted that easier processing of metaphor in L1 should manifest in an N400 for metaphorical sentences that is absent in L2 (but present in the P600). Easier comprehension of metaphor should manifest in an N400 for metaphor in both languages but reduced in the L1.

Method

Participants A new sample of bilingual Welsh-English bilinguals was recruited, who nevertheless had an identical demographic profile to those recruited to Experiment 1a (*N* = 21, 16 females, 5 males, *M* age = 21.8, *SD* = 3.5). A further eight participants were excluded due to low data quality. On a Language History Questionnaire, bilinguals self-reported acquisition of Welsh at birth, and acquisition of English as a second language at

an early age (*M* = 3.8, *SD* = 2.11). They also reported more frequent use of Welsh (*M* = 74%, *SD* = 15.91) and higher Welsh proficiency (*M* = 9.7, *SD* = 0.23) compared to English use (*M* = 26%, *SD* = 15.91) and proficiency (*M* = 9.1, *SD* = 0.29). The MEIM (Phinney, 1992; Roberts, Phinney, Masse, Chen, Roberts & Romero, 1999) also revealed strong Welsh cultural identity with Wales (*M* = 3.38, *SD* = 0.28).

Materials, Design & Procedure. The stimuli used were identical to the literal and metaphorical sentences constructed for use in experiment 1a (having removed the anomalous sentences). Thus, the stimulus set comprised Welsh and English literal sentences (translation equivalents, *n* = 160) and Welsh and English metaphorical sentences (translation equivalents, *n* = 160). Sentences from each set were counterbalanced across participants, such that each participant saw any given sentence in English or in Welsh only. Sentences were presented in four blocks of 40 trials.

On a single trial, sentences were presented using a self-paced procedure for the first clause, followed by serial presentation of words for the final 3-5 words, culminating in the target word, in an identical procedure to Experiment 1a. However, given that sentences in 1b were all meaningful, it was necessary to change the task. In order to engage focused attention and to ensure that sentences were processed semantically, a comprehension question was presented following filler items on 30% of all trials presented in the experiment. Filler items were composed of both metaphorical and literal sentences to ensure that literal or metaphorical meanings were not over-represented in the experiment. See figure 13 for a schematic of the experimental procedure.

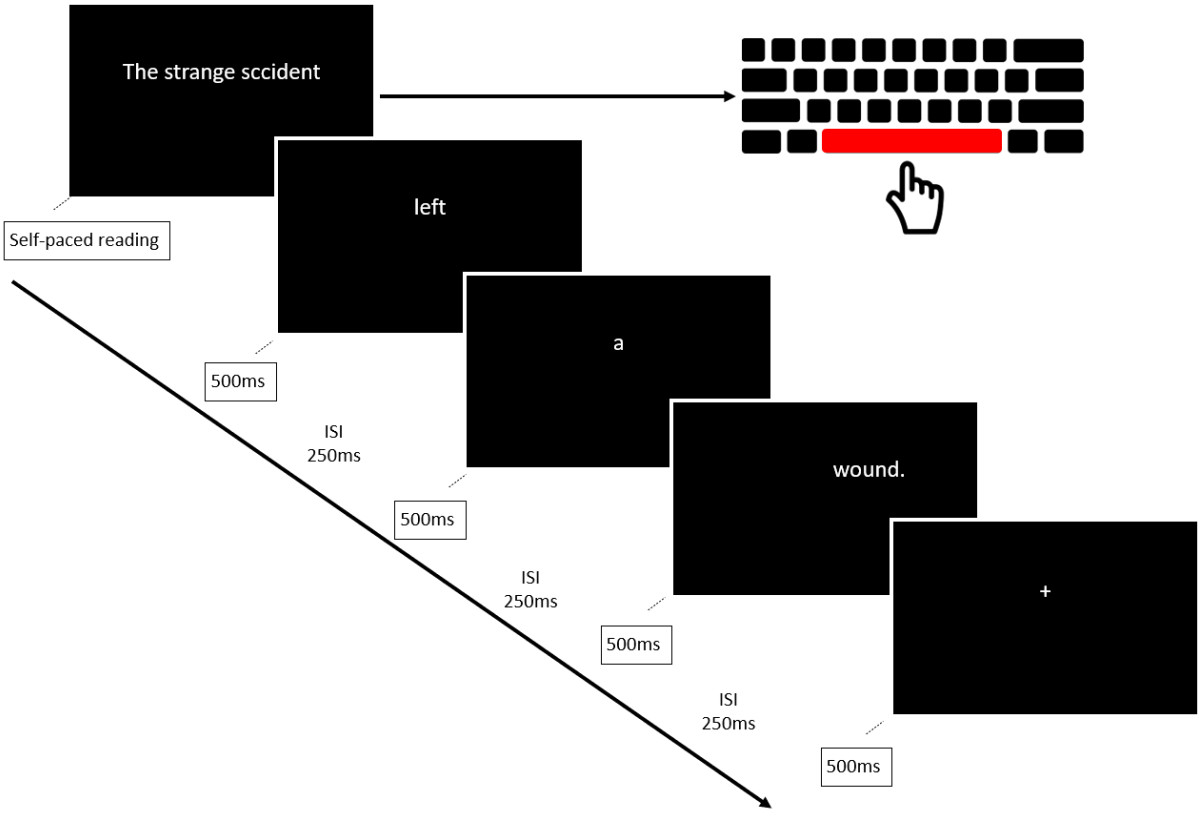


Figure 13. Schematic of the experimental procedure used in experiment 1b.

Results & Discussion

N400. ERP amplitudes were analysed over nine fronto-central, central, and central-parietal electrodes (FC1 FCZ FC2 C1 CZ C2 CP1 CPZ CP2) in the classic N400 (300-500ms) time window. Whilst no significant main effect of language (F (1, 20, 1) = .79, p = .39) or figurativeness (F (1, 20) = .04, p = .82) emerged, a significant language*figurativeness interaction (F (1, 20) = 4.35, p = .04, η_p^2 = .172) showed that in Welsh, literal sentences elicited larger N400 amplitudes (M = -.48, SE = .3) relative to metaphorical sentences (M = -.13, SE = .27) whilst in English, literal sentences (M = -.322, SE = .3) elicited smaller N400 effects relative to metaphorical sentences (M = -.61, SE = .25; see figure 14).

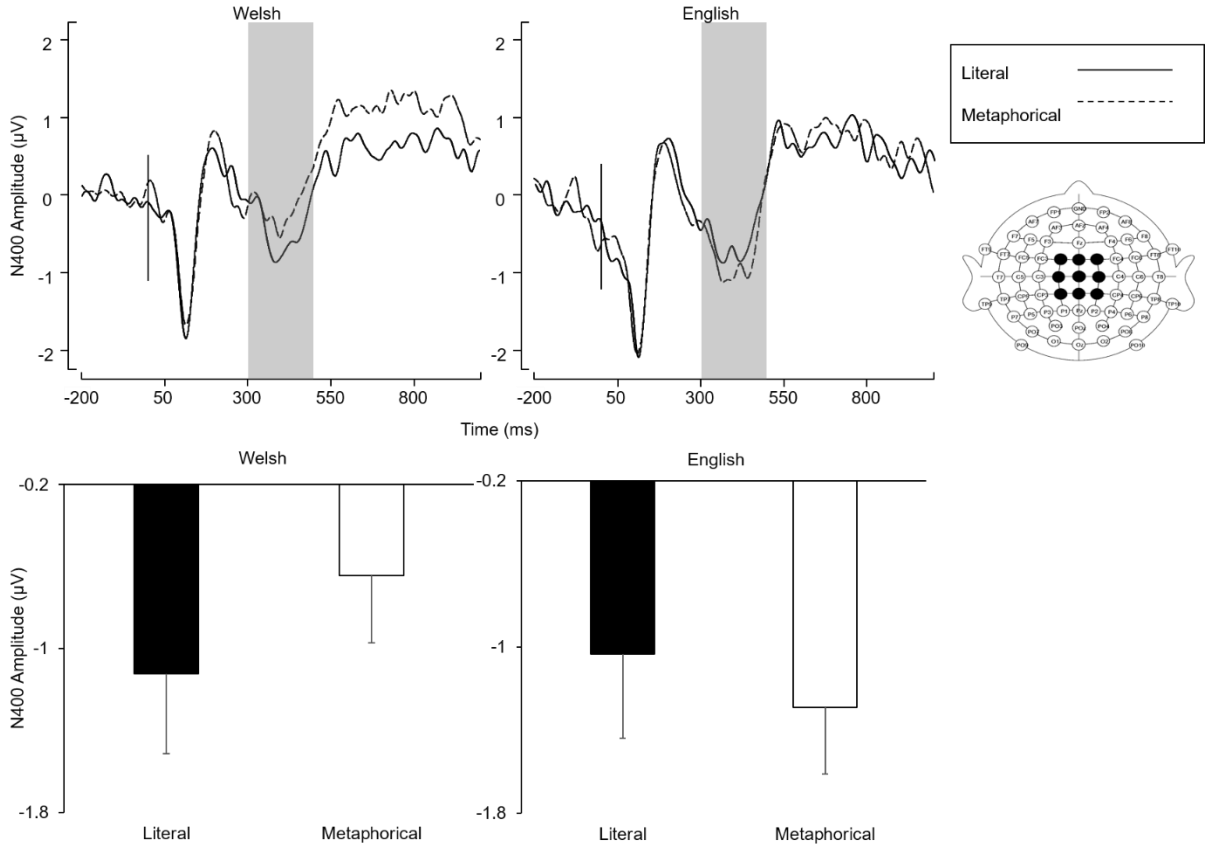


Figure 14. Mean amplitude (µV) of the N400 effect for Welsh and English literal/metaphorical sentences. Error bars represent the standard errors.

P600. We then analysed the P600 time window (600-800ms) over 6 central parietal electrodes (CP1 CPZ CP2 P1 PZ P2). A significant main effect of language emerged (F (1, 20) 6.70, p = .01, η_p^2 = .251) in which P600 amplitudes were reduced to Welsh sentences (M = 1.67, SE = .35) compared to English sentences (M = 2.34, SE = 28; see figure 15). No significant main effect of figurativeness (F (1, 20) =1.05, p = .32) or language*figurativeness interaction (F (1, 20) =1.05, p = .32) emerged (see figure 15).

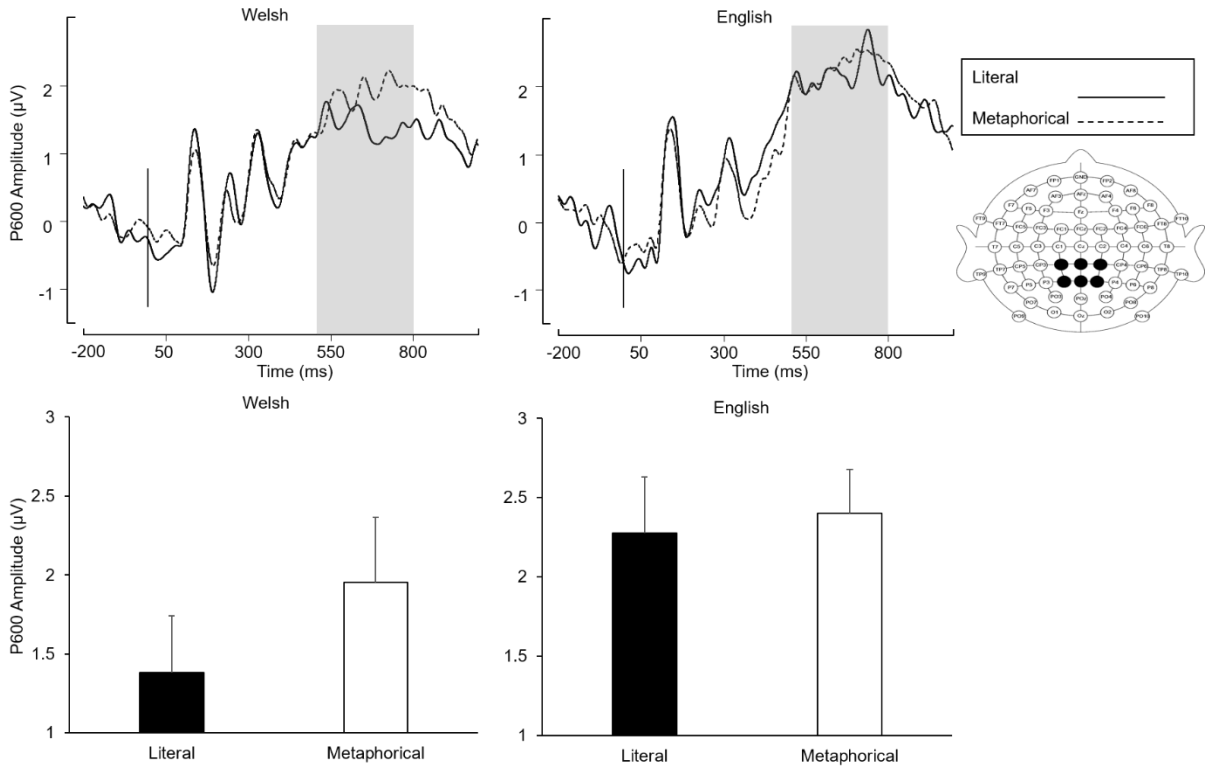


Figure 15. Mean amplitude (µV) of the P600 effect for Welsh and English literal/metaphorical sentences. Error bars represent the standard errors.

In Experiment 1b, we attempted to increase sensitivity to literal-metaphorical distinctions in modulation of the N400 wave, by removing anomalous sentences. We showed that overall (for both literal and metaphorical sentences), fluent Welsh-English bilinguals showed greater ease of semantic processing (reduced N400 and P600) in the L1 compared with the L2. We also showed that bilinguals differentiated literal and metaphorical sentences in the L1 Welsh, but not in the L2 English (manifest in differential N400 amplitudes to literal and metaphorical in the L1 but not in the L2). Both findings are consistent with an account of more efficient semantic integration in the L1 (Ardal, Donald, Meuter, & Muldrew, 1990; Kutas & Kluender, 1994; Weber-Fox &

Neville, 1996; Hahne & Friederici, 2001; Moreno & Kutas, 2005), and with the results of Experiment 1a, in which detection of anomaly only occurred in the L1. However, the interaction observed in Experiment 1b was not in accordance with our hypotheses: Although literal sentences elicited similar modulation of the N400 in both the L1 and the L2, and metaphorical sentences elicited smaller N400s in the L1 than in the L2 (Beck & Webber, 2016; Cieslicka, 2006; Jankowiak, Rataj & Naskrecki, 2017), *metaphorical sentences also elicited smaller N400s – suggestive of easier semantic integration – compared with literal sentences, within the L1*.

Our interpretation of this surprising finding is necessarily post-hoc, and difficult to account for, given the very strict control of our sentences. Recall that target words were fully rotated across conditions, allowing very little scope for extraneous lexical effects. The only identifiable difference between literal and metaphorical sentences in our sets was the subject word in the sentence, which determined whether the overall sentence meaning was literal or metaphorical. Upon inspection, these words tended to be more abstract in metaphorical sentences than in literal sentences (see Methods chapter, in which we determined that metaphorical sentences by definition include more abstract concepts), which may have introduced more ambiguity into the sentence meaning. However, these subject words were counterbalanced across literal and metaphorical conditions, therefore if this hypothesis is correct, we would have observed a similar effect in the anomalous condition. As no effects were found this cannot be a valid explanation.

A second explanation may be the syntactic ambiguity introduced by creating a stimulus set across two languages that do not share the same syntactic structure. Whilst English follows a strict SVO (subject-vowel-object) structure, Welsh may follow an SVO

as well as a VSO structure (Deuchar, 2006). Thus, the syntactic structure may have been more acceptable in one language resulting in differential online processing. This explanation however is also unlikely for two reasons. First, as explained above, due to the sentence rotation and counterbalancing procedures use performed, we would have observed the same effects across conditions, which we did not. Finally, any semantic ambiguity is unlikely to have elicited the N400 and would more likely have elicited components such as the Left Anterior Negativity (LAN; peaking around 180ms at left anterior electrode sites; Coulson, King & Kutas, 1998; Friederici, Pfeifer, & Hahne, 1993).

In the General Discussion, I now synthesise the results of Experiments 1a and b, and I propose two possible interpretations for our data, which are then tested in Experiment 2.

General Discussion

In two experiments, we examined fluent bilinguals' conceptual processing in the L1 vs. the L2. In Experiment 1a, we showed that bilinguals are more sensitive to sentence anomaly in the L1 Welsh than in the L2 English. Indeed, there was very little evidence of N400 modulation as a function of sentence anomaly or metaphoricity. On the other hand, this L1 'advantage' at the level of online semantic processing does not appear to translate into a behavioral advantage (i.e., faster and more accurate responses). Rather, during offline and presumably meta-analytic stages of sentence processing, the L2 was at a greater advantage in terms of behavioral accuracy in verifying semantic relatedness and response times. Experiment 1b then examined whether we could observe the more subtle

effect of metaphoricity in the L1 (but not in the L2; i.e., analogous to the anomaly effect in Experiment 1a). Our results showed overall easier semantic processing in the L1 and a metaphoricity effect in the L1. However, contra our expectations, metaphorical sentences elicited a smaller N400 than literal sentences in the L1. Overall, whilst our general pattern of results at the level of online semantic processing suggests greater sensitivity to differences in conceptual mapping requirements, the direction of these findings is not entirely consistent with our expectations. I now discuss our two main findings in turn.

Online semantic processing of sentence anomaly in L1 and L2

Overall, our findings suggest that fluent bilinguals' L1 and L2 do not engage the same processes during online comprehension. Although these participants were highly proficient in the second language, an L1-L2 asymmetry seems to persist (The BIA model, van Heuven & Dijkstra, 2010; RHM, Kroll and Stewart, 1994), in which L1 more readily enables semantic-level processing, shown in greater sensitivity to sentence anomaly. These findings largely concur with previous studies, showing delayed conceptual processing in the L2 despite high fluency levels (Moreno & Kutas, 2005; Ardal, Donald, Meuter, Muldrew, Luce, 1990; Hahne & Friederici, 2001). This asymmetry is assumed to be independent of proficiency and rather occurs as a consequence of weaker linguistic experience (van Heuven & Dijkstra, 2010; Kroll and Stewart, 1994; Moreno & Kutas, 2005; Ardal, Donald, Meuter, Muldrew, Luce, 1990; Hahne & Friederici, 2001). Indeed, our bilinguals report being from Welsh homes, receiving predominantly Welsh primary and secondary education (in line with the Welsh language policy in Gwynedd (Gwynedd Council 2016), and higher daily use of Welsh. However, we expected to observe less

pronounced N400 effect to sentences in the L1 than in the L2 (as previously observed) but instead found the opposite effect (less pronounces N400 and greater P600 in the L2) suggesting that semantic processing in the L2 is more delayed than previously anticipated.

Whilst these findings generally fit with current models of bilingual lexico-semantic links (Kroll & Stewart, 1994; Dijkstra and Van Heuven, 2002; Finkbeiner et al, 2004), we propose that our use of sentences to test these links also suggests that the linguistic context (here, sentences) can also bias the language system to recognise and produce words in a language-specific way (Bultena, Dijkstra, & van Hell, 2014; Schwanenflugel & Shoben, 1985; Foucart, Martin, Moreno, & Costa, 2014; Schwartz & Van Hell, 2012; Van Hell & De Groot, 2008, Schwartz & Kroll, 2006; Duyck et al, 2007), meaning that predictive processes in semantic processing may be more efficient in the L1 than in the L2. In the General Introduction to this thesis, I proposed that such findings in the bilingualism literature are consistent with transitional probabilities described in models of language learning (e.g., Elman, 1990; Dell & Chang, 2014), in which repeated activation of specific lexical strings would presumably enable the individual to make efficient predictions concerning upcoming words on subsequent exposures to those specific strings.

Therefore, even when L2 fluency is high, the L1 is assumed to be composed of a richer set of words and stronger lexical-semantic links (Kroll & Stewart, 1994; Luo, Cheung, Bel, Li, Chen, & Mo, 2013; Finkbeiner, Forster, Nicol & Nakamura, 2004). In contrast, the non-native language has weaker lexical-semantic links and restricted inter-conceptual networks (Finkbeiner, Forster, Nicol, Nakamura, 2004). According to these

models, inferior connections and experiences in the L2 result in delayed and more effortful processing, and in our studies, this may manifest in minimal modulation of the N400 wave by sentence anomaly or metaphoricity in the L2 English, and greater and reanalysis to English sentences in both experiments.

One other way to conceptualise the current finding is via a framework of 'good enough' language comprehension (Ferreira et al, 2002). This model describes the phenomenon of sentence misinterpretation in cases such as "*The authorities had to bury the survivors"* (Barton & Sanford, 1993), in which the meaning is implausible, yet the anomaly is often overlooked during the initial stages of processing and only recognised during reanalysis. The plausibility of these conceptual co-occurrences (authorities, bury, survival), means that the reader has a 'good enough' representation of meaning until pressed for a full analysis (Christianson, 2016). At the neural level, such sentences typically do not elicit modulation of the N400 wave, contra the effects usually found in sentence anomaly; rather, effects are found in the P600 wave, indicative of reanalysis (e.g., Brouwer, Fitz, & Hoecks, 2012; Osterhout & Holcomb 1992; Osterhout & Mobley 1995; van Berkum et al. 2005; Kim & Osterhout 2005; Van Herten et al, 2005). In general, readers with poorer memory capacity – weak readers (Hannon & Daneman, 2004) and older adults (Christianson, Williams, Zacks, & Ferreira, 2010) – are typically more susceptible to good enough processing misinterpretations. Although tentative, a similar mechanism may underpin bilinguals' L2 processing, in which weaker lexico-semantic links engender an initial semantic processing style based on heuristics rather than online semantic analysis. Interestingly, we do not find a cost to offline semantic

verification, suggesting that later semantic analysis does not compromise bilinguals' function in L2 at a behavioral level.

Online semantic processing of sentence metaphoricity in L1 and L2

Whilst Experiment 1a revealed no online sensitivity to metaphoricity, in Experiment 1b, bilinguals showed attenuated N400 responses to metaphorical meanings in L1, superficially suggesting that processing metaphor in the L1 is easier than processing literal language. I suggest two post-hoc explanation for this unexpected finding, which is then explored further in Experiment 2.

First, these bilinguals may have been susceptible to 'semantic illusion' during the initial processing of metaphor in the L1, initially being unaware of the unconventional / metaphorical meaning. This effect is indexed by a reduced N400 suggests that although the retrieval of meaning from the long-term memory was not necessarily taxing (which is not surprising given that this is the native language), A later *trend* emerged during the P600 window however, in which metaphor appeared to elicit greater reanalysis effort. Therefore, the sentence was processed more fully for meaning during later stages, typically associated with the reanalysis of meaning (Brouwer, Fitz, & Hoeks, 2012; Hoeks et al, 2004) suggesting that integrating meaning into the larger context of the sentence was more difficult (Rataj et al 2018; Brouwer, Fitz, & Hoeks, 2012; Hoeks et al, 2004).

Although many studies investigating metaphorical processing have observed modulations of the P600 component the results are somewhat inconsistent; with some studies finding increased amplitudes to metaphors (Coulson & Van Petten, 2002; De

Grauwe et al, 2010) whilst others finding the opposite effect (Arzouan et al, 2007; Goldstein et al, 2012). This matter is further confounded by the failure of many studies to examine the component all together (Rataj, Przekoracka-Krawczyk, & van der Lubbe, 2018). Therefore, making definitive conclusions as to the relationship between the N400 and P600 here (and indeed in general metaphor processing) is tentative. We must also ask why these bilinguals did not show the same effect in the L2 (as found in experiment 1a)? Thus, whilst this explanation is theoretically tangible it directly contradicts the conclusions of experiment 1a (that shallow processing occurs in the L2). Although discussed within the metaphorical literature (Rataj et al 2018) semantic illusion (indexed by reduced N400) is a novel finding within the metaphorical literature. It is, however, a well-established effect in anomaly processing (Brouwer, Fitz, & Hoeks, 2012). We must therefore consider alternative explanations and conduct further investigations (experiment 2) to elucidate the issue.

The second, more speculative explanation for this finding is that the statistical probability of the occurrence of metaphorical language is higher in Welsh than English. Metaphorical language is a poetic device frequently used in Welsh literature and each child receiving Welsh medium-education receives specific instruction on how to decipher such language (specifically during Welsh GCSE and A Levels (WJEC/CBAC, 2020. WJEC GCSE in Welsh Literature; WJEC/CBAC, 2020. WJEC GCE AS/A LEVEL in Welsh (first language); WJEC/CBAC, 2020. WJEC GCSE English Language); Jones, 2016; Trefor, 2014). In fact, mastering the interpretations of devices such as metaphors are imperative in comprehending the meaning of overall Welsh literary text (Rowlands, 2015). Our participants therefore have received greater

instruction and experience in processing metaphorical language in Welsh. This instruction, experience and knowledge may have facilitated the comprehension of metaphor in Welsh.

Conclusions

In summary, the current studies reveal greater discrimination of meaning in bilinguals' L1 during online semantic processing stages of sentence comprehension, but which does not incur a behavioral advantage (Experiment 1a). In Experiment 2, we examine whether the metaphoricity effects seen in L1 are genuinely linked to the native language. Thus, we will recruit native English-Welsh bilinguals, using an identical paradigm, to ascertain whether similar effects can be found when in L1 English.

Chapter 4

Bilinguals making sense (II):

Online semantic processing of figurative meanings may depend on language context, not bilinguals' L1 status

Acknowledgements: Thank you to Yang Lee, Jen Lewendon and Laurie Mortimore for their assistance fitting the EEG cap,

Abstract

Current accounts of online figurative language processing suggest that semantic processing of literal language is easier than metaphorical language, as indexed by *larger* N400 amplitudes to metaphorical expressions. In experiment 1b, however, we found that in native Welsh-English bilinguals, metaphorical sentences elicited *reduced* N400 amplitudes compared to low cloze-probability literals in the native Welsh, even though the structure of literal and metaphorical sentences were identical. Moreover, we found no evidence of differential processing in the bilinguals' non-native language. Here, we aimed to elucidate these findings. Native English – Welsh bilinguals (i.e., reversed L1-L2) undertook an identical task to that described in Experiment 1b: Event related potential (ERP) data was recorded as participants read English and Welsh sentences with literal and metaphorical meanings. Results showed that in the L1 (English), no differences in N400 amplitudes emerged between literal and metaphorical sentences, supporting previous accounts of direct access to metaphorical language. However, in the L2 (Welsh), metaphorical sentences were processed with greater ease than literal sentences (indexed by reduced N400 to metaphor), broadly consistent with the findings of Experiment 1b. Overall, our findings suggest that the linguistic properties of a given language may affect figurative language processing.

In experiments 1a and 1b, we examined fluent Welsh-English bilinguals' conceptual mapping in the L1 and L2. In Experiment 1a, we presented Welsh and English sentences, which were manipulated orthogonally for sense (sensible vs. anomalous sentences) and figurativeness (literal vs. metaphorical sentences). Our results showed that online semantic processing is indeed different between the L1 and the L2. In the non-native language, our bilinguals showed greater processing effort for anomalous sentences in the L1, but no such difference emerged in the L2. Our aim was to examine differences in semantic analysis (detection of a full violation in the case of anomaly, or greater difficulty in the case of metaphor) between the L1 and the L2. We concluded that meaning is accessed at an earlier time point in the L1 than in the L2 – indexed by earlier semantic search in the L1, regardless of the sensibility of the sentence. That is, even though the meaning may have been novel or anomalous, a semantic search occurred earlier in the L1 (indexed by greater N400 amplitudes in the L1). This however, does not translate into facilitated behavioural performance in an overt semantic judgement (Experiment 1a).

To examine the case of metaphor with greater precision we conducted a second experiment that excluded the anomalous sentences (Experiment 1b). Once again, L2 processing was comparable for both literal and metaphorical sentences. In the native language (Welsh) however, N400 amplitudes for literal and metaphorical diverged, surprisingly with metaphorical sentences processed with greater ease than literal sentences. These results are contra to findings suggesting that accessing metaphorical

meaning is more difficult (Pynte, Besson, Robichon & Poli, 1996; Coulson & Van Petten, 2002; 2007; Lai et al, 2009).

We proposed two possible reasons for this finding. First, semantic processing in the L1 is more susceptible to good-enough processing, such that metaphorical meanings are coarsely evaluated during the N400 phase and processed in more depth at a later time point. Second, and more speculatively, is the statistical probability of the occurrence of metaphor may be higher in the Welsh language, and greater experience with poetic devices, leading to a processing advantage of metaphor in Welsh. Although speculative, recall that our norming data showed that Welsh literal and metaphorical sentences were rated similarly 'figurative' compared with the greater divergence in ratings found for English sentences.

To test these competing hypotheses, a group of fluent English-Welsh (i.e., L1 English) bilinguals underwent an identical procedure to that employed in experiment 1b. Based on the explanations presented in Chapter 1 we had two main predictions:

1. Under a good-enough processing account, English literal sentences will yield greater amplitudes to that of English metaphorical sentences. Metaphorical sentences are likely to be processed later yielding a larger P600 amplitude. There will be no difference between literal and metaphorical in the L2 Welsh.
2. If access to metaphor, however, is direct and the reduced N400 to metaphorical Welsh sentences were attributable to properties of the Welsh language, we expect the same results to occur regardless of the Welsh language native-ness status. That is, in Welsh we expect metaphorical sentences to be processed more easily than literal sentences (indexed by

reduced N400 to metaphor). Furthermore, comparable amplitudes to English literal and metaphorical sentences in English would support the assumption of direct access to metaphorical meaning.

Methods

Participants

Twenty-four English-Welsh bilinguals (*N* = 24; 18 females, 6 males; *M* age = 24.6) were recruited via opportunity sampling (Social Media and University forums). These participants acquired Welsh at a very early age (*M* = 2.6, *SD* = 1.76), and therefore earlier than our L1 Welsh participants; consistent with the age at which early Welsh education begins (e.g., nursery schools). Participants who reported acquiring English and Welsh from birth were deemed simultaneous bilinguals and removed prior to analysis. One participant was excluded from the final sample due to low quality data. Self-report measures from a language history questionnaire and Multi-Group Ethnic Identity Measure (see Chapter 2 and Appendix A & B for full review) revealed that participants' English proficiency and use (*M* = 9.6, *SD* = 0.14; 63% daily use) was higher than their Welsh proficiency and use (*M* = 7.96, *SD* = 0.55; 37% daily use). Participants self-identified as culturally Welsh or British (*n* = 20; *n* = 4). Ethical approval was obtained from the School of Psychology, Bangor university and participants provided informed consent before taking part.

Materials, design and procedure

The materials, design and procedures used in this experiment were identical to those used in experiment 1b.

Results

The analysis comprised a 2-way repeated measures ANOVA with the independent factors, language (English, Welsh) and figurativeness (literal, metaphorical).

N400. In the N400 time window (300 - 500 ms), ERP amplitudes were analysed over 9 fronto-central, central and centro-parietal electrode sites (FC1 FC2 FCZ C1 C2 CZ CP1 CP2 CPZ). A significant main effect of language emerged (F (1, 23) = 6.91, p = .02, ηp2 = .23) in which English sentences elicited reduced N400 amplitudes (M = -38, SE = .23) compared with Welsh sentences (M = -.76, SE = .21). No main effect of figurativeness (F (1, 23) = .002, p = .96, ηp2 = .0) and no significant language*interaction emerged (F (1, 23) = 1.58, p = .22, ηp2 = .06).

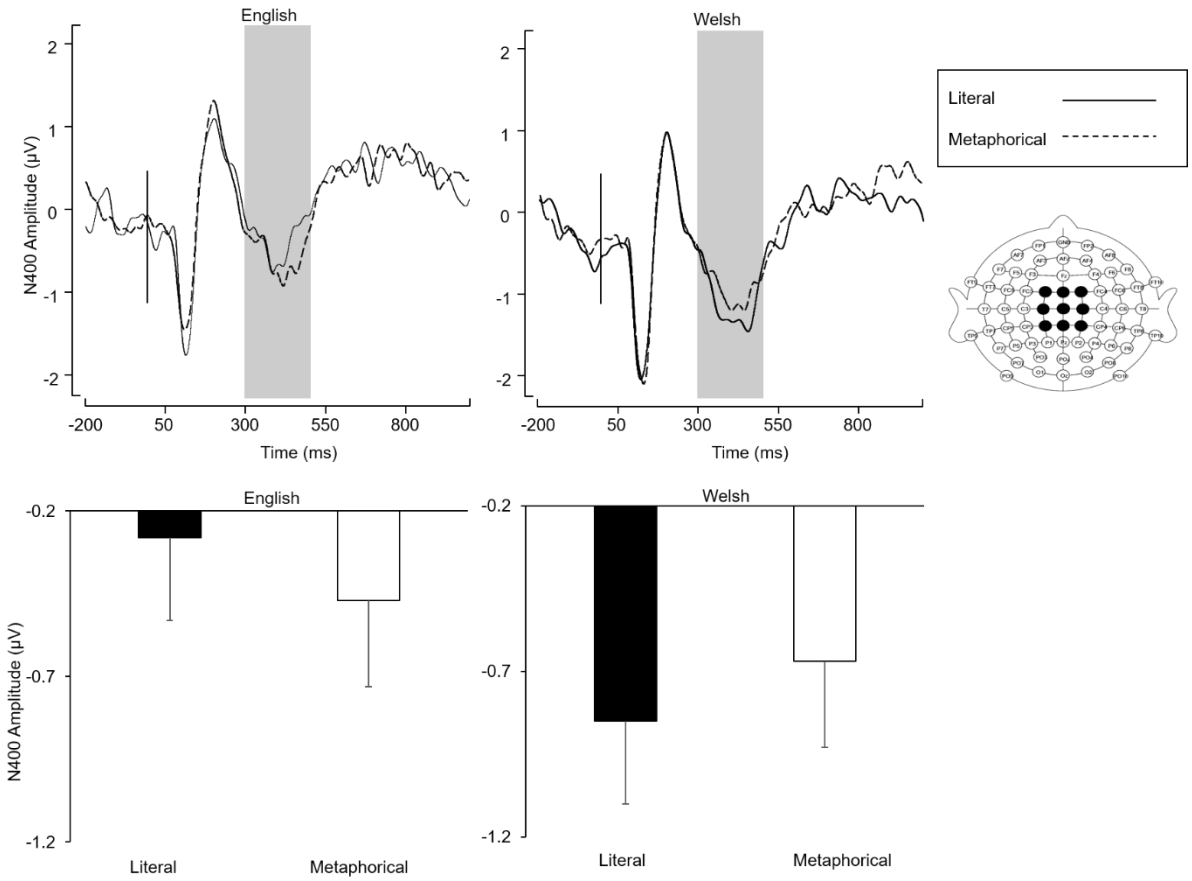


Figure 16. Mean amplitude (µV) of the N400 component for literal and metaphorical sentences in English and Welsh. Error bars represent the standard errors.

P600. In the P600 time window (500 – 800 ms), ERP amplitudes were analysed over 6 parietal electrodes (CP1 CPZ CP2 P1 PZ P2). A significant main effect of language emerged (F (1, 23) = 8.88, p = .007, ηp2 = .27) in which English sentences yielded higher P600 amplitudes (M = 1.56, SE = .25) than Welsh sentences (M = .71, SE = .24). No main effect of figurativeness (F (1, 23) = 1.595, p = .22, ηp2 = .07) and no interaction emerged (F (1, 23) = .43, p = .52, ηp2 = .03).

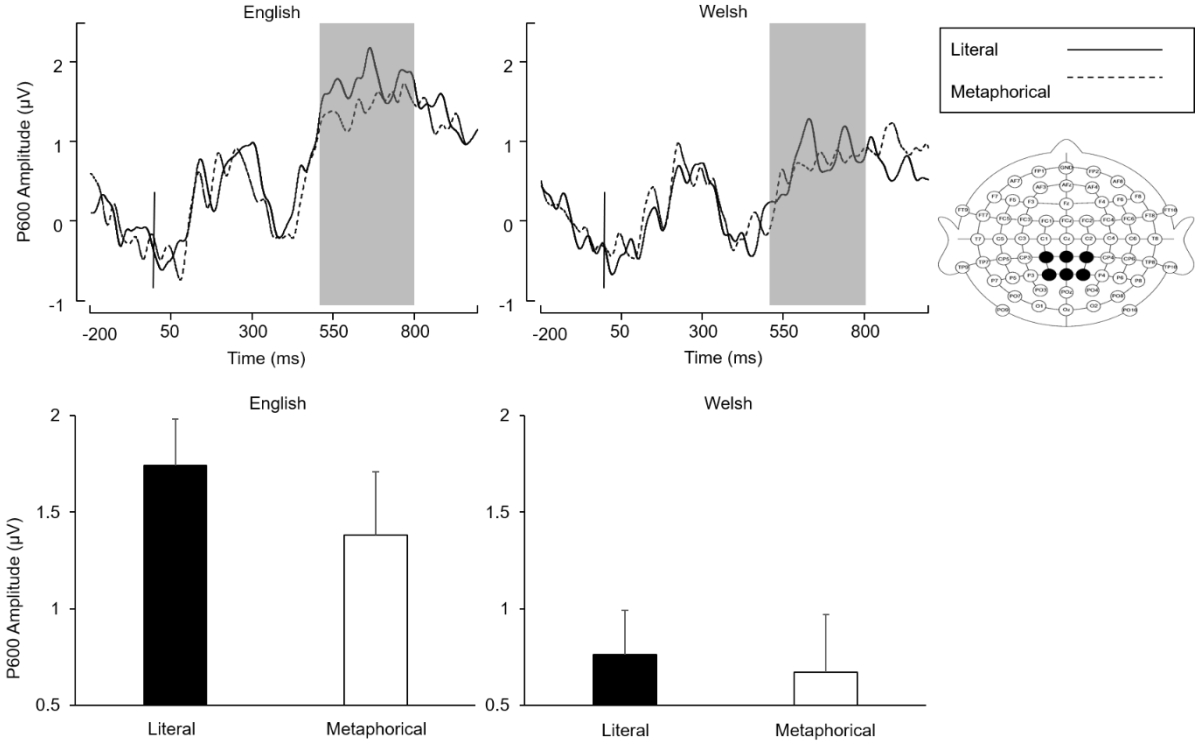


Figure 17. Mean amplitude (µV) of the P600 component for literal and metaphorical sentences in English and Welsh. Error bars represent the standard errors.

Discussion

The aim of this study was to cast light on the unexpected findings of experiment 1b, in which greater sensitivity was found to literal vs. metaphorical language in the L1, but in an unexpected direction (metaphor yielded attenuated amplitudes compared with literal language). Thus, Experiment 2 comprised an identical paradigm to Experiment 1b; the only change being the population studied. We recruited English-native English-Welsh bilinguals in order to ascertain whether our findings reflected good-enough processing in the L2 (a bilingual sampling effect). If this was the case, we expected that English-Welsh

bilinguals would show shallow processing to metaphoricity (and reduced N400 amplitudes to metaphor) in English, but in Welsh we expected no differences between conditions. Or, whether distinguishing and assimilating metaphor at an earlier point in comprehension reflects natural properties of Welsh. If so, then we expect to replicate the trend seen in Experiment 1b (Welsh metaphor would elicit reduced N400 relative to Welsh literal sentences).

Overall, the data suggests that proficient English-Welsh bilinguals encountered greater difficulty in processing Welsh compared to English sentences (as indexed by greater N400 amplitudes to Welsh sentences). This finding is consistent with our own findings (see experiments 1a and 1b) and the bilingual literature (Ardal, Donald, Meuter & Muldrew, 1990; Kutas & Kluender, 1994; Weber-Fox & Neville 1996). However, during the later time windows indicative of reanalysis, we found more effortful processing to English compared to Welsh sentences. I now discuss these findings in turn.

Direct access to figurative language

In contrast to experiment 1b (however, in line in experiment 1a) we found no significant effects of metaphoricity in the native (or non-native) language. Based on these results we postulate that a lack of divergence between literal and metaphorical sentences across the three studies suggests that these participants accessed the metaphorical meaning directly – or at least in conjunction with the low probability literal sentences – supporting the direct access hypothesis (de Grauwe et al., 2010; Iakimova, Passerieux, Laurent, Hardy-Bayle, 2005).

These results contradict those previously observed which have consistently found more pronounced amplitudes to metaphorical compared to literal sentences. Neurocognitive models propose two competing models in describing the comprehension of metaphors. The original hierarchical model (Grice 1975; Searle 1979) proposes that a reader / listener will initially search for the literal meaning of the sentences; once this interpretation is rendered meaningless, the search for metaphorical meaning commences. Contrastingly, the direct access hypothesis (Gibbs & Gerrig 1989; Gibbs 2002) postulates that access to the metaphorical meaning of a sentence does not succeed literal meaning but is rather accessed in conjunction provided that the context supports a metaphorical interpretation.

Results from behavioural experiments primarily support the direct access hypothesis, indicating that comprehension of literal and metaphorical sentences is equally easy (e.g., McElree & Nordlie 1999; Hoffman & Kemper 1987; see Glucksberg 2003 for an overview). Specifically, increased reaction times for metaphorical sentences relative to anomalous sentences is interpreted as literal and non-literal meanings being accessed together (Glucksberg, Gildea & Bookin 1982; Faust & Weisper 2000). In Glucksberg, Gildea & Bookin's (1982) study participants were significantly slower to respond to metaphorical sentences when asked to make literal truth judgements. This suggests that the metaphorical interpretation was instantly available and difficult to ignore.

Although many studies have found increased N400 amplitudes to metaphorical sentences relative to literal sentences (e.g., Pynte, Besson, Robichon & Poli, 1996) it does not necessarily support the hierarchical model (i.e., that metaphorical interpretation is accessed after literal access). In fact, a hierarchical or serial processing account would

additionally elicit the P600 component indicative of reanalysis (De Grauwe, Swain, Holcomb, Ditman, & Kuperberg, 2010). However, if the metaphorical interpretation is accessed in conjunction with the literal meaning, and is equally easily to interpret, why then do studies continue to observe greater N400 amplitudes?

One factor famously known to influence the amplitude of the N400 component is plausibility and cloze probability (see methods chapter for full review). Coulson, & van Petten (2007) investigated the effects of cloze probability on literal v metaphorical processing and found that although low cloze literals elicited increased N400 amplitudes relative to high-cloze literals, they also elicited reduced amplitudes to metaphorical sentences. This suggests that metaphors are more difficult to process semantically than low cloze literals. However, although the authors obtained cloze probability ratings using a sentence completion task, further norming to ascertain ratings for probability and figurativeness (to name a few) were not conducted. Furthermore, although target words were rotated so that they appeared in both literal and metaphorical conditions, sentences leading up to final words were not rotated (e.g., literal - *They ended the year with a huge party that everyone remembered as the orgy*; metaphorical - *Unfortunately, what started as mere flirtation with the stock market has become an orgy*). We, therefore, cannot be certain that any effects found in Coulson, & van Petten's study are attributable to the literal / metaphorical distinction alone. Differences in such things as plausibility may also be driving observed effects.

To the best of our knowledge, our studies represent the first attempt to equate literal and metaphorical sentences on their plausibility, cloze probability, and word frequency, as well as achieving both sentence and target word rotation. Literal sentences

were deliberately designed to be low in cloze probability so that these were equated with their metaphorical counterpart on plausibility ratings. As stated by Cardillo et al (2010), achieving equality between literal and metaphorical sentences may distort the metaphoricity of the sentence. Therefore, previous research has allowed for some qualitative differences between literal and metaphorical stimuli. It is somewhat unclear whether literal and metaphorical sentences are matched on complexity and structure (e.g., Coulson & Van Petten 2002, 2007; Iakimova et al. 2005; Laurent et al. 2006) and target words are not controlled for variables such as frequency, concreteness and imageability (e.g., Laurent et al. 2006; Tartter et al. 2002). Whilst preserving the metaphorical meanings, it is highly likely that such unconstrained factors lead to the different findings reported in the metaphor processing literature. We believe our sentence sets succeeded in being well-controlled, yet metaphorical sentences were also objectively rated as more 'figurative' than literal sentences.

In this context, our findings show that metaphor detection is consistently achievable during online semantic processing, yet in a direction – metaphors yielding reduced N400s compared with literal sentences – that is contra previous literature. Moreover, the L1 is not reliably the language in which metaphor is detected during the N400 window; rather, we showed that online semantic metaphor detection rather depended on language context, which I discuss next.

Properties belonging to the Welsh language may facilitate metaphor processing

In two experiments, we found that metaphor is apparently easier to process than literal language when presented in Welsh (as indexed by reduced N400 to metaphor). In experiment 1b, we proposed two possible explanations: First, we speculated that participants were susceptible to 'semantic illusion' – being temporarily unaware of the unorthodox overall meaning of the sentence. We hypothesised that a reduced N400 to metaphor in the native language indexed the ease of retrieval of target word meaning from long term memory, but an increased P600 indicated greater difficulty integrating said meaning into the larger sentence context (Rataj et al 2018; Brouwer, Fitz, & Hoeks, 2012; Hoeks et al, 2004). Given that this pattern is evident in both native and second language Welsh participants, the native-ness or proficiency status of the language may then be irrelevant, rendering this explanation erroneous. However, the common denominator across these experiments is the language context: the effect happened in Welsh context sentences but not in English context sentences. The effects may therefore be attributable to certain characteristics belonging to the Welsh language that makes metaphor easier to process. Although highly speculative, this explanation warrants post-hoc investigation.

One interesting feature of Welsh is that it diverges into two distinct languages: Literary Welsh and Colloquial Welsh (Fife, 1986). Literary Welsh derives from historical Welsh, is commonly encountered in poetic form, and will comprise of various stylistic devices including metaphor, rhyme, cynghanedd (repetition and / or internal rhymes that follow distinct stress patterns; Greene, 2012; Vaughan-Evans et al, 2016), personalisation (attributing human characteristics to objects) among others (see table 1 for examples). Metaphors are, therefore, very prevalent in literary Welsh. Jones (2016) explains how the

mind of a Welsh litterateur when constructing metaphor today, is the same as the mind of a litterateur two centuries ago. Furthermore, Rowlands (2015) suggests that metaphors are so prevalent in Welsh literature that metaphorical interpretations for some words (e.g., *rain* and *night*) will be as apparent as their literal interpretations.

Children receiving Welsh medium education are taught to read literature by focusing on the devices outlined in table 9 (Rowlands, 2015) and accessing meaning when approaching new text should be approached with the same methods (Jones 2016). In fact, the identification of metaphorical styles is believed to be key to comprehending the overall meaning of text (Rowlands, 2015). For example, the poetry element of the Welsh Literature GCSE subject consists of 10 compulsory poems (WJEC/CBAC, 2020. WJEC GCSE in Welsh Literature). These poems are meticulously studied, discussed and analysed for themes and poetic devices before being contrasted with novel non-compulsory poems, which are also discussed and examined for literary devices. Moreover, during further education and A-level Welsh, students are introduced to a further 12 poems and are again expected to consider and analyse themes, poetic devices, skills, and styles (WJEC/CBAC, 2020. WJEC GCE AS/A LEVEL in Welsh (first language)). Moreover, during final examinations, students are expected to recall and discuss these poems (GCSE = 1 compulsory poem; A Level = 3 compulsory poems) and again contrast with novel poems. Such emphasis on poetic devices is not placed upon these literary devices in English GCSE and A-level subjects however. The focus here is placed upon on text such as letters, articles, factsheets, blogs, leaflets, e-mails, and reports (WJEC/CBAC, 2020. WJEC GCSE English Language).

Additionally, in the case of less able and confident readers, these poetic devices are used as educational tools to facilitate comprehension (Rowlands, 2015). Indeed, research shows that even those who believe they would not be able to comprehend written Welsh literature (such as second language Welsh speakers), are in fact able to understand literary Welsh with ease (Trefor, 2014). The reason for this is that Welsh literature is more prominent in society than one might think and although completely unaware, readers are exposed to such language almost daily (within pieces in newspapers and online articles for example). Thus, formal Welsh literature may not be all that novel or challenging to proficient speakers, and even less so to dominant / everyday speakers.

Thus, in addition to being prevalent in Welsh medium education (compulsory until the age of 16), metaphors and literary Welsh are also frequently encountered outside of the literary context. In Welsh dictionaries for example, both literal and metaphorical interpretations are included; the term *llew*, meaning '*lion'*, is described as an animal, as a strong man, and finally, as temptation (Hawke, 2014). Figurative use of language is also commonplace in Welsh communities: The Eisteddfod for example (a Welsh national festival with various competitions) holds an annual week-long Welsh Literature Festival for both children and adults. However, there is very little empirical evidence to show how Welsh literature and its devices are processed within the Welsh population, nor how the emphasis on metaphor in Welsh compares with its usage in English.

One extant study has examined neurocognitive effects of poetry in Welsh sentence processing (Vaughan-Evans et al, 2016). Sentences were either consistent with the rhythmic and alliterative rules of cynghanedd, (e.g., *Y geiriau brwd ger y bryn*) or violated cynghanedd (e.g., *Y geiriau brwd ger y bont* - Consonantal violation; *Y geiriau*

brwd ger y border - Stress violation; *Y geiriau brwd ger y clawdd* - Double violation). Despite being native speakers of Welsh, participants had no prior knowledge of the traditional forms of cynghanedd. A comparison sample of non-Welsh speakers was also used. The unexperienced Welsh natives elicited enhanced P3b responses (indicative of target detection) to sentences that conformed with cynghanedd rules. These naive speakers of Welsh therefore, implicitly detected the poetic form of cynghanedd, suggesting that poetic devices and patterns are available prior to the consideration of literal meaning, and that poetry is processed implicitly and independent of meaning.

Seeing that (a) metaphorical utterances are common within Welsh literature and (b) each Welsh speaker is taught to use devices such as metaphors, we tentatively propose that participants' prior experience of Welsh metaphor facilitated comprehension. Both groups received Welsh medium education from an early age and although the second language speakers used English more frequently, they did report moderate use of Welsh (37%). Moreover, all participants lived in Wales and would therefore be exposed to the Welsh language daily, even if only on an unconscious level. Indeed, research shows that those who live in communities such as Gwynedd where over 30% of the population speak Welsh are twice as likely to use the language themselves; this number increases four times in communities where more than 60% speak the language (Jones, 2008)

Table 9. Examples of literary devices taken from literary pieces taught on the compulsory Welsh educational curriculum.

Device	*Example*	*Title & Author*
Personalisation	*Siopau'n agor llygaid* - The shops open eyes	Prifddinas Caerdydd yn dihuno, Mihangel Morgan
	Pan fydd y niwl yn gwisgo'r bryniau draw - When the mist wears the far hills	Y Sbectol Hud, Mererid Hopwood
Metaphor	*Mae popty'r Hydref wedi'u rhostio* - The Fall oven have roasted them	Walkers Wood, Myrddin ap Dafydd
	Treiddiodd dart trwy hedd y dwr - A dart penetrated the calm of the water	Glas y dorlan, Rhys Dafis
Cynghanedd	*Gwerth cynnydd yw gwarth cenedl* - The value of increase is the disgrace of a generation	Etifeddiaeth, Gerallt Lloyd Owen
	Cawsom wlad i'w chadw, darn o dir yn dyst - We recieved a country to keep, and a piece of land as a witness	Etifeddiaeth, Gerallt Lloyd Owen
Alliteration	*Hen, hen yw murmur llawer man* – old, old are the whispers of many places	Eifionydd, R. Williams Parry
	Dilynem ddartiau gwyn y gwylain aflonydd yn trywanu targed y creigiau - We followed the white darts of restless seagulls piercing the rocks target	Glas, Bryan Martin Davies
Adjective	*Y ferch lwyd* - The grey girl	Gail fu Farw, Nesta Wyn Jones
	Yr ugeinfed yw'r fwyaf barbaraidd ohonynt hwy i gyd - The twentieth is the most barbaric of them all	Y Coed, Gwenallt

We also consider that the nature of our bilingual samples may contributed to these findings. It is well discussed within the literature that bilingualism is a spectrum of knowledge and experiences (DeLuca, Rothman, Bialystock and Pliatsikas, 2019), along which, no two bilinguals are the same (De Bruin, 2019). Indeed, bilinguals vary considerably in the context of language use, education and attitude toward bilingualism

(Bak, 2016). Thus, although our self-report measures allowed us to gather some interesting information regarding our bilingual samples, the information we obtained is extremely superficial given the complexity of bilingualism (I discuss this issue further in chapter 6). Considering the explanation proposed above, specific information regarding the context of language use (Bak, 2016) would have been beneficial to determine the extent of exposure and use of Welsh and Welsh literature. For example, information regarding participants further and higher education (subject and language medium), along with participation in Welsh festivals (such as the Eisteddfod).

It is difficult to determine how linguistic differences between these participants would have impacted the data. However, when we look closer at the participant linguistic history, we find that the samples used across these experiments were not identical; especially when comparing L1 Welsh vs L1 English (see table 10), Moreover, although a pattern emerges in the L1 English speakers, a stronger effect in the L1 Welsh (reaching significance in experiment 1b) suggests that greater exposure, use, and knowledge may have facilitated comprehension. Indeed, a pattern emerges in all of our samples and the effect sizes suggest that there may be an effect that we fail to observe due to the low experimental power - likely resulting from insufficient sample sizes. Although the sample sizes used are very typical of a language ERP experiments, Button, Loannidis, Mokrysz, Nosek, Flint, Robinson and Munafo (2013) suggest that the typical sample sizes used in neuroscience are too low, resulting in genuine effects being missed. I return to this discussion in chapter 6.

Table 10. Participant age of acquisition, proficiency and use across experiments 1a, 1b, and 2.

	Age of acquisition		Proficiency		Use	
	Welsh	English	Welsh	English	Welsh	English
Experiment 1a	Birth	4.7	9.78	8.3	74%	26%
Experiment 1b	Birth	3.8	9.7	9.1	74%	26%
Experiment 2	2.6	Birth	7.9	9.6	37%	63%

We note again however, that this explanation is tentative, and an interesting test would be the investigation late (adult) speakers of Welsh. If metaphors are indeed more easily integrated than literal sentences low in cloze-probability as a result of the exposure and training in Welsh specific educational subjects, no such effects should occur in adult speakers who received no such instruction.

Conclusions

To summarise Part 1 of this thesis, we draw three main conclusions. First, detection of anomaly appears to proceed more efficiently in the L1 compared with the L2. However, detection of metaphor appears to be linked with language context rather than the bilingual's L1/L2 status. I will discuss these points in the General Discussion,

but to presage my argument, I suggest that sentence anomaly represents a language universal, whereas metaphoricity may be more dependent on language-specific factors.

Chapter 5

Part 2

Inter-sense mapping in bilinguals

Acknowledgements: Thank you to Yang Lee, Jen Lewendon and Laurie Mortimore for their assistance fitting the EEG cap. Furthermore, I would like to thank Manon Jones, Awel Vaughan-Evans and Guillaume Thierry for their valuable feedback and support in the creation of the experimental stimulus.

Chapter Overview

In chapters 3 and 4 we investigated whether highly fluent Welsh-English bilinguals show differences in *within*-language conceptual processing (*intra-sense mapping*). Our findings show evidence of earlier detection of semantic anomaly in the L1, though differences in detection of literal vs. figurative language are somewhat more subtle. In this chapter, we examined whether conceptual representations *between* languages (*inter-sense mapping*) are co-active. Specifically, whether representations that are unique to one language are simultaneously available to the unrelated language. To this end, we presented Welsh-English bilinguals and English monolinguals with English sentences, comprising a (translated) Welsh idiomatic sentence ('*She thought the woman was an old hat'*), a semantically anomalous sentence ('*He walked to the shop with the wind in his hat'*), or a semantically acceptable sentence ('*He was criticised by his friend for being a front hat'*). Although we found no between-groups differences on a behavioural level, ERP responses suggest that Welsh-English bilinguals accessed the semantic meaning of Welsh idioms with an ease comparable to that of acceptable sentences; indexed by reduced N400 and P600 amplitudes to Welsh idiom and acceptable sentences relative to anomalous sentences. In the English monolinguals however, we found that the Welsh idiom presented processing difficulty comparable to that of anomalous sentences; indexed by greater N400 and P600 amplitudes to Welsh idiom and anomalous sentences relative to acceptable sentences. These results indicate that our Welsh-English bilingual participants accessed language-specific meanings even in the incongruent language, suggesting that language co-activation occurs at the level of semantic access.

Much research endeavour has focused on whether bilinguals activate a single language or both languages in parallel during language comprehension (Kroll & De Groot, 2005; Thierry & Wu, 2004; 2007; Schwartz & Van Hell, 2012; Gollan, Froster & Frost 1997; Hoshino & Kroll, 2008; Starreveld, De Groot, Rossmark, & Van Hell, 2014; Schoonbaert, Duyck, Brysbaert, & Hartsuiker, 2009; Hartsuiker, Pickering, & Veltkamp, 2004; Vaughan-Evans, Kuipers, Thierry, Jones, 2014; Van Hell & Dijkstra, 2002; van Hell & de Groot, 2008; Dijkstra, van Jaarsveld, & Brinkle, 1998; Brysbaert, van Dyck, & van de Poel, 1999; Costa, Caramazza, & Sebastia´n-Galle´s, 2000; Costa, Miozzo, & Caramazza, 1999; de Groot, Delmaar, & Lupker, 2000; Dijkstra, Grainger, & van Heuven, 1999; Dijkstra, van Jaarsveld, & ten Brinke, 1998; Jared & Kroll, 2001; van Heuven, Dijkstra, & Grainger, 1998; Von Studnitz & Green, 2002). Current evidence suggests that bilinguals spontaneously translate from one language to the other, accessing both lexical (Thierry & Wu, 2007; 2012; Kroll & Sholl, 1992; Tzelgov & Eben-Ezra, 1992; Keatley et al., 1994; Beauvillain & Grainger, 1987; McClelland & Rumelhart, 1981) and syntactic (Vaughan-Evans et al., 2013; Hartsuiker, Pickering, & Veltkamp, 2004) information from both languages. What is currently less well known is whether they also access information in both languages at the semantic level. That is, whether activating senses that are unique to one language is possible via the other language. Here, we examined whether highly fluent bilinguals have direct access to unique L1 senses via the L2 (in which the information is objectively nonsensical to a monolingual speaker).

A common misconception is that words from one language can straightforwardly translate into other languages (Jakobson, 2000; Panou, 2013), when, in fact, languages range from having highly overlapping features, to partially-overlapping features; and in

some cases, completely independent features (i.e., the sense in one language has no equivalent in the other language). In the case of bilinguals, an additional complexity concerns the case of polysemy, in which semantic information may be shared among the bilinguals' two languages (RHM, Kroll and Stewart, 1994; BIA, Dijkstra, Van Heuven, & Grainger, 1998); BIA+, van Heuven, & Dijkstra, 2010), but with additional non-overlapping features (Jarvis and Pavlenko, 2008; Malt et al., 2015; Gathercole & Moawad, 2010). For example, whilst translation equivalents such as '*hat*' and '*het*' may overlap completely across languages (e.g., the English word '*hat'* and Welsh word '*het'* share the semantic representation of 'clothing'), '*het'* has multiple senses in Welsh, depending on the context (i.e., the additional semantic features of an 'idiotic woman'; Taylor, Devereux, & Tyler, 2011; Finkbeiner et al, 2004).

Under a language selective account, only word candidates belonging to the language of operation will become activated, but under the language non-selective view, candidates from both languages should become active in parallel. At the lexical and syntactic levels, there is now considerable evidence in support of the language non-selective view (Thierry & Wu, 2004, 2007; Wu & Thierry, 2012; Kroll and Sholl, 1992; Tzelgov & Eben-Ezra, 1992; Keatley et al., 1994; Beauvillain & Grainger, 1987; McClelland & Rumelhart, 1981;Vaughan-Evans et al., 2013; Kroll & De Groot, 2005; Schwartz & Van Hell, 2012; Gollan, Forster & Frost, 1997; Hoshino & Kroll, 2008; Starreveld, De Groot, Rossmark, & Van Hell, 2014; Schoonbaert, Duyck, Brysbaert, & Hartsuiker, 2009; Hartsuiker, Pickering, & Veltkamp, 2004; Vaughan-Evans, Kuipers, Thierry, & Jones, 2014; Van Hell & Dijkstra, 2002; van Hell & de Groot, 2008; Dijkstra, van Jaarsveld, & Brinkle, 1998; Brysbaert, van Dyck, & van de Poel, 1999; Costa,

Caramazza, & Sebastia´n-Galle´s, 2000; Costa, Miozzo, & Caramazza, 1999; de Groot, Delmaar, & Lupker, 2000; Dijkstra, Grainger, & van Heuven, 1999; Jared & Kroll, 2000; Von Studnitz & Green, 2002).

Moreover, there is some evidence that bilinguals' semantic access is non-selective. In two ERP experiments, Martin, Dering, Thomas & Thierry (2009) presented fluent Welsh-English bilinguals with word pairs, manipulated according to semantic relatedness and prime/ target language (English targets followed by Welsh primes or Welsh targets followed by English primes). Participants made word length decisions on the target word presented in the 'active' language whilst ignoring the prime presented in the 'non-active' language. Semantically related pairs elicited priming effects for both English and Welsh words as indexed by a reduced N400 to semantically related pairs, even when target-prime pairs were language-incongruent. The authors suggest that, even when told to ignore one language, bilinguals spontaneously access semantic representations in both of their languages.

Such findings are in broad agreement with the assumptions of the BIA and BIA+ models, in which orthographic representations from the L1 and L2 are co-activated (Dijkstra, Van Heuven, & Grainger, 1998; van Heuven, & Dijkstra, 2010), leading to parallel access of phonological and semantic level representations in a fully interactive system. Whilst models such as the BIA+ can straightforwardly account for translation-equivalents in the case of bilinguals, therefore, they currently provide less detail concerning bilinguals' semantic processing in the case of language-specific senses. In fact, bilingual semantic processing is a relatively understudied topic in the field (Dijkstra et a., 2019), and one of the few models which have attempted to outline the bilingual semantic system

is the Sense Model (Finkbeiner, Forster, Nicol & Nakamura, 2004). Under this account, the senses attached to lexical representations are polysemous, consisting of both language-specific and non-specific features. Multiple senses are more likely to be characteristic of the L1, whose semantic features exceed that of the non-native language due to superior proficiency and frequency of use (Finkbeiner et al, 2004).

However, unique senses are not restricted to individual words; they can also emerge from sentence-level information, such as is the case with idiomatic language, characterised by expressions in which a literal meaning is complemented by an additional figurative meaning. For example, the English expression '*in hot water'* can be interpreted as literal submersion, or as being in trouble (Beck & Weber, 2016). Current findings suggest that access to the literal vs. idiomatic meaning is determined by saliency, or frequency, with figurative meanings therefore being accessed directly when the idiom is familiar (Ortony et al., 1978; Swinney & Cutler, 1979; Cacciari & Tabossi, 1988), specifically when its meaning is salient in comparison to unfamiliar idioms and literal controls (Giora 1997; 2002; Cacciari & Tabossi, 1988; Conklin & Schmitt, 2008; Libben & Titone, 2008; Rommers, Dijkstra & Bastiaansen, 2013; Tabossi, Fanari & Wolf, 2009).

Idiomatic language – consider again '*in hot water'* – also tends to be language-specific, or at least language-biased, and the figurative phrase of this sentence is nonsensical in other languages. Thus, presenting an idiom in a different language would plausibly elicit a processing difficulty analogous to the difficulty shown when required to process an unfamiliar idiom (Carrol, Conklin & Gyllstad, 2016; Carrol & Conklin, 2016; Beck & Weber, 2016; Cieslicka & Heredia, 2017). The question then arises: Can a bilingual for whom an idiom is sensible in one language access its meaning in the other

language (in which it is ostensibly an un-idiomatic form)? To test this hypothesis, Carrol and Conklin (2016) presented Chinese speakers with Chinese idioms but in the L2 English, and used eye-tracking methods to index processing difficulty. Although recognition was slower than for literal text meaning, L1 idiomatic forms were recognizable even when encountered in L2, suggesting that online translation of the idioms into the L1 Chinese may have resulted in automatic activation of the idiomatic meaning.

Here, we examine whether bilinguals can access unique L1 idiomatic meanings via the L2, and further, whether access is direct (at the level of online semantic processing), or indirect (rather at the level of sentence reanalysis). To this end, we presented fluent, native Welsh-English bilinguals, and a control group of monolingual English speakers, with English sentences as we recorded ERP responses. Sentences were constructed so that their overall meaning (determined by a sentence-final target word) comprised a semantically acceptable literal meaning, a semantically anomalous meaning, and a Welsh idiomatic meaning. A ‘best’ sentence completion also allowed us to balance the experiment in terms of semantically acceptable and anomalous sentences. Participants judged whether the sentence-final (target) word of each sentence comprised the best possible semantic completion. According to English sentence semantics, anomalous and Welsh meanings should elicit a ‘no’ response, whilst acceptable and best completions should elicit a ‘yes’ response. Crucially, our use of a strict monolingual paradigm (sentences were only presented in English) meant that we incurred minimal cross-contamination from the ‘other’ language.

Direct access to the Welsh idiomatic meaning via the L2 (English) would be associated with reduced N400 to the 'Welsh idiom' sentences in the bilingual but not in the monolingual group. More indirect access to the Welsh idiom would incur a similar effect but during reanalysis (reduced P600 effect in the bilinguals but not the monolinguals). For English monolinguals participants, Welsh idiomatic sentences should be anomalous, incurring equivalent N400 and P600 amplitude responses to the anomalous sentences. Based on the findings of Carrol and Conklin (2016) we might also expect the Welsh-English bilinguals' behavioural responses to be slower in response to the Welsh idiom than to semantically acceptable and semantically anomalous sentences. Moreover, if bilinguals retrieve the Welsh idiomatic meaning, we expect that they will be more error prone in judging idiomatic sentences compared with monolinguals.

Method

Participants

Bilingual group: *N* = 21 native Welsh-English bilinguals (4 males, 17 females *M* ages = 22, *SD* = 4.3) were included in the final analysis (one other participant was excluded due to low quality data). Completion of a Language History Questionnaire (see appendix A), assessing L1 and L2 proficiency and experience, attested to participants' acquisition of Welsh from birth and English at an early age (*M* = 3.3, *SD* = 2.37). Participants also reported more daily use of Welsh than English (*M* = 68%, *SD* = 20.98; *M* = 32%, *SD* = 20.98), and self-ratings of reading, writing, speaking and comprehension on a scale of 1 (not very literate) to 10 (very literate) were high for both Welsh and English *(M* = 9.54,

SD = 0.27; *M* = 9.25, *SD* = 0.14). The Multigroup Ethnic Identity Measure (MEIM; Phinney, 1992; Roberts, Phinney, Masse, Chen, Roberts & Romero, 1999; see appendix B), which measures cultural belonging on a scale of 1 (indifferent) to 4 (strong sense of belonging) revealed strong cultural identity with Wales (*M* = 3.33, *SE* = 0.26).

Monolingual group: Monolingual English speakers were also recruited (*N* = 19, males = 7, females = 12, *M* age = 21, *SD* = 4.9) who had no prior learning of the Welsh language and had not lived in Wales for a period exceeding three years to eliminate exposure effects. Ethical approval was obtained from the Bangor University ethics committee. Participants provided informed consent and were compensated for their participation.

Stimuli

A total of 59 English sentence sets were constructed. Each set comprised four sentences including a translation of a Welsh idiomatic expression, a semantically acceptable condition, a semantically anomalous condition and a semantically 'best' completion (filler sentences, which were included to create equality between sense and anomaly). Sentences were identical up to the point of the target word. Target words were rotated across sets among the Welsh, acceptable and anomalous sentences such that the ending for Welsh idiom sentences would also appear for acceptable and anomalous sentences. The best completion sentences were also identical but did not include rotated target words. Target words for these sentences were selected based upon the results of the

cloze probability study from which the third most common ending was selected (see Table 11 a sentence set example; Table 12 for a target word rotation example). Rotation was meticulously conducted on a sentence rather than item level to maximise the acceptability and anomalous meanings of each sentence.

Table 11. Experimental design and example of a sentence set.

Condition	*Sentence*	*Target Word*
Welsh	She came out of the store smiling like a	gate
Acceptable	She came out of the store smiling like a	goblin
Anomalous	She came out of the store smiling like a	sandwich
Best (filler)	She came out of the store smiling like a	cat

Table 12. Example of Target word rotation.

Condition	*Sentence*	*Target Word*
Welsh	She came out of the store smiling like a	gate
Acceptable	The car thieves managed to pass the	gate
Anomalous	He was told off by his father for being a	gate

Norming

N = 14 native Welsh-English bilinguals, who did not subsequently participate in the experiment, were asked to judge whether or not Welsh sentences in a list of 91 expressions were idiomatic in Welsh. Sentences that were judged idiomatic by over 65% of the bilinguals were included in the final set. Although all sentences were Welsh idioms (created by three Welsh native speakers) we found that familiarity ranged from one area of Wales to another. In an attempt to create a stimulus set, in which the recommended number of trials required in a sentence reading N400 experiment (30-50; Luck, 2014) is familiar to each participant we included 59 sentence sets (i.e. each participant is familiar with at least 30-50 of the idioms). Any effect of presenting a few unfamiliar idioms would therefore, be minimised during the averaging process.

These sentences were subsequently presented to monolingual English speakers (N = 15) along with semantically acceptable and semantically anomalous sentences, who scored the semantic acceptability of each sentence on a scale of -2 (unacceptable) to +2 (acceptable). Results revealed that the best condition was rated as the most semantically acceptable (*M* = 1.57, *SE* = .06) followed by the semantically acceptable condition (*M* = .52, *SE* = .13), Welsh idiom condition (*M* = -.53, *SE* = .11), and finally the semantically anomalous condition (*M* = -1.14, *SE* = .0.94). We consider the rating of idiomatic expressions as more acceptable than anomalous to be acceptable, as it is likely that making inferences about the meaning of these sentences is easier than for more salient anomalous sentences. We should thus see a similar pattern in the monolingual participants' ERP responses; although, to a lesser extent. Results from cloze probability

ratings, also from this group allowed us to remove sentences with a rating of > 40% from the final stimulus list, and to create filler sentences for our Best condition. Moreover, sentences that were rated as acceptable and high in cloze probability by the English native speakers were removed to reduce contamination effects from English and/or universal idioms. The outcome of these norming studies resulted in a final total of 236 sentences (59 items).

Procedure

Participants first completed 6 practice trials, followed by the experiment, which comprised 6 experimental blocks: 4 blocks of 39 trials and 2 blocks of 40 trials. Sentences were pseudorandomised such that only one sentence from each set occurred in each block.

In a single trial, the sentence was presented visually, in silver font on a black background. The first half of the sentence was presented as continuous text, involving self-paced reading, and the rest was then presented word by word (presentation time: 500ms; ISI: 250ms). Upon presentation of a fixation cross, participants were asked to respond to the question: 'Was this the best completion of the sentence?' Yes and No responses were made using the F and J keys, which were counterbalanced across participants. Correct responses were coded according to their English interpretation. As such 'No' responses to Welsh idioms and anomalous sentences were coded as correct, whilst 'Yes' responses to acceptable and filler 'best' sentences were coded as correct.

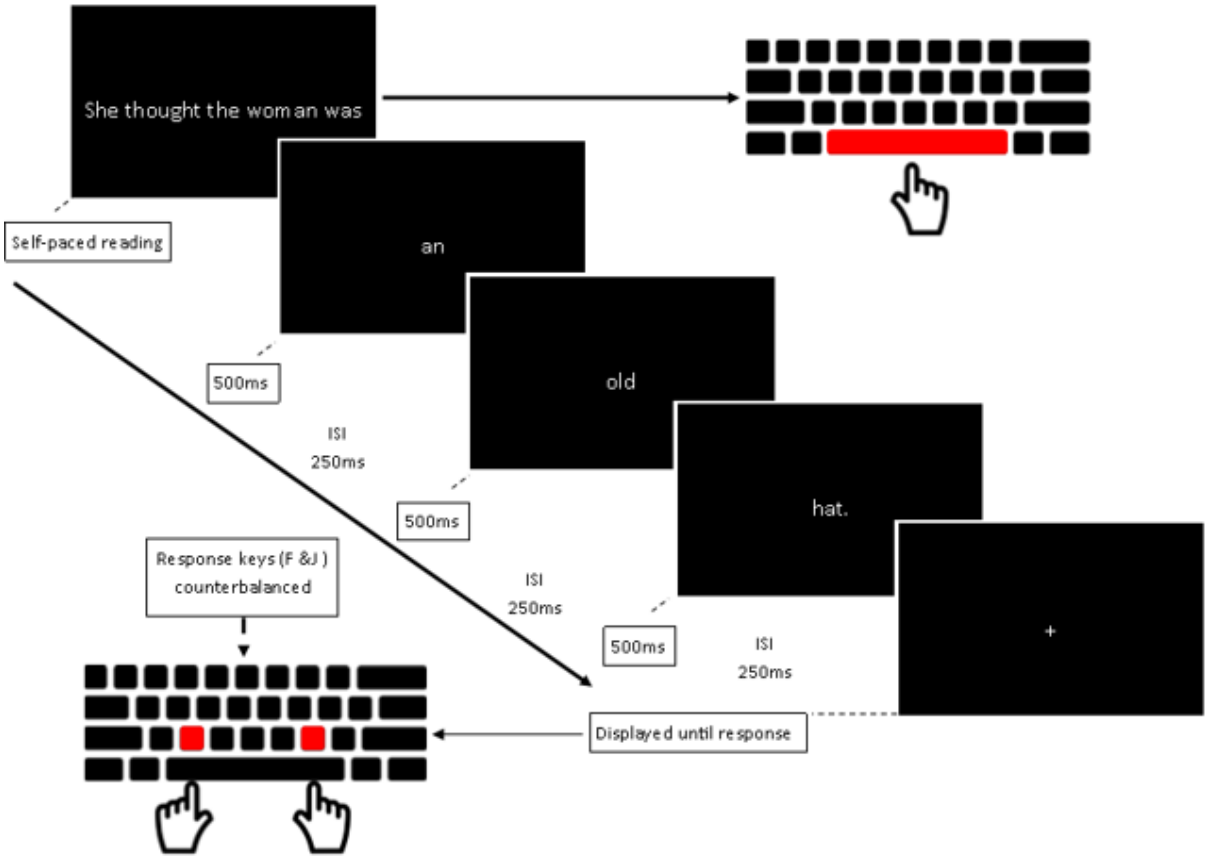


Figure 18. Schematic of the experimental procedure.

Electrophysiological Recording

Electrophysiological activity was recorded from 64 electrodes placed upon the scalp at a rate of 1 kHz, referenced to the CZ electrode. Filtering occurred both online using a band-pass filter between 0.1 and 200 Hz, and offline using a low-pass zero-shift filter cut off at 20 Hz. Eye artefacts were mathematically modelled and corrected. Remaining artefacts were removed manually using NeuroScan 4.4 software. Epochs ranging from -200 to 1000ms post target word presentation were extracted with a

minimum of 30 epochs per condition for each participant. Activities exceeding +_75Uv were automatically discarded. A baseline correction procedure was conducted.

Results

Behavioural Results

Accuracy data and reaction times were modelled as a function of one between-groups factor: Group (Bilingual, Monolingual), and one within-subjects factor: Condition (Welsh, Acceptable, and Anomalous). Both factors were centred for the analyses to minimise collinearity. Accuracy data was submitted to a generalized mixed-effects model (*glmer* function in lme4 package; Bates, Mächler, Bolker, & Walker, 2014), in which we modelled the maximal random effect including sentence (by group) and subject (by condition) intercepts and slopes until the model converged (Barr, Levy, Scheepers, & Tily, 2013). Recall that accuracy to the question 'Was this the best completion of the sentence?' was coded according to English sentence meaning (i.e., a 'no' response to anomalous & Welsh idiom conditions was coded as correct, whilst a 'yes' response to acceptable and best conditions was coded as correct). Reaction time data was log transformed to achieve a normal distribution and submitted to a linear mixed effects model (LMER function in lme4), again with maximal random effects including sentence (by group) and subject (by condition) intercepts and slopes until the model converged. Only correct trials were analysed in the RT analysis.

Accuracy analysis revealed a significant fixed effect of condition in which participants were more accurate in detecting anomalous sentences (b = 2.53, SE = 0.31, z = 8.15, p <.001) compared to Welsh idioms (b = 1.99, SE = 0.33, z = 6.03), and less accurate in detecting acceptable sentence (b = -2.76, SE = 0.37, z = -7.47, p <.001) compared to Welsh idioms. No fixed effect of Group (b = 0.91, SE = 0.6, z = 1.51, p = 0.13) or significant group*condition interaction emerged (BilingualWelsh*MonolingualAcceptable b = -0.3, SE = 0.63, z = -0.49, p = 0.62; BilingualWelsh*MonolingualAnomalous b = -0.18, SE = 0.49, z = -0.37, p = 0.72).

Analysis of participant reaction times revealed a significant fixed effect of condition in which responses were faster to anomalous sentences (b = -0.04, SE = 0.01, df = 101.19, t = -3.68, p = .01) than to Welsh idioms (b = 6.13, SE = 0.03, df = 47.53, t = 216.11), and slower to acceptable sentences (b = 0.07, SE = 0.02, df = 79.41, t = 3.39, p = .01) than Welsh sentences. No fixed effect of group (b = -0.00, SE = 0.05, df = 40.4, t = -0.1, p = 0.91) or significant group*condition interaction emerged (BilingualWelsh*MonolingualAcceptable b = 0.01, SE = 0.03, df = 32.08, t = 0.37, p = 0.71; BilingualWelsh*MonolingualAnomalous b = -0.01, SE = 0.01, df =36.41, t = 0.46, p = 0.64).

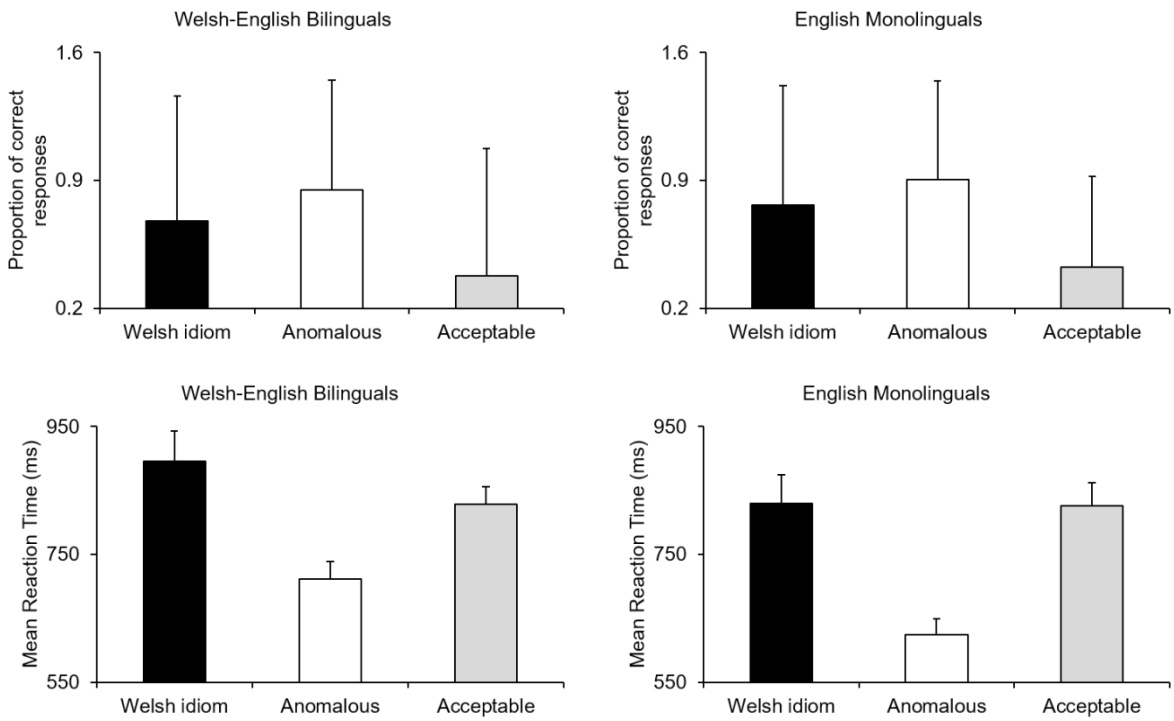


Figure 19. Mean accuracy (proportion of correct responses) and reaction times (ms) to Welsh idiomatic expressions, acceptable and anomalous sentences for the Welsh-English bilinguals and English monolinguals. Error bars represent the standard errors.

ERP results

2 x 3 repeated measures ANOVA with group (Welsh English bilingual, English monolingual) as the between-subjects variable and condition (anomalous, acceptable, welsh idiom) as the within-subjects variable.

N400. In the 300-500 (N400) time window, we found a significant main effect of condition (F (2, 37) = 5.16, p = .008, ηp2 = .2) over 6 fronto-central, central and centro-

parietal electrode sites (FC1 FC2 FCZ C1 C2 CZ CP1 CP2 CPZ). Bonferroni post hoc comparisons revealed that anomalous sentences (*M* = .09 *SE* = .3) were more negative than acceptable sentences (*M* = .5, *SE* = .28) and Welsh idiomatic sentences (*M* = .4, *SE* = 31).

A trend approaching an interaction between condition and group (*F (2, 37)* = 2.48, *p* = .09, ηp2 = .13) was also found. For the Welsh-English bilinguals, acceptable sentences (*M* = .57, *SE* = .38) and Welsh idiomatic expressions (*M* = .43, *SE* = .43) yielded comparable amplitudes with anomalous sentences yielding greater negativity (*M* = -1.21, *SE* = .42). In the English monolinguals however, amplitudes were comparable between acceptable sentences (*M* = .43, *SE* = .4), Welsh idiomatic expressions (*M* = .37, *SE* = .46), and anomalous sentences (*M* = .3, *SE* = .47).

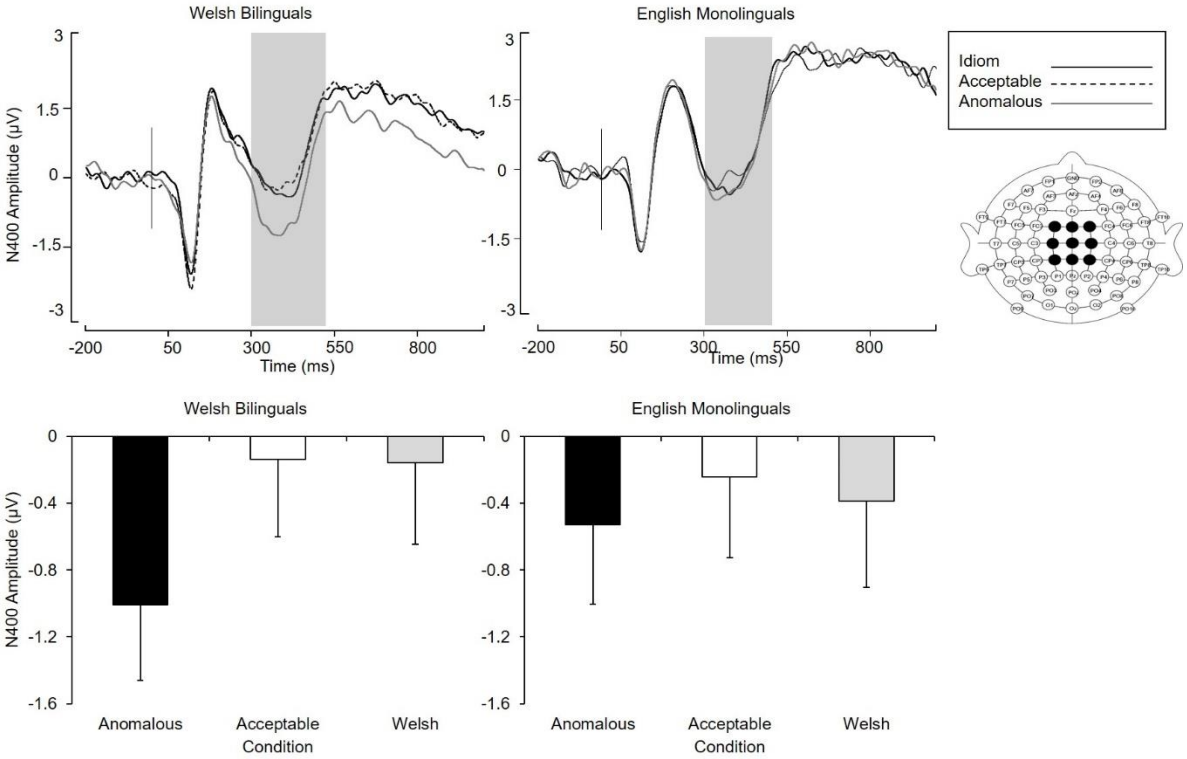


Figure 20. Mean amplitude (µV) of the N400 effect for Welsh idiom, acceptable, and anomalous sentences for the Welsh-English bilinguals and the English monolinguals. Error bars represent the standard errors.

P600. In the 500 - 700 time window (P600) we found a significant main effect of condition (F (1, 38) = 7.06, p < .001, ηp2 = .43) over 6 central-parietal electrode sites (CP1 CPZ CP2 P1 PZ P2). A Bonferroni post-hoc comparison revealed that anomalous sentences (M = 4.15, SE = .30) yielded the largest P600 amplitudes followed by Welsh idiomatic expressions (M = 3.71, SE = .33) and acceptable sentence (M = 3.47, SE = .31).

A condition*group interaction was not found (F (1, 38) = 1.90, p = .133, ηp2 = 1.3)

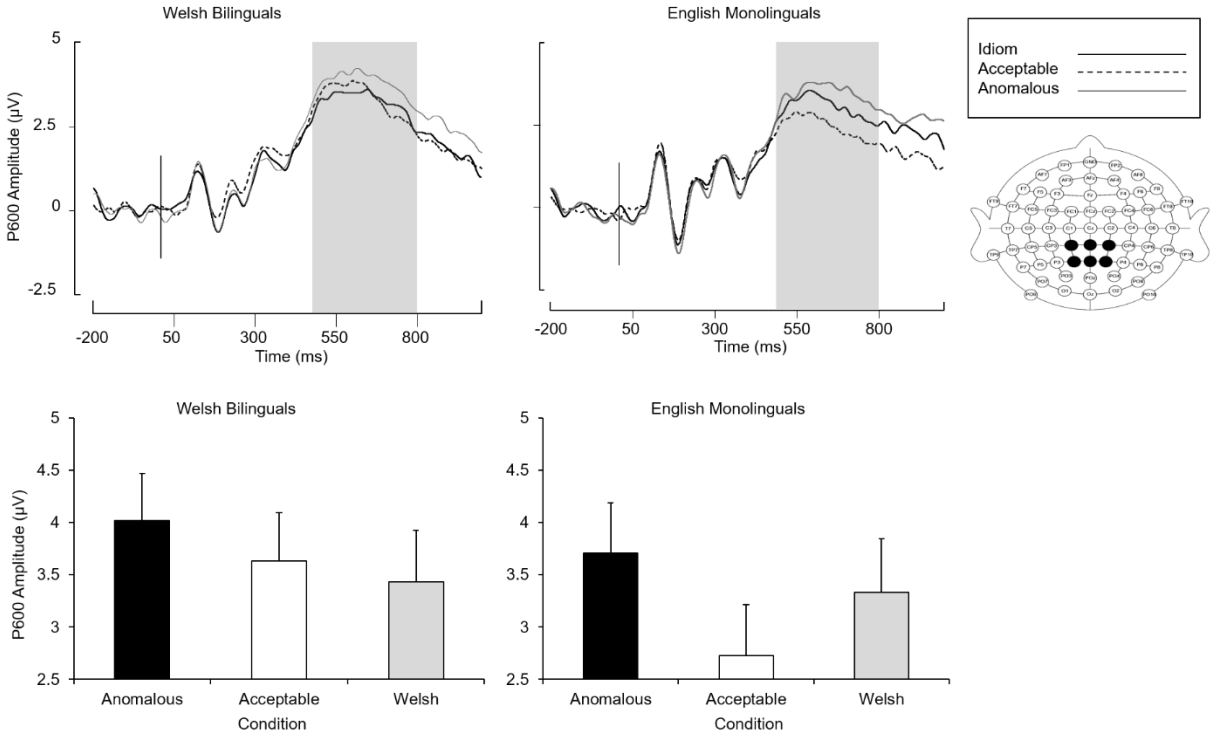


Figure 21. Mean amplitude (µV) of the P600 effect for anomalous sentences, acceptable sentences and Welsh idiomatic expressions for the Welsh bilinguals and English monolinguals. Error bars represent the standard errors.

Discussion

Here, we tested whether Welsh-English bilinguals spontaneously activate Welsh-specific senses in a purely English monolingual reading task. We measured behavioural and ERP responses in Welsh-English bilinguals and English monolinguals as they read sentences manipulated to be acceptable, anomalous, or a Welsh idiom (anomalous in English). Although, behavioural data showed no differences between groups, we found that overall participants were faster and more accurate in response to anomalous sentences followed by Welsh idioms and acceptable sentences. Trends in the ERP data suggested that Welsh-English bilinguals' processing of Welsh idiomatic sentences and sensible sentences were comparable in both the N400 and P600 time windows. Whilst for English monolinguals Welsh idioms were processed more similarly to anomalous sentences. Our findings tentatively suggest that the semantic representation of the idiom was directly available even in the idiom-incongruent language.

Our behavioural results on the other hand showed no differences between monolingual and bilingual processing. Such inconsistencies in behavioural and N400 outcomes is compatible with previous findings and reflects that the N400 component – indexing a semantic search mechanism – is quite distinct from behavioural responses (Kutas & Federmeier, 2011). Here, whilst bilinguals appeared to conduct implicit co-

activation of the idiomatic meaning (cf. no indication at the neural level that 'Welsh' idiomatic sentences were deemed unacceptable), they judged the acceptability of the sentence final word as quickly and accurately as the monolinguals; denoting that 'Welsh' idiomatic sentences were, indeed, unacceptable. We suggest that for the bilingual group, anomalous sentences were distinct due to availability of online access to meaning for all other sentences. When explicitly asked to judge each sentence, however, the bilinguals suppressed the Welsh specific meaning and responded according to the English interpretation. In contrast to the bilinguals, the monolingual English participants did not appear to distinguish between sentence types in terms of online semantic processing effort (N400 effect) even though they show clear sensitivity behaviourally. We suggest that the inclusion of 'best' completion sentences may have altered their processing of 'acceptable' and 'anomalous' sentences, creating less of a distinction (online) between the two than would have been the case had 'best' sentences been excluded. Best sentences may not have been as prominent for the bilingual group due to the process of prediction during reading being less efficient in the L2 (Martin et al 2013). A future version of this study would exclude 'best' sentence completions from the experiment.

In mechanistic terms, our data provides some tentative evidence that L2 lexico-semantic links extend to unique L1 senses. That is, in the English sentence: *she thought the old woman was a hat, hat* may result in spreading activation of all senses of *hat* and its translation equivalent, '*het*', resulting in direct access to the Welsh-specific idiom. Our results are therefore consistent with previous indications that bilinguals can access semantics via both languages interchangeably (Martin et al., 2013), and support the central assumption of models of visual word recognition such as the BIA and BIA+

models (Dijkstra, Van Heuven, & Grainger, 1998; van Heuven, & Dijkstra, 2010), which postulate a fully interactive, co-active system. In fact, the current findings may hint at even greater interactivity than has been previously specified in the extant models: Languages can apparently access even incongruent lexico-semantic meanings with very little semantic processing cost. Our findings –following confirmatory replication – will therefore be useful in informing future implementations of bilingual word recognition models (cf. Dijkstra et al., 2019), and suggest that models such as the Sense model (Finkbeiner et al., 2004) should be adapted to include links between language-unique senses and the incongruent language.

We note that some of these conclusions are based upon near significant results. It is debated if a significant (or indeed non-significant) result in neuroscience actually reflects true effect (Button, Loannidis, Mokrysz, Nosek, Flint, Robinson, & Munafo, 2013). This problem is the result of low statistical power due to factors such small sample sizes. We suggest that the sample sizes recruited for the current studies were not sufficient to observe the true effect. I return to this discussion in Chapter 6.

Conclusions

To summarise, our current findings suggest that the level of co-activation and interactivity in bilingual's language system is even more extensive than previously supposed. Our data lends tentative support to the notion that semantic representations are available online, even in a language with incongruent lexico-semantic links.

Chapter 6

General Discussion

6.0. Chapter Overview

The primary goal of this thesis was to investigate the functional structure of the bilingual semantic system(s). My aims were two-fold:

1. In Part 1 I investigated conceptual mapping within the L1 and L2 (*intra*-sense mapping) and whether stronger lexico-semantic links in the L1 (as specified in bilingual comprehension models) lead to less processing effort in the L1 to access meaning.
2. Part 2 investigated conceptual mapping across the L1 and L2 (*inter*-sense mapping) and whether implicit co-activation of language occurs at the conceptual level.

In this chapter, I review the findings of four empirical studies which sought to address these aims. I will discuss the implications of these findings in the context of current research on bilingualism and propose directions for future research.

6.1 Part 1: Intra-Sense mapping in the L1 and L2

To test the hypothesis that L1 lexico-semantic processing incurs less effort, we examined L1 vs. L2 sentence processing using manipulations of (a) sense violation (Experiment 1a) and (b) figurativeness (Experiments 1b & 2), compared with baseline literal sentence processing. Thus, (a) allowed an examination of L1 vs. L2 semantic processing in the highly explicit context of anomaly, whereas (b) enabled an examination of L1 vs. L2 semantic processing in the more subtle context of indirect access to meaning (whilst keeping sense preserved). Recall that in all three experiments, we examined

bilinguals' access to sentence meaning online (~ 400 ms post target word onset) using event related potentials (ERPs).

6.1.1 Online semantic processing of sentence anomaly in L1 and L2

We predicted that bilinguals would more easily detect sentence anomaly in L1, indexed by reduced N400 amplitudes to sensible sentences in the L1 vs. L2. In Experiment 1a, highly proficient Welsh-English bilinguals read sentences ending in target words that rendered the overall sentence meaning as either sensible (literal / sensible - *The strange accident left a wound*; metaphorical / sensible – *The strange statement left a wound*) or anomalous (literal / anomalous - *The strange accident left a hunger*; metaphorical / anomalous – *The strange statement left a hunger*). These bilinguals differentiated sensible and anomalous sentences at the level of online semantic processing, manifest in a more negative N400 for anomalous over sensible sentences in the L1 Welsh. Interestingly (and contra our predictions), these bilinguals also showed reduced N400 and an increased P600 to English sentences overall, suggesting more superficial processing at the online semantic stage and greater differentiation later downstream. Crucially, however, bilinguals' increased L1 sensitivity to sentence meaning at an earlier time point did not translate into superior L1 behavioural performance (accuracy and RT). I now elaborate on these findings below.

When reading or listening to language, we generate predictions about upcoming words, allowing for ease of sematic integration; the more predictable a word, the faster it will be processed (Foucart, Martin, Moreno & Costa, 2014; Pickering & Garrod, 2007;

Wicha, Morena & Kutas, 2004; DeLong et al , 2005; Neely, 1977; Morton & Long, 1976; Levy, 2008). Research suggests, however, that this predictive process may not operate comparably across languages (Martin et al 2013). In addition, language comprehension models specify that more frequent exposure to certain linguistic strings will lead to greater activation of such strings ('transitional probability'; Elman, 1990), which is presumed to be modulated by linguistic knowledge and exposure (Dell & Chang, 2014). Applied to bilingualism, less exposure to L2 would result in more effortful and slower activation (Francis, Arteaga, Liano, & Taylor, 2020; Whitford & Titone, 2017; Diependaele, Lemhofer, & Brysbaert, 2012; Duyck, Vanderelst, Desmet & Hartsuiker, 2008), which concurs with findings of more effortful conceptual integration in L2 sentence processing (Hahne, 2001; Hahne & Friederici, 2001), and delayed recognition of violations (Moreno & Kutas, 2005; Moreno, Rodriguez-Fornells, & Laine, 2008; Ardal, Donald, Meuter, & Muldrew, 1990; Kutas & Kluender, 1994; Weber-Fox & Neville, 1996). Weaker lexico-semantic links in L2 also feature in models of bilingualism (Kroll & Stewart, 1994; Dijkstra and Van Heuven, 2002; Finkbeiner et al, 2004).

Whilst we found greater differentiation of meaning in L1 sentences at the level of online semantic processing, L2 sentences incurred reduced N400 modulation overall. Whilst this is initially surprising, it is perhaps rather less so considered in the context of language as less familiar or superficially ambiguous, and may therefore be delayed, or approached with a 'good enough' processing strategy' (Ferreira et al, 2002; Barton & Sanford, 1993; Christianson, 2016). As such, our bilinguals incurred smaller N400 responses, but greater P600 amplitudes (though interestingly, still not differentiating sensible vs. anomalous sentence meaning at this stage). These findings may therefore be

consistent with bilingual theorizing, in which the L2 has weaker lexico-semantic links (Kroll & Stewart, 1994), incurs a temporal delay (Dijstra & Van Heuven, 2002; Grainger & Dijkstra, 1992, Dijkstra & Van Heuven, 1998), has access to reduced number of semantic representations (Finkbeiner, Forster, Nicol & Nakamura, 2004), and accesses conceptual representations via a different route to the L1 (de Groot, 1992). These implications are striking in the face of the very high proficiency level of these bilinguals. Crucially, whilst access is believed to improve with increased proficiency, it is assumed that an asymmetry will persist due to superior experience in the L1 (Kroll & Stewart, 1994; Finkbeiner, Forster, Nicol & Nakamura, 2004), which is attested in our study, given the very high L2 proficiency of our bilingual group.

Indeed, when we consider the behavioural results from Experiment 1a, it is apparent that whilst L1 and L2 result in different early analysis during sentence processing, the initial sensitivity to meaning in L1 does not necessarily result in a behavioural advantage in explicit semantic judgement. In fact, our bilinguals showed greater behavioural accuracy and faster reaction times in their second language compared to the native language. Our findings suggest that L1 may enable earlier detection of sense, but high proficiency in the L2 allows bilinguals to rapidly ‘catch up’ downstream, enabling comparable if not higher performance at the behavioural level.

This discrepancy between the online (ERP) and offline (behavioural) measures is not surprising given that the N400 is well known to be quite distinct from behavioural responses (Kutas & Federmeier, 2011). Individual ERP components only reflect a small subset of the overall processing that contribute to later behavioural responses, thus the dissociations found here are not necessarily surprising. In fact, these findings largely

concur with previous accounts that suggest reaction times are longer in response to metaphorical language due to the availability of multiple competing interpretations (Glucksberg, Gildea & Bookin 1982; Faust & Weisper 2000). Similarly, I propose that the L1 delay found in experiment 1a may have been attributable to the availability of multiple interpretations, or at least activation of multiple senses, in the L1 relative to the L2. If the L1 benefits from less effortful conceptual mapping and access to greater representations, it is then reasonable to assume that the L1 is better able to construct several meanings. In the L2 on the other hand, more effortful conceptual mapping and reduced availability of representations will result in the construction of limited interpretations. The L2 therefore, will not be required to discriminate between multiple representations manifesting in an L2 reaction time advantage.

6.1.2 Mapping multiple conceptual representations in the L1 and L2

We predicted that bilinguals would be able to accomplish multiple sense mapping more quickly and easily in the L1, enabling greater sensitivity to figurativeness. We further predicted that this effect would manifest in a smaller N400 difference between literal and metaphorical sentences in the L1 compared to the L2. To test these hypotheses in Experiments 1a, 1b and 2, highly proficient Welsh-English bilinguals read sentences in which the final (target) word rendered the sentence meaning as either literal (*The strange accident left a wound*) or figurative (*The strange statement left a wound*; recall that in Experiment 1a, this manipulation was orthogonal with sentence anomaly; in the two other experiments, anomaly was dropped). Experiment 1a yielded no effect of figurativeness

(likely owing to potentially overwhelming effect of sentence anomaly, rendering sensitivity to the more subtle figurativeness manipulation less detectable). In experiment 1b, we therefore removed the anomaly manipulation sentences to examine the effect of figurativeness only. Whilst bilinguals distinguished literal and metaphorical sentences at the online semantic level in the L1, surprisingly, metaphor was found to be easier to process than literal language. No such differentiation was evidenced in the L2. In Experiment 2, we recruited native English-Welsh bilinguals, to examine whether we would find the reverse language pattern (greater differentiation in L1 English, and no differentiation in L2 Welsh), which would implicate L1 status as responsible for the Experiment 1b effects. Surprisingly, our findings in fact replicated Experiment 1b, in which Welsh (despite being the L2 in this context), incurred greater sensitivity to figurativeness and in the same direction as Experiment 1b, in which metaphor yielded reduced mean N400 amplitudes compared with literal sentences. We concluded that some languages (e.g., Welsh) may have statistical properties, such as higher natural occurrences of metaphor in Welsh medium education (WJEC/CBAC, 2020. WJEC GCSE in Welsh Literature; WJEC/CBAC, 2020. WJEC GCE AS/A LEVEL in Welsh (first language); WJEC/CBAC, 2020. WJEC GCSE English Language), that render detection of metaphor more readily available than low cloze-probability literal meaning in that language (Jones, 2016; Rowldands, 2015; Trefor, 2014; Pyrs, 2014; see appendix G for an illustration of this effect over our three experiments). Our norming study (see Chapter 2) is consistent with this interpretation, given that literal sentences tended to be rated as more figurative than the same sentences presented in English.

6.1.3 Interim conclusions on bilingual intra-sense mapping

In Experiment 1a, we found that **detection of anomaly occurs at an earlier, online semantic stage in L1**. In Experiments 1b and 2, we found that **access to metaphor processing can be direct (regardless of native-ness)**. This conclusion is based on bilinguals' comparable N400 processing in the online semantic stage for metaphor compared with literal sentences, and consistent with the logic shown in previous studies, wherein comparable N400 amplitudes for literal and metaphorical meaning is assumed to denote comparable (direct) semantic access (cf. Gibbs, 1994, 2002). However, our findings can also perhaps be used to critique this logic: As shown in Experiment 1a, sensitivity to figurativeness can be susceptible to the conditions of the experiment (in this case, the presence of sentence anomaly, rendering no effect of metaphoricity), and also the language context (Experiments 1b and 2). Thus, the perils of deriving conclusions from a null finding (no difference in N400 modulation between literal and metaphorical processing) are highlighted. Our findings also suggest that **access to metaphor may be influenced by language-specific properties**: metaphor in Welsh more consistently elicited reduced N400 amplitudes, irrespective of whether Welsh was the native language, suggesting that the statistically higher incidence of metaphor in Welsh may influence perception of and initial processing of metaphor. This finding dovetails with the notion of linguistic relativity, in which cognition and perception is influenced by linguistic properties (cf. Flecken, Athnosopoulos, Kuipers, Thierry, 2015; Thierry & Wu, 2009; Boutonnet, Athanasopoulos & Thierry, 2012). Recently, Ellis, Kuipers, Thierry, Lovett, Turnbull and Jones (2015) showed that when cultural information and the language in which it is presented are linked, significantly less

cognitive processing is required to facilitate comprehension. We also find that comprehension is facilitated when the information presented is congruent with the language in which the participant has greater experience with metaphor. Moreover, we suggest that although effects are stronger in the native language (reaching significance in experiment 1b), the general pattern of results in experiment 2 suggests this effect also occurs in the second language in proficient bilinguals (although to a lesser extent – indexed by a lack of significant result).

6.1.4 A schematic of intra-sense mapping in bilinguals

Taken together, results from Part 1 suggest that bilinguals' access to meaning during online semantic processing is easier in the L1 than in the L2. Yet, there is no observable benefit at the behavioural level. These findings are in line with the assumptions of the RHM, which assumes strong bidirectional links between lexical-semantic concepts and direct access to concepts are established with greater L2 proficiency (Kroll and Stewart, 1994; Kroll, van Hell, Tokowicz & Green, 2010). Thus, although the L1 retains a processing advantage, the L2 does indeed benefit from access in a similar manner. I now turn to present an illustration of this effect along with our other findings.

Figure 22 presents an illustration of the online semantic processing of literal and figurative language observed in L1 and L2 for both the Welsh-English bilinguals and the English-Welsh bilinguals.

For both the L1 and the L2, arriving at a literal and figurative interpretation is assumed to follow an identical pattern; as indexed by comparable N400 and P600 amplitudes to literal and metaphorical sentences in Welsh and English. That is to say, in both the L1 and L2 mapping for literal sentences (mapping '*man*' and '*cry'*) and metaphorical sentences (mapping '*cry*' and '*heart*') is direct. We found that the L1 however, benefits from a processing advantage (due to stronger lexico-semantic links assumed on the basis of psycholinguistic models) manifesting in greater sensitivity to sentence meaning (sensibility) during the time window of semantic integration (N400) and a reduced need for reanalysis (P600). This is represented in the model by solid line mappings between semantic concepts in the L1. In the L2 on the other hand, we found shallow and delayed semantic integration (N400) and more effortful processing with greater need for reanalysis (P600). This effect is represented in the model by dotted line mappings between semantic concepts in the L2. Possibly our most surprising finding was that regardless of native-ness, metaphor comprehension was facilitated in Welsh by greater occurrence and experience. Moreover, this effect was found to be stronger in the native speakers of Welsh (indexed by a significant result in the L1 and a general trend in the L2) and is thus represented by bolder lines for L1 Welsh metaphor relative to the L2 Welsh metaphor.

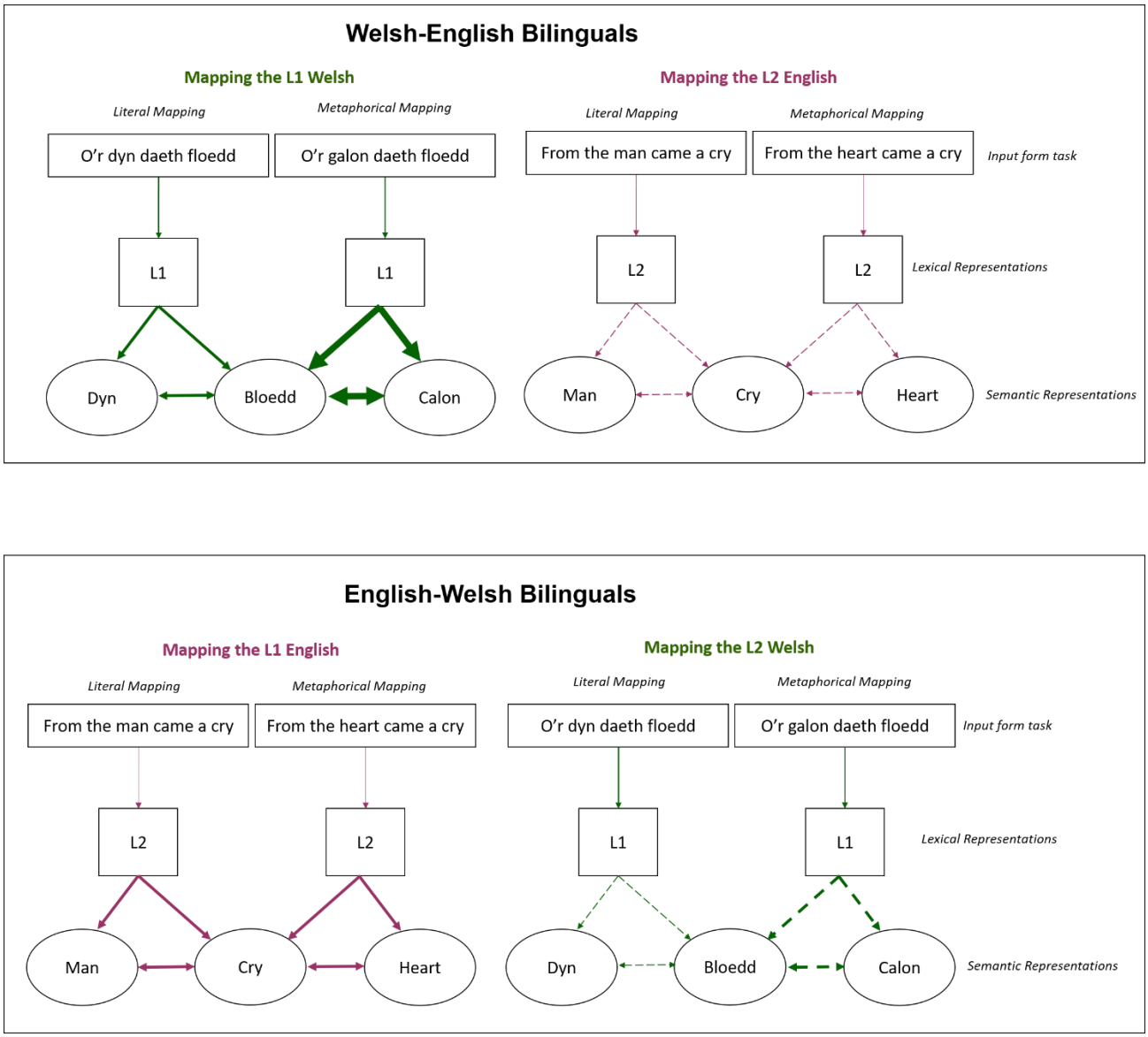


Figure 22. An illustration of the findings from chapters 3 & 4.

6.2 Part 2: Inter-sense mapping

Simultaneous co-activation of languages has previously been found at both the lexical and syntactic levels. In chapter 5, I investigated whether such language co-activation also occurs at the semantic level. To this end I conducted an ERP experiment

that examined how conceptual representations specific to the native language are accessed via the non-native language. More specifically, I presented Welsh idiomatic expressions (*She thought the woman was a hat*) to Welsh-English bilinguals and English monolingual speakers in the idiom-incongruent language (i.e. English – in which the meaning is nonsensical) along with anomalous (*He was criticised by his friend for being a front hat*) and low probability sensible (*He walked to the shop with the wind in his hat*) sentences.

Under a language selective account, in which only word candidates congruous with the language of operation would be activated, it would not have been possible for these bilinguals to access the Welsh specific semantic representation during online semantic processing. If this account was correct, then comprehension would first require rejection of the English anomalous interpretation and later translation into Welsh. Effects would therefore manifest later (during the P600 time window). Our results however support the opposing language non-selective view. We found that in the Welsh – English bilinguals, the Welsh idiom was processed with ease during the time window associated with semantic integration and reanalysis (indicated by reduced N400 and P600 amplitudes to Welsh idioms and acceptable sentences compared to anomalous sentences). In the English monolingual speakers however, the Welsh idiom required more effortful processing and reanalysis (indicated by greater N400 and P600 amplitudes to welsh idioms and anomalous sentences compared to acceptable sentences). Thus, whilst the English monolinguals treated the idiom as semantically anomalous (as indeed they should), the Welsh-English bilinguals processed the idiom in a way more similar to the processing of a semantically acceptable sentence. Our behavioural results however,

revealed that both group responses were faster and more accurate to anomalous sentences followed by welsh idioms and acceptable sentences, irrespective of group membership.

Together, these results suggest that whilst the Welsh specific meaning of the idiom was instantly available to the Welsh-English bilinguals, when explicitly asked to judge the acceptability of these sentences these bilinguals were able to suppress the welsh-specific meaning. Thus, comprehension was not determined by the language of presentation corresponding to the language membership of the concept. In fact, upon the activation of lexical candidates, all associated representations were activated. I thus suggest that a spreading activation occurs in which lexical candidates automatically activate all corresponding representations regardless of the degree of language overlap between the lexical input and the representation in the semantic store. This means that even language specific information is not only connected to lexical representations of the same language, but also to the unrelated language (Kroll & Stewart; Dijstra & Van Heuven, 2002; Dijstra & Van Heuven 1998; Grainjer & Dijstra, 1992).

With this in mind I suggest that the nature of the bilingual semantic network is far more complex than is currently described by psycholinguistic models such as the Sense Model, which assumes representations belong to both languages (core representations) or to a single language (language-specific representations; Finkbeiner, et al 2004). Our results suggest that representations do not simply belong to one language and activated by said language but rather they are shared and activated by all associated lexical candidates. This is the first tentative evidence that bilinguals do in fact co-activate conceptual representations from both languages during sentence reading (language non-selective). In line with previous accounts of lexical and syntactic activation (Dijkstra,

Van Heuven, & Grainger, 1998; van Heuven, Dijkstra, 2010), conceptual representations from both languages are co-activated during sentence comprehension, and the bilingual conceptual store is a highly interactive system and activation is not dependent upon activation of translation equivalents. Currently, this complex interaction is greatly oversimplified within psycholinguistic models and therefore highlights the need for new models such as the Multilink (Dijkstra et al., 2019) to incorporate these complex networks. Failure to do so significantly restricts our understanding of how the bilingual conceptual system truly operates.

6.2.1 A schematic of intra-sense mapping in bilinguals

Figure 23 is an illustration of the findings of inter-sense mappings from Chapter 5. The grey area represents the semantic store and the arrows represent lexico-semantic links and connections between concepts. When presented with the English sentence '*She thought the woman was a hat'* the corresponding lexical representation '*hat*' is activated. If semantic concepts from the non-attended language were not simultaneously activated (supporting the language selective view of semantic level co-activation) access would have occurred via the translation route (TR) – resulting in an increased N400 & P600. However, the findings showed comparable N400 and P600 amplitudes to Welsh idioms and acceptable sentences, which were reduced compared with anomalous sentences. These results suggest that all representations associated with the target word were activated (even language specific representations) supporting a language non-selective view of semantic level co-activation. This activation resulted in access occurring via the

direct route (DR). Thus, access to semantic concepts is achieved by both the L1 and L2 regardless of the language to which concepts correspond

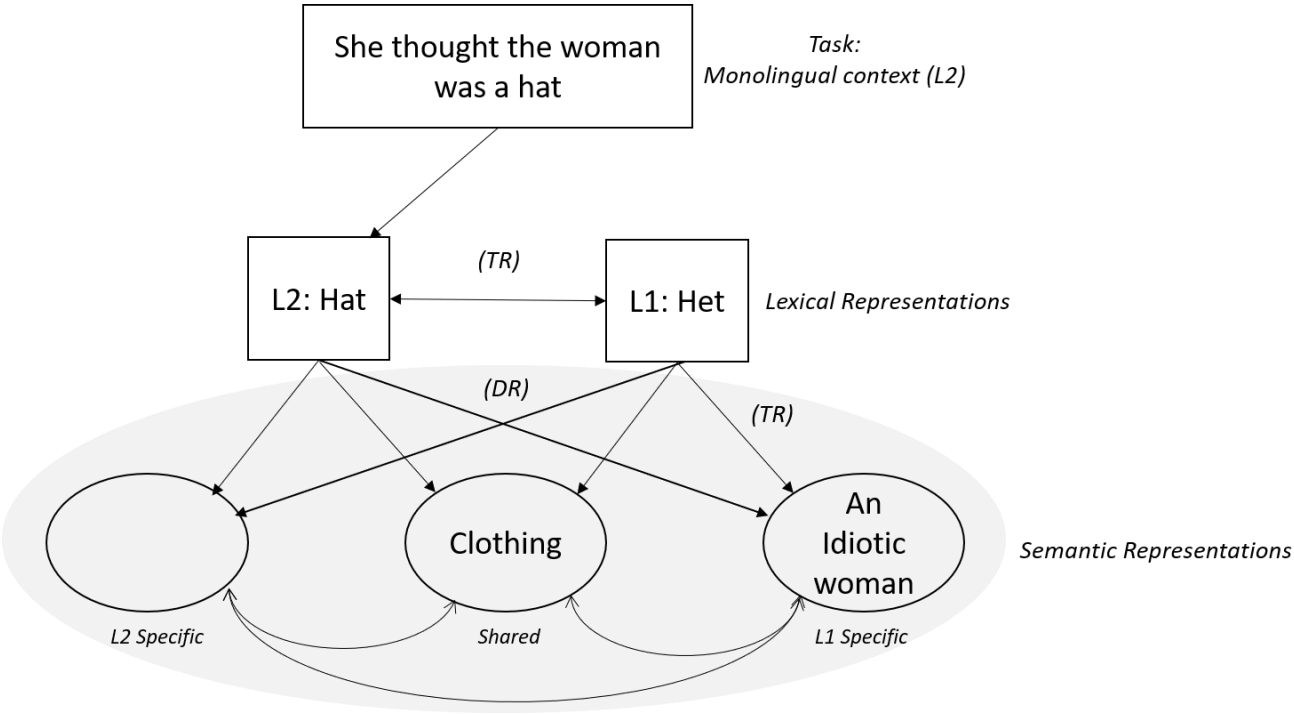


Figure 23. An illustration of conceptual co-activation within monolingual contexts – *between language mapping within concepts*.

6.3 Thesis Limitations

6.3.1 Data quality and analysis

We note several limitations of this thesis. First, the ERP data collected in experiment 1b and 2 contains significant alpha wave contamination, which affected a majority of the participants and could not therefore be improved through filtering or participant exclusion. In all likelihood, the level of alpha arose from the experimental

task, which only required a response on 30% of all trials. Future replicative work would need to build in a task requiring a response on the majority of trials in order to avoid such an effect on the data.

A second limitation is the lack of statistical power (as noted in chapters 4 and 5). When we look at the effect sizes for our non-significant data, a trend emerges within the data, in which we consistently find small to moderate effect sizes. In fact, an effect size was observed on all but one occasion (Experiment 2, non-significant N400 for figurativeness, effect size = .0). These effect sizes suggest that there may be some effects here that we fail to observe. It may well be, that our sample sizes, along with the level of alpha contamination, render us unable to observe true effects and determine the extent of such effects in the population

Although power analysis is becoming increasingly popular in psychological studies (Brysbaert & Stevens, 2018) it would appear that ERP studies are yet to adopt this approach of estimating power and required sample size prior to testing (Fields, & Kuperberg, 2020). In fact, the average statistical power in neuroscience is very low (Button, Loannidis, Mokrysz, Nosek, Flint, Robinson, & Munafo, 2013). An a priori power analysis would have enables us to determine the number of participants required to determine if any observed effect is in fact a genuine effect. Thus, it is imperative that future versions of this experiment use a priori power analysis techniques to determine the required sample size, and by extension increase the statistical power.

6.3.2. Experimental stimuli

Although the use of sentential context is more representative of natural language processing, the construction of sentences that are both semantically and grammatically meaningful, in both languages is challenging. To this end, each sentence set was created simultaneously in both languages rather than subsequently translated in an attempt to avoid translation effects. This may however, resulted in some sentences carrying an unorthodox (but not anomalous) grammatical structure. Moreover, given that certain words carry metaphorical and/or idiomatic meanings in some languages, some subject or target words may have carried additional meanings to some individuals (i.e., hat is often used in the English idiom ‘talking through your hat’).

As noted in chapter 5, we attempted to mitigate the effects of these confounds by including a total number of trials which exceeded the expectation of ERP experiments, and separate norming studies were conducted on each set until equivalence (and non-equivalence where appropriate) was achieved. Another method used to control and investigate the effects of such factors was the meticulous rotation of sentences and target words. This method allowed us to determine if such factors would have impacted the data by observing effects across conditions (for example, in both semantically acceptable and anomalous conditions in experiment 1 and 2). As this was not observed, we conclude that the grammatical structures of these sentences (which may have been unconventional in some cases) did not influence the overall ERP results.

An interesting addition to these measures would have been a separate study investigating the syntactic acceptability of these sentences. This would have allowed us

to determine the extent to which these sentences are unorthodox, and determine if any inherent differences exist between the syntax across languages. For example, perhaps the Welsh sentences are more unorthodox than their English counterparts, or, given the increased grammatical flexibility in Welsh (Deuchar, 2006) and the stimuli were created by native-Welsh speakers, the English syntax may be more unorthodox. A norming study specifically investigating the syntactic structure would have allowed us to investigate these potential differences.

6.3.3 Participant selection

We use of the term bilingual (including simultaneous, early, and late) to categorise such individuals for research. A major confound however, is that ‘no two bilinguals are the same’ (de Bruin, 2019) and bilingualism is not a categorical variable (Luk & Bialystok, 2013). Thus, within these categories, bilinguals will vairy considerably in their age of acquisition, proficiency, use and switching practices, and even when equality is achieved on some dimensions (age of acquisition and proficiency for example), another (e.g., language use) may differ considerably (de Briun, 2019). For this reason, it is extremely difficult to obtain samples that match on all demographic and linguistic variables.

Although creating a quantifiable measure of each individual’s experience is challenging, measuring bilingualism using subjective measures (such as the questionnaires used in the current thesis) is problematic as participants often over- or under-estimate abilities such as proficiency level. Moreover, language use and exposure

are difficult given that context is a crucial factor that is greatly underestimated by typical subjective measures (including those used here). Nevertheless, these measures do provide valuable insight into different aspect of bilingualism and should not be disregarded completely (de Bruin, 2014). A more robust approach may be to use both subjective and objective methods such as language comprehension, proficiency, and mutation tasks (in the context of Welsh, as per Vaughan-Evans, Kuipers, Thierry & Jones, 2014),

Given that factors such as context is underestimated, subjective measures should also endeavour to be as comprehensive as possible. For example, measures should investigate language exposure and use by context (home and family, peers, community, school, university, work, leisure, media) rather than an overall percentage (as per Anderson, Mak, Chahi, & Bialystok, 2018). Here perhaps, bilingual experience such as field of study/work, participation in Welsh medium activities such as the Eisteddfod, extent of formal Welsh instruction (i.e., GCSE, A level, University course, medium of University course) may have been important contributing factors. Furthermore, to avoid a more stringent inclusion criteria and 'cherry picking' based on certain characteristics (de Bruin, 2019), a quantifiable measure of such experiences may have allowed the inclusion of these factors as covariates in the final analysis.

Indeed, our studies were already subject to a strict inclusion criteria, including educated to University level (or working toward degree), from Welsh only homes, 18-35 years of age and no known learning disabilities. Although our methods of recruitment (snowball and convenience via Social Media, University forums, Library notice boards) allowed us to target our intended demographic they resulted in a slightly restrictive sample making generalization to the entire bilingual population is difficult. However,

allowing greater variation of individual differences into our sample may have had a detrimental effect on our ERP components rendering results unreliable and incomprehensible (Luck, 2005; Woodman, 2010). Our restricted sample allowed us to control for some individual differences known to modulate the N400 component such as reading and comprehension level, as well as alpha production.

Another limitation concerns the bilingual populations sampled in Experiment 1b (native Welsh-English) and 2 (native English-Welsh), and the probability that full bidirectionality in proficiency was not achieved (Gass, 1984; Pham, Donovan, Dam, & Contant, 2018). Although every attempt was made to recruit bilinguals with equivalent proficiency levels and age of acquisition in the L1/L2 across groups, each group may be characterised by a distinct language profile. For example, whilst both groups received Welsh medium education, the age of acquisition is younger, and frequency of L2 use is higher in the native speakers of English. Furthermore, regular language switching is a more common requirement of native Welsh bilinguals relative to native English speakers (i.e., an English native speaker is less likely to switch into their L2 Welsh, compared with a native Welsh speaker for whom switching into L2 English is common).

A final limitation concerning our sample was that participants were predominantly female across all experiments. The issue of gender differences in language processing literature is inconsistent. Whilst some researchers have discovered no difference between genders (Frost et al, 1999; Sommer et al, 2004, Weiss et al, 2003) others have indeed found differences in male and female lateralization (Kaiser et al, 2007; Baxter et al, 2003). Indeed, research into figurative language processing have found gender differences in processing. In their fMRI investigation of literal and

idiomatic comprehension Kana et al (2012) found greater and wider activation in females to both literal and idiomatic sentences. The authors therefore suggest, that females process language on a more global level whilst processing is localised to language specific areas in males. This may not be true however, for the current study as the ERP technique has poor spatial resolution and is thus, not concerned with laterization (Luck, 2014). Moreover, to the best of our knowledge no gender differences have yet been found in the visual-linguistic N400 literature, meaning the gender imbalance here is unlikely to have influenced responses.

6.4 Directions for future research

I now turn to propose a direction for future research required to investigate the remaining empirical questions that follow the overall conclusions of the thesis. The focus here is how access to semantic information is achieved by the native and non-native language (intra-sense) and how semantic connections interact across languages (inter-sense).

6.4.1 Intra-sense mapping

In Chapter 2, I presented a stimulus set comprising a cultural factor that was not used in the later ERP studies. I decided that the additional cultural factor was too complex as a starting point to establish an understanding of the underlying processes involved in literal vs non-literal comprehension, and therefore removed this factor from

the investigations. Now that we have a foundation from which to extend this enquiry, I propose that the culturally specific stimuli would provide an interesting approach to further extend the findings of experiments 1 and 2. Specifically, such an investigation would allow further insight into the influence of linguistic experience and knowledge on semantic processing. According to the linguistic relativity hypothesis when the contextual information corresponds is in line with language of presentation - metaphorical sentences containing culturally relevant information to Wales – semantic access and by extension metaphorical comprehension should be facilitated further (Ellis et al, 2015). An interesting extension of this proposed experiment would be to again investigate both native and non-native speakers of Welsh to determine the extent of these language-culture links, using the stimulus set created in chapter 2 and the procedures employed in chapters 3 and 4.

6.4.2 Inter-sense mapping

The results of Experiment 3 provide, to the best of our knowledge, the first evidence of bilingual conceptual co-activation. With this in mind, we need to investigate this effect further to establish a greater understanding of both the structure of the semantic networks and the processes by which they operate. To achieve this, it is imperative to use various alternative methods such as polysemy processing. Perhaps more importantly however, we should endeavour to investigate using paradigms from which the bulk of evidence in support of bilingual models emerge such as masked priming.

Although a step in the right direction, this thesis leaves many questions left unanswered regarding the nature of bilingual semantic links. For example, are language specific semantic representations instantly available when the direction is reversed? I.e. are L2 specific conceptual representations accessible when presented in the L1? However, research suggests that individuals are not familiar with extended meaning in the L2 including polysemous and idiomatic meanings (Finkbeiner et al, 2004). Thus, investigating conceptual co-activation using language specific meaning in this direction may present a challenge. Another viable and perhaps more worth-while question would be to ask when during second language acquisition does the semantic system become fully integrated across languages? Current bilingual models propose that with greater proficiency comes stronger links between lexical-semantic representations. Here we only tested highly fluent bilinguals, testing bilinguals of varying proficiency levels would offer insight into the trajectory of the semantic system becoming fully integrated between the L1 and L2.

Further investigation into these effects are imperative for the evolution of traditional bilingual models, which describe the semantic store as a unitary. Whilst these models describe a fully interactive lexical system, they fail to consider the complex interaction that also occurs within the conceptual store. Furthermore, representations are currently classified simply as single units whilst in fact they consist of multiple meanings and connotations.

6.5 Final Remarks

The aim of this thesis was to investigate the bilingual semantic system and the implications of this structure for language processing. To this end, I first categorised the semantic system into *intra*-sense mapping, i.e., within the L1 and the L2, and *inter*-sense mapping, i.e., between the L1 and L2. Part 1 of the thesis investigated intra-sense mapping, in which I conducted three experiments (chapters 3 and 4) examining how bilinguals process 1) anomalous language, and 2) figurative language. Based on the results of Part 1 I make three main conclusions. First, we find that whilst the L1 benefits from greater sensitivity to sense and overall, less effortful processing, the L2 displays shallow, delayed and more effortful processing. Second, we find that access to metaphorical meaning is direct and accessed in conjunction with literal meaning in both the L1 and L2 (although more effortful in the L2). Finally, access to metaphorical language is mediated by the statistical properties of the language. Although the effect was stronger in the native language, trends also suggested that language properties also mediated access in the non-native language. Part 2 of the thesis investigated inter-sense mapping. To address this question, I investigated semantic co-activation by means of examining how semantic information that is unique to the native language is processed in the other - incongruous – language. In chapter 5, I discovered that language co-activation indeed also occurs at the semantic level, suggesting that the nature of the bilingual semantic network is more interactive than previously assumed.

Pennod 1

Adolygiad o’r Lenyddiaeth ac Amcanion y Traethawd Ymchwil

1.0 Trosolwg o’r bennod

Bydd y bennod hon yn adolygu/dadansoddi modelau cyfredol o semanteg ddwyieithog, yn ogystal â chanfyddiadau empirig cysylltiedig. O ganlyniad bydd yr adran gyntaf yn canolbwyntio’n bennaf ar brosesu ar lefel geiriau. Bydd yna yn troi tuag at yr amcanion, sef esbonio’r (1) mapio mewn-synnwyr (o fewn ieithoedd), a (2) mapio rhyng-synnwyr (rhwng ieithoedd) o gysyniadau yn y cyd-destun mwy cymhleth (ond fwy naturiol) o brosesu brawddegau. Daw'r bennod i ben trwy amlinellu nodau'r traethawd ymchwil, gan fynd i'r afael â chwestiynau damcaniaethol sy'n ymwneud â chynrychioliadau semanteg yn yr ymennydd dwyieithog.

1.1 Amlygu’r gwahaniaethau sylfaenol rhwng semanteg uniaith a dwyieithog

Gall cynhyrchu un nodwedd ddiffiniol ar gyfer y mwyafrif o gysyniadau fod yn heriol (Wittgenstein, 1953). Mae’r theori glasurol semanteg yn disgrifio cysyniad semantig fel diffiniad sydd wedi'i adeiladu o gyfuniad o gysyniadau llai, symlach. Hynny yw, gall un gair fod yn gysylltiedig yn uniongyrchol â llawer o nodweddion diffiniol. Mae’r gair *ci* er enghraifft yn gysylltiedig â siâp penodol, symudiad, arogl, swn, lliw, teimlad, hyd ffwr, a nodweddion fel yn gwisgo coler. Er hyn, deuir ar draws cymhlethdod ychwanegol pan fydd afreoleidd-dra sy'n anghydnaws â'r wybodaeth hyn yn digwydd; h.y. wrth ddod ar draws ci newydd o liw, maint, siâp, ffwr, neu sain wahanol. O ganlyniad, mae'n rhaid i'r unigolyn fod yn sensitif i'r baich a roddir i bob nodwedd ar wahanol achlysuron, gan hefyd, gadw'r gallu i ddeillio cynrychiolaeth craidd y gair *ci*. Yn ogystal, bydd nodweddion semanteg ddiffiniol y gair *ci* yn gorgyffwrdd yn sylweddol â

nodweddion y gair *cath*. O ganlyniad bydd cysylltiadau cryfach yn bodoli rhwng y cysyniadau hyn na chysyniadau gyda llai o nodweddion sy'n gorgyffwrdd fel *ci – bwrdd*, a llai fyth rhwng *ci – lemwn* (Yee, Jones, McRae, 2018). Dywedwyd bod y nodweddion sydd yn gorgyffwrdd fel hyn yn cynhyrchu perthynas dacsonomig sy'n grwpio cysyniadau yn gategorïau semanteg yn seiliedig ar briodweddau sy'n gorgyffwrdd (h.y. anifeiliaid, dodrefn, ffrwythau). Dywedir bod y cysyniadau hyn sy'n rhannu nodweddion cyffredin yn debyg o ran tacsonomeg ac felly'n perthyn i'r un categori; mae *ci* a *chath* neu *gi* ac *arth* yn rhannu perthynas dacsonomig ac yn perthyn i'r categori mamaliaid (Mirman, Landrigan, & Britt, 2017).

Fodd bynnag, gall cysyniadau hefyd orgyffwrdd yn sylweddol wrth berthyn i gategorïau hollol wahanol. Er enghraifft, mae gan '*gi*' a '*thennyn*' gyswllt thematig tra bod un yn perthyn i'r categori *anifail* a'r llall i'r categori *offer*. Er hyn, 'rydym yn dod ar draws y cysyniadau hyn yn aml o fewn yr un achlysur neu senario (h.y. cerdded ci). Mae'r rhagdybiaeth ddosbarthu (*The distributional Hypothesis*; Firth, 1957; Harris, 1954; 1958; 1970) yn tybio bod gan eiriau sy'n digwydd yn aml mewn cyd-destun tebyg, ystyron tebyg sy'n gorgyffwrdd. Felly, mae'r cyd-destunau ieithyddol lle deuir ar draws gair yn nodwedd bwysig o'i gynrychiolaeth gysyniadol, ac mae'r graddau y mae geiriau'n rhannu cyd-destun cyffredin yn pennu maint y gorgyffwrdd yn y storfa cysyniadol (Rotaru, Vigliocco, Frank, 2018). Mae'r geiriau *ci* a *chath*, er enghraifft, yn digwydd yn aml mewn cyd-destun ieithyddol tebyg (h.y. mewn cyd-destyn anifail, anifail anwes, blewog, tŷ) sy'n awgrymu bod eu hystyron yn gorgyffwrdd yn sylweddol. Mae cysylltiadau dosbarthu fel arfer yn bwysicach ar gyfer gwrthrychau y gellir eu trin fel

offer, tra bod cysylltiadau tacsonomig yn bwysicach ar gyfer gwrthrychau mwy naturiol fel *anifeiliaid* (Bonthoux a Kalénine, 2007; Kalénine et al., 2009).

Ymhelaethwyd ar yr egwyddor sylfaenol hon o drefnu a chaffael gwybodaeth semanteg yn y theori prototeip olaf (Latter prototype theory; Rosch, 1975) a’r theori strwythur rheiddiol (Radial structure theory; Lakoff, 1987), sy'n cynnig bod gan eiriau ddiffiniad confensiynol neu graidd gyda strwythurau rheiddiol (*radial-like structure*) sy'n cael eu hymestyn a'i fapio. Yn achos *polysemy* (geiriau sydd â sawl ystyr sy'n rhannu nodweddion semanteg) mae diffiniadau craidd yn cael eu hymestyn trwy drosiad (Gathercole, Stadthagen-Gonzalez, Perez-Tattam, Yava, 2016; Lakoff & Johnson, 1980). Er enghraifft, y diffiniad craidd o *chwaer* yw *chwaer fenywaidd yn y teulu*, ond trwy estyniad trosiadol gall hefyd gyfeirio at *leian*, gan fod y berthynas rhwng lleianod yn efelychu perthynas chwiorydd benywaidd teuluol.

Yn achos dwyieithrwydd, mae'r anhawster o gynhyrchu un nodwedd ddiffiniol ar gyfer cysyniad penodol yn cael ei gymhlethu gan y ffaith nad oes yr un ddwy iaith yn rhannu'r un nodweddion semanteg (Jarvis a Pavlenko, 2008; Malt et al., 2015; Gathercole & Moawad , 2010). Er y gall termau sy'n cyfateb i’w gyfieithiad yn y naill iaith neu'r llall orgyffwrdd yn llawn a'u rhannu ar draws ieithoedd, mewn sawl achos, nid oes cywerthedd o'r fath, dim ond bras amcan. Er enghraifft, gall gair mewn un iaith fod â mwy nag un cyfieithiad sy'n cyfateb yn yr iaith arall (ee, mae'r term Sbaeneg '*dedo*' yn cael ei gyfieithu fel '*finger*' a '*toe*' yn Saesneg, neu *fys* a *bodyn* yn y Gymraeg), neu gall categori mewn un iaith fod yn absennol o'r iaith arall (ee, nid oes gan y gair Saesneg '*nut*' gyfwerth yn Sbaeneg; Gathercole, Gonzalez, Perez-Tattam, Yavas, 2016). Ar ben hynny, gall geiriau *polysemous* fod â nifer o ystyron ac ystyron iaith-benodol ychwanegol, tra

bod homoffonau a homograffau yn rhannu ffurf gair ond mae iddynt lawer o ystyron anghysylltiedig na ellir eu rhannu ar draws ieithoedd (Frances, 2018). Yn ychwanegol, mae tystiolaeth niwroffisiolegol ddiweddar yn awgrymu bod dwyieithrwydd yn arwain at newid dealltwriaeth gysyniadol yn y naill iaith neu'r llall - sef y ddamcaniaeth o berthnasedd ieithyddol (‘l*inguistic relativity’*) - lle mae categoreiddio gwrthrychau (ee Boutonnet, Athanasopoulos & Thierry, 2012), y canfyddiad o symudiad (Athanasopoulos, Bylund, Montero-Melis, Damjanovic, Schartner, Kibbe, Riches, & Thierry, 2015), a deallusrwydd o wybodaeth ddiwylliannol-amlwg (Ellis, Kuipers, Thierry, Lovett, Turnbull, & Jones, 2015; Ellis, Thierry, Vaughan-Evans, & Jones, 2017) yn wahanol rhwng L1 a L2.

Mae'n rhaid i'r system semanteg felly, fod yn ddigon soffistigedig i addasu ar gyfer y mapiau ystyr lluosog hyn er mwyn galluogi pobl ddwyieithog gael gafael ar ystyr yn y naill neu'r llall o'u hieithoedd yn ddiymdrech. Fodd bynnag, mae strwythur a chydberthynas y mapiau hyn yn parhau i gael eu dadlau ymysg ymchwilwyr.

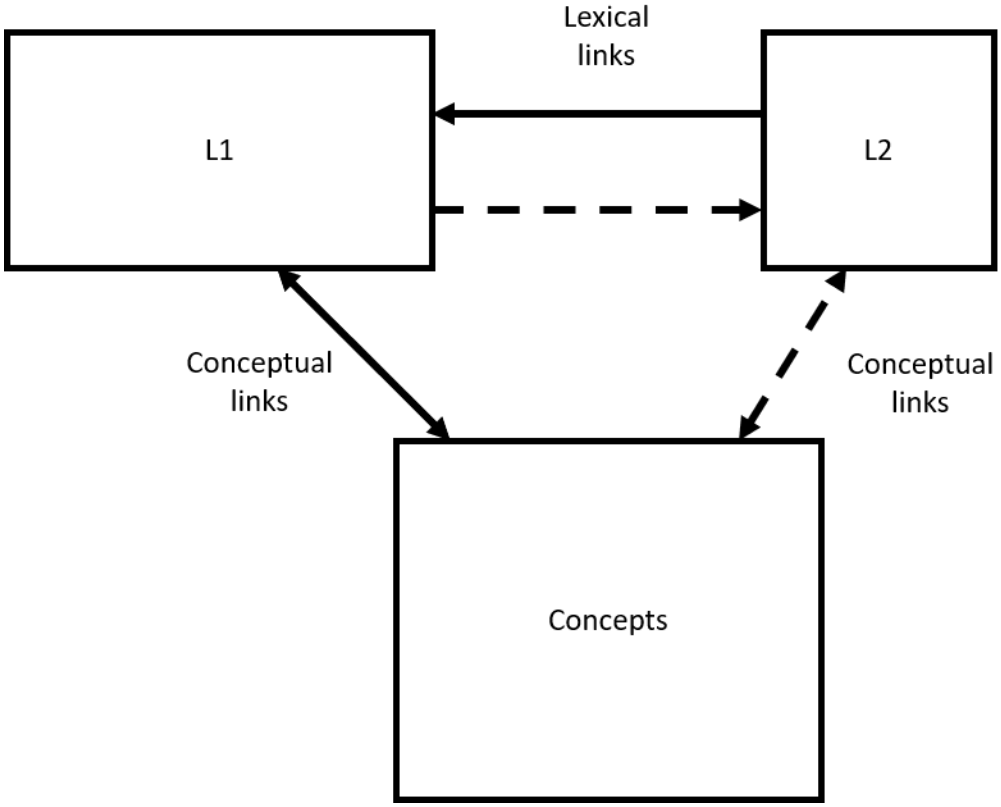
1.2 Modelau Seicieithyddol Dwyieithrwydd

Mae sawl model bellach yn ceisio disgrifio, i raddau amrywiol, cyfundrefn a mynediad geiriol-semantig a semantig dwyieithog. Bydd y modelau hyn yn cael eu hadolygu yma, ynghyd â chanfyddiadau empirig ategol. Er nad yw'r ddau fodel cyntaf a adolygwyd: y *Revised Hierarchical Model* (RHM) a’r *Bilingual Interactive Model* (BIA a'i olynydd BIA +) yn gwahaniaethu cynrychioliadau cysyniadol ar gyfer L1 a L2, maent i raddau helaeth yn asgwrn cefn damcaniaethu dwyieithog yn ystod y ddau ddegawd

diwethaf, ac yn wrthbwynt gwerthfawr i fodelau sy'n canolbwyntio'n fwy penodol ar wahaniaethu geirfa-semantig ddwyieithog.

1.2.1 Revised Hierarchical Model (RHM)

Mae'r RHM (Kroll a Stewart, 1994) yn cynnwys haenau cynrychioladol geirfaol a chysyniadol (gan gynnwys dwy eirfa ar wahân ar gyfer L1 a L2), ac fe'i defnyddir rhan amlaf i ddisgrifio cynhyrchu geiriau a chyfieithu mewn unigolion dwyieithog. Tybir bod y ddwy iaith yn cyrchu cynrychioliadau cysyniadol cyffredin, wedi'u storio mewn un storfa gysyniadol.



Ffigwr 1. Y Revised Hierarchical Model wedi'i addasu o Kroll & Stewart (1994) tt.158

Yn ogystal â disgrifio cysylltiadau geirfaol L1-L2 a chysylltiadau geirfa-semantig, mae hefyd yn gweithredu fel model datblygiadol, gan ddisgrifio'r taflwybr o ddechreuwr i siaradwr hyfedr (van Hell & Tanner, 2012). Er nad yw'r model yn cael ei weithredu'n gyfrifiadol, mae'n rhagdybio cysylltiadau ysgarthol rhwng y ddwy eirfa, fel y bydd actifadu gair mewn un iaith (e.e., '*horse*' yn Saesneg) yn actifadu ei gyfwerth cyfieithu yn yr iaith arall (e.e., *ceffyl* yn Gymraeg). Tybir bod cryfder y cysylltiadau geiriadurol yn amrywio yn ôl hyfedredd. Mae pobl ddwyieithog fel arfer yn caffael yr ail iaith mewn lleoliadau ystafell ddosbarth, yng nghanol neu ddiwedd plentyndod (1994; Van Hell & Tanner, 2012; Brysbaert & Duyck, 2010), ac erbyn hynny mae cysylltiadau cryf rhwng cynrychioliadau cysyniadol a geirfa L1 eisoes wedi'u sefydlu (Kroll a Stuart, 1994). Felly, mewn siaradwr newydd mae gan L1 fynediad uniongyrchol at ystyr semantig tra nad oes gan L2 fawr ddim mynediad uniongyrchol at ystyr (Van Hell & Tanner, 2012). Mewn achosion o'r fath, credir bod cysylltiadau geirfaol L1-L2 yn gryfach na chysylltiadau cysyniadol L2, sy'n arwydd o ddysgu L2 trwy gyfieithu (Kroll & Stewart, 1994; Kroll, van Hell, Tokowicz & Green, 2010). Er enghraifft, byddai siaradwr brodorol Sbaeneg yn dysgu gair Saesneg L2 '*house*' i ddechrau trwy fapio'n uniongyrchol ar yr hyn sy'n cyfateb i L1 '*casa*' (Heredia, 1997). Gyda mwy o hyfedredd, mae cysylltiadau dwyochrog rhwng y geiriadur L2 a'r storfa semantig yn cael eu sefydlu a'u cryfhau, gan ganiatáu mynediad uniongyrchol i gysyniadau trwy L2 (Kroll a Stewart, 1994; Kroll, van Hell, Tokowicz & Green, 2010). Felly, mae profiad yn galluogi'r eirfa L2 i ddod yn fwy annibynnol a llai dibynnol ar L1 (Heredia, 1997), ac mae mynediad at gynrychioliadau cysyniadol yn newid o'r llwybr wedi'i gyfryngu'n eiriol i'r llwybr wedi'i gyfryngu'n

gysyniadol. Yn hanfodol, fodd bynnag, mae anghymesuredd L1-L2 yn parhau i fodoli: yn naturiol mae gan ddwyieithwr fwy o brofiad yn L1, gan arwain at eirfa L1 mwy a chyfoethocach, gyda chysylltiadau geirfa-semantig cryfach parhaus. Felly mae'r oruchafiaeth L1 hon yn goroesi er gwaethaf rhuglder L1-L2 (Kroll & Stuart, 1994).

Mae’r dystiolaeth i gefnogi'r RHM yn deillio o dasgau cyfieithu (L1-L2 a L2-L1) sy'n trin cyd-destun semantig rhestr o gyfieithu (h.y. un rhestr semantig gymysg ac un arall wedi'i chategoreiddio'n semantig - pob ffrwyth, pob anifail er enghraifft). Darganfuwyd fod cyfieithu i gyfeiriad L1 - L2 yn cael ei effeithio gan gyd-destun semantig; roedd cyfieithu yn arafach ar gyfer geiriau mewn rhestrau wedi'u categoreiddio'n semantig nag ar gyfer yr un geiriau yn y rhestr gymysg. Ni welwyd yr effaith hon yn y cyfeiriad L2-L1. Mae'r canfyddiadau hyn yn cefnogi'r rhagdybiaeth bod cyfieithu L1-L2 yn cynnwys cyfryngu cysyniadau tra nad yw L2-L1 yn gwneud hynny.

Fodd bynnag, mae'r RHM wedi cael ei feirniadu'n helaeth yn ystod y blynyddoedd diwethaf am y dystiolaeth gyfyngedig i gefnogi bodolaeth geiriaduron annibynnol a mynediad dewisol iaith (Brysbaert & Duyck, 2010). Mewn gwirionedd, mae cryn dystiolaeth i awgrymu'r gwrthwyneb; hynny yw, awgrymu mynediad iaith nad yw'n ddetholus mewn pobl ddwyieithog (Brysbaert a Duyck, 2010; Dijkstra, 2005, Schwartz & Kroll, 2006; Thierry & Wu, 2007; van Hell & de Groot, 2008; Dijkstra, Timmermans, & Schriefers, 2000 ; Van Heuven, Schriefers, Dijkstra & Hagoort, 2008). Beirniadaeth fwy amlwg, yn arbennig ar gyfer y traethawd ymchwil cyfredol, yw bod y model yn rhagdybio storfa semantig unedol, gyda rhagdybiaeth (anghywir) o gydraddoldeb llwyr mewn cynrychioliadau cysyniadol dwyieithog ’(Bysbaert & Duyck,

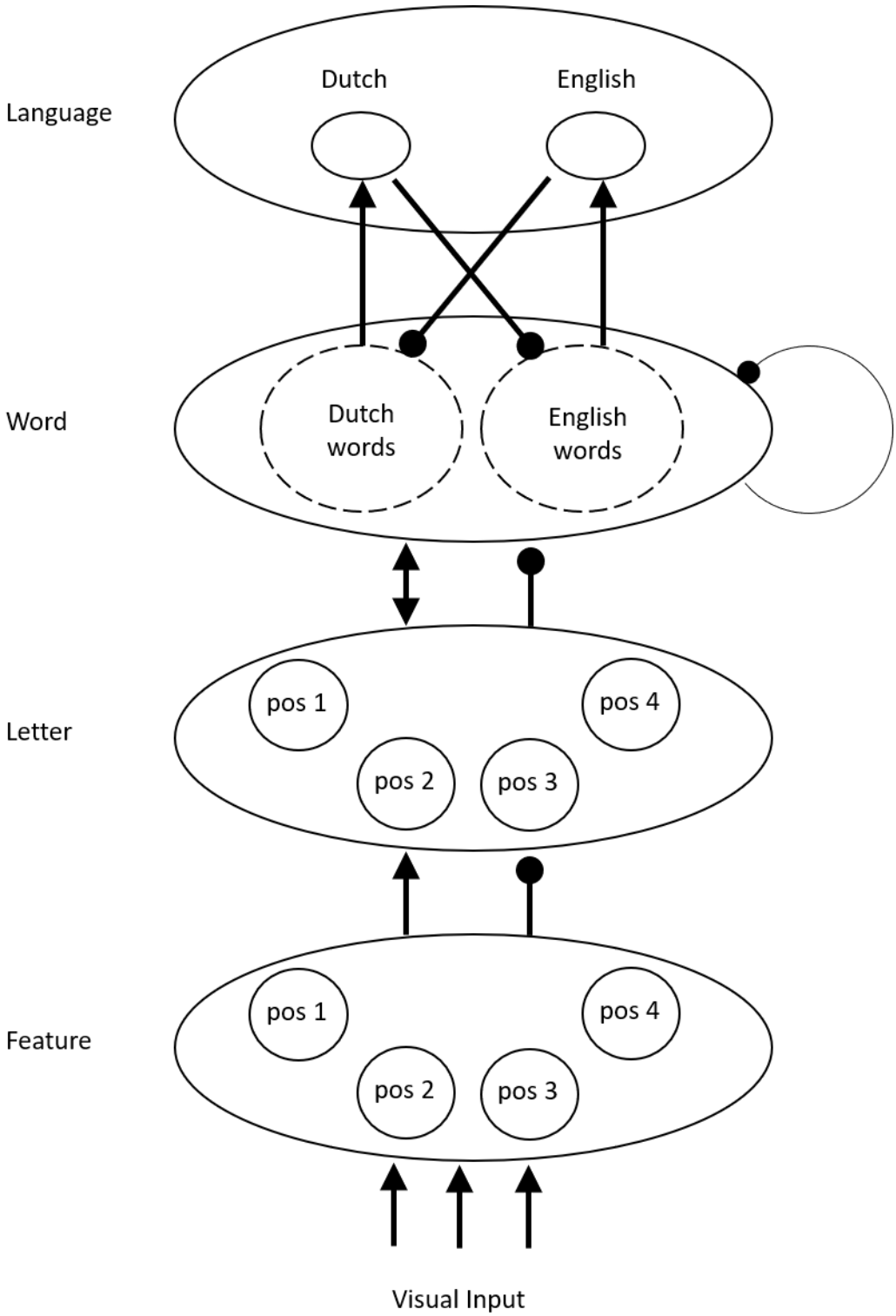
2010; Tokowicz a Kroll, 2007). Mae'r cyfrif wedi'i orsymleiddio o brosesu a ddarperir gan y model yn peri problemau sylweddol i'w weithredu.

1.2.2. Y modelau BIA a BIA+

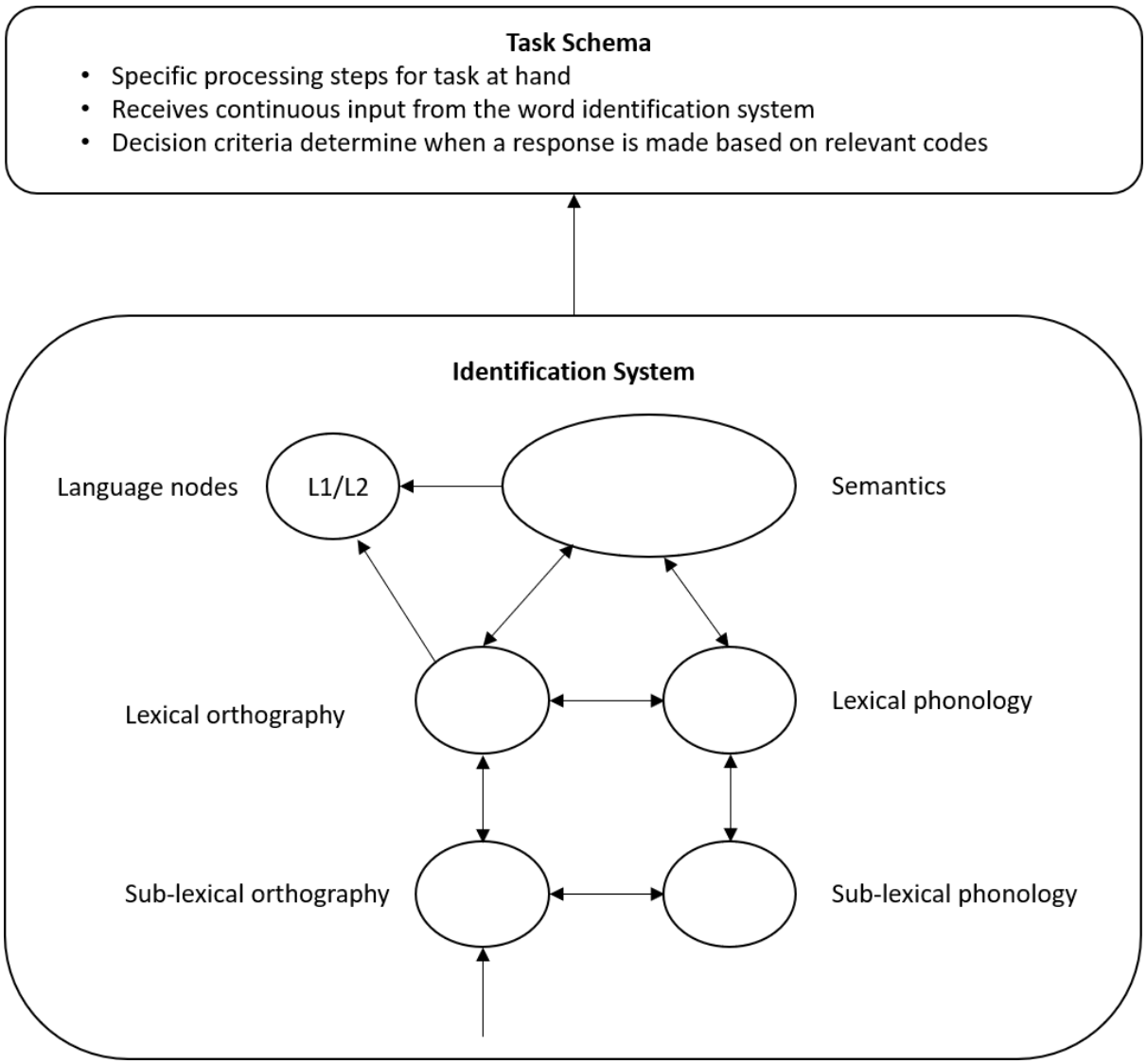
Mae'r '*Bilingual Interactive Activation' (*BIA*)* a'i olynydd, y BIA + (Dijstra & Van Heuven, 2002; Grainger & Dijkstra, 1992; Dijkstra & Van Heuven, 1998) yn gyfrifon cyfrifiadol o gydnabod geiriau dwyieithog, sy'n rhagdybio mynediad ac actifadu detholus o eitemau geirfaol a rennir, ar y lefelau cynrychioladol orthograffig, ffonolegol a semantig. O ganlyniad, mae dod ar draws gair mewn un iaith yn caniatáu actifadu lledaenol o eiriau cysylltiedig mewn iaith arall, sy'n amlwg ar bob lefel is-eiriol a geirfaol, gan ddefnyddio dull nad yw'n ddetholus.

Er nad yw actifadu geirfaol yn ddetholus yn ol y model hwn, mae actifadu pob cynrychiolaeth yn cael ei ddylanwadu gan ei lefel gorffwys actifadu ('*resting level activation'*) sy'n perthyn i amlder ei defnydd. Bydd gair neu gynrychiolaeth sydd ag lefel gorffwys actifadu uchel (yn agos at sero) yn cael ei ddefnyddio'n aml ac yn cael ei actifadu'n gyflym. Bydd gair neu gynrychiolaeth sydd ag lefel gorffwys actifadu isel (mwy na sero) yn cael ei ddefnyddio'n llai aml ac yn cael ei actifadu'n arafach. Ar gyfer y rhai dwyieithog, mae eu hyfedredd a'u defnydd yn wahanol rhwng ieithoedd, bydd actifadu lefel gorffwys ar gyfer L1 fel arfer yn uwch nag un L2, gan achosi oedi wrth actifadu ar bob lefel. Mae hyn yn achosi i ddylanwadau traws-ieithyddol o'r L1 i L2 fod yn fwy nag o L2 i'r L1; y cyfeirir ato fel y dybiaeth oedi amserol ('*temporal delay assumption'*) sydd wedi'i chefnogi gan astudiaethau niwrowybyddol (van Heuven & Dijkstra, 2010).

Mae'r modelau hefyd yn tybio bod nodau iaith-benodol yn bodoli i neilltuo aelodaeth iaith i eiriau, gan ganiatáu i'r unigolyn atal yr iaith anweithredol. Er bod y model BIA yn rhagdybio system gwbl ryngweithiol lle mae gwybodaeth a weithredir gan y nodau hyn yn cael ei bwydo yn ôl i gyfryngu mynediad geirfaol mewn dull o'r brig i lawr, mae'r BIA + yn tybio nad yw gwybodaeth yn cael ei hadborth i'r lefel eirfaol gan bod actifadu nodau iaith yn digwydd yn ôl-eiriol mewn dull o'r gwaelod i fyny. Yn ogystal, nid yw'r BIA yn gwneud unrhyw ragdybiaethau ynghylch actifadu geiriau yn seiliedig ar ddisgwyliadau, tra bod y BIA+ yn cydsynio bod gofynion tasgau a chyd-destun ieithyddol yn dylanwadu ar ddisgwyliad y gair targed.



Ffigwr 2. Y *Bilingual Interactive Activation* (BIA) ar gyfer adnabod geiriau dwyieithog wedi'i addasu o van Heuven, Dijkstra, a Grainger (1998), tt. 475.



Ffigwr 3. Y Model BIA+ ar gyfer adnabod geiriau dwyieithog wedi'i addasu o Dijkstra & van Heuven (2002).

O’u hystyried gyda’i gilydd, mae’r modelau RHM a’r BIA yn darparu cyfrif manwl o actifadu geirfaol, cysylltiadau L1-L2, a chysylltiadau geirfa-semantig, gan

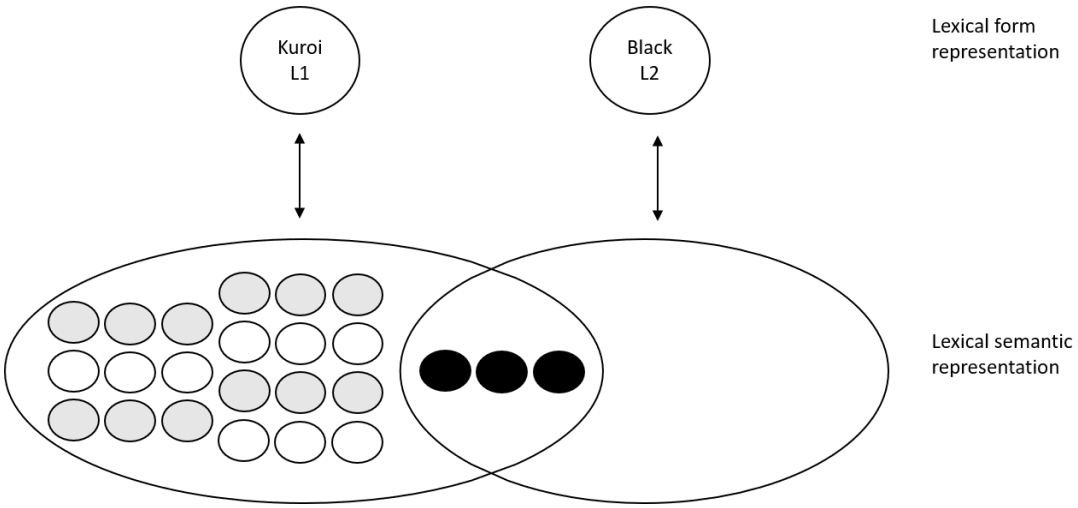
gynnwys newidiadau ansoddol yn natblygiad ieithyddol dwyieithog. Fodd bynnag, mae'r ddau fodel yn rhagdybio mynediad L1 a L2 i storfa semantig gyffredin, nad yw'n cael ei wahaniaethu ar sail synhwyrau unigryw yn L1-L2, na threfniadaeth swyddogaethol y synhwyrau hyn.

1.2.2 Y *Sense Model*

Mae'r *Sense Model* (Finkbeiner, Forster, Nicol & Nakamura, 2004), yn ceisio darparu cyfrif mwy crai o brosesu semantig dwyieithog na'r hyn a ddarperir gan y RHM neu'r modelau BIA. Mae'r fodel yn tybio (Chen, Zhou, Gao, & Dunlap, 2013), bod y mwyafrif o eiriau – er gwaethaf dwyieithrwydd - yn *polysamous*: mae gan bob gair sawl ystyr ac mae'n gysylltiedig â synhwyrau semantig lluosog. Er enghraifft, mae'r gair '*hammer*' yn gysylltiedig â sawl ystyr gan gynnwys yr enw '*tool*', neu'r ferf *'the act of hitting a nail*, '*the act of violently striking an object'*, gan gynnwys mewn ystyr fwy ffigurol, '*working hard and persistently'*, neu'n '*criticizing relentlessly'*. Cynrychiolir pob synnwyr yn unigol yn y system semantig (Chen, Zhou, Gao, & Dunlap, 2013; Basnight-Brown & Altarriba, 2007).

Mae'r *Sense Model* yn tybio bod y storfa gysyniadol yn cynnwys synhwyrau a rennir, sy'n gorgyffwrdd, a synhwyrau sydd ddim yn gorgyffwrdd gan eu bod yn iaith benodol (Brysbaert & Duyck, 2010; Finkbeiner, Forster, Nicol & Nakamura, 2004). Nid mapio un i un syml yw cywerthoedd cyfieithu (translation equvalents) mewn dwy iaith; yn dibynnu ar yr iaith weithredu, gall pob iaith gael mynediad at ystod wahanol o synhwyrau (Brysbaert & Duyck, 2010). Ar draws ieithoedd, mae pob gair fel rheol yn rhannu synnwyr craidd cyffredin amlwg ond yn wahanol yn y synhwyrau sy'n weddill

(Wang & Forster, 2010). Mae'r gair Saesneg *'black'* a'i gyfwerth Siapaneaidd '*kuroi*' yn rhannu'r ystyr amlycaf '*colour*' (gweler Ffigwr 2). Fodd bynnag, y tu hwnt i'r ystyr graidd hon, gellir defnyddio'r '*kuroi'* Siapaneaidd cyfatebol i ddisgrifio '*an evil-minded individual'*, tra gall y gair Saesneg gynrychioli '*humour' neu iseldra*. Ymhellach, mae gan bob iaith ei chyfyngiadau ei hun ar ystyr geiriau. Er enghraifft, mae '*big sister'* yn dderbyniol yn Saesneg, tra fod '*large sister'* ddim yn dderbyniol (Brysbaert & Duyck, 2010). Er bod unigolion dwyieithog fel arfer yn fwy hyfedr ac yn gyfarwydd â'r ystod o gynrychioliadau semantig yn L1, efallai na fyddant yr un mor gyfarwydd â'r holl synhwyrau sy'n gysylltiedig â gair penodol yn L2 (Finkbeiner, Forster, Nicol & Nakamura, 2004; Chen, Zhou, Gao, & Dunlap, 2013). O ganlyniad, mae geiriau L1 wedi'u cysylltu â nifer fwy a chyfoethocach o synhwyrau na geiriau yn L2, lle mai dim ond cynrychioliadau craidd a ddysgir yn nodweddiadol (Luo, Cheung, Bel, Li, Chen, & Mo, 2013). Mae'r *Sense Model* yn cynnig bod anghymesureddau a geir mewn tasgau penderfyniad geirfaol a semantig yn ganlyniad o nifer y synhwyrau a actifadir gan y preim, gyda thargedau a sawl synnwyr yn cynyddu actifiant (Finkbeiner, Forster, Nicol & Nakamura, 2004). Os yw'r synhwyrau sy'n gorgyffwrdd rhwng y preim a'r targed yn gyfyngedig, yna mae'r actifiant yn gyfyngedig, a bydd preimio yn aneffeithiol. O ganlyniad ni fydd targed L1 yn cael ei weithredu'n effeithiol gan breim L2 oherwydd cyfran gyfyngedig y synhwyrau sydd ar gael yn L2. Yn gyferbyniol, i'r cyfeiriad L1-L2, bydd nifer gyfoethog o breim sydd ar gael i'r L1 yn cyn-actifadu synhwyrau L2 sy'n gorgyffwrdd.



Ffigwr 4. Y *Sense Model* wedi'i addasu o Finkbeiner, Forster, Nicol & Nakamura, (2004)

1.2.3 Y *Distributed Feature Model*

Mae'r *Distributed Feature Model* (de Groot, 1992; De Groot, 1992b; De Groot, 1995; De Groot, Dannenburg, & Van Hell, 1994; Van Hell, 1998; Van Hell & De Groot, 1998) yn cynnig bod y raddfa y mae cynrychioliadau mewn iaith benodol yn gorgyffwrdd neu'n unigryw yn dibynnu ar gategori geirfaol y gair. Er enghraifft, tybir bod enwau concrit a chytras (*cognate)* yn debyg ar draws ieithoedd, gyda chyfwerth cyfieithu yn rhannu holl nodau cynrychioliadau cysyniadol, tra tybir bod enwau haniaethol ac anghyras (*noncognates)* yn fwy penodol i iaith gyda dim ond is-set o nodau cysyniadol a rennir gan gyfwerth cyfieithu (gweler Ffigwr 5).

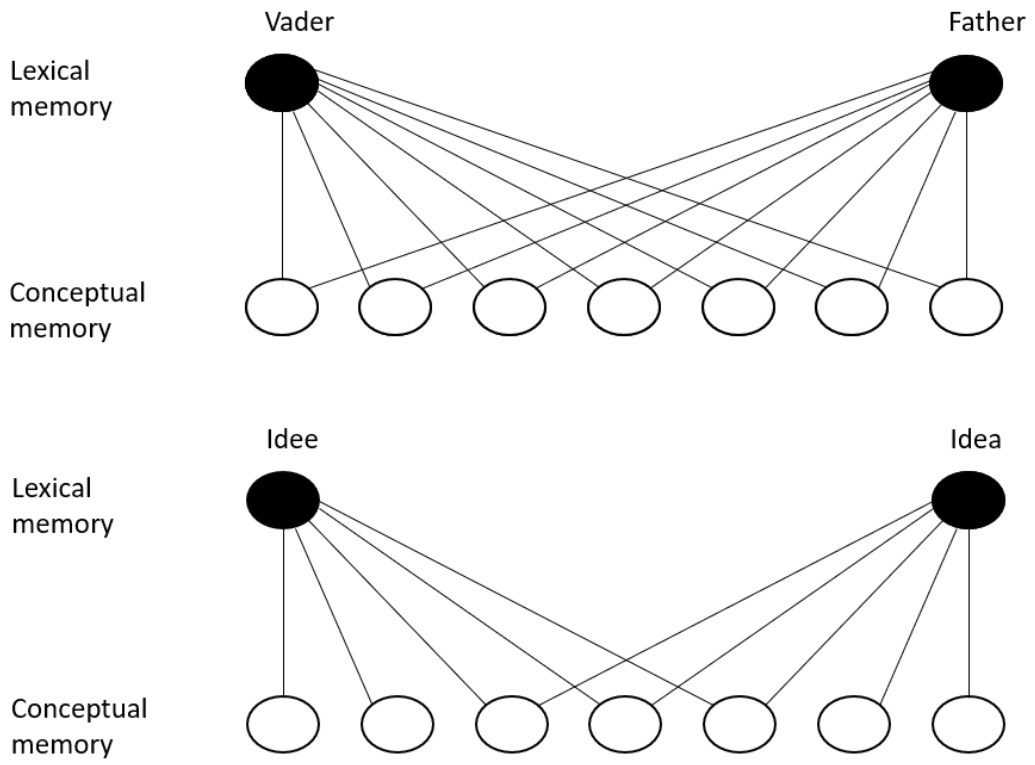
Mae'r model yn honni bod cyfieithu mewn pobl ddwyieithog rhugl ar gyfer geiriau concrit yn digwydd trwy'r llwybr geirfaol (T1) a'r llwybr wedi'i gyfryngu'n gysyniadol (T2) tra bod geiriau haniaethol yn cael eu cyfieithu trwy'r llwybr geirfaol yn unig (T1; gweler Ffigwr 6). Ar y llaw arall, mae cyfieithu mewn pobl ddwyieithog di-rugl

yn digwydd trwy gysylltiad geiriau, gan awgrymu, bod y llwybr y mae cyfieithu yn digwydd yn y pen draw yn newid o'r llwybr cysylltiad geiriau i'r llwybr wedi'i gyfryngu'n gysyniadol yn ystod dysgu ail iaith (De Groot, 1992), yn debyg i'r newid a gynigiwyd gan yr RHM (van Hell & Tanner, 2012).

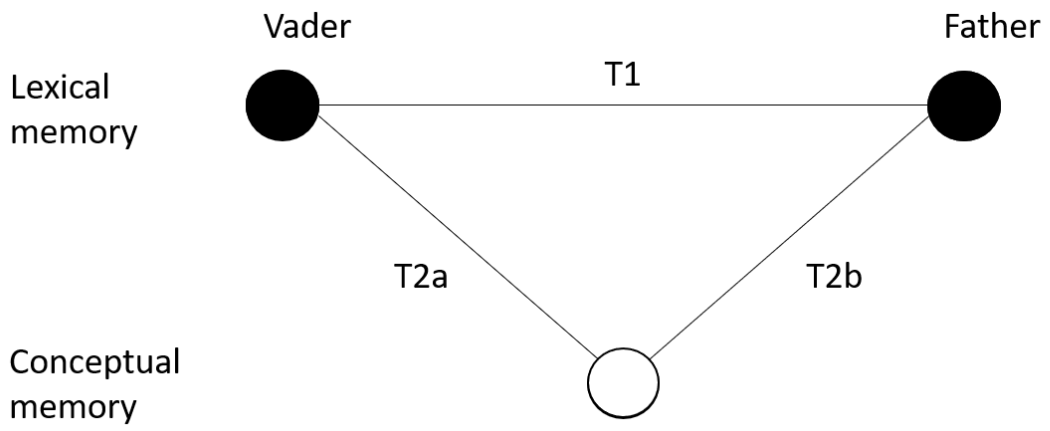
Mae rhwyddineb cyfieithu yn ôl y DFM yn cael ei bennu gan raddau'r gorgyffwrdd rhwng cyfwerth cyfieithu. Bydd nifer fwy o nodau cysyniadol sy'n gysylltiedig â chysyniad penodol yn arwain at ledaenu actifadu semantig mwy, gan arwain at gyfieithu cyflymach. Felly, bydd cyflymder mynediad at gynrychioliadau semantig yn dylanwadu ar berfformiad cyfieithu. Mae hyn yn caniatáu inni ragweld yr amser y bydd yn ei gymryd i gydnabod a yw geiriau'n gyfwerth cyfieithu neu i gyfieithu o un iaith i'r llall.

Ar gyfer cytrasau ac enwau concrit, gwelwyd bod cydnabod cywerthoedd cyfieithu yn gyflymach na chydnabod enwau haniaethol ac anghytras mewn tasgau cyfieithu, adnabod cyfieithiad, penderfyniad geirfaol, a chysylltu geiriau (De Groot, 1992a; De Groot, 1992b; De Groot, 1995; De Groot et al., 1994; Van Hell, 1998; Van Hell & De Groot, 1998). Ar ben hynny, mae perfformiad cyfieithu yn cael ei ddylanwadu gan nifer y cyfieithiadau a all fod gan air; mae cydnabyddiaeth yn arafach i'r rheini sydd â chyfieithiadau lluosog nag i'r rhai sydd â chyfieithiad sengl (Tokowicz, 2000). Mae hyn yn awgrymu y gall pobl ddwyieithog fod â chysyniadau union yr un fath ynghyd a chysyniadau nad ydynt yn union yr un fath ar gyfer geiriau, sy'n arwain at raddau amrywiol o ystyron sy'n gorgyffwrdd (Kroll & Tokowicz,). Er enghraifft, mae'r gair *chwarae* yn derm eang a all olygu chwarae *chwaraeon*, *gêm fwrdd* neu *offeryn*. Defnyddir ei gyfieithiad Sbaeneg '*jugar*' i gyfeirio at chwaraeon neu gêm fwrdd yn unig,

tra bod *‘tocar’* yn cael ei ddefnyddio i gyfeirio at chwarae offeryn. Yn y Gymraeg, ‘rydym o bosib yn *chwrae* offeryn mewn iaith lafar ac yn *canu* offeryn mewn iaith fwy ffurfiol. Yn ôl y DFM bydd pob ystyr yn cael ei gynrychioli gan nod gwahanol, felly, dim ond yn rhannol y bydd *chwarae*, ‘*jugar*’ a ‘*tocar*’ yn gorgyffwrdd. Bydd graddfa'r gorgyffwrdd yn dibynnu ar lefel hyfedredd a chyd-destun caffael yr unigolyn dwyieithog (e.e. Dufour & Kroll, 1995; Finkbeiner, 2003; Jiang, 2000; Silverberg & Samuel, 2003).



Ffigwr 5. Strwythur cynrychioliadau cysyniadol dosbarthedig mewn cof dwyieithog wedi'i addasu o De Groot (1992).



Ffigwr 6. Cynrychiolaeth o gof dwyieithog wedi'i addasu o De Groot, 1992.

1.2.4 *Multilink*

Mae'r model *Multilink* (Dijkstra, Wahl, Buytenhuijs, Van Halem, Al-Jibouri, De Corte, & Rekke, 2019), yn fodel cyfrifiannol sy'n ceisio integreiddio modelau cyfredol o ddwyieithrwydd a'r gwahanol agweddau ar ddwyieithrwydd y maent yn eu disgrifio, gan gynnwys adalw, cynhyrchu a chyfieithu gair, prosesu geirfaol-semantig, actifadu iaith, amledd geiriau a systemau tasgau penderfynu. Gan ymgorffori rhagdybiaethau o'r modelau BIA + a'r RHM, gelwir y model ei hun yn '*Multilink*' oherwydd y nifer fawr o gysylltiadau rhwng cynrychioliadau sy'n ofynnol wrth lunio model cynhwysfawr o adfer geiriau. Mae ei strwythur yn cynnwys geirfa integredig sy'n dadlau yn erbyn gwahanu'r ddwy iaith ddwyieithog. Ar ôl cyflwyno ysgogiad gweledol gweithredir cynrychioliadau geirfaol-orthograffig o ganlyniad i actifadu cynrychioliadau aelodaeth ffonolegol, semantig ac iaith gyfatebol. Yn unol â'r model BIA mae'r storfau hyn yn rhyngweithiol iawn gydag actifadu deu-gyfeiriadol.

Daw tystiolaeth empeiraidd gyfredol i gefnogi'r model hwn o astudiaethau ysgogi. Cryfder modelau cyfrifiannol yw eu bod yn caniatáu ar gyfer cymharu cydrannau'r model â data empirig, ac yn bwysicach fyth, yn penderfynu pa mor dda y mae'r model yn egluro canfyddiadau empirig (Van Heuven & Wen, 2019). Un enghraifft o'r fath yw esboniad y model o gyfieithu geiriau. Fe wnaeth yr awduron efelychu arbrawf gan Chistoffels et al (2006) a ddaeth o hyd i gyfieithu cyflymach i gyfeiriad L1 - L2 (cyfieithu ymlaen) nag yn y cyfeiriad L2-L1 (cyfieithu yn ôl); roedd yr effeithiau'n fwy pan oedd hyfedredd yn is. Cafodd yr arbrawf ei ailadrodd gyda rhai mân newidiadau i'r dyluniad arbrofol (gweler Pruijn et al, mewn paratoad; Dijkstra, Wahl, Buytenhuijs, Van Halem, Al-Jibouri, De Corte, & Rekke, 2018) a darganfuwyd cyfieithu cyflymach yn y cyfeiriad ymlaen (L1 - L2). Fe wnaeth Multilink hefyd efelychu'r effaith cyfeiriad cyfieithu ymlaen. Gellir esbonio'r canlyniadau hyn trwy gysylltiadau cryfach â chysyniadau yn L1, neu drwy gysylltiadau geiriau uniongyrchol L1 - L2 cryfach. Fodd bynnag, mae'r canfyddiadau hyn yn amrywio'n sylweddol o'r rhagdybiaethau a'r dystiolaeth sy'n cefnogi'r RHM (Kroll & Stewart, 1994), sy'n rhagweld cysylltiadau cryfach o'r L1 - L2 nag i'r gwrthwyneb. Mae tystiolaeth i gefnogi'r RHM (yn ogystal â llawer o astudiaethau adnabod a chynhyrchu geiriau eraill) yn deillio o'r patrwm preimio wedi'i guddio (‘*masked priming paradigm’)* felly mae gallu'r model i ddal yr anghymesureddau hyn gan ddefnyddio'r dull hwn yn brawf hanfodol o unrhyw fodel. Felly, er bod yr *Multilink* yn cynnig cynnydd mawr yn natblygiad model cynhwysfawr o gydnabod a chyfieithu geiriau dwyieithog, nid yw wedi'i ddatblygu'n llawn eto i fod yn gyffredinol (Van Heuven & Wen, 2019).

Materion allweddol eraill sy'n gofyn am fanyleb yn ei ail weithrediad yw'r actifadu o cynrychioliadau cysyniadol sy'n rhannu cysylltiadau geirfa-semantig sy'n

gorgyffwrdd yn rhannol yn y naill iaith neu'r llall. Ar hyn o bryd mae'r model yn rhagdybio bod cynrychioliadau semantig yn unedau cyfannol syml. Mae dylanwad cyd-destun iaith (fel y nodwyd wrth hyrwyddo'r BIA i'r BIA +; Dijkstra & Van Heuven, 2002; Van Hell, 2018), actifadu lledaenol rhwng cynrychioliadau semantig, a phrosesu nodweddion semantig dibynnol ar iaith yn erbyn nodweddion semantig annibynnol, ar hyn o bryd heb eu hystyried.

Bydd ail weithrediad *Multilink* yn ymchwilio i actifadu rhwng cynrychioliadau cysyniadol, yn ogystal â mapiau geiriadurol-semantig rhannol nad ydynt yn gorgyffwrdd yn L1 a L2 (Dijkstra, Wahl, Buytenhuijs, Halem, Al-Jibouri, De Korte, Rekke, 2018).

1.2.5 Casgliad Dros Dro a Chwestiynau Amlwg

Mae'r modelau a amlinellir uchod yn rhoi cyfrif cynhwysfawr o gydnabod a chynhyrchu geiriau dwyieithog, efallai yn arbennig ar lefel actifadu geirfaol a chyfieithu L1-L2, (Kroll & Stewart, 1994); Dijstra & Van Heuven, 2002; Dijkstra & Van Heuven, 1998; Finkbeiner, Forster, Nicol & Nakamura, 2004); De Groot, 1992). Fodd bynnag, mae cyfrif pob model o'r strwythur semantig dwyieithog yn amrywio'n sylweddol. Mae'r modelau BIA / BIA + a RHM yn cysynoli'r system semantig fel storfa unedol, ac er nad yw'r modelau BIA yn nodi mynediad breintiedig i semanteg ar gyfer y naill iaith neu'r llall, mae'r RHM o leiaf yn nodi cysylltiadau geirfa-semantig cryfach yn L1. Mae'r *Sense Model* yn ceisio rhoi cyfrif am y diffyg cyfatebiaeth cyfieithu rhwng ieithoedd (de Groot, 2011; Pavlenko, 2009) trwy nodi cysylltiadau geirfa-semantig a rennir ac unigryw ar gyfer L1 a L2. Yn ogystal, mae nifer fwy o eitemau semantig yn perthyn i'r iaith frodorol, sy'n arwain at ledaenu ac actifadu mwy o nodweddion cysyniadol. Yn yr un modd, mae'r

DFM yn gwahaniaethu synhwyrau L1-L2 a rennir a sy’n unigryw, ond mae hefyd yn rhagdybio mwy o orgyffwrdd cysyniadol ar gyfer geiriau concrit dros eiriau haniaethol.

Felly, mae damcaniaethu cyfredol yn ymestyn i gydnabod a gweithredu mapio geirfaol-semantig a rennir a sy’n unigryw ar gyfer L1 a L2, a disgrifiad o'r mathau o eiriau sy'n debygol o ddod o fewn y naill gategori neu'r llall. Er hyn, mae nifer o gwestiynau damcaniaethol amlwg yn ymwneud â strwythur swyddogaethol y system semantig ddwyieithog a goblygiadau'r strwythur hwn ar gyfer prosesu iaith.

At ddibenion y traethawd ymchwil hwn, rydym yn categoreiddio'r cwestiynau hyn i'r rhai sy'n ymwneud â mapio mewn-synnwyr dwyieithog, h.y., o fewn L1 a L2, a mapio rhyng-synnwyr, h.y., rhwng L1 a L2. Mae'r cwestiynau mewn-synnwyr yn codi o arsylwi dro ar ôl tro bod y geiriadur L1 fel arfer yn cael ei ystyried yn 'fwy' (Kroll & de Groot, 1997) ac yn 'gyfoethocach' (Finkbeiner, Forster, Nicol & Nakamura, 2004) na'r geiriadur L2, gan fod cysylltiadau geirfaol-semantig fel arfer yn cyflymu o'u genedigaeth neu yn ifanc o leiaf (Kuhn, Wiloughby, Wilbourn, Vernon-Feagans & Blair, 2014). Felly, gofynnwn: A oes nodweddion neu fanteision prosesu yn L1, oherwydd ei faint a'i gysylltiadau geiriadurol-semantig cryfach? Yn L1, a yw'r mapio rhwng synhwyrau yn cael ei gynnal gyda llai o ymdrech brosesu, oherwydd y lefel uwch o brofiad ieithyddol, gan arwain at gysylltiadau rhyng-gysyniadol cryfach a chyfoethocach? Mae'r cwestiynau mapio rhyng-synnwyr yn codi o gorff o dystiolaeth (adolygir isod) sy'n archwilio cyd-actifadu ymhlyg iaith. Gofynnwn, ar y lefel gysyniadol: A yw synhwyrau yn unigryw i un iaith yn cael eu cyrchu yn yr iaith honno yn unig, neu a allant hefyd gael eu cyrchu yn yr iaith arall? Os felly, a allwn ni ddod o hyd i dystiolaeth o fynediad ar unwaith (semantig

ar-lein) i’r synhwyrau unigryw hyn yn yr iaith arall - ‘anghywir’, sy’n awgrymu system eirfa-semantig gwbl ryngweithiol mewn unigolion dwyieithog.

Mae'r rhannau sy'n weddill o'r bennod hon yn delio yn eu tro â'r cwestiynau mapio rhyng-a-synnwyr penodol yr ymdrinnir â hwy yn y traethawd ymchwil hwn.

1.3 RHAN 1 ~ Mapio Mewn-Synnwyr mewn pobl ddwyieithog

Os yw mwy o brofiad yn L1 yn arwain at eirfa fwy a chyfoethocach, a yw hyn yn arwain at lai o ymdrech brosesu yn a) cyrchu ystyr, a b) mapio cynrychiolaethau cysyniadol lluosog er mwyn cael ystyr gyda llai o ymdrech brosesu.

Er mwyn profi'r rhagdybiaethau hyn, mae Arbrofion 1a, 1b a 2 yn archwilio'r dystiolaeth ar gyfer mantais L1 wrth (a) brosesu anghysondeb brawddegau, hy, adnabod brawddegau ystyrlon dros frawddegau ac ystyr anghyson (*non-sensical*), a (b) prosesu ystyron ffigurol mewn brawddegau, hy, metafforaidd. dehongliad sy'n gofyn am fapiau cysyniadol lluosog er mwyn cael ystyr (eglurir hyn ymhellach yn adran 1.3.3 isod). Aethpwyd i'r afael â'r cwestiynau hyn yng nghyd-destun prosesu brawddegau, yn hytrach na phrosesu geiriau unigol, yn bennaf er mwyn trin ystyr yn haws wrth gadw geiriau targed yn union yr un fath ar draws gwahanol fathau o frawddegau, ond hefyd i archwilio semanteg dwyieithog mewn cyd-destun iaith fwy naturiol. Byddaf yn awr yn adolygu llenyddiaeth sy'n ymwneud â phrosesu semantig mewn cyd-destun brawddeg.

1.3.1 Prosesu semantig mewn cyd-destun brawddeg

Cynigir bod darllenwyr / gwrandawyr yn rhagweld geiriau sydd ar fin ymddangos wrth i frawddeg ddatblygu, wedi'i galluogi gan gyfyngiadau cystrawennol a phragmatig amrywiol, ac yn y pen draw yn arwain at hwyluso prosesu ac integreiddio semantig wrth i'r gair ymddangos (Foucart, Martin, Moreno & Costa, 2014; Pickering & Garrod, 2007; Wicha, Morena & Kutas, 2004; DeLong et al , 2005; Neely, 1977). Felly, mae prosesau rhagfynegol o'r fath yn galluogi dealltwriaeth gyflym o destun a lleferydd parhaus (Pickering & Garrod, 2007). Mewn niwrowyddoniaeth wybyddol, mae corff mawr o lenyddiaeth yn tystio i ragfynegiad geiriau cyd-destunol, fel y datgelir ym modiwleiddio'r N400 mewn paradeimau potensial cysylltiedig â digwyddiad (*Event related potentials*, ERP) (a ddisgrifir ymhellach ym Mhennod 2, ond yn fyr, mae negyddiaeth ar ~ 400 ms ar ôl ysgogiad yn cynyddu fel swyddogaeth o anhawster i integreiddio gair gyda'r cyd-destun ieithyddol blaenorol (Kutas & Federmier, 2011; Lau, Phillips, Poppel, 2008; Wlotko & Federmier, 2015).

Yn y maes dwyieithrwydd, mae modelau ar hyn o bryd yn canolbwyntio ar brosesu geiriau unigol, ac mae cyd-destun ieithyddol wedi'i dangynrychioli hyd yma (van Hell, 2018). Gwyddom ei fod yn rhoi cryn ddylanwad ar weithrediad ieithyddol dwyieithog, gan ragfarnu'r system iaith yn aml i gydnabod a chynhyrchu geiriau mewn ffordd iaith-benodol (Egan, Oppenheim, Moll, Saville, & Jones, 2019; Bultena, Dijkstra, & van Hell, 2014; Schwanenflugel & Shoben, 1985; Foucart, Martin, Moreno, & Costa, 2014; Schwartz & Van Hell, 2012; Van Hell & De Groot (2008), Schwartz & Kroll (2006); Duyck et al (2007). Er hyn, mae un corff tystiolaeth yn dod i'r amlwg sy'n awgrymu efallai na fydd prosesau rhagfynegol yn gweithredu yn yr un modd ar draws

ieithoedd; mae'r canfyddiadau'n awgrymu bod prosesau rhagfynegol yn cael eu defnyddio i raddau mwy, neu o leiaf yn fwy effeithlon yn L1. Er enghraifft, nododd Martin et al. (2013) frawddegau lle'r oedd y gair olaf naill ai'n rhagweladwy iawn ai peidio i unigolion uniaith Saesneg a rhai dwyieithog Sbaeneg-Saesneg hwyr. Er bod y grŵp uniaith yn dangos effaith N400 glasurol, gyda thon barhaus fwy negyddol ar gyfer geiriau anrhagweladwy, ni ddangosodd y grŵp dwyieithog unrhyw wahaniaeth N400 ar draws amodau. Mae'r awduron yn ei ddehongli fel gallu gwannach i ragfynegi'r gair sydd ar fin ymddangos yn L2 o'i gymharu â L1, o ganlyniad i oedi wrth brosesu ieithyddol.

Yn gyson â'r canfyddiadau hyn, gwelir bod troseddau disgwyliad semantig dwyieithog yn cael eu gohirio ac yn fwy amlwg yn L2 (Ardal, Donald, Meuter, & Muldrew, 1990; Kutas & Kluender, 1994; Weber-Fox & Neville, 1996), sy'n awgrymu fod pobl ddwyieithog yn arafach i werthfawrogi fod gair ddim yn cyd-fynd â chyd-destun y frawddeg (Moreno & Kutas, 2005) o bosibl oherwydd mwy o anawsterau integreiddio semantig (Hahne & Friederici, 2001). Er mwyn profi a all rhuglder (Ardal, Donald, Meuter, & Muldrew, 1990) neu oedran yr amlygiad (Webber-Fox & Neville, 1996) fodiwleiddio'r effaith hon, cyflwynodd Moreno & Kutas (2005) ddwyieithrwydd Sbaeneg-Saesneg, a oedd naill ai'n ddysgwyr L2 cynnar neu hwyr, gyda brawddegau Saesneg a Sbaeneg derbyniol ac annerbyniol. Arweiniodd troseddau semantig at effeithiau N400 mwy o gymharu ag eitemau cyfathrach semantig waeth beth oedd goruchafiaeth iaith. Fodd bynnag, cynhyrchodd yr effaith cyfarthiant effaith N400 wedi'i gohirio yn L2 i'r ddau grŵp, gan awgrymu prosesu L1 cyflymach hyd yn oed mewn pobl ddwyieithog gynnar, hyfedr iawn.

Er bod y canfyddiadau hyn yn awgrymu anghymesuredd prosesu rhwng brawddegau semantig cyfathrach ac anghydweddol yn L2, canfuwyd bod prosesu brawddegau semantig ystyrlon hefyd yn fwy ymdrechgar yn yr iaith anfrodorol o'i chymharu â'r iaith frodorol (Hahne, 2001; Hahne & Friederici, 2001). Canfu Hahne & Friederici (2001) fwy o bositifrwydd yn ffenestr amser P600 (cydran ERP gadarnhaol sy'n nodi ail-ddadansoddi brawddegau; gweler y bennod fethodolegol am adolygiad) i frawddegau semantig ystyrlon ac anghyson mewn siaradwyr anfrodorol o gymharu â siaradwyr brodorol. Mae'r canlyniadau hyn yn awgrymu, waeth beth fo synhwyriad eu hystyr, bod angen ymdrech ychwanegol i brosesu yn yr ail iaith gan awgrymu mynediad cysyniadol mwy ymdrechgar yn yr iaith anfrodorol o'i chymharu â'r iaith frodorol.

Felly, ymddengys bod prosesu iaith anfrodorol yn dilyn cwrs amser a phroses ddeall gwahanol mewn perthynas â'r iaith frodorol ac â siaradwyr uniaith (Moreno, Rodriguez-Fornells, & Laine, 2008). Pam gallai hyn fod? Un esboniad posibl yw bod dod i gysylltiad yn amlach â llinynnau geirfaol penodol yn L1 yn arwain at actifadu'r digwyddiadau wrth gefn hyn yn fwy ar ddatguddiadau dilynol, yn debyg i'r tebygolrwyddau trosiannol a ddisgrifir mewn modelau dysgu iaith (‘*transitional probability’* ee, Elman, 1990; Dell & Chang, 2014). Byddai dod i gysylltiad â llinynnau penodol yn L2 yn llai aml yn arwain at lai o actifadu, gyda llai o gyfle i ragfynegi geiriau sydd ar fin ymddangos. O dan y cyfrif hwn, gall cyrchu sylwadau semantig ar-lein fod yn gymharol aneffeithlon neu orhuedig yn L2.

Am hynny yn Rhan 1 o'r traethawd ymchwil hwn rydym yn archwilio a yw canfod torri semantig mewn brawddegau ar-lein yn fwy effeithlon yn L1 nag yn L2. Ail nod yw archwilio gwahaniaethau posibl yn yr effeithlonrwydd y mae pobl ddwyieithog

yn mapio cynrychioliadau cysyniadol wrth brosesu brawddegau. I'r perwyl hwn, defnyddiwyd brawddegau llythrennol a ffigurol, y gellir deillio ystyr y frawddeg yn uniongyrchol neu'n anuniongyrchol yn eu tro. Felly mae iaith ffigurol yn cyflwyno cyd-destun lle mae'r frawddeg yn ystyrlon, ond mae cyrchu ystyr yn llai syml nag sy'n wir am iaith lythrennol. Yn yr adran nesaf, byddaf yn crynhoi'r llenyddiaeth sylweddol ar drosiad cyn disgrifio sut y defnyddiwyd iaith lythrennol a throsiadol yn benodol yn ein harbrofion.

1.3.2 Iaith lythrennol a ffigurol

Mae ffocws dwys ar iaith lythrennol mewn ymchwil sydd yn bychanu’r ffaith bod iaith bob dydd yn llawn o ymadroddion an-lythrennol (Citron, Cacciari, Kucarski, Beck, Conrad, & Jacobs, 2016), ac mewn gwirionedd, defnyddir tua chwe mynegiad trosiadol y funud (Polio, Barlow, Fine, & Pollio, 1977). Mae trosiad, fel math o iaith ffigurol, yn digwydd pan gymhwysir gair at wrthrych neu weithred nad yw'n berthnasol iddo yn llythrennol, sy'n ei gwneud yn ofynnol i fynd y tu hwnt i ystyr confensiynol gair a mapio dau gysyniad neu fwy i'w gilydd trwy gynrychioliadau cyffredin i'r ddau (Citron et al, 2016; Landau, Keefer, a Meier, 2010; Rapp, Leube, Erb, Grodd, Kircher, 2004). Er enghraifft, yn y datganiad: *O'r galon unig y daeth floedd*, mae'r ystyr lythrennol yn ffôl, gan na all galon grio. Serch hynny, daw'r datganiad yn ystyrlon pan ystyrir y cysyniadau hyn yn ôl eu priodweddau sy'n gorgyffwrdd, megis *emosiwn*, *cyfathrebu anhapusrwydd*, ac ati (Lai, Curran, a Menn, 2009; Rapp, Leube, Erb, Grodd, Kircher, 2004). Cyferbynnwch y datganiad trosiadol hwn â’r datganiad llythrennol: *O'r babi unig ddaeth floedd*, lle gellir mapio *babi* a *chrio* yn syml (yn llythrennol) i’w gilydd. Felly, mae iaith

drosiadol yn ei gwneud yn ofynnol i unigolion gysylltu dau gysyniad sy'n ymddangos yn anghysylltiedig ar sail eu nodweddion sy'n gorgyffwrdd (Bambini, Bertini, Schaeken, Stella a Russo, 2016; Cardillo et al, 2010; Lai, Curran, & Menn, 2009; Rapp, Leube , Erb, Grodd, Kircher, 2004; Pynte, Besson, Robichon, & Poli, 1996). Felly, gall trosiadau o bosibl daflu goleuni ar y berthynas gymhleth rhwng yr haenau cynrychiolaeth eirfaol a semantig (Bolognesi, 2016).

O ystyried cymhlethdod cymharol iaith ffigurol, rhagdybiaeth gyffredin, a gefnogir hefyd gan dystiolaeth empeiraidd, yw bod ystyr lythrennol yn cael ei chyrchu a'i gwrthod yn gyntaf, cyn ystyried yr ystyr ffigurol (Citron et al, 2016; Gibbs, & Colston, 2006; Glucksberg, 2003). Er bod iaith drosiadol yn aml yn arwain at amseroedd ymateb hirach mewn tasgau deall brawddegau, mae canfyddiadau eraill yn awgrymu bod modd cyrchu ystyr trosiadol mor hawdd ag ystyr lythrennol (Bambini et al, 2016; Glucksberg, 2003), gyn bellad â bod y cynrychiolwyr o lefelau amlygrwydd semantig tebyg (cf. *The graded salience hypothesis*, Giora, 1997; De Grauwe et al, 2010; Glucksberg, 2003). Mae amlder defnydd hefyd yn penderfynu a oes mynediad at ystyr trosiadol ai peidio heb droi at wrthod ystyr llythrennol yn gyntaf. Gellir cyrchu trosiadau confensiynol fel *ideas are food* / *food for thought* yn unol ag iaith lythrennol, ond mae trosiadau newydd fel *theories are fathers / the father of a theory* yn gofyn am adeiladu cysylltiadau cysyniadol gwahanol ar-lein ac felly mwy o ymdrech brosesu (Lai, Curan & Menn, 2009; Rataj , 2014; Rataj, Przekoracka-Krawczyk, & Lubbe, 2018). Credir, gyda defnydd aml, bod synnwyr cyffredinol newydd yn cael ei gaffael, a gellir ei gyrchu'n uniongyrchol, yn ychwanegol at yr ystyr benodol wreiddiol (Lai, Curran & Menn, 2009). Mae'r caffaeliad uniongyrchol yma yn digwydd pan fo'r trosiad yn cael ei sefydlu yn y lecsicon

(lexicalized) drwy ddefnydd parhaol, sydd yn arwain at eiriau yn cael eu cysylltu ag ystyr llythrennol a throsiadol (Geiger & Ward, 1999).

Mae’r llenyddiaeth ERP yn darparu cefnogaeth gymysg ar gyfer mynediad trosiad anuniongyrchol yn erbyn uniongyrchol. Mae astudiaethau sy'n cefnogi'r model anuniongyrchol yn adrodd am fodiwleiddiadau anghymesur o N400-P600 (Bambini et al, 2016; De Grauwe et al, 2010; Coulson & Van Petten, 2002). Er enghraifft, canfu de Grauwe et al (2010) effaith N400 gynnar bach i drosiadau cyfarwydd o gymharu â brawddegau llythrennol, gan awgrymu, er y cyrchwyd yr ystyr trosiadol, roedd modylu mwy o'r gydran gadarnhaol hwyr dilynol (LPC: 550-750ms) yn dangos gwrthdaro rhwng y dehongliad llythrennol annhebygol a'r ystyr trosiadol credadwy. Ar y llaw arall, mae canfyddiadau sy'n cefnogi'r farn uniongyrchol yn dangos modiwleiddiadau N400 mwy i frawddegau trosiadol: “*Those fighters are lions*” nag i frawddegau llythrennol: “*Those animals are lions*” (Pynte, Besson Robichon a Poli, 1996), sy'n awgrymu er ei fod yn fwy ymdrechgar i gael gafael ar ystyr trosiadol, caiff ei ddatrys serch hynny yn ystod mynediad semantig ar-lein ac nid yw'n arwain at brosesau ail-ddadansoddi mwy (Coulson & Van Petten, 2007; Bambini et al, 2016). Yn yr un modd â chanfyddiadau ymddygiadol, gall amlder neu ‘gonfensiwn’ y trosiad hefyd fodiwleiddio mynediad semantig ar-lein. Dangosodd Lai, Curran & Menn (2009) osgledau N400 mwyaf i frawddegau anghyson, trosiadau nofel, a throsiadau confensiynol o gymharu â brawddegau llythrennol. Yn y ffenestr N400 ddiweddarach (440-560 ms), roedd osgledau i drosiadau confensiynol yn cyd-fynd ag osgled brawddegau llythrennol, tra bod trosiadau newydd a brawddegau anghyson yn arwain at negyddiaeth N400 barhaus. Felly, er bod trosiadau confensiynol hyd yn oed yn gofyn am rywfaint o brosesu semantig ychwanegol ac ychydig yn hwyrach

o'i gymharu ag iaith lythrennol, mae trosiadau newydd yn gofyn am lefelau mwy sylweddol o ymdrech, yn debyg i'r hyn sy'n ofynnol wrth brosesu brawddegau anghyson.

Hyd yn hyn, ychydig a wyddys am sut mae iaith ffigurol yn cael ei phrosesu ar-lein mewn ail iaith. Ac eto, gall trosiad fod yn offeryn defnyddiol iawn i archwilio sut mae mapio cysyniadol yn cael ei gynnal yn yr iaith gyntaf a'r ail iaith. Gan ddefnyddio ERPs, ymchwiliodd astudiaeth ddiweddar ymatebion ‘dwyieithog’ i barau geiriau trosiadol newydd, trosiadol gonfensiynol, llythrennol ac anghyson yn yr iaith gyntaf (Pwyleg) ac ail iaith (Saesneg; Jankowiak, Rataj, & Naskrecki, 2017). Canfu'r astudiaeth fod pobl ddwyieithog hwyr yn ymateb i drosiadau nofel a chonfensiynol yn yr un modd yn eu hail iaith (wedi'u mynegi gan osgledau tebyg o'r gydran gadarnhaol hwyr; LPC). Yn yr iaith frodorol (o fewn yr un ffenestr amser), roedd yr un bobl ddwyieithog yn arddangos ymdrech brosesu barhaus yn unig ar gyfer trosiadau newydd. Mae'r canfyddiadau hyn yn awgrymu bod prosesu anfrodorol yn golygu gostyngiad mewn awtomatigrwydd a sensitifrwydd i gonfensiwn ystyron trosiadol.

Mae'r dull o ymchwilio i barau geiriau a ddefnyddir fodd bynnag, fel y trafodwyd yn flaenorol, yn anghynrychioliadol o brosesu iaith naturiol (Egan, Oppenheim, Moll, Saville, & Jones, 2019; Bultena, Dijkstra, & van Hell, 2014; Schwanenflugel & Shoben, 1985; Foucart, Martin, Moreno, & Costa, 2014; Schwartz & Van Hell, 2012; Van Hell & De Groot (2008), Schwartz & Kroll (2006); Duyck et al (2007)). Er mwyn osgoi rhagfarnu'r unigolion, yma, rydym yn defnyddio iaith drosiadol mewn cyd-destun gan ddefnyddio brawddegau cyflawn.

I grynhoi, mae modelau cyfredol dwyieithrwydd yn canolbwyntio ar gydnabod a chynhyrchu geiriau ar y lefel eirfaol, a disgrifir cynrychioliadau cysyniadol yn

gyffredinol yn nhermau cysylltiadau geirfa-semantig. Mae Rhan 1 o'r traethawd ymchwil hwn yn archwilio gwahaniaethau L1 a L2 posibl yn y modd y mae pobl ddwyieithog yn cynnal mapio rhyng-gysyniadol, mewn ymgais i ddatgelu a ellir cyflawni integreiddio cynrychioliadau cysyniadol lluosog yn haws yn L1 nag yn L2. I'r perwyl hwn, mae Arbrofion 1a ac 1b (Pennod 4) ac Arbrawf 2 yn cymharu prosesu brawddegau dwyieithog L1 a L2 ar gyfer iaith anghyson, lythrennol a throsiadol.

1.4 Rhan 2 ~ Mapio rhyng-synnwyr mewn pobl ddwyieithog

Tra bod Rhan 1 o'r traethawd ymchwil hwn yn ymwneud â mapio cysyniadol dwyieithog *o fewn* L1 a L2, mae Rhan 2 yn archwilio'r dystiolaeth ar gyfer cyd-actifadu cynrychioliadau cysyniadol *rhwng* ieithoedd. Mae corff mawr o ymchwil bellach yn bodoli i ategu'r farn ddetholus iaith sy'n awgrymu na all pobl ddwyieithog rwystro geiriau a strwythurau cystrawennol yn yr iaith anfwriadol, hyd yn oed o fewn cyd-destunau uniaith (Kroll & De Groot, 2005; Thierry & Wu, 2004;2007; Schwartz & Van Hell, 2012; Gollan, Froster & Frost; Hoshino & Kroll, 2008; Starreveld, De Groot, Rossmark, & Van Hell, 2014; Schoonbaert, Duyck, Brysbaert, & Hartsuiker, 2009; Hartsuiker, Pickering, & Veltkamp, 2004; Vaughan-Evans, Kuipers, Thierry, Jones, 2014; Van Hell & Dijkstra, 2002). Yn Rhan 2, gofynnaf os yw cyd-actifadu o'r fath hefyd yn digwydd ar lefel y gynrychiolaeth gysyniadol. Mewn geiriau eraill, os yw’r cynrychiolwyr sy'n unigryw i un iaith yn cydweithredu'n ddigymell yn yr iaith anweithredol?

1.4.1 Cyd-actifadu iaith

Mae'r graddau y mae geiriau'n gorgyffwrdd ar draws ieithoedd yn amrywio'n sylweddol. Er bod rhai fel cytrasau (yn rhannu ffurf ac ystyr) yn gorgyffwrdd yn sylweddol, mae eraill ond yn gorgyffwrdd yn rhannol, megis homograffau rhyng-iaith (ffurf rhannu ond nid ydynt yn cyfateb i gyfieithu), a chymdogion orthograffig (mae'r ffurf eirfaol yn debyg i'r ffurf darged). Mae'r cwestiwn os yw pobl ddwyieithog yn actifadu cynrychioliadau o un iaith neu'r ddwy iaith yn gyfochrog yn ystod deall iaith, wedi bod o ddiddordeb mawr i ymchwilwyr iaith yn ystod y blynyddoedd diwethaf.

Mae'r farn ddethol iaith yn rhagdybio bod pobl ddwyieithog yn actifadu ymgeiswyr geiriau o'r iaith weithredol yn unig (Macnamara & Kushnir, 1971). Yn unol â hynny, mae presenoldeb cyfieithiad sy'n gorgyffwrdd yn unig yn amherthnasol i brosesu targed penodol; yn debyg i brosesu uniaith (Kroll & Tokowicz, 2005). Er enghraifft, byddai'r geiriau Saesneg *'lip'* neu '*apple*' yn cael eu prosesu gan ddwyieithwr Iseldireg-Saesneg yn ddiamwys, heb ymyrraeth o'u cyfieithiad Iseldireg '*lip*' ac '*appel'* (van Hell & de Groot, 2008). Mae'r dystiolaeth, fodd bynnag, yn awgrymu'r gwrthwyneb. Mewn gwirionedd mae geiriau cytras yn cael eu cydnabod a'u prosesu'n gyflymach na'r rhai nad ydynt yn gytras pan gânt eu cyflwyno yn yr iaith frodorol ac anfrodorol (van Hell & Dijkstra, 2002; Costa et al., 2000; de Groot & Nas, 1991; de Groot et al. , 2000; Dijkstra et al., 1998; Dijkstra et al., 1999).

Mae cydnabod geiriau cytras yn gyflymach yn awgrymu bod cynrychioliadau ar lefel geiriau o'r ddwy iaith yn cael eu gweithredu ochr yn ochr (van Hell & de Groot, 2008). Felly, mae'r farn an-ddetholus iaith yn credu bod cynrychioliadau yn y ddwy iaith yn cael eu gweithredu ar yr un pryd. Mae nifer yr achosion o dystiolaeth sy'n cefnogi'r

farn an-ddetholus yn sylweddol, gan olygu bod y farn iaith-ddetholus yn unig yn gynrychiolaeth gamarweiniol o fynediad iaith mewn pobl ddwyieithog (Dijkstra, van Jaarsveld, & Brinkle, 1998; Brysbaert, van Dyck, & van de Poel, 1999; Costa, Caramazza, & Sebastia´n-Galle´s, 2000; Costa, Miozzo, & Caramazza, 1999; de Groot, Delmaar, & Lupker, 2000; Dijkstra, Grainger, & van Heuven, 1999; Dijkstra, van Jaarsveld, & ten Brinke, 1998; Gollan, Forster, & Frost, 1997; Jared & Kroll, 2000; van Hell & Dijkstra, 2002; van Heuven, Dijkstra, & Grainger, 1998; Von Studnitz & Green, 2002).

Mae'r mater a yw geiriau o'r iaith arall yn gydweithredol yn ddigymell pan fydd dwyieithwyr yn gweithredu mewn un o'u hieithoedd yn unig, bellach wedi'i hen sefydlu ar y lefel eirfaol. Er enghraifft, mae tystiolaeth ymddygiadol yn cynnwys hwyluso ar gyfer adnabod geiriau pan fo'r targed yn gyfwerth â chyfieithiad y preim ('*doctor*' - '*arts*' (doctor yn Iseldireg)) na phan fo preim a tharged yn gysylltiedig yn semantig (‘*doctor’ – ‘nurse’*) neu'n anghysylltiedig (‘*doctor’ – ‘fish’*; Kroll and Sholl, 1992; Tzelgov ac Eben-Ezra, 1992; Keatley et al., 1994). Ar ben hynny, mae amseroedd ymateb mewn tasgau penderfyniad geirfaol yn gyflymach pan fydd y targed (ee, '*money*') yn homograff rhyng-eiriol o'r preim Ffrengig (ee, '*coin*', sy'n golygu cornel, ond hefyd yn uned arian cyfred yn Saesneg) o'i gymharu â phreim Ffrangeg anghysylltiedig (ee, '*feuille*', sy'n golygu deilen; Beauvillain a Grainger, 1987). Cyflwynodd Thierry a Wu (2007) barau geiriau Saesneg i unigolion Tsieineaidd, yr oedd hanner ohonynt yn rhannu sillaf gyntaf wrth eu cyfieithu i Tsieinëeg (ee, mae'r geiriau Saesneg '*train*' a '*ham*' yn cyfieithu i *'huo che'* a *'huo tui'*). Cafodd y treialon hyn effaith preim, fel y nodwyd gan N400 gostyngedig i ailadroddiad cymeriad Tsieineaidd cudd, er nad oedd y treialon hyn yn cael unrhyw wahaniaeth o'r

fath ar y lefel ymddygiadol. Felly, roedd pobl ddwyieithog Tsieineaidd-Saesneg yn cyfateb yn ddigymell i gyfieithiadau Tsieineaidd, hyd yn oed mewn cyd-destun Saesneg uniaith.

Mewn astudiaeth ddiweddarach ymchwiliodd yr un awduron i ddylanwad falens emosiynol ar actifadu traws-ieithyddol digymell (Wu & Thierry, 2012). Gan ddefnyddio patrwm tebyg o ailadrodd sain Tsieineaidd cudd, gofynnwyd i'r cyfranogwyr farnu perthnasedd semantig geiriau a oedd yn bositif, yn negyddol neu'n niwtral yn eu falens emosiynol. Er bod geiriau Saesneg niwtral a chadarnhaol yn preimio eu cyfwerth cyfieithu Tsieineaidd, ni ddarganfuwyd unrhyw effeithiau o'r fath ar gyfer y geiriau falens negyddol. Felly, mae actifadu traws-ieithyddol mewn pobl ddwyieithog yn cael ei gyfyngu gan ysgogiadau a allai fod yn aflonyddu semantig (megis '*trais'*) sy'n gweithredu i atal mynediad llawn i gynrychioliadau geirfaol-semantig. Mae hyn yn awgrymu bod gwybodaeth semantig yn chwarae rhan bwysig mewn actifadu traws-ieithyddol. Yn wir, nid yw dewis geirfaol yn cynnwys orgraffau yn unig; os yw'r system yn gwbl ryngweithiol (McClelland & Rumelhart, 1981) yna bydd nodweddion ffonolegol, cystrawennol a semantig hefyd yn pennu actifadu.

Mae tystiolaeth hefyd yn cefnogi actifadu gwybodaeth gystrawennol ar draws iaith. Yn un o'r astudiaethau cyntaf i archwilio cydweithredu cystrawen, gofynnodd Hartsuiker, Pickering, & Veltkamp (2004) i bobl ddwyieithog Sbaeneg-Saesneg ddisgrifio cardiau i bobl ddwyieithog Sbaeneg-Saesneg eraill mewn gêm ddeialog. Roedd y cyfranogwyr yn tueddu i ddefnyddio'r un ffurf brawddeg â'r un a glywyd o'r blaen i ddisgrifio'u cerdyn. Defnyddiwyd brawddegau goddefol Saesneg yn aml ar ôl clywed brawddeg oddefol Sbaeneg, gan ddarparu tystiolaeth o friwio cystrawennol traws-

ieithyddol. Yn fwy diweddar, dangosodd Vaughan-Evans et al (2014) gan ddefnyddio ERP y gellir trosglwyddo rheolau morffosyntactig sy'n benodol i un iaith yn anymwybodol i'r iaith arall. Roedd ymatebion N400 dwyieithwyr Cymraeg-Saesneg i eiriau ffug a oedd wedi eu lleoli ar ddiwed brawddeg Saesneg, yn gwahanu pan oedd y geiriau ffug yn dilyn treiglad ffonolegol cyfreithiol y Gymraeg, ac yn digwydd o fewn cyd-destun morffosyntactig a fyddai'n ennyn treiglad yn Gymraeg. Mae cynrychioliadau cydweithredol ar y lefel eirfaol yn cydymffurfio â modelau dwyieithrwydd cyfredol a adolygwyd uchod (e.e., Dijkstra & van Heuven, 2002), er nad yw modelau o'r fath ar hyn o bryd yn gweithredu neu ddamcaniaethu'r sylfaen ar gyfer cydweithredu cystrawennol yn llawn.

Mewn cyferbyniad, mae actifadu digymell synhwyrau semantig yn cael ei danamcangyfrif ar hyn o bryd. Mewn system gwbl ryngweithiol, mae detholiad o ymgeiswyr geirfaol yn cael eu ddylanwadu gan wybodaeth semantig o gyd-destunau cyfagos sy'n cael eu bwydo yn ôl i'r lefel orthograffig (BIA + Dijkstra & van Heuven, 2002, ac effeithiau ataliol homograffau rhyng-iaith (Dijkstra et al., 1999; Mae Libben a Titone, 2009) yn awgrymu y gall gwybodaeth semantig y ddwy iaith fod yn weithredol ochr yn ochr. I archwilio mynediad awtomatig at wybodaeth semantig yn L1 a L2, cyfarwyddodd Martin, Dering, Thomas & Thierry (2009) ddwyieithrwydd Cymraeg-Saesneg i wneud penderfyniadau ynglyn a hyd geiriau mewn un iaith, wrth anwybyddu ysgogiad tynnu sylw - wedi'i drin yn unol â pherthnasedd semantig - gyda geiriau o'r iaith arall. Cafwyd hyd i breimio yn y ddwy iaith, gan awgrymu bod gwybodaeth ar lefel ystyr hefyd yn weithredol yn y ddwy iaith.

Yn Arbrawf 3 y traethawd ymchwil hwn, rydym yn archwilio cyd-actifadu ystyr mewn dwy iaith unigolion dwyieithog gan ddefnyddio cyd-destun brawddeg uniaith. Felly, mae ein hastudiaeth yn osgoi rhagfarnau cynhenid wrth gyflwyno dwy iaith ar yr un pryd, ac wrth dybio cywerthedd ystyr ar draws ieithoedd ar gyfer geiriau sengl. Rydym hefyd yn archwilio cyd-actifadu digymell synhwyrau semantig mewn pobl ddwyieithog trwy gyflwyno iaith idiomatig - sy'n benodol i un iaith - yn iaith arall yr unigolyn dwyieithog, sef yr iaith 'idiom-anghydweddol'.

1.4.2 Ymadroddion Idiomatig

Yn nodweddiadol mae ymadroddion idiomatig yn cynnwys cadwyn sefydlog o eiriau sy'n dynodi ystyr y gellir ei ddehongli'n llythrennol ac yn ffigurol; hy mae'r idiom Saesneg poblogaidd *'she was in hot water'* yn awgrymu cael ei boddi'n llythrennol mewn dŵr poeth, a bod mewn trafferth yn ffigurol (Carrol, Conklin, & Gyllstad 2016; Carol & Conklin, 2017; Beck & Weber, 2016; Beck & Weber, 2016). Mae tystiolaeth ddiweddar yn dangos bod ystyr ffigurol idiomau adnabyddus ar gael cyn yr ystyr lythrennol (Giora 1997; 2002; Libben & Titone, 2008; Rommers, Dijkstra & Bastiaansen, 2013; Siyanova-Chanturia, Conklin & Schmitt, 2011;), ac wedi eu sefydlu ar y lefel eiriol, gan fodoli fel unedau cyfan yn y geiriadur (Ortony et al., 1978; Swinney a Cutler, 1979; Cacciari a Tabossi, 1988.)

Fodd bynnag, mae iaith idiomatig yn aml yn benodol i iaith. Er enghraifft, mae gan yr idiom Gymraeg *roedd y ddynes yn het* ystyr *roedd y ddynas yn wirion* yn Gymraeg, er nad oes iddi unrhyw ystyr synhwyrol yn Saesneg. Felly gall idiomau a gyflwynir yn yr iaith anghydweddol a) gael eu prosesu yn yr un modd ag yn yr iaith

gyfathrach, os yw'r ystyr yn gydweithredol, neu b) yn cyflwyno oedi prosesu os yw ystyr yn cael ei actifadu yn unig ar ôl prosesu semantig ar-lein (efallai'n debyg i brosesu nofel neu idiom lai cyfarwydd; Carrol, Conklin & Gyllstad, 2016). Ymchwiliodd Carrol a Conklin (2017) i sut mae idiomau Tsieineaidd wedi'u cyfieithu yn cael eu prosesu gan siaradwyr Tsieineaidd brodorol pan ddaw ar eu traws yn L2 (Saesneg). Er bod cydnabyddiaeth yn arafach nag ar gyfer ystyron llythrennol, roedd siaradwyr brodorol Tsieineaidd yn gallu adnabod ffurf idiomatig L1 hyd yn oed pan ddaethpwyd ar eu traws yn L2. Mae'r awduron felly'n awgrymu, er bod yr idiomau Tsieineaidd wedi'u cyfieithu yn actifadu cynrychioliadau geirfaol L1, nid oedd gwybodaeth gysyniadol sy'n gysylltiedig â'r idiomau yn cael ei actifadu'n awtomatig. Fodd bynnag, ar hyn o bryd nid yw'n hysbys sut mae idiomau iaith frodorol yn cael eu prosesu yn ystod camau ar-lein semantig pan ddônt ar eu traws yn yr iaith anfrodorol.

Yn yr ail ran o’r traethawd ymchwil cyfredol, rydym yn defnyddio’r dull ERP i ymchwilio a yw synhwyrau ‘unigryw’ pob iaith yn gwbl ryngweithiol ac yn cael eu hactifadu heb unrhyw gost brosesu ganfyddadwy yn yr iaith idiom-anghydweddol. Neu, os yw oedi mewn prosesu yn arwydd bod synhwyrau iaith-unigryw yn cael eu hactifadu yn yr iaith anghydweddol yn unig ar ôl actifadu ystyr yn yr iaith gyfath. Yn Arbrawf 3 felly, byddaf yn cymharu pobl ddwyieithog Gymraeg-Saesneg a Saesneg uniaith wrth brosesu brawddegau Saesneg a gafodd eu trin i greu brawddegau a) synhwyrol a b) anghyson, sydd yn ffurfio amodau sylfaenol y gallwn gymharu a phrosesu c) idiomau Cymraeg wedi'u cyfieithu.

1.5 Crynodeb o’r Bennod

Yn y bennod hon, adolygais fodelau cyfredol o brosesu semantig dwyieithog, eu seiliau empirig a sut yr eglurir cynrychioliadau ar lefel geiriau. Bydd y traethawd ymchwil yn ymestyn ymdrechion ymchwil cyfredol trwy ganolbwyntio’n llwyr ar brosesu ar lefel brawddeg a bydd yn ceisio egluro ’(1) y mapio o fewn synnwyr (o fewn ieithoedd), a (2) mapio rhyng-synnwyr (rhwng ieithoedd) mewn unigolion dwyieithog. Mae'r bennod ganlynol yn amlinellu'r gweithdrefnau arbrofol, y methodolegau a'r ystyriaethau a ddefnyddir wrth gasglu data.

Pennod 2

Ystyrieuthau Methodolegol

Cydnabyddiaethau: Diolch i Awel Vaughan Evans a Yang Lee am eu cymorth yn ystod fy nghyfnod hyfforddiant ERP.

2.0 Trosolwg o'r Bennod

Mae'r bennod hon yn amlinellu tri prif fanylion methodolegol y traethawd ymchwil: 1) y poblogaethau targed dwyieithog, a'r mesurau hunan-adrodd a ddefnyddir i bennu hanes iaith, defnydd a hyfedredd pob cyfranogwr. 2) y rhesymeg dros ddefnyddio ERP i fynd i'r afael â'r cwestiynau ymchwil a amlinellwyd yn y bennod flaenorol, gan gynnwys adolygiad byr o'r ddwy gydran o ddiddordeb (N400 a P600), a thrafodaeth ar sut y defnyddiwyd y dull hwn mewn astudiaethau o iaith ffigurol. 3) ystyried priodweddau naturiol iaith lythrennol a ffigurol, gan gynnwys gwahaniaethau ar nifer o ffactorau. At y diben hwn, byddaf yn cyflwyno astudiaeth normio a oedd yn allweddol wrth lywio ein dewis o ddyluniad arbrofol yn yr arbrofion.

2.1 Cyfranogwyr: y boblogaeth ddwyieithog Gymraeg-Saesneg

Tynnwyd ein poblogaeth o bobl ddwyieithog o gymuned Gymraeg-Seisnig yng Ngogledd Cymru. Byddaf yn awr yn manylu ar ddemograffig y boblogaeth hon.

Mae’r Gymraeg yn cael ei hystyried yn iaith leiafrifol (Martin, Dering, Thomas, & Thierry, 2009), ac yn ôl Cyfrifiad yr Iaith Gymraeg (Swyddfa Ystadegau Gwladol, 2011) dim ond 19% o boblogaeth gyffredinol Cymru sy'n siarad yr iaith. Er hynny, mae ei chyffredinrwydd yn llawer mwy wrth edrych ar siroedd unigol (65% yng Ngwynedd), a hyd yn oed yn fwy o fewn rhanbarthau penodol yng Ngogledd-orllewin Cymru (86% yng Nghaernarfon er enghraifft). O ran addysg, o yng Ngwynedd (ble mae ein poblogaeth ddwyieithog bresennol yn deillio ohoni), mae’r mwyafrif yr ysgolion yn rhai cyfrwng Cymraeg yn bennaf (84 Cymraeg; yn unol a pholisi iaith y sir; Gwynedd Council, 2016)

a'r gweddill naill ai'n ddwyieithog (12) neu’n Saesneg yn bennaf (2; Welsh Government, 2019/20). Mewn ysgolion cyfrwng Cymraeg, mae'r hyfforddiant yn Gymraeg yn bennaf, ond cyflwynir Saesneg fel pwnc ail iaith yn ystod cyfnod olaf y blynyddoedd sylfaen (6-7 oed), ac mae mwy o ffocws ar ddefnyddio'r Saesneg wrth i'r ysgol fynd yn ei blaen. (Cynllun strategol Cymraeg mewn Addysg Gwynedd 2017-2020, 2017). Felly, ar gyfer pobl ddwyieithog Gymraeg L1 frodorol (sy'n derbyn y Gymraeg gartref yn bennaf), mae'r system addysg, y gymuned ddwyieithog, a chyffredinrwydd cyfryngau Saesneg, yn golygu y bydd y mwyafrif yn cyrraedd a lefel uchel iawn o hyfedredd Saesneg L2 (Gathercole, 2007). Yn yr un modd, ar gyfer iaith frodorol L1 Saesneg ddwyieithog (sy'n derbyn Saesneg gartref yn bennaf), mae'r cyfansoddiad addysgol a chymdeithasol yn sicrhau y bydd y plentyn yn debygol o gyrraedd lefel uchel o hyfedredd L2 (Cymraeg) yn ifanc. Mae bodolaeth nifer fawr o siaradwyr Cymraeg / Saesneg L1 a L2 (ond pob un â lefelau hyfedredd uchel iawn) yn golygu bod archwilio sut mae statws L1 / L2 yn effeithio ar brosesu iaith ffigurol yn bosibl. Yn yr adran ganlynol, rwy'n manylu ar y modd y gwnaethom ddarganfod statws a hyfedredd dwyieithog yn y ddwy iaith.

2.1.1 Oedran Caffaeliad

Mae natur y boblogaeth ddwyieithog yng Nghymru yn peri penbleth diddorol o ran categoreiddio unigolion ar sail oedran caffael L2. Mae ymchwil yn dangos bod sgiliau iaith ddwyieithog yn gysylltiedig yn gryf â phrofiadau ieithyddol gartref (Scheele, Leseman, & Mayo 2010) a bod mwy o amlygiad i Gymraeg yn arwain at sefydlu strwythurau a geirfa yn gynharach (Gathercole, 2007). Felly, Wrth geisio categoreiddio pobl ddwyieithog yn gydamserol (simultaneous) neu ddilyniannol (sequential), mae’n

hanfodol ystyried dau ffactor; 1) pryd mae amlygiad iaith yn dechrau, a 2) y cyd-destun y mae iaith yn cael ei gaffael ynddo (De Houwer, 1990, 2009). Ar gyfer ein cyfranogwyr ni, dechreuodd gaffaeliad yr ail iaith wedi caffaeliad rhannol L1 mewn plentyndod cynnar o fewn lleoliadau addysgol, Gyda hyn mewn golwg, rydym wedi ystyried yn ofalus sut y gall cyd-destun caffael ail iaith (h.y., o fewn amgylchedd yr ysgol) wahaniaethu'r gwahanol brofiadau caffael Cymraeg yn well, gyda llai o bwyslais ar ffiniau oedran.

Bu i’n boblogaethau dwyieithog gaffael eu hail iaith yn ifanc iawn; 4.7 (arbrawf 1a), 3.8 (arbrawf 1b), 2.6 (arbrawf 2), 3.3 (arbrawf 3) ac am y rheswm hwn, rydym yn categoreiddio ein cyfranogwyr fel pobl ddwyieithog gynnar. At hynny, gan na fu chaffael y ddwy iaith ochr yn ochr o enedigaeth, nid ydym yn categoreiddio'r sampl hon fel pobl ddwyieithog gydamserol, er bod oedran y caffaeliad yn gynnar iawn yn achos arbrawf 2 er enghraifft (M = 2.7). Nid yw oedran caffael mor gynnar yn sampl Cymraeg L2 yn syndod o ystyried bod y polisi iaith yng Ngwynedd yn anelu at sicrhau amlygiad i'r Gymraeg yn ystod blynyddoedd cynharaf addysg (ee meithrinfa a derbyniad; Gwynedd Council, 2016; Gwynedd Council, 2017).

At hynny, mewn ymgais i leihau gwahaniaethau dehongli rhwng cyfranogwyr, trafodwyd ac esboniwyd ystyr oedran caffaeliad i bob cyfranogwr unigol (fel yr awgrymwyd gan de Bruin, 2019). Yn benodol, fe'u cyfarwyddwyd i ystyried yr iaith / ieithoedd yr oeddent wedi eu hamlygu iddynt o'u genedigaeth, yn hytrach na'r oedran y dechreuodd cynhyrchiad iaith. Mynegwyd yn ein neges recriwtio hefyd ein bwriad i astudio unigolion o gartrefi Cymraeg yn unig (neu Saesneg yn unig), a chafodd unrhyw

un a nodwyd eu bod wedi eu hamlygu i ddwy iaith o'u genedigaeth eu diddymu cyn y dadansoddiad.

2.2 Mesurau hunan-adroddol

Mae’r holiadur hanes iaith yn fedur hunan-adroddiad a ddyluniwyd i gasglu gwybodaeth am gefndir iaith y cyfranogwyr, gan gynnwys oedran caffaeliad a sefyllfa dysgu pob iaith. Yn ogystal, mae'r mesur yn galluogi casglu data hyfedredd darllen, ysgrifennu, sgwrsio a deall ar gyfer pob iaith ar raddfa ‘*Likert’* gyda 10 pwynt (10 = hyfedr iawn, 1 = ddim yn hyfedr). Yn olaf, gofynnir i'r cyfranogwyr nodi canran yr amser y maent yn defnyddio'r Gymraeg a'r Saesneg, a pha mor aml y maent yn darllen, ysgrifennu, siarad, gwylio'r teledu, a gwrando ar radio a darlithoedd yn y ddwy iaith eto gan ddefnyddio graddfa *‘Likert’* a 10 pwynt (10 = bob amser, 1 = byth; gweler atodiad A). Nid oedd y cwestiynau yn ymestyn I ddefnydd iaith aelodau o’r teulu (megis rhieni) gan y diddymwud unrhyw gyfranogwyr a adroddwyd magwraeth dwyieithog (h.y. Cymraeg a Saesneg o’u genedigaeth)

Mae'r Mesur Hunaniaeth Ethnig Aml-grŵp (Multi-group Ethnic Identity Measure; MEIM; Phinney, 1992; Roberts, Phinney, Masse, Chen, Roberts, & Romero, 1999) yn fesur 12 eitem o hunaniaeth ethnig a diwylliannol. Gofynnwyd i'r cyfranogwyr nodi eu hunaniaeth ddiwylliannol (yn hytrach na hunaniaeth ethnig) ac ateb cwestiynau ynghylch eu hymgysylltiad, eu hymdeimlad o berthyn, a'u hymlyniad â'r gymuned ar raddfa ‘*Likert*’ gyda 4 pwynt yn amrywio o 1 = anghytuno'n gryf i 4 = cytuno'n gryf. Gweler atodiad B.

Defnyddiwyd y mesurau hyn i ddilysu ein meini prawf o ‘L1 Cymraeg’ neu ‘L2 Cymraeg’ ar gyfer y gwaith arbrofol a gasglwyd ym mhennodau empirig y traethawd ymchwil hwn. Diystyrwyd y rhai nad oeddent yn cwrdd â'r meini prawf ar gyfer yr arbrawf penodol cyn y dadansoddiad data. Roedd yr holiaduron hyn ar gael mewn Saesneg yn unig a cwblhawyd hwy cyn y weithdrefn arbrofol (10 munud).

2.3 Cofnodi electroffisiolegol

Mae electroencephalogram (EEG) yn fethodoleg anfewnwthiol a ddefnyddir i ganfod gweithgaredd trydanol a gynhyrchir yn yr ymennydd fel ymateb i gyflwyniad ysgogiad, trwy osod electrodau ar groen y pen. Cynhyrchir y gweithgaredd hwn gan ddau fath o symudiadau trydanol; yn gyntaf, pan fydd egni'n teithio ar hyd corff y niwron o bwynt dechreuad yr acson (corff y celloedd) i derfyn yr acson, ac yn ail, pan fydd niwrodrosglwyddyddion niwronau yn rhwymo i dderbynyddion y gellbilen postynaptig, a elwir yn botensial postynaptig (Stemmer & Whitaker, 2008; Luck 2014). Pan gofnodir cryn dipyn o weithgaredd niwronau lleol ar yr un pryd, mae'n bosibl crynhoi potensial y foltedd trwy gyfrifo'r gwahaniaeth rhwng y weithgaredd a ganfyddir ym mhob un o'r electrodau a roddir ar groen y pen, ac yr electrodau cyfeirio a daear (*reference and ground*). Gellir cofnodi gweithgaredd o'r fath mewn ymateb i ysgogiad neu ddigwyddiad penodol; a elwir yn Botensial sy'n Gysylltiedig â Digwyddiad (*Event Related Potensials*; ERP).

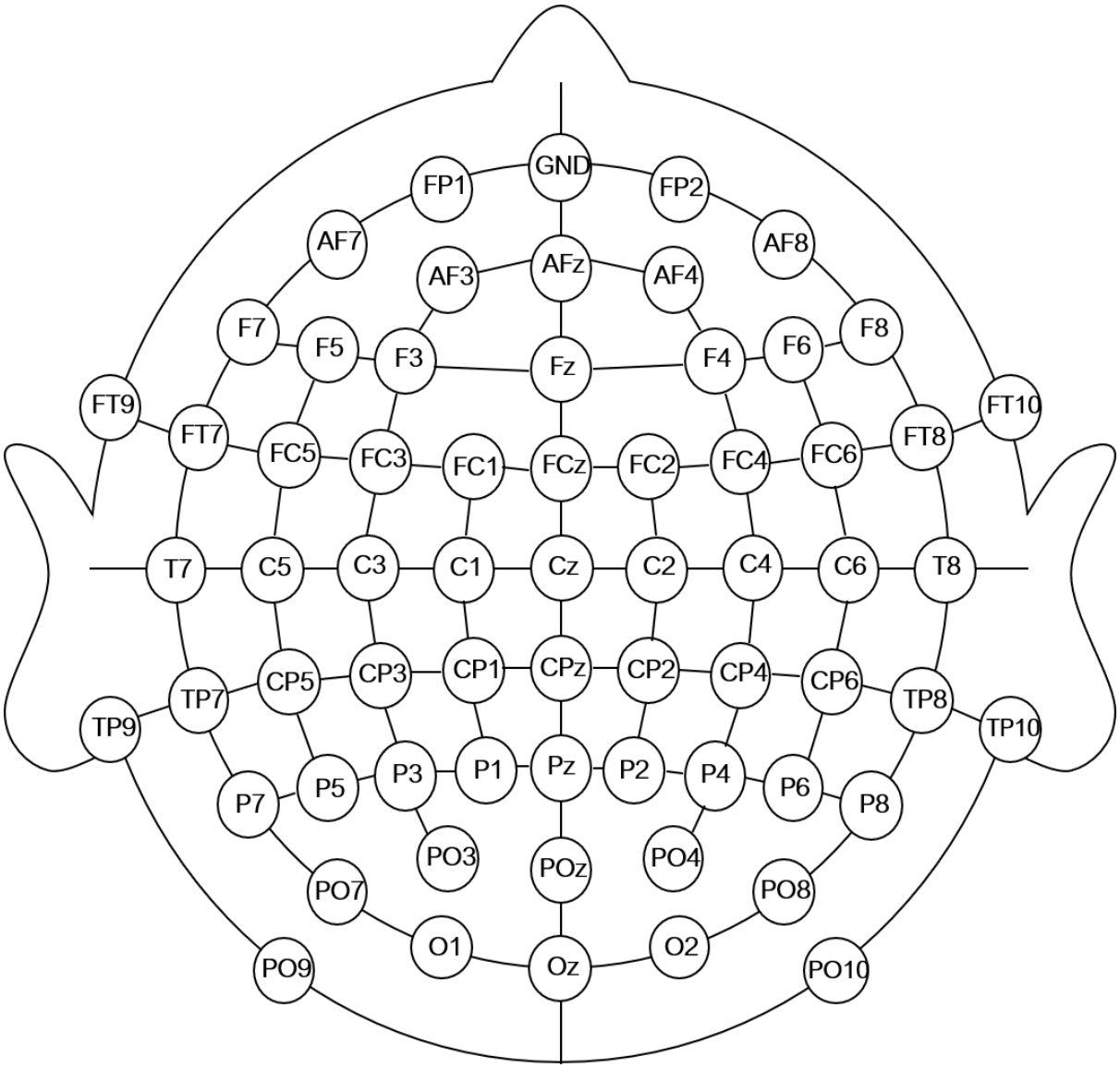
Y system EEG a ddefnyddiwyd i gasglu data ar gyfer y traethawd ymchwil cyfredol oedd cap 64-electrod (Gweler y ffigwr 7) gyda phedwar electrod ychwanegol yn

mesur blinciau a symudiadau llygad fertigol a llorweddol. Mae'r symudiadau hyn yn creu potensial trydanol sy'n lledaenu i'r ardal gyfagos, gan arwain at arteffactau yn y signal EEG a gofnodir gan electrodau ar flaen y pen (Luck, 2014). Felly mae sicrhau recordiad o'r signal hwn yn caniatáu cywiro'r data yn fathemategol.

Sefydlwyd cysylltiad rhwng croen y pen a'r cap gan ddefnyddio gel dargludol electro. Ar ôl sefydlu cysylltiad, cofnodwyd, ymhelaethwyd a samplwyd y gweithgaredd trydanol ar gyfradd o 1 pwynt data fesul milieiliad (1kHz). Defnyddiwyd hidlydd ar-lein (‘*online filter’*) gan ddefnyddio hidlydd band-basio (‘*band-pass filter’*) wedi'i osod rhwng 0.1 a 200 Hz. Yn ddiweddarach, cafodd y data ei hidlo oddi ar-lein gan ddefnyddio hidlydd sifft sero pasio isel (‘*low-pass zero-shift filter’*) gydag amledd torri i ffwrdd yn 20Hz, ac i leihau effeithiau gan ffynonellau allanol cafodd gweithgareddau sy'n fwy na + _75Uv eu taflu'n awtomatig. Cafodd arteffactau o’r lygad eu modelu a'u cywiro yn fathemategol gan ddefnyddio algorithm a gynigiwyd gan Gratton, Coles a Donchin (1983). Cynhaliwyd cywiriad sylfaenol *(‘baseline correction’*) i sicrhau nad oedd unrhyw wahaniaethau systematig rhwng amodau cyn cyflwyno’r ysgogiad. Er mwyn lleihau drifft a sŵn araf yn y data yn effeithlon (Tanner, Norton, Morgan, Short & Luck, 2016) awgrymir llinell sylfaen o 'ychydig gannoedd' milieiliadau (Alday, 2019) sydd yn 20% o'r cyfnod (*epoch*) cyffredinol (Luck, 2014); felly, yn y traethawd ymchwil cyfredol, defnyddiwyd cywiriad sylfaenol o -200. Yna cyfeiriwyd y signal a gofnodwyd (‘*re-referenced’*) at y cyfartaledd eang (‘*global average’*) er mwyn atal arteffactau trydanol wedi'u lleoleiddio i bob sianel (gan gynnwys y cyfeirnod CZ).

Tynnwyd gweithgareddau yn ymwneud â digwyddiadau penodol yr ysgogiad (‘*stimulus-locked events’*) o’r EEG parhaus gyda chyfnod (‘*epoch*’) yn amrywio o -200 i

1000ms ar ôl cychwyn yr ysgogiad. Bu cyfrifo cyfartaledd y digwyddiadau hyn yn ddiweddarach ar draws cyflwr a chyfranogwyr. Y cydrannau o ddiddordeb oedd yr N400 a P600, ac felly, cynhaliais ddadansoddiad data i'r cydrannau hyn ar wahân. Yn yr adran nesaf byddaf yn cyflwyno ac yn trafod y cydrannau hyn.



Ffigwr 7. Trefniant electrod 64 sianel a ddefnyddir ym mhob ymchwiliad empirig yn y traethawd ymchwil cyfredol.

2.3.1 Cydrannau ERP

Mae ERPau sy'n digwydd trwy gydol yr epoc o 1000 milieiliad yn ymddangos fel tonnau positif neu negyddol gyda cyfnod penodol. Cyfeirir at y rhain fel cydrannau ERP (Steinhauer, 2014). Mae'r cydrannau hyn yn rhoi gwybodaeth i ni am natur prosesu wrth iddo ddatblygu dros amser, gyda sawl cydran yn rheolaidd yn gysylltiedig â phrosesu iaith, gan gynnwys y P1 a'r N1. Mae'r cydrannau hyn yn adlewyrchu prosesau cynnar a lefel isel sy'n mynegi canfyddiad a sylw i ysgogiad (Luck, 2014), ond mae ein prif ffocws ar ddwy gydran ddiweddarach: yr N400 a'r P600.

2.3.2 N400: Elfen sydd wedi ei sefydlu yn dda iawn mewn llenyddiaeth ERP yw'r N400, a ddogfennwyd gyntaf gan Kutas & Hillyard (1980) ac sy'n cyrraedd uchafbwynt rhwng 300 - 500 ms dros safleoedd canolog-parietal ('*central-parietal'*). Ers ei ddarganfod, defnyddiwyd y gydran yn helaeth mewn ymchwil iaith, ac ystyrir ei bod yn mynegi prosesu semantig ar-lein (Kutas & Federmier, 2011). Yn benodol, mae cynlluniau sydd wedi'u dylunio i ennyn anghysondeb brawddeg neu air annisgwyl yn gyffredinol (o ran cyd-destun y frawddeg), yn ennyn ton fwy negyddol ar oddeutu 400 ms ar ôl yr ysgogiad. Gan ddefnyddio patrwm brawddeg synhwyrol yn erbyn anghyson, canfu Kutas & Hillyard (1980) fod terfyniadau geiriau anghydweddol *('I take coffee with cream and dog')* yn dangos osgled negyddol mawr tua 400 ms ar ôl y gair targed annisgwyl 'ci', o'i gymharu i reolaethau cyfathrach ('*I shaved off my moustache and beard'*) a therfynau geiriau annhebygol ('*he planted string beans in his car')* a oedd yn cynhyrchu osgledau canolradd. Mae'r canlyniadau hyn yn awgrymu bod yr N400 yn sensitif i droseddau semantig ac felly yn fynegiant o integreiddio semantig. Mae astudiaethau pellach sy'n

dangos sensitifrwydd y gydran i '*concreteness*' (Gomes et al. 1997) ac amlder / ailadrodd geiriau (Van Petten & Kutas, 1991; gyda geiriau concrit a chyfarwydd / amledd uchel yn ennyn osgledau N400 llai) yn awgrymu bod y gydran N400 yn adlewyrchu'r rhwyddineb o adalw gwybodaeth sy'n gysylltiedig â'r mewnbwn geirfaol o'r cof tymor hir (Kutas & Federmeier, 2000).

Yn bwysicach efallai ar gyfer y traethawd ymchwil cyfredol, mae cydberthynas uchel rhwng osgled yr N400 â disgwyliad geiriau a '*cloze probability'* (y tebygolrwydd y bydd brawddeg yn cael ei gwblhau gan air penodol fel y dangosir gan sampl o raddfeuwyr unigol; Kutas & Federmier, 2011; Van; Berkum, 2009; Brouwer et al, 2012). Yn benodol, mae astudiaethau wedi dangos bod darllenwyr a grandawyr yn defnyddio gwybodaeth gyd-destunol i ragfynegi geiriau sydd ar fin ymddangos (Federmeier, 2007) ac mae brawddegau sy'n dderbynniol yn semantig, ond yn gorffen mewn geiriau disgwyliedig isel (ee '*she was stung by a wasp'*) yn arwain at fodyliad mwy, mewn perthynas â terfyniadau mwy disgwyliedig (ee '*she was stung by a bee'*; Kutas & Hillyard, 1984; Luck & Kappenman, 2011). Mae'r sefyllfa'n cael ei chymlethu ymhellach gan y gwahaniaeth rhwng brawddegau '*cloze probability'* uchel ac isel. Mae rhai brawddegau yn gyd-destunol iawn gan osod cyfyngiadau ar botensial geiriau sydd ar fin ymddangos; e.e. byddai disgwyliad yn uchel i'r frawddeg '*I take my coffee with milk and'* ddod i ben gyda'r gair '*sugar*', tra bod cwblhau ar gyfer y frawddeg '*I ate the the'* yn llawer llai rhagweladwy. Bydd cwblhad annisgwyl or frawddeg '*I take my coffee with milk and',* ynghyd ag unrhyw gwblhad o'r frawddeg '*I ate the'* yn ymofyn integreiddio semantig mwy a gaiff ei adlewyrchu mewn osgled N400 mwy.

Yn yr un modd, mae ymchwil yn awgrymu bod iaith an-lythrennol (gan gynnwys trosiad) yn ennyn osgled N400 mwy, ac felly'n awgrymu ei bod yn anoddach integreiddio iaith an-llythrennol yn semantig (gweler pennod 1, adran 1.3.2 am drosolwg o'r lenyddiaeth). Fodd bynnag, mae Kutas a Federmeier (2011) yn egluro bod yr N400 i iaith ffigurol yn datblygu mewn modd tebyg a chyda phatrymau amseru tebyg i iaith lythrennol; yn benodol, maent yn datblygu yn yr un modd ag iaith lythrennol sy'n gofyn am fapio ac integreiddio (e.e. '*He used cough syrup as an intoxicant*') tebyg i frawddeg drosiadol (e.e. '*He knows that whisky is a strong intoxicant').*

Felly cynlluniwyd y brawddegau llythrennol a throsiadol a ddefnyddiwyd yn y traethawd ymchwil cyfredol i fod yr un mor isel o ran hygrededd a '*cloze probability'* i sicrhau bod brawddegau'n wahanol ar eu lefelau ffigurol yn unig. Bydd hyn yn caniatáu i ni ddisgrifio'n gywir sut mae iaith an-llythrennol yn cael ei brosesu mewn perthynas ag iaith llythrennol. Dychwelaf at y mater hwn yn hwyrach yn y bennod.

2.3.3 P600: Mae gan y P600 dopograffi ganolog-parietal ('*central-parietal'*), gan gyrraedd uchafbwynt bositif rhwng 500 - 800 ms ar ôl ysgogiad (van Herten, Kolk, a Chwilla, 2005). Mae osgledau positif uwch yn yr ystod y cyfnod hwn yn gysylltiedig â ail-ddadansoddi uwch, yn nodweddiadol mewn ymateb i ysgogiadau anghonfensiynol (Regel, Gunter, Friederici, 2011; Burkhardt, 2006). Felly, yn debyg i'r gydran N400, arsylwyd modyliad o'r P600 mewn ymateb i frawddegau anghyson yn semantig naill ai yn ddilynol i neu yn absenoldeb effaith N400 (Brouwer, Fitz, & Hoeks, 2012; Hoeks et al, 2004). Er mwyn dod i ystyr ddealladwy o droseddau semantig, mae'r unigolyn yn aml yn gorfod ymgymryd mewn prosesu ychwanegol a mwy ymdrechgar i ddatrys unrhyw

wrthdrawiad, a chreu cynrychiolaeth feddyliol gywir o'r hyn sy'n cael ei gyfleuu. O ganlyniad, mae prosesau o'r fath yn cynhyrchu cynnydd yn osgled y P600.

Yn y traethawd ymchwil cyfredol, gall y ddwy gydran hyn ddarparu gwybodaeth hanfodol ar y gwahaniaethau yng nghwrs amser ar gyfer prosesu brawddegau llythrennol a ffigurol. Yn benodol, sut mae prosesu ystyron ffigurol yn wahanol ar lefel prosesu semantig ar-lein (N400) neu yn ystod camau prosesu ôl-semantig, ail-ddadansoddi (P600). Yn ogystal, sut mae'r gwahaniaethau hyn yn newid fel swyddogaeth o ddeall y frawddeg yn L1 neu L2. Felly, mae ERP a gaiff eu hystyried ar y cyd â mesurau ymddygiad megis amseroedd ymateb a chywirdeb, yn rhoi cyfrif mwy cynhwysfawr o'r prosesau sy'n cyfrannu at ddeall iaith (Kutas & Federmier, 2011). At hynny, er y canfyddir yn aml bod modyliad o'r N400 yn wahanol i fesurau ymddygiad (Kutas & Federmier, 2011), mae'r P600 yn aml yn cydberthyn yn gadarnhaol ag amseroedd ymateb (Brouwer, Fitz, & Hoeks, 2012).

Fe wnaethom hefyd ystyried y ddadl bod arbrofion rheoledig yn gymharol isel o ran dilysrwydd oherwydd eu hamgylcheddau reolaeth uchel (Coolican, 2009). Er, ni allem newid yr amgylchedd rheoledig heb gyfaddawdu ar ansawdd yr ERP, mae ein defnydd o gyd-destun trwy frawddegau llawn yn adlewyrchu prosesu a darllen iaith naturiol i raddau uwch na defnyddio parau o eiriau megis yr hyn a ddefnyddir gan arbrofion iaith draddodiadol (fel yr awgrymwyd gan Van Hell & de Groot, 2008). Dylai hyn gynyddu dilysrwydd ecolegol ein harbrofion (Van Assche, Duyck, & Hartsuiker, 2016).

2.3.4 Ystyriaethau methodolegol astudiaethau ERP

Mae llond llaw o astudiaethau wedi defnyddio ERP er mwyn archwilio sut mae prosesau iaith lythrennol a throsiadol yn wahanol. Yn ffenestr amser yr N400, gwelir bod brawddegau ffigurol yn ennyn osgledau mwy o gymharu ag iaith lythrennol, sy'n arwydd o integreiddio semantig mwy ymdrechgar (Pynte et al, 1996; Coulson & Van Petten, 2002; Coulson & Van Petten, 2007; Tatter et al 2002; Lai et al, 2009). Fodd bynnag, mae osgledau P600 yn datgelu canfyddiadau anghyson. Er bod iaith ffigurol yn gyffredinol yn ennyn ymatebion P600 mwy, mae rhai astudiaethau'n adrodd am osgledau mwy i drosiad (De Grauwe, 2010), tra bod eraill yn nodi losgledau llai (Arzouan, 2007). Rwyf eisoes wedi adolygu canlyniadau damcaniaethol yr astudiaethau hyn ym Mhennod 1, ond fy mhwyslais yn y bennod hon yw archwilio ffenestri amserol a safleoedd topograffig yr astudiaethau ERP presennol, gan ganolbwyntio ar ddeall trosiad. Fel y dangosir yn Nhabl 1, mae'r safleoedd amserol a'r ffenestri amser a ddewisir mewn gwahanol astudiaethau yn amrywio'n sylweddol.

Tabl 1. Trosolwg o astudiaethau trosiadol ERP gan gynnwys ffenestri amser y cydrannau, ynghyd a safleoedd dosraniad y prif effeithiau a phrif ganfyddiadau.

Awduron	*Ffenestr Amser & safleoedd dosraniad*	*Canfyddiadau*
Bambini, Bertini, Schaeken, Stella, & Russo (2016)	• 320 – 440 ms: fronto-central, central & centro-parietal • 550 – 700 ms: parietal, parieto-occipital	• N400 a P600 mwy i drosiadol o gymharu â llythrennol

Yang, Bradley, Huq, Wu & Krawczyk (2013)	• 300 - 700 ms • 600 – 1200 ms • Quadrant analysis	• Dim N400 • Osgledau P600 mwy i amodau anghydweddol (llythrennol a throsiad) mewn perthynas â chyflwr cyfathrach (llythrennol a throsiad)
De Grauwe, Swain, Holcomb, Ditman, Kuperberg (2010)	• 325 – 400 ms • 400 – 500 ms • 550 – 750 ms • 750 – 900	• N400 cynnar i drosiad sy'n cyd-fynd â brawddegau llythrennol erbyn diwedd y cyfnod N400. • N400 i anghyson mewn perthynas â throsiadol a llythrennol • Mwy o LPC i drosiad o gymharu â llythrennol
Rataj, Przekoracka-Krawczyk, & Lubbe (2018)	• 300 - 500 ms: central & parietal sites • 500 - 800 ms: parietal sites	• Cynydd yn N400 i drosiad newydd o'i gymharu â brawddegau llythrennol • Gostyngiad P600 i drosiad newydd o'i gymharu â brawddegau anghyson
Lai, Curran & Menn (2009)	• 320 - 400 ms: Central sites • 440 - 560 ms: Central sites	• Modyliad N400 mwy i anghyson, trosiad newydd a throsiad confensiynol o gymharu â brawddegau llythrennol. • Yn ddiweddarach, mae trosiadau confensiynol yn cydgyfarfod â brawddegau llythrennol.
Bambini, Canal, Resta, & Grimaldi (2019)	• 300-500: midline, frontal • 600-900: frontal	N400 mwy a negyddiaeth yn parhau yn hwyrach i drosiad o gymharu â llythrennol
Schneider, Rapp, Haeubinger, Ernst, Hamm, Fallgatter & Ehlis, (2014)	• 300 - 500 ms • Left fronto-central • (Based on Duncan et al, 2009)	• N400 mwy i drosiadol o gymharu â llythrennol
Pynte, Besson, Robichon, & Poli (1996)	• 300 - 600 ms: central • 600 – 1000 ms	• N400 mwy i drosiad o gymharu â llythrennol • Dim gwahaniaethau mewn ffenestri amser diweddarach
Coulson & Van Petten (2007)	• 300 – 500 ms: Midline, dorsal, ventral • 600 – 900 ms: Midline, dorsal, ventral	• Mwy o N400 a negyddoldeb parhaus yn hwyrach i drosiadol o gymharu â llythrennol

O ystyried yr anghysondeb hwn ac absenoldeb rhesymeg yn gyffredinol yn y rhan fwyaf o'r astudiaethau a nodwyd, rydym yn seilio ein dewis electrod a ffenestr amser ar gyfer y traethawd ymchwil cyfredol ar y llenyddiaeth sefydledig ar gyfer pob cydran yn hytrach na'r llenyddiaeth drosiadol. Felly, mae'r safleoedd electrod N400 yn cynnwys blaen-ganolog, canolog a chanolog-parietal ('*fronto-central, central, a central-parietal'*; FC1 FCZ FC2, C1, CZ, C2, CP1, CPZ, CP2) ac mae ffenestri amser yn cynnwys yr amser N400 nodweddiadol (300-500) (Kutas & Hillyard, 1980; 1984; Thierry & Wu, 2007; Kutas & Federmeier, 2000; Kuipers, van Koningsbruggen, Thierry, 2013; Lau, Phillips, Poppel, 2008; Holcombe, 1993; Barber, Donamayor, Kutas, & Munte, 2010; West & Holcomb, 2002). Mae'r safleoedd a'r ffenestri amser hyn hefyd yn gorgyffwrdd yn bennaf â'r llenyddiaeth trosiad. Yn debyg, ar gyfer y P600 gwnaethom ddewis safleoedd electrod ('*central-parietal'*; CP1 CPZ CP2 P1 PZ P2) a ffenestr amser (500-800) sy'n gysylltiedig ag effeithiau iaith glasurol; er y dylid nodi nad yw'r gydran hon wedi'i sefydlu mor dda â'r N400.

Yn ogystal, mae astudiaethau sy'n archwilio ymatebion gwybyddol i drosiad yn aml yn methu sôn am y newidynnau allanol a allai ddylanwadu ar ddehongliad yng ngwahaniaethau mewn prosesu brawddegau llythrennol yn erbyn trosiad. Ymhlith y rhain mae gwahaniaethau cynhenid rhwng y mathau hyn o iaith, megis '*concreteness*' ac amlder er enghraifft (mae dehongli enwau ac ystyron mwy concrit, ac dehongliadau ag amledd uwch yn fwy nodweddiadol o iaith lythrennol; Cardillo et al., 2010). Felly mae sawl astudiaeth wedi ceisio adeiladu setiau brawddegau wedi'u normio, lle mae

brawddegau llythrennol a throsiadol yn cael eu paru mor agos â phosib (Cardillo, Schmidt, Kranjec, & Chatterjee, 2010; Nordmann & Jambozazova, 2017; Katz, Paivio, Marscark & Clark, 1988 Torreano, Cacciari, & Glucksberg, 2005). Er enghraifft, mewn ymgais i fynd i'r afael â chyfyngderau sy'n gysylltiedig â chreu ysgogiad, datblygodd Cardillo et al. (2010) set fawr o frawddegau trosiadol a llythrennol. Casglwyd mesuriadau helaeth arnynt, gan arwain at restr derfynol o 560 brawddeg. Ar y lefel geiriau, fe wnaethant gasglu gwybodaeth am *'concreteness'*, hyd, ac amlder gan ddefnyddio cronfeydd data seicoieithyddol ar-lein, ynghyd a graddfeydd cyfranogwyr. Ar lefel y frawddeg, fe wnaethant hefyd gasglu sgoriau goddrychol ar gyfarwydd, naturioldeb, delweddadwyedd, ffigurol a dealladwyedd. Yn bwysig, mae'r awduron yn nodi bod gwahaniaethau rhwng iaith lythrennol a throsiadol ar y mesurau hyn yn debygol o ddrysu dehongliad o brosesu trosiad, gan arwain at dystiolaeth sy'n gwrthdaro. Er bod arolygiad ar lefel geiriau (cymharu cymedrau) yn nodi graddfeydd tebyg ar gyfer hyd, '*concreteness*' ac amlder y ddwy fath o frawddeg, daeth gwahaniaethau pwysig i'r amlwg ar lefel y frawddeg. Yn benodol, barnwyd bod brawddegau llythrennol yn fwy cyfarwydd, naturiol a delweddadwy o'u cymharu â brawddegau trosiadol. Fodd bynnag, barnwyd bod brawddegau trosiadol yn fwy ffigurol. Ni adroddir ar unrhyw ystadegau casgliadol, ond mae'r awduron yn nodi bod anghysondebau mewn brawddegau llythrennol yn erbyn trosiadau yn gyson â nodweddion y mathau hyn o frawddegau. Yn ogystal, byddai'r gor-addasu brawddegau yn arwain at eitemau na sydd ddim yn gynrychioliadol. Maent yn argymell felly defnyddio cyd-amrywiadau lle mae diffyg cywerthedd o'r fath yn amlwg.

Ffactor ychwanegol a allai effeithio ar brosesu brawddegau yw rhagweladwyedd geiriau sydd ar fin ymddangos (Chou, Huang, Lee & Lee, 2014). Mae rhagweladwyedd yn cael ei bennu'n empirig cyn astudiaeth arbrofol gan ddefnyddio '*cloze probability'*, a bennir trwy gyfrifo canran y cyfranogwyr sy'n cwblhau brawddeg benodol gyda gair penodol (Taylor, 1953). Defnyddir y dull '*cloze probability'* yn gyffredin mewn astudiaethau ERP oherwydd bod rhagweladwyedd yn effeithio ar rhwyddineb prosesu semantig ac mae osgled N400 yn sensitif iawn i'r ffactor hwn (Chou, huang, Lee & Lee, 2014). Yn benodol, gwelir gostyngiad mewn osgled pan fydd geiriau'n hawdd eu rhagweld / yn uchel mewn '*cloze probability'* o gymharu â mwy o negyddoldeb ar gyfer geiriau sy'n anodd eu rhagweld / '*cloze probability'* isel (van Berkum, Hagoort, & Brown, 1999; Kutas & Hillyard, 1980a, 1980b, 1984; Van Petten & Kutas, 1990, 1991).

Wrth adeiladu setiau brawddegau sy'n addas ar gyfer y cwestiynau ymchwil cyfredol (ac y manylir arnynt ymhellach yn yr adran nesaf), gwnaethom geisio osgoi'r cyfyngiadau yma a chyfyngu ar unrhyw effeithiau o gyfyngiadau o'r fath. Felly gwnaethom lunio ein brawddegau fel bod a) yr un gair targed yn ymddangos ym mhob cyflwr (fel yn achos Cardillo et al 2010; 2012), b) roedd brawddegau'n union yr un fath ac eithrio geiriau pwnc (fel yn achos De Grauwe, 2010), c) ddim yn hollol ragweladwy (yn isel mewn '*cloze probability'*; yn unol â De Grauwe, 2010) ac ch) yn cyfateb o ran hygrededd. Gwnaethom graffu ar frawddegau llythrennol, yn benodol, er mwyn osgoi terfyniadau cwbl ragweladwy, a thrwy hynny sicrhau '*cloze probability'* a hygrededd tebyg â brawddegau trosiadol. Dylai hyn osgoi rhagfarn rhwng amodau, ond dylai hefyd ganiatáu digon o le i fodyliad yr N400, gan osgoi effeithiau nenfwd (cf. Ellis, Thierry, Vaughan-Evans, & Jones, 2017). Ceisiwyd cyflawni cywerthedd ar holl nodweddion y

brawddegau heb law am ffigurol. Byddai hyn yn ein galluogi i ddehongli ein canlyniadau yn ôl llythrennol a ffigurol yn unig a rheoli am yr elfennau o ddryswch a welir yn y llenyddiaeth gyfredol.I'r perwyl hwn, gwnaethom gynnal astudiaeth normio gymharol fawr cyn yr ymchwiliadau ERP (a gyflwynir isod). Rydym yn cyflwyno'r gwaith hwn yma, i ddangos dosbarthiad cyffredinol brawddegau llythrennol a throsiadol ar nodweddion seicoieithyddol amrywiol (h.y., sut roedd ein brawddegau yn gosod o gymharu â chanlyniadau Cardillo et al., 2010).

2.4 Normio ysgogiadau llythrennol a throsiadol

Roedd pob brawddeg mewn set yn cynnwys strwythur syml gyda phwnc, wedi ei ddilyn gan ferf neu ymadroddiad berf. Roedd pob set yn cynnwys pedair brawddeg, a oedd yn cynrychioli dau o'n cyflyrau arbrofol (e.e., brawddeg ddiwylliannol amhenodol / llythrennol; Brawddeg ddiwylliannol amhenodol / trosiadol; Brawddeg ddiwylliannol benodol / llythrennol; Brawddeg ddiwylliannol benodol / drosiadol; gweler tabl 2). Felly, roedd gwahaniaethau rhwng brawddegau llythrennol a throsiadol yn cynnwys newid yn y pwnc (e.e., damwain / perthynas), ond ym mhob achos arhosodd y ferf yn union yr un fath ar draws brawddegau, mewn gweithdrefn debyg i'r un a ddefnyddir gan de Grauwe et al. (2010). Cyflwynwyd pob brawddeg yn Gymraeg a’r Saesneg er mwyn creu'r ffactor rhwng iaith. Gweler atodiad C am restr cyflawn o’r brawddegau arbrofol.

Tabl 2. Enghraifft o ysgogiadau arbrofol Cymraeg a Saesneg

Ffigurol	*Perthnasedd Diwylliannol*	*Brawddeg*	*Targed*
Llythrennol	Diwylliannol amhenodol	Gadawodd y ddamwain niweidiol	Friw
Trosiadol	Diwylliannol amhenodol	Gadawodd y berthynas niweidiol	Friw
Llythrennol	Diwylliannol benodol	Gadawodd y brathiad y ddraig goch	Friw
Trosiadol	Diwylliannol benodol	Gadawodd fethiant y ddraig goch	Friw

Ffigurol	*Perthnasedd Diwylliannol*	*Brawddeg*	*Targed*
Llythrennol	Diwylliannol amhenodol	The harmful crash left a	Wound
Trosiadol	Diwylliannol amhenodol	The harmful relationship left a	Wound
Llythrennol	Diwylliannol benodol	The red dragon’s bite left a	Wound
Trosiadol	Diwylliannol benodol	The red dragon’s failure left a	Wound

2.4.1 Nodau'r astudiaeth normio gyfredol

Ein prif nod oedd a) sicrhau bod brawddegau llythrennol a throsiadol yn gyfwerth ar hygrededd a ‘*cloze probability’*, a b) yn fwy archwiliadol, gwnaethom geisio darganfod os oedd dwyieithrwyr Cymraeg-Saesneg yn graddio'n wahanol yn L1 (Cymraeg) a L2 (Saesneg), ac os oedd ymatebion yn rhagfarnllyd yng nghyd-destun brawddeg (penodoldeb perthnasedd diwylliannol: sydd yn cyd fynd â'r L1 ond nid L2). Roedd ein mesur ar lefel geiriau yn cynnwys hyd ac amlder ar draws amodau. Yna, o gofio bod ein harbrofion ERP yn canolbwyntio ar integreiddio semantig ar lefel y frawddeg, ein prif nod oedd sicrhau graddfeydd ar lefel brawddeg os oedd yn gyson ag astudiaethau blaenorol. Felly, gwnaethom gasglu data ar gyfarwydd, delweddadwyedd,

ffigurol a hygrededd, yn unol â Cardillo et al. (2010). Ein nod oedd gweld os oedd ein brawddegau'n cyfateb ar draws amodau, neu os nad oeddent yn cyfateb, bod cyfeiriad y sgôr yn cyfateb i ganfyddiadau blaenorol. Gwnaethom hefyd gasglu data ar '*cloze probability'*, a oedd yn dilyn yr un rhesymeg â graddfeydd brawddegau. Fe wnaethom benderfynu ymlaen llaw bod yn rhaid i gredadwyedd a '*cloze probability'* fod yn gyfwerth ar draws brawddegau llythrennol a throsiadol, ac y byddai di-gywerthedd yn cael ei ddilyn gan adolygu'r brawddegau nes sicrhau cywerthedd.

Ein prif ffactor o ddiddordeb felly oedd gwahaniaethau yn Ffigurol y brawddegau (llythrennol yn erbyn trosiadol), ac unrhyw ryngweithiad rhwng ffigurol a ffactorau eraill; yn benodol ffigurolrwydd * iaith (Saesneg yn erbyn Cymraeg). Yn fwy archwiliadol, gwnaethom hefyd archwilio diwylliant * ffigurol (amhenodol yn erbyn penodol).

2.4.2 Dulliau

2.4.2.1 Cyfranogwyr

Recriwtiwyd 32 o bobl ddwyieithog Gymraeg-Saesneg rhugl gan ddefnyddio'r dull samplu cyfle, gyda'r iaith frodorol (hunan-adroddol) yn Gymraeg (26 benyw, 6 gwryw; *M oedran* = 37, *SD* = 15.55). Gofynnwyd am gymeradwyaeth foesegol gan banel moeseg Seicoleg Prifysgol Bangor, a chafwyd caniatâd gwybodus cyn profi.

2.4.2.2 Dull a Chanlyniadau

Crëwyd arolwg ar-lein gan ddefnyddio ffurflenni Google (‘*Google forms’*). E-bostiwyd y ddolen i’r arolwg ynghyd â chopïau electronig o'r ffurflen wybodaeth a chaniatad i bob cyfranogwr. Cyn dechrau'r arolwg gofynnwyd i'r cyfranogwyr ddarllen y daflen wybodaeth yn ofalus a dychwelyd copi o'r ffurflen ganiatad wedi'i lofnodi i'r arbrofwr. Dyrannwyd y cyfranogwyr i un o'r rhestrau a fanylir yn Atodiad D. Roedd pob fersiwn yn cynnwys 320 o frawddegau, yn cyfateb i bob brawddeg arbrofol a gyflwynwyd naill ai yn Saesneg neu Gymraeg (h.y., cyfanswm o 160 brawddeg Saesneg a 160 brawddeg Gymraeg). Cyflwyniad y brawddegau ar hap. Er mai dim ond chwarter o’r holl frawddegau a welodd pob cyfranogwr (o ystyried fod cyfanswm y setiau yn fawr iawn), mae calyniadau normio brawddegau llythrennol / trosiadol gan ddefnyddio cynllyn rhwng grŵpiau neu gynllyn chymysg yn debyg i ganlyniadau a chynllyn o fewn grŵpiau (Libben & Titone, 2008; Titone & Connie, 1994; Nordmann & Jambazova, 2017).

Cyflwynwyd cyfarwyddiadau cyffredinol yn Gymraeg a Saesneg, ond cyflwynwyd cyfarwyddiadau penodol ym mhob gweithdrefn yn yr un iaith a gyflwynwyd y brawddegau yn y weithdrefn honno. E.e., Os oedd y brawddegau a gyflwynwyd mewn bloc penodol yn Gymraeg, yna roedd y cyfarwyddyd hefyd yn Gymraeg.

2.4.2.3 Geiriau. Casglwyd data ar hyd ac amlder ar gyfer y gair pwnc ymhob brawddeg (e.e., damwain yn erbyn perthynas). Cafwyd amledd (geiriau fesul miliwn; cyfrifiadau amledd arsylwadau / achlysuron fesul miliwn o eiriau) ar gyfer y brawddegau Saesneg trwy gronfa ddata CELEX (Baayen, Piepenbrock, & Gulikers. 1995), a chafwyd amlder

geiriau Cymraeg gan ddefnyddio cronfa ddata Cronfa (Ellis, O'Dochartaigh, Hicks, Morgan, & Laporte, 2001). Ar gyfer geiriau Saesneg, roedd data amledd ar gael ar gyfer 93% o gronfa ddata Celex (Saesneg amhendol, 97%; Saesneg penodol, 89%). Ar gyfer geiriau Cymraeg, roedd data amledd amrwd (cyfrif amleddau arsylwadau / achlysuron mewn samplau o destun Cymraeg) ar gael ar gyfer 88% o gronfa ddata Cronfa (Cymraeg amhendol, 91%; Cymraeg benodol 84%). Cyfrifwyd sgôr amledd cymedrig ar gyfer pob cyflwr, ynghyd â gwyriadau safonol (gweler Tabl 3). Heblaw am effaith diwylliant, lle'r oedd eitemau diwylliannol amhenodol gydag amledd uwch nag eitemau penodol, ni ddaeth unrhyw effeithiau eraill i'r amlwg.

Tabl 3. Crynodebau o hyd brawddeg (cyfanswm nifer y geiriau a'r cymeriadau) ac amlder y geiriau pwnc yn seiliedig ar gronfa ddata Celex.

Llythrennol

	Saes-Amhendol		*Saes-Penodol*		*Cym-Amhendol*		*Cym-Penodol*	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Cyf. geiriau	6.43	1.12	6.7	1.39	5.98	1.08	6.16	1.41
Cymeriadau	31.45	6.04	35.36	6.47	31.61	5.99	35.48	6.20
Amlder	202.04	487.33	120.4	440.85	181.26	261.7	117.3	149.75

Trosiadol

	Saes-Amhendol		*Saes-Penodol*		*Cym-Amhendol*		*Cym-Penodol*	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Cyf. geiriau	6.48	1.13	6.81	1.42	6.11	1.69	6.33	1.41
Cymeriadau	32.56	5.86	36.42	6.55	32.98	6.33	36.73	6.96

Amlder	257.94	678.18	157.8	628.43	228.84	303.0	154.6	237.59

2.4.2.4 Data brawddegau. Cafodd pob un o'r 640 brawddeg (320 ym mhob iaith) eu graddio am gyfarwydd (cyfarwydd – anghyfarwydd), credadwyedd (naturiol neu annaturiol), delweddadwyedd (ddim yn ennyn darlun – ennyn darlun yn syth), ffigurol (llythrennol – ffigurol) a *'cloze probability'* (gweler Tabl 4 am gymhedrau a gwyriadau safonol ac atodiad D i gael cyfrif llawn o raddfeydd graddio a mesurau '*cloze probability'*). Cafodd tri cyfranogwr eu gwahardd oherwydd addysg Saesneg (2) neu fethu ddeall gofynion y dasg (1).

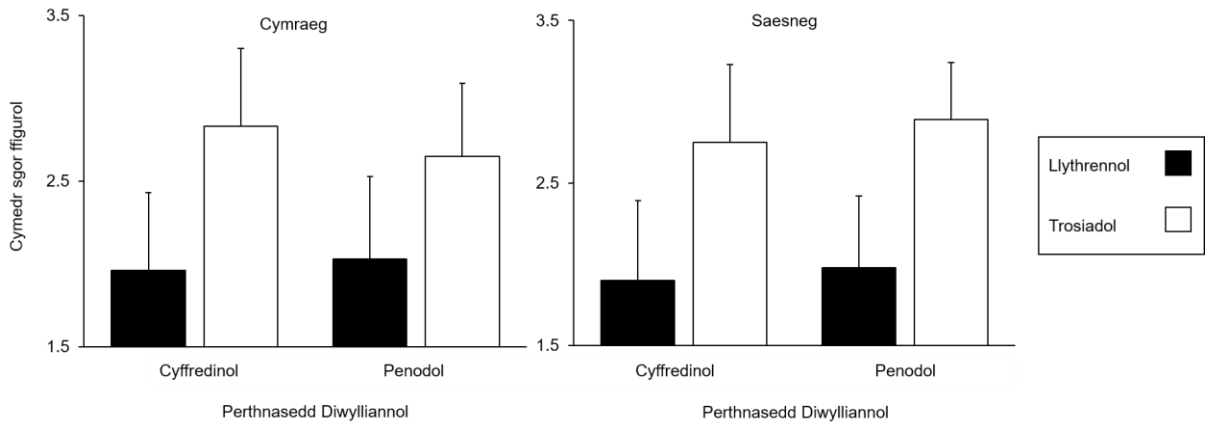
Tabl 4. Crynodeb o sgorau Cymedr (M) a Gwyriad Safonol (SD) ar gyfer pob un o'r pedwar newidyn dibynnol, ym mhob un o'r wyth cyflwr.

	Llythrennol								***Trosiadol***							
	Saes-Cyff		*Saes-Pen*		*Cym-Cyff*		*Cym-Pen*		*Saes-Cyff*		*Saes-Pen*		*Cym-Cyff*		*Cym-Pen*	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Cyfarwydd	2.83	0.59	2.76	0.49	2.67	0.5	2.21	0.69	2.46	0.66	2.37	0.56	2.11	0.58	2.24	0.61
Credadwyedd	3.13	0.54	3.1	0.46	2.94	0.53	2.89	0.7	2.64	0.65	2.65	0.63	2.46	0.58	2.55	0.64
Ffigurol	1.83	0.54	1.9	0.47	1.91	0.51	2.04	0.6	2.79	0.43	2.91	0.36	2.82	0.5	2.67	0.49
Delweddadwyedd	3.19	0.59	3.02	0.46	2.86	0.54	2.9	0.7	2.6	0.6	2.55	0.54	2.29	0.55	2.53	0.6

Er y caiff data categoriaidd ei ddadansoddi gan ddefnyddio profion amharamedrig yn draddodiadol (e.g. y prawf Pearson chi-square), gan fod nifer o newidynnau anibynnol

yma dadansoddwyd.y data gan ddenyddio dadansoddiad o amrywiant amlamrywedd (MANOVA; fel yr awgrymwyd gan Field, 2009). Darganfuwyd brif effaith arwyddocaol Ffigurol, lle cafodd brawddegau llythrennol raddfeydd uwch na brawddegau trosiadol ar gyfarwydd (M = 2.71 vs M = 2.31; F = (1, 632) = 71.78, p <.001, $\eta p2$ = .10), delweddadwyedd (M = 2.99 vs M = 2.49; F = (1, 632) = 121.66, p <.001, $\eta p2$ = .16), a hygrededd (M = 3.20 vs M = 2.57; F = (1, 632) = 87.96, p <.001, $\eta p2$ = .122). Ar y raddfa raddio ffigurol, cafodd brawddegau trosiadol raddfeydd uwch na brawddegau llythrennol (M = 1.92 vs. M = 2.80; F = (1, 632) = 504.96, p <.001, $\eta p2$ = .003). Daeth prif effaith arwyddocaol iaith i'r amlwg hefyd, lle cafodd brawddegau Saesneg raddfeydd uwch na brawddegau Cymraeg ar gyfarwydd (M = 2.6 vs. M = 2.43; F = (1, 632) = 13.26, p <.001, $\eta p2$ = .02), delweddadwyedd (M = 2.84 vs. M = 2.64; F = (1, 632) = 19.06, p <.001, $\eta p2$ = .03), a hygrededd (M = 2.88 vs. M = 2.71; F = (1 , 632) = 12.67, p <.001, $\eta p2$ = .02). Nid oedd gwahaniaeth arwyddocaol rhwng ieithoedd ar gyfer ffigurol (M = 2.36 vs. M = 2.36; F = (1, 632) = .00, p = .677.), Ac ni ddaeth unrhyw brif effaith Diwylliant i'r amlwg (F = (1, 632) = .556, p = .456).

Gwelwyd rhyngweithiad tair ffordd hefyd rhwng iaith, ffigurol a diwylliant (F = (1, 632) = 5.1, p = .024, $\eta p2$ = .008). Yn Saesneg, cafodd brawddegau trosiadol raddfeydd ffigurol uwch ar draws brawddegau diwylliant-amhendol a phenodol. Yn y Gymraeg, daeth patrwm tebyg i'r amlwg ond yn ddiddorol, graddiwyd brawddegau trosiadol sy'n ddiwylliant benodol (h.y., sy'n benodol i Gymru) yn llai ffigurol na brawddegau diwylliant-amhenodol.



Ffigwr 8. Rhyngweithiad tair ffordd rhwng iaith, ffigurol a diwylliant ar y raddfa ffigurol. Cynrychiolir gwall safonol y cymedr gan y bariau gwall.

***2.4.2.5 Cloze Probability*.** Cafodd ymatebion nad oeddent yn cyfateb i'r ysgogiad arbrofol eu codio fel 0 tra bod ymatebion cyfatebol wedi'u codio fel 1.

Cyfartaleddwyd y sgoriau ar draws pob eitem gan gynhyrchu sgôr tebygolrwydd cloze o dan y trothwy o 40% (Coulson, Urbach a Kutas, 2006). Gellir gweld canran tebygolrwydd clogyn cyfartalog ar gyfer pob cyflwr yn Nhabl 5. Mae'r tebygolrwydd cyffredinol yn isel iawn, yn ôl y disgwyl, ond mae hygrededd (a gyflwynir eto yn Nhabl 5 er hwylustod ar gyfer cymhariaeth) ar ben uchaf y raddfa ar gyfer yr holl amodau, fel bod nid oedd brawddegau'n cael eu hystyried yn arbennig o od.

Tabl 5. Sgôr ganran '*cloze probability'* ar gyfer pob cyflwr (llythrennol vs trosiadol; Cymraeg vs Saesneg; amhenodol vs penodol). Rydym yn cynnwys sgorau hygrydedd er mwyn creu cymarieuthau.

	Llythrennol				*Trosiadol*			
	Saes-Amh	*Saes-Pen*	*Cym-Amh*	*Cym-Pen*	*Saes-Amh*	*Saes-Pen*	*Cym-Amh*	*Cym-Pen*
'Cloze'	13%	7%	9%	6%	4%	4%	3%	2%
Hygrydedd	3.13	3.1	2.94	2.89	2.64	2.65	2.46	2.55

2.4.3 Addasiadau i frawddegau yn seiliedig ar sgoriau graddfa a data 'cloze probability'

2.4.3.1 Data graddfa. Yn seiliedig ar y data cymedrau ac ystadegau casgliadol a gyflwynir uchod, gwnaethom nodi brawddegau a allai fod yn broblemus i'w haddasu. Ar gyfer y data graddfa, gwnaethom gyfrifo sgoriau gwahaniaeth ar gyfer brawddegau llythrennol a throsiadol fesul eitem ac adnabod unrhyw rai â sgôr gwahaniaeth cymedrig > 1.5 pwynt. Gwnaethpwyd hyn ar gyfer pob un o'r graddfeydd (cyfarwydd, credadwyedd, delweddadwyedd a ffigurol). Amlygwyd eitemau a nodwyd â sgoriau gwahaniaeth mor fawr ar ddwy neu fwy o'r graddfeydd hyn (e.e. credadwyedd a chyfarwydd) i'w haddasu (cyfanswm o 5% o'r holl barau brawddegau: llythrennol / trosiadol). Er mwyn archwilio effaith cael gwared ar yr eitemau hyn ar gymedr cyflwr, gwnaethom gyfrifo gymedrau newydd yn seiliedig ar y 95% sy'n weddill o frawddegau, a gyflwynir yn Nhabl 6.

Tabl 6. Crynodeb o gymedrau a gwyriadau safonol newydd ar ôl cael gwared ar eitemau problemus a nodwyd.

	Llythrennol								***Trosiadol***							
	Saes-Amh		*Saes-Pen*		*Cym-Amh*		*Cym-Pen*		*Saes-Amh*		*Saes-Pen*		*Cym-Amh*		*Cym-Pen*	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Cyfarwydd	2.81	0.59	2.72	0.48	2.67	0.5	2.49	0.65	2.48	0.63	2.40	0.55	2.23	0.57	2.29	0.62
Credadwyedd	3.10	0.53	3.07	0.46	2.93	0.53	2.81	0.67	2.69	0.61	2.68	0.61	2.47	0.58	2.61	0.63
Ffigurol	1.84	0.55	1.93	0.47	1.91	0.51	2.08	0.60	2.77	0.43	2.91	0.36	2.82	0.49	2.68	0.49
Delweddadwyedd	3.16	0.59	3.00	0.46	2.85	0.54	2.81	0.68	2.63	0.59	2.58	0.52	2.30	0.55	2.56	0.61

Felly roedd y set wedi'i haddasu yma, yn cyfateb yn well ar draws amodau.

2.4.3.2 Cloze Probability. Amlygwyd brawddegau a oedd yn achosi pryder pan gafodd y fersiwn lythrennol neu'r fersiwn drosiadol sgor '*cloze probability'* o > 40%, a'i dynnu os bydd anghydbwysedd rhwng yr amodau (h.y. > 40% mewn un cyflwr a < 40% yn y cyflwr arall). Gellir gweld y data sy'n deillio o hyn yn Nhabl 7.

Tabl 7. Crynodebau graddfeydd '*cloze probability'* newydd ar gyfer pob cyflwr ar ôl cael gwared ar frawddegau '*cloze probability'* uchel.

Llythrennol				Trosiadol			
Saes-Cyff	*Saes-Pen*	*Cym-Cyff*	*Cym-Pen*	*Saes-Cyff*	*Saes-Pen*	*Cym-Cyff*	*Cym-Pen*
6%	5%	5%	3%	0%	3%	2%	1%

Unwaith eto, roedd dileu'r eitemau problemus hyn yn arwain at fwy o gywerthedd ar draws amodau. Fodd bynnag, gan fod ein brawddegau wedi'u cynllunio i fod a '*tebyglorwydd cloze'* isel, efallai na fydd tasg gwblhau brawddeg fel y defnyddir yma yn adlewyrchu derbynioldeb semantig y frawddeg yn gywir. Felly, ar gyfer ein brawddegau arbrofol gwnaethom gynnal astudiaeth dderbynioldeb gyda chyfranogwyr yn graddio brawddegau ar raddfa o +2 (derbyniol iawn) i -2 (ddim yn dderbyniol).

2.4.4 Trafodaeth

Mae canlyniadau'r astudiaeth normio gyfredol yn awgrymu nad yw brawddegau llythrennol a throsiadol yn gyfwerth â'r graddfeydd graddio allweddol a ddyfeisiwyd. Graddiwyd brawddegau llythrennol yn fwy cyfarwydd, credadwy a delweddadwy na brawddegau trosiadol, yn Saesneg ac yn Gymraeg. Roedd brawddegau llythrennol hefyd yn tueddu i fod â sgôr '*cloze probability'* uwch (cf. de Grauwe et al., 2010). At hynny, graddiwyd brawddegau trosiadol yn fwy ffigurol. Mae'r canlyniadau hyn yn gyson â'n disgwyliadau a priori a gyda chanfyddiadau astudiaethau eraill ag amcanion tebyg (Cardillo et al., 2010; De Grauwe et al, 2010). Fodd bynnag, gwelsom ganfyddiadau rhyfeddol yn deillio o'n harchwiliad mwy archwiliadol o frawddegau L1 (Cymraeg) a L2 (Saesneg) (sydd, cofiwch, yn gyfwerth cyfieithiadau). Yn benodol, cafodd brawddegau Saesneg raddfeydd uwch o gyfarwydd, credadwyedd a delweddadwyedd na brawddegau Cymraeg. Er mai Cymraeg yw iaith frodorol y cyfranogwyr, nid yw'n anghyffredin i siaradwyr Cymraeg gael eu magu mewn cartrefi cwbl ddwyieithog. Felly, cyn rhedeg yr arbrofion ERP, byddwn yn sgrinio pob dwyieithwr gan ddefnyddio holiadur hanes iaith;

er mwyn, er enghraifft, sicrhau bod ein sampl dwyieithog Cymraeg-Saesneg yn cael eu trochi mwy yn y Gymraeg nag yn yr iaith Saesneg (cf. Arbrawf 1).

Roedd rhyngweithiad rhwng ffigurol (llythrennol yn erbyn trosiad) ac iaith ar raddfeydd ffigurol hefyd yn dangos bod brawddegau llythrennol Cymraeg yn tueddu i gael eu graddio yn fwy ffigurol na brawddegau llythrennol Saesneg, gan nodi bod y bwlch rhwng ystyr lythrennol a throsiadol yn llai yn Gymraeg nag yn Saesneg. Daeth rhyngweithiad iaith-diwylliant diddorol i'r amlwg hefyd o ran graddfeydd delweddadwyedd, lle graddiwyd brawddegau amhenodol yn fwy delweddadwy na brawddegau penodol yn Saesneg, ond daeth batrwm gwrthwynebol i'r amlwg yn Gymraeg. Mae'r rhyngweithiad hwn yn tystio i wahaniaethau mewn aliniad diwylliant iaith, fel y dangosir mewn graddfeydd gwaith blaenorol (fel yn achos Ellis et al., 2015, 2017).

I gloi, mae'r data'n datgelu diffyg cywerthedd rhwng brawddegau llythrennol a throsiadol, ond mewn ffyrdd sy'n gyson yn fras â'r llenyddiaeth bresennol (Cardillo et al., 2010; Nordmann & Jambazova, 2017; Lai, Curran & Menn, 2009). Er bod ein casgliadau yn cael pwysau ychwanegol wrth fod yn gyson â chanfyddiadau blaenorol, nodwn y gallai maint y sampl fach a'r nifer gyfyngedig o bwyntiau graddfa yn ein mesurau fod wedi bod yn broblemus (Nordmann & Jambazova, 2017; Lai, Curran & Menn, 2009; Keit, 2002; Durand, 2013; Leon, & Heo, 2009; Aguinas & Stone-Romero, 1997). Byddai cynllun o fewn grwpiau hefyd wedi bod yn well (Normann a Jambazova (2017).

2.4.5 Addasu'r brawddegau ar gyfer arbrofion ERP: Dysgu o'r data normio

Datgelodd ein hastudiaeth normaleiddio amrywiadau naturiol yn y modd y mae iaith lythrennol a throsiadol yn wahanol o ran ffactorau megis delweddadwyedd, credadwyedd a ffigurol. Fodd bynnag, at ddibenion rheolaeth arbrofol a data dilys, yn ein gwaith empeiraidd, mae'n hanfodol ein bod yn sicrhau'r cydbwysedd cywir rhwng brawddegau sy'n llythrennol a throsiadol (ac felly ychydig yn barchus o'r gwahaniaethau naturiolaidd a nodwyd), ond sydd hefyd yn cyfateb mor agos â phosibl ar bob graddfa, er mwyn peidio â chyflwyno cyfyngderau i'r data.

I gyflawni hyn, mae ein setiau brawddegau a grëwyd ar gyfer Arbrofion 1 a 2 yn y ddwy bennod empirig ganlynol, yn dilyn y meini prawf canlynol: Yn gyntaf, rydym nid yn unig yn cylchdroi geiriau targed ar draws yr holl amodau (mecanwaith rheoli ysgogiad hanfodol a ddefnyddir mewn gwaith ERP er mwyn osgoi bod gwahanieuthau lefel isel (fel amlygrwydd) yn rhaeadru i brosesau lefel uwch: Yr Egwyddor Hillyard, Luck 2014), gwnaethom hefyd gylchdroi brawddegau yn llawn ar draws amodau. Hynny yw, byddai unrhyw frawddeg benodol (y darn cyn gair targed) a gyflwynir fel brawddeg drosiadol mewn un cyflwr yn cael ei chyflwyno fel brawddeg lythrennol mewn un arall, ac i'r gwrthwyneb. Bydd hyn yn helpu i leihau rhagfarnau yn y setiau brawddegau. Gellir gweld enghreifftiau yn y bennod nesaf.

Nesaf, fe benderfynon ni ganolbwyntio ar frawddegau llythrennol yn erbyn trosiadau yng nghyd-destun L1 a L2. Felly, roedd ein set olaf o frawddegau ar gyfer Arbrawf 1, yn cynnwys y ffactorau Ffigurol (llythrennol yn erbyn trosiadol) ac Iaith (Saesneg yn erbyn Cymraeg). Fe wnaethom hefyd gyflwyno trydydd ffactor, anghysondeb brawddeg (synhwyrol, anghyson), fel mesur sylfaenol lle gallem wahaniaethu effaith torri semantig (anghysondeb) oddi wrth anhawster fwy cynnil wrth

gyrchu ystyr (trosiad). Mae'r ffactor Diwylliannol yn cyflwyno llwybr diddorol ar gyfer gwaith yn y dyfodol. Fodd bynnag, gyda’r cyflwyniad o frawddegau anghyson yn arbrawf 1, byddai cynnwys y ffactor ychwanegol hwn wedi arwain at ddyluniad arbrofol yn llawer rhy gymhleth fel man cychwyn, ac felly cafodd ei ddileu.

2.5 Crynodeb o'r Bennod

Yn y bennod hon, trafodais yr ystyriaethau methodolegol sy'n ofynnol i fynd i'r afael â'r nodau a amlinellir ym mhennod 1. Yn y penodau canlynol, trafodir dair astudiaeth ERP empirig a ddefnyddir i ymchwilio'r nodau hyn.

Pennod 3

Dwyieithrwyr yn gwneud synnwyr (I): Canfod anghysondeb ar-lein yn gynharach yn L1 nag yn L2 yn ystod amgyffred brawddegau.

Cydnabyddiaethau: Hoffwn ddiolch i Yang Lee am ei chymorth wrth ffitio'r cap EEG, ac i Manon Jones, Awel Vaughan-Evans a Guillaume Thierry am eu hadborth wrth lunio'r ysgogiadau arbrofol.

Crynodeb

Ni ellir dal cysyniadau semantig yn llawn gan ddefnyddio un nodwedd ddiffiniol yn unig. Mae gan hyn oblygiadau sylweddol i siaradwyr sawl iaith, ble mae un nodwedd cysyniadol yn mapio i gyfieithiad gyfatebol ymhob iaith. Fodd bynnag, mae'r lenyddiaeth ar fynediad cysyniadol dwyieithog yn eithaf prin, gyda modelau cyfredol yn cynnig esboniadau anghyson (Dijkstra, Wahl, Buytenhuijs, Halem, Al-Jibouri, De Korte, & Rekke, 2019; Van de Putte, De Baene, Brass, & Duyck, 2017). Yma, gwnaethom archwilio os oedd pobl ddwyieithog Gymraeg-Saesneg rhugl iawn – gyda hyfedredd uchel iawn yn L2 - yn dangos mynediad llai ymdrechgar i wybodaeth gysyniadol yn L1. Defnyddiwyd brawddegau oedd yn torri ystyr (anghysondeb) neu yn cyflwyno anhawster wrth dynnu ystyr (ffigurol). Yn Arbrawf 1a, gwnaethom gyflwyno brawddegau synhwyrol yn semantig ac anghyson yn semantig yn orthogonaidd gydag ystyr lythrennol a throsiadol, yn y Gymraeg L1, neu'r Saesneg L2, wrth recordio potensial sy'n gysylltiedig â digwyddiadau (ERPs). Roedd y rhai dwyieithog hyn yn gallu barnu os oedd y frawddeg yn 'gwneud synnwyr' a chywirdeb uwch pan oedd yn anghyson yn semantig, pan oedd yn llythrennol ac wrth ei chyflwyno yn Saesneg. Fodd bynnag, datgelodd ERPs fwy o sensitifrwydd i ystyr brawddeg (anghysondeb) yn L1 Cymraeg yn ystod ffrâm amser sy'n gysylltiedig â phrosesu semantig. Yn Arbrawf 1b, rydym yn dangos, pan fydd pobl ddwyieithog yn darllen brawddegau llythrennol a throsiadol, ac eithrio brawddegau anghyson yn semantig, bod ffigurolrwydd iaith yn arwain at brosesu semantig gwahaniaethol yn L1 ond nid yn L2. Gyda'i gilydd, mae ein canfyddiadau'n awgrymu bod ystyr brawddeg ar gael ar bwynt amser cynharach yn L1, ac eto nid yw'r sensitifrwydd hwn o reidrwydd yn trosi i farnu brawddegau yn well.

Mae ystyron geiriau yn cael eu hystyried yn enwog fel *‘slippery customers’* (Labov, 1973), gan fod eu ffiniau a’u nodweddion yn amwys ac yn dibynnu ar eu cyd-destun. Cynyddir y broblem hon yng nghyd-destun dwyieithrwydd – a gaiff ei ystyried yn ‘slippery customer’ yn ei hun gan fod pob unigolyn dwyieithog yn unigryw (Bak, 2016; De Bruin, 2019; De Luca, Rothman, Bialystock, & Pliatsikas, 2019) - lle rhoddir sawl term i gysyniadau sy'n gorgyffwrdd yn rhannol. Er enghraifft, yn Japaneeg a Saesneg, mae gan y cyfwerth cyfieithu '*kuroi*' a '*black*' synhwyrau sy'n gorgyffwrdd (hy, lliw), yn ogystal â synhwyrau nad ydynt yn gorgyffwrdd (ee, mae '*black'* yn Saesneg yn nodi hiwmor, tra bod '*kuroi*' yn nodi unigolion drwg neu euog; Finkbeiner, et al, 2004). Ar ben hynny, yn yr iaith frodorol, mae pobl ddwyieithog fel rheol yn gallu cyrchu mwy o synhwyrau sydd yn gysylltiedig a gair nag yn yr iaith anfrodorol. Er gwaethaf sawl degawd o ymchwil yn archwilio mynediad at wybodaeth ar lefel eirfaol a syntactig yn yr ymennydd dwyieithog (Dijkstra & van Heuven 1998; Kroll & Stewart, 1994; Thierry & Wu, 2007; Vaughan-Evans, Thierry, Kuipers, & Jones, 2014), mae ymchwil ar fynediad at ystyr ym mhob un o ieithoedd dwyieithog yn eithaf prin (er, bydd modelau diweddar o ddwyieithrwydd, (ee Multilink, Dijkstra, Wahl, Buytenhuijs, Van Halem, Al-Jibouri, De Korte, & Rekke, 2019), yn disgrifio cysylltiadau iaith-amhenodol a-phenodol rhwng synhwyrau yn achos pobl ddwyieithog yn fuan). Gan ddefnyddio dulliau niwrowybyddol, rydym yn archwilio os yw rhwydwaith synhwyrau cyfoethocach a chryfach yn L1 yn arwain at fapio synnwyr yn fwy rhwydd nag yn L2. Yn benodol, p'un a yw pobl ddwyieithog yn integreiddio cysyniadau unigol i'r cyd-destun mwy yn haws wrth ddarllen brawddegau L1.

Mewn iaith benodol, yn aml gall geiriau (ee, *'hammer'*) gyfateb i ganolwr sengl (‘*tool to break things/drive in nails'*), ond mae ganddo gynodiadau eilaidd sy'n deillio o'r ystyr wreiddiol (ee, ail ddehongliad llythrennol ar ffurf berf: *'to hammer'*, a dehongliad trosiadol: ‘*to be heavily criticised'*), gyda'r canlyniad bod gan un eitem eirfaol sawl ystyr sy'n gorgyffwrdd yn rhannol yn y system semantig (Taylor, Devereux, Tyler, & 2011). Mae mynediad at yr ystyron amgen hyn yn cael ei yrru i raddau helaeth gan gyd-destun brawddeg a / neu gliwiau cyd-destunol cyfoethog eraill lle cyflwynir gair (VanHell & DeGroot, 2008; Dijkstra, VanHell & Brenders, 2015; Payne, Lee & Federmeier, 2015). Er enghraifft, ‘*to drive in the nail, he used a* ***hammer'*** vs. ‘*he was as incalcitrant as a* ***hammer'***. Yn y ddau achos, wrth i'r frawddeg ddatblygu, mae geiriau yn cael eu mapio'n barhaus i ystyr semantig gyffredinol y frawddeg, gan arwain at ddisgwyliad o eiriau posib sydd ar fin ymddangos. Pan deuir ar draws gair disgwyliedig, mae ei ystyr felly'n cael ei brosesu a'i integreiddio'n rhwydd, ond mae integreiddio terfyniadau annisgwyl neu anghyson yn anoddach (ee, ‘*I take coffee with cream and dog'*; Kutas & Hillyard, 1980) (Fisher-Baum et al, 2014; Federmeier, 2007; Kutas & Van Petten, 1994; Federmeier & Laszlo, 2009; Kutas a Hillyard, 1980; Payne, Lee & Federmeier, 2015). Mewn ymchwil ERP, mynegir rhwyddineb integreiddio semantig gan drawsgyweiriad yn y don N400 (cydran ERP negyddol sy'n sensitif i'r broses o integreiddio ystyr, gan gyrraedd ei uchafbwynt am tua 400ms; Kutas & Hillyard, 1980; Kutas & Federmeier, 2011), lle mae cysyniadau llai disgwyliedig yn ennyn negyddiaeth N400 mwy. Gwelir bod cyd-destun brawddeg hefyd yn modiwleiddio effeithiau amledd geiriau: Mae geiriau a gyflwynir ar eu pennau eu hunain neu ar ddechrau brawddeg yn ennyn effeithiau N400 mwy, o

gymharu â phan gyflwynir yr un gair ar ddiwedd brawddeg (Van Hell, 2002; Moreno, Rodriguez- Fornells, & Laine, 2008; Van Petten & Kutas, 1990, 1991).

Gall cyd-destun brawddeg felly ychwanegu at neu oedi adnabyddiaeth geiriau unigol, ond eto gall cyfosodiad cysyniadau - a gynrychiolir gan enwau, neu hyd yn oed berfau - mewn brawddeg hefyd newid yr ystyr gyffredinol yn ddramatig. Efallai mai'r enghraifft orau o ddangos hyn yw'r gwahaniaethau rhwng dehongliadau llythrennol a throsiadol. Er enghraifft, mae'r frawddeg lythrennol *O'r baban unig daeth floedd* yn cynnwys dau gysyniad y gellir eu mapio neu eu cysylltu'n uniongyrchol (baban - bloedd). Fodd bynnag, mae addasiad bach o'r frawddeg hon, *O'r galon unig daeth floedd* yn cynnwys dau gysyniad (calon - bloedd) sydd yn cysylltu trwy gysyniad cyffredin (unigrwydd) yn unig, gan arwain at ystyr trosiadol (Bolognesi, 2016; De Grauwe, Swain, Holcomb, Ditman, & Kuperberg, 2010; Citron et al, 2016; Landau, Keefer, & Meier, 2010; Rapp, Leube, Erb, Grodd, & Kircher, 2004; Lai, Curran, & Menn, 2009; Rapp, Leube, Erb, Grodd, Kircher, & 2004; Pynte, Besson, Robichon, & Poli, 1996). Mae llawer o lenyddiaeth wedi archwilio os ellir cyrchu ystyr trosiadol yn uniongyrchol, neu os yw mynediad iddo yn digwydd ar ôl gwrthod yr ystyr lythrennol (Grice, 1975; Searle, 1979; Gibbs & Gerrig 1989; Gibbs, 2002; Giora, 1997). Mae tystiolaeth niwroffisiolegol ddiweddar yn awgrymu bod ystyr trosiadol yn deillio ochr yn ochr ag ystyr lythrennol (de Grauwe et al., 2010; Iakimova, Passerieux, Laurent, & Hardy-Bayle, 2005). Fodd bynnag, mae trosiadau hefyd yn ennyn modyliad osgledau N400 mwy, sy'n arwydd o integreiddio semantig mwy ymdrechgar (Arzouan et al., 2007; Coulson a Van Petten, 2002, 2007; De Grauwe et al., 2010; Goldstein et al., 2012; Lai et al., 2009; Pynte et al.,

1996), gan adlewyrchu'r ymdrech ychwanegol sy'n gysylltiedig â mapio cysyniadau a gaiff eu cysylltu yn anuniongyrchol.

Felly, mae llenyddiaeth sefydledig yn dangos, bod cyd-destun brawddeg yn modiwleiddio mynediad semantig mewn uniaithrwydd, trwy ddylanwadu ar ragfynegi geiriau a thrwy gyfosod cysyniadau a gaiff eu cysylltu yn uniongyrchol ac yn anuniongyrchol. Fodd bynnag, mewn prosesu iaith ddwyieithog, mae ein dealltwriaeth o fynediad semantig yn fwy cyfynedig. Er bod modelau traddodiadol o ddwyieithrwydd yn disgrifio'r cysylltiadau rhwng cynrychioliadau geirfaol a semantig (e.e., Kroll & Stewart, 1994; Dijkstra, Van Heuven, & Grainger, 1998), mae llawer llai o ddata empirig yn egluro cysylltedd synnwyr semantig o fewn a rhwng ieithoedd. Mae modelau presennol yn nodi bod cynrychioliadau semantig dwyieithog yn amrywio o rai nad ydynt yn gorgyffwrdd (hy, yn bodoli mewn un iaith yn unig) i gyfwerthoedd cyfieithu sy'n gorgyffwrdd bron yn llawn (ee '*black*' a '*kuroi*'), ac yn awgrymu bod rhwydwaith semantig cyfoethocach ynghyd a mantais amserol yn bodoli yn L1 o'i gymharu â L2 (Finkbeiner, Forster, Nicol, & Nakamurs, 2004; De Groot, Kroll & Stuart, 1994; Hahne, 2001; Hahne & Friederici, 2001; Moreno & Kutas, 2005).

Er gwaethaf disgrifiadau arwynebol y prosesau hyn mewn modelau dwyieithog cyfredol, mae tystiolaeth empeiraidd sy'n deillio o ymchwiliadau ERP yn honni ei bod yn haws cyrchu ystyr yn L1 o'i gymharu â L2. Yn yr iaith anfrodorol, cynhyrchai troseddau semantig oediad ac effeithiau N400 mwy (Ardal, Donald, Meuter, & Muldrew, 1990; Kutas & Kluender, 1994; Weber-Fox & Neville, 1996), yn ogystal ag effeithiau P600 mwy sy'n arwydd o ail-ddadansoddi (Hahne & Friederici, 2001). Fodd bynnag, mae effeithiau o'r fath yn cael eu gwanhau yn achos caffaeliad cynnar a hyfedredd uchel

(Moreno & Kutas, 2005). Mae sut a pham mae'r gwahaniaethau hyn yn amlygu ar draws y cwrs amser deall yn ymofyn ymchwiliadau pellach sydd yn defnyddio offer sy'n mynd tu hwnt i droseddau semantig, yn debyg i'r rhai a gynhaliwyd gan astudiaethau sy'n archwilio prosesu semantig yn y llenyddiaeth uniaith plaen (Moreno, Rodriguez-Fomells, & Laine, 2008). Un dull o'r fath yw archwilio mapio semantig uniongyrchol ac anuniongyrchol, er enghraifft mewn cyd-destunau llythrennol a throsiadol.

Yr astudiaeth gyfredol

Yma, gwnaethom ddefnyddio’r dechneg ERP i archwilio os yw pobl ddwyieithog Gymraeg-Saesneg, sydd a hyfedr uchel yn y ddwy iaith, serch hynny yn dangos mynediad semantig llai ymdrechgar yn L1 o'i gymharu â L2 wrth ddarllen brawddegau. Yn Arbrawf 1a, mae pobl ddwyieithog yn darllen brawddegau semantig synhwyrol neu anghyson wedi'u croesi ag ystyron llythrennol a throsiadol. Cyflwynwyd cyfieithiaid o'r brawddegau hyn ym mhob un o'u hieithoedd. Nodir bod y lenyddiaeth yn awgrymu bod angen mapio cysyniadau yn anuniongyrchol er mwyn cael mynediad at ystyron trosiadol, ond mae mynediad at ystyron llythrennol yn digwydd trwy fapio synnwyr uniongyrchol. Felly, mae trosiad yn cynnig achos diddorol ar gyfer ymchwilio pa mor hawdd y gellir integreiddio synhwyrau ym mhob iaith. Ar sail canfyddiadau blaenorol felly, roeddem yn rhagfynegi y byddai pobl ddwyieithog yn canfod anghysondeb yn haws yn yr iaith frodorol, a gaiff ei fynegi mewn effaith N400 llai i frawddegau synhwyrol yn L1 nag yn L2 (Ardal, Donald, Meuter, & Muldrew, 1990; Kutas & Kluender, 1994; Weber-Fox & Neville, 1996; Moreno & Kutas, 2005). Fe wnaethom ragweld hefyd, gan dybio bod L1 yn cynnwys amrywiaeth gyfoethocach o synhwyrau (Finkbeiner et al, 2004), y byddai

pobl ddwyieithog yn integreiddio ystyr drosiadol yn haws yn yr iaith frodorol, a gaiff ei fynegi mewn gwahaniaethau N400 llai rhwng brawddegau llythrennol a throsiadol yn L1 nag yn L2. I gael rhagolwg o'n canfyddiadau, roedd pobl ddwyieithog yn wir yn fwy sensitif i anghysondeb semantig yn L1 nag yn L2, ond roedd mwy o oediad nag yr oeddem wedi ei ragweld yn L2 (gan amlygu yn y gydran P600). Ni chanfuom unrhyw effeithiau ffigurol ar-lein. Yn Arbrawf 1b, felly gwnaethom archwilio prosesu semantig L1 a L2 ar-lein yng nghyd-destun brawddegau llythrennol a throsiadol yn unig, ac eithrio'r ffactor o anghysondeb brawddegau a allai fod yn llethol yn arbrawf 1a.

Arbrawf 1a

Dull

Cyfranogwyr Cafodd ugain o bobl ddwyieithog frodorol Gymraeg-Saesneg (3 gwryw, 17 benyw; *M* oed = 23.5, *SD* = 6.08) eu cynnwys yn y dadansoddiad terfynol. Cafodd pedwar cyfranogwr arall eu gwahardd oherwydd ansawdd data isel. Cafwyd cymeradwyaeth foesegol gan bwyllgor moeseg Prifysgol Bangor. Bu recrwtio’r cyfranogwyr gan ddefnyddio’r dulliau samplu pel eira a samplu cyfleus via y cyfryngau cymdeithasol, hysbysfyrddau Prifysgol Bangor, hysbysfyrddau llyfrgelloedd (y brifysgol a chymundedau lleol), grwpiau ebost y brifysgol (staff a myfyrwyr), Rhoddodd y cyfranogwyr gydsyniad gwybodus a chawsant arian neu gredydau cwrs (myfyrwyr Seicoleg Prifysgol Bangor – tua 30%) am eu cyfranogiad.

Aseswyd Holiadur Hanes Iaith (gweler atodiad A) a weinyddwyd cyn yr arbrawf a hyfedredd a phrofiad L1 a L2 mewn Cymraeg a Saesneg. Caffaelodd yr holl gyfranogwyr Gymraeg o'u genedigaeth a Saesneg yn ifanc (*M* = 4.7, *SD* = 2.22), a

nodwyd ddefnydd dyddiol mwy o'r Gymraeg na'r Saesneg (*M* = 74%, *SD* = 0.22; *M* = 26%, *SD* = 0.19). Bu i'r cyfranogwyr adrodd galluoedd darllen, ysgrifennu, siarad a deall gan defnyddio graddfa 1 (ddim yn wybodus iawn) i 10 (gwybodus iawn), uchel ar gyfer Cymraeg a Saesneg (M = 9.78, SD = 0.38; M = 8.33, SD = 0.46). Yn ogystal datgelodd y Y Mesur Hunaniaeth Ethnig Aml-grŵp (MEIM; Phinney, 1992; Roberts, Phinney, Masse, Chen, Roberts & Romero, 1999; gweler atodiad B), sy'n mesur perthyn diwylliannol i raddfa 1 (difater) i 4 (ymdeimlad cryf o berthyn) hunaniaeth Gymraeg ddiwylliannol gryf (M = 3.79, SE = 0.1).

Ysgogiadau Adeiladwyd cyfanswm o 80 set o frawddeg Cymraeg ac 80 set o'u cyfieithiad gyfatebol Saesneg. Gall gyfieuthu ysgogiadau ysgrifennedig achosi problameau semantig a chystrawennol, ac felly, llunwyd y brawddegau Cymraeg a Saesneg ar y cyd

Cynhaliwyd astudiaeth normio lle graddiodd cyfranogwyr uniaith Saesneg bob brawddeg Saesneg ar pa mor ffigurol a derbynioldeb semantig gair olaf y brawddeg ar raddfa o -2 (llythrennol iawn; annerbyniol iawn) i +2 (ffigurol iawn; derbyniol iawn). Cafodd cyfran fach o eitemau (18.75%) eu haddasu a'u hail-normio er mwyn sicrhau cywerthedd ar draws y brawddegau ar dderbynioldeb y geiriau targed (synhwyrol llythrennol *M* = 0.14, *SD* = 0.51; anghyson llythrennol *M* = 0.12, *SD* = 0.47; synhwyrol trosiadol *M* = - 0.3, *SD* = 0.61; anghyson trosiadol *M* = -0.29, *SD* = 0.61), on dim cywerthedd ar lefel ffigurolrwydd brawddeg (synhwyrol llythrennol *M* = -1.08, *SD* = 0.53; anghyson llythrennol *M* = 0.58, *SD* = 0.19; synhwyrol trosiadol *M* = 0.58; 0.5, *SD* = 0.72; anghyson trosiadol *M* = 0.83, *SD* = 0.56). Yn y ddwy iaith, roedd pob set brawddeg

yn cynnwys pedair brawddeg lle cafodd synnwyr a ffigur y brawddeg eu trin. Roedd setiau felly'n cynnwys brawddeg synhwyrol lythrennol, brawddeg synhwyrol drosiadol, brawddeg anghyson llythrennol a brawddeg anghyson drosiadol. Roedd y ddwy frawddeg lythrennol (synhwyrol ac anghyson) union yr un fath hyd at y gair olaf targed. Roedd y ddwy frawddeg drosiadol (synhwyrol ac anghyson) hefyd yn union yr un fath hyd at bwynt y gair targed - ac wedi'u haddasu cyn lleied â phosibl o'r frawddeg lythrennol er mwyn lleihau amrywiant o fewn y frawddeg a osodwyd. O fewn set benodol, roedd y geiriau targed ar gyfer brawddegau synhwyrol yn union yr un fath, ac roedd y geiriau targed ar gyfer brawddegau anghyson yn union yr un fath. Yna cafodd geiriau targed eu cylchdroi yn llawn ar draws setiau, fel y byddai'r diweddglo ar gyfer brawddegau synhwyrol hefyd yn ymddangos ar gyfer brawddegau anghyson. Cafodd y brawddegau eu gwrthbwyso ymhellach fel bod pob cyfranogwr yn gweld naill ai fersiwn lythrennol neu drosiadol pob brawddeg mewn un iaith yn unig. Roedd pob brawddeg yn cynnwys strwythur gramadegol syml (pwnc, wedi'i ddilyn gan ferf) fel a welir yn yr enghraifft yn Nhabl 8. Gweler atodiad E am restr lawn o’r frawddegau arbrofol.

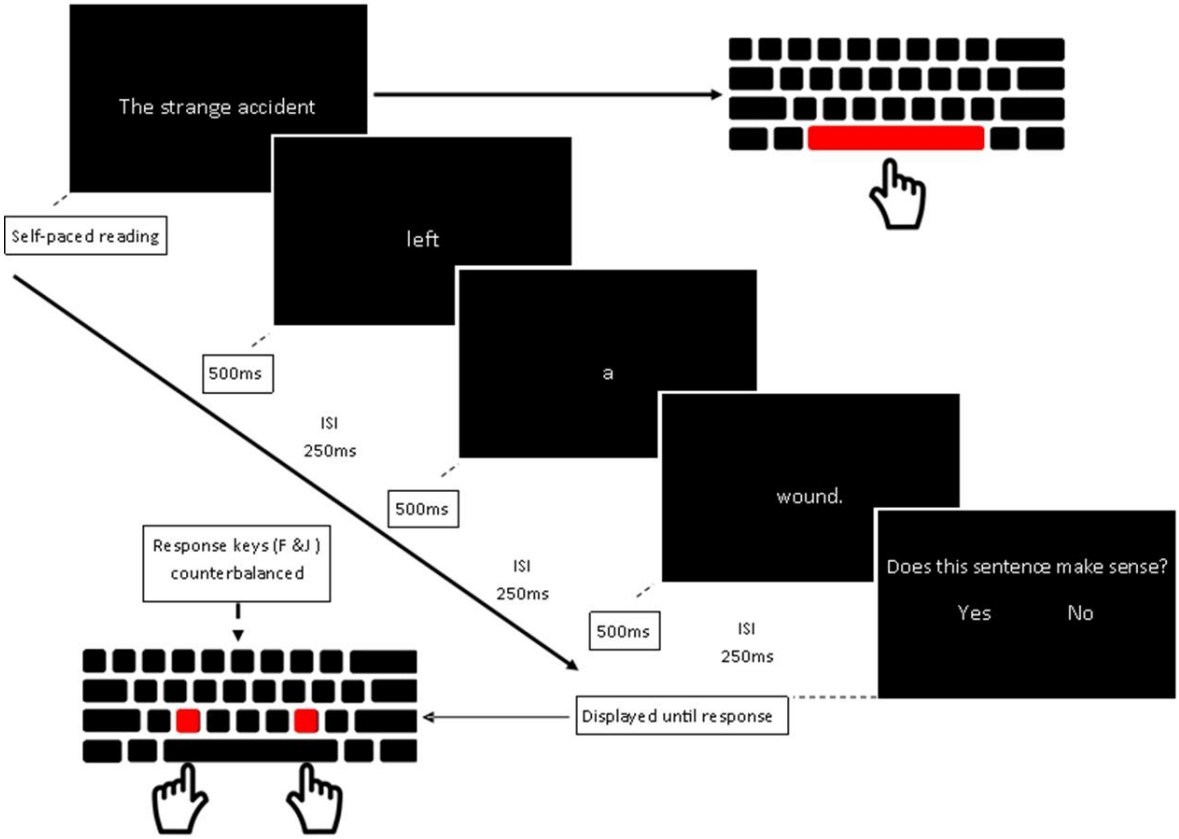
Tabl 8. Dyluniad arbrofol ac enghraifft o set o frawddegau.

Iaith	*Synwyrusrwydd*	*Ffigurol*	*Brawddeg*	*Targed*
Cymraeg	Synhwyrol	Llythrennol	Gwnaeth lleoliad lletchwith ei chadair iddi	faglu
Cymraeg	Synhwyrol	Trosiadol	Gwnaeth lleoliad lletchwith ei geiriau iddi	faglu
Cymraeg	Anghyson	Llythrenol	Gwnaeth lleoliad lletchwith ei chadair iddi	chwipio
Cymraeg	Anghyson	Trosiadol	Gwnaeth lleoliad lletchwith ei geiriau iddi	chwipio
Saesneg	Synhwyrol	Llythrennol	Her awkwardly placed stool made her	stumble

Saesneg	Synhwyrol	Trosiadol	Her awkwardly placed words made her	stumble
Saesneg	Anghyson	Llythrenol	Her awkwardly placed stool made her	whip
Saesneg	Anghyson	Trosiadol	Her awkwardly placed words made her	whip

Gweithdrefn Cyflwynwyd brawddegau mewn ffont 18 pwynt gwyn ar gefndir du. I ddechrau, cyflwynwyd hanner cyntaf y frawddeg i'r cyfranogwyr fel testun parhaus gyda'r cyfranogwyr yn darllen ar eu cyflymdra eu hunain, ac yna cyflwynwyd gweddill y brawddeg fesul gair (amser cyflwyno: 500ms; ISI: 250ms). Yna, gofynwyd i'r cyfranogwyr ymateb i'r cwestiwn 'A yw'r frawddeg yn gwneud synnwyr?' ar ddiwedd pob treial, ac ymateb gan ddefnyddio bysellfwrdd (y / n) a oedd wedi eu gwrthgytbwys. Cyfarwyddwyd hwy i ganolbwyntio ar ystyr (semantig) y frawddeg yn hytrach na'i strwythur cystrawennol, a rhoddwyd esiamplau iddynt cyn y bloc ymarfer. Rhoddwyd cyfarwyddiadau cyffredinol yn ddwyieithog a chyfarwyddiadau o fewn y blociau arbrofol yn unol ag iaith y brawddegau (h.y.. cyfarwyddiadau Cymraeg pan fo'r brawddegau'n Gymraeg, a chyfarwyddiadau Saesneg pan fo'r brawddegau'n Saesneg).

Cyn y bloc arbrofol, cwblhaodd y cyfranogwyr chwe threial ymarfer. Roedd yr arbrawf yn cynnwys wyth bloc arbrofol yn cynnwys 40 treial yr un. Cafodd y brawddegau eu hapgyrchu fel mai dim ond un frawddeg o bob set a gyflwynwyd ym mhob bloc. Er mwyn rheoli am unrhyw halogid gan yr iaith anweithredol, bu blocio yn ol iaith a gafodd e'i gwrthbwyso ar draws y cyfranogwyr (e.e. bu i gyfranogwr 1 weld 4 bloc Cymraeg wedi eu dilyn gan 4 bloc Saesneg, a chyfranogwr 2 weld 4 bloc Saesneg wedi eu dilyn gan 4 bloc Cymraeg).



Ffigwr 9. Sgematig y weithdrefn arbrofol.

Cofnodi electroffisiolegol. Cofnodwyd data electroffisiolegol gan ddefnyddio 64 o electrodau a osodwyd ar recordiad croen y pen ar gyfradd o 1 kHz, gan ddefnyddio'r electrod CZ fel cyfeirnod (reference). Digwyddodd hidlo ar-lein ('*online filtering'*) gan ddefnyddio hidlydd band-basio ('*band-pass filter'*) rhwng 0.1 a 200Hz, ac oddi ar-lein gan ddefnyddio hidlydd sero-shifft pasio isel ('*low-pass zero-shift filter'*) wedi'i dorri i ffwrdd ar 20Hz. Cafodd arteffactau llygaid eu modelu a'u cywiro yn fathemategol. Tynnwyd yr arteffactau sy'n weddill â llaw gan ddefnyddio meddalwedd NeuroScan 4.4. Tynnwyd y ddau gyfnod (*'epoch'*) rhwng -200 a 1000 ms cyflwyniad gair ôl-darged gydag o leiaf 30 cyfnod fesul cyflwr ar gyfer pob cyfranogwr. Roedd gweithgareddau

sy'n fwy na ± 75Uv yn cael eu taflu'n awtomatig. Cynhaliwyd gweithdrefn cywiro llinell sylfaen (‘*baseline correction’*).

Canlyniadau a Thrafodaeth

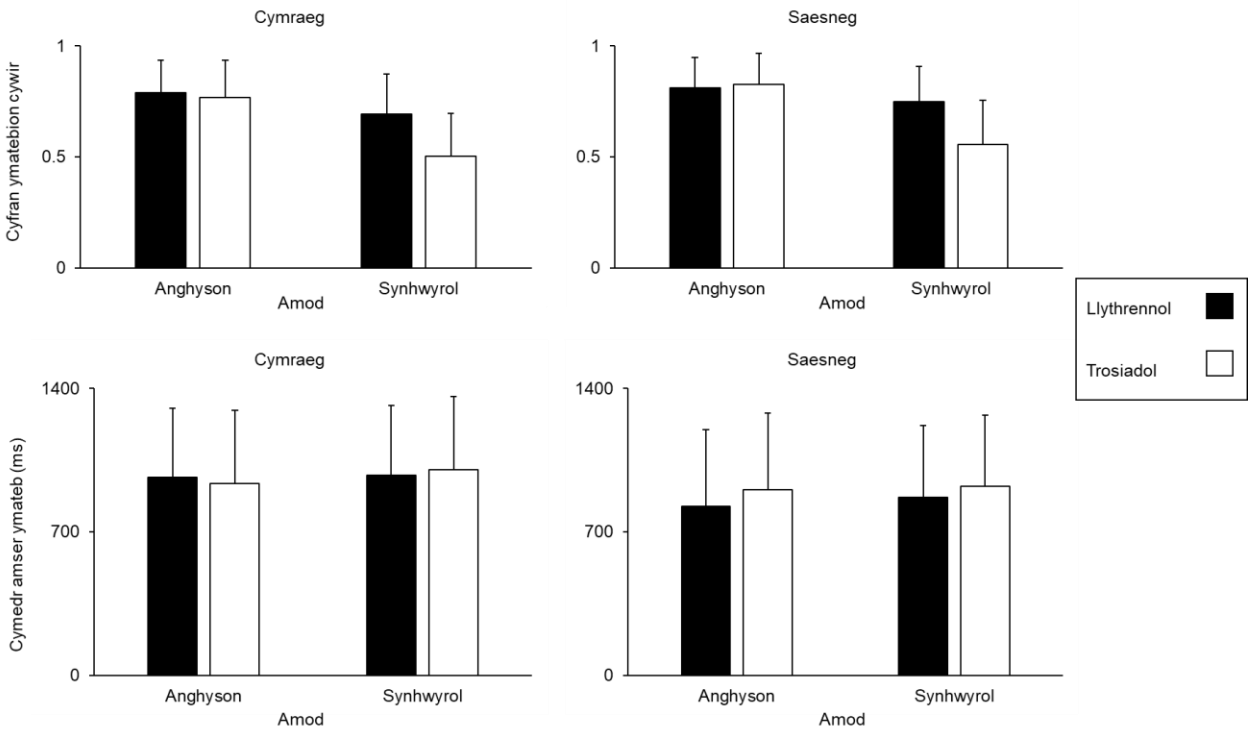
Data ymddygiadol

Modelwyd data cywirdeb ac amseroedd ymateb fel swyddogaeth o un ffactor rhwng grwpiau: Iaith (Saesneg, Cymraeg), a dau ffactor o fewn pynciau: Synwyrusrwydd (synhwyrol, anghyson), a Ffigurol (llythrennol, trosiadol). Roedd y tri ffactor wedi'u canoli (*‘centred’*) ar gyfer y dadansoddiadau i leihau gwrthlinoledd (‘*collinearity’*). Cyflwynwyd y data cywirdeb i fodel effeithiau cymysg cyffredinol (‘*Generalized mixed-effects model’* – swyddogaeth glmer yn lme4; Bates, Mächler, Bolker, & Walker, 2014) lle gwnaethom fodelu'r effaith ar-hap fwyaf posibl (‘*maximal random effects*’) gan gynnwys rhyngdoriadau a llethrau cyfranogwyr ac eitemau (Barr, Levy, Scheepers, & Tily, 2013), yn trimio’r effeithiau yn systematig (cael gwared o ryngweithiad) os nad oedd y model ar y dechrau yn cydgyfarfod.

Darganfuwyd effaith sefydlog arwyddocaol o Iaith, Ffigurol a Sensitifrwydd, fel bod brawddegau Saesneg yn ennyn cywirdeb uwch na brawddegau Cymraeg (b = -0.28, SE = 0.12, z = -2.33, p = 0.02), roedd brawddegau llythrennol yn ennyn cywirdeb uwch na brawddegau trosiadol (b = -0.46, SE = 0.06, z = -6.70, p <.001), ac roedd brawddegau anghyson yn ennyn cywirdeb uwch na brawddegau synhwyrol (b = -0.90, SE = 0.06, z = -14.63, p <.001). Daeth rhyngweithiad Ffigurol * Synwyrusrwydd i'r amlwg hefyd (b = -0.89, SE = 0.12, z = -7.25, p <.001), lle canfuwyd fod brawddegau llythrennol yn fwy cywir na brawddegau trosiadol ar gyfer brawddegau synhwyrol, ond ar gyfer brawddegau

anghyson, nid oedd ffigurol yn effeithio ar gywirdeb. Ni ddaeth unrhyw effeithiau eraill i'r amlwg ($p > .05$).

Trawsnewidiwyd (log transformation) y data amser ymateb ar gyfer normalrwydd a'i gyflwyno i fodel effeithiau cymysg llinol (*linear mixed effects model'*, swyddogaeth lmer yn lme4), eto gyda'r effeithiau ar hap mwyaf posibl yn cael eu trimio ar gyfer cydgyfeiriant y model. Daeth prif effaith arwyddocaol o iaith i'r amlwg, lle roedd pobl ddwyieithog yn gyflymach i ymateb yn Saesneg nag yn Gymraeg ($b = 90.55$, $SE = 27.81$, $t = 3.25$, $p = .001$) a dangosodd rhyngweithiad iaith*ffigurol ar ben hynny fod y cyfranogwyr yn gyflymach i ymateb i frawddegau llythrennol na metafforaidd yn Saesneg,, ond roedd amseroedd ymateb i frawddegau llythrennol a throsiadol yn gymharol yn y Gymraeg ($b = -69.86$, $SE = 34.47$, $t = -2.02$, $p = .04$). Ni ddaeth unrhyw effeithiau eraill i'r amlwg ($p > .05$).



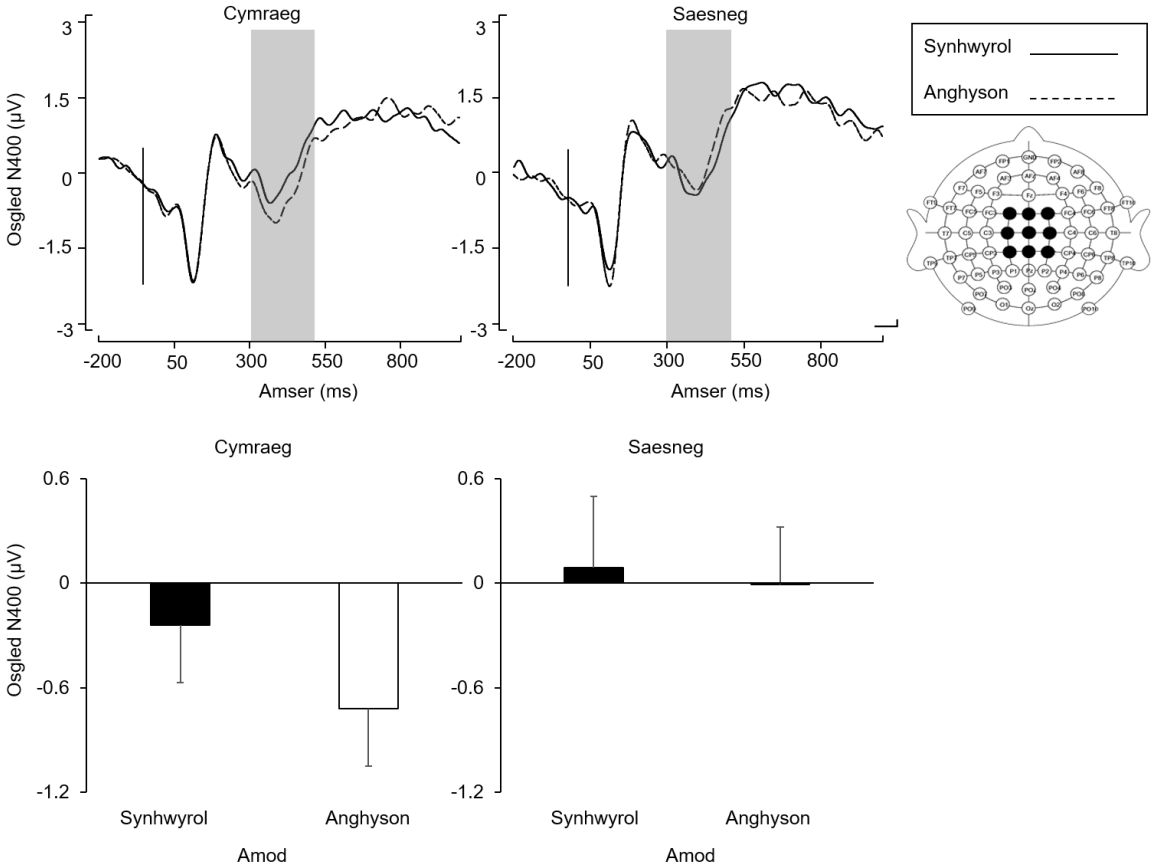
Ffigwr 10. Cymedr ymatebion cywir (cyfran o ymatebion cywir) ac amseroedd ymateb ar gyfer brawddegau synhwyrol / anghyson Cymraeg a Saesneg, gydag ystyron llythrennol / trosiadol. Mae’r bariau gwallau yn cynrychioli'r gwallau safonol.

I grynhoi'r canlyniadau ymddygiadol, dangosodd y cyfranogwyr gywirdeb uwch wrth ganfod brawddegau anghyson, a awgrymai fod y brawddegau hyn yn wir yn anghyson yn semantig. Dangosodd y cyfranogwyr gywirdeb uwch wrth ganfod brawddegau ag ystyron llythrennol, na'r achos mwy amwys o ystyron trosiadol hefyd. Felly roedd y cyfranogwyr yn sensitif i ystyr lythrennol yn erbyn ystyr drosiadol, ac yn rhyfeddol, roeddent yn fwy cywir yn y Saesneg L2 nag yn y Gymraeg L1. Roedd amseroedd ymateb yn darparu tystiolaeth gydgyfeiriol ar gyfer perfformiad ymddygiadol gwell yn L2: Yn L2, roedd ymatebion y cyfranogwyr yn gyffredinol yn gyflymach ac roedd ymateb i frawddegau llythrennol ar ben hynny yn gyflymach na brawddegau trosiadol. Fodd bynnag, ni ddaeth unrhyw wahaniaethau amseroedd ymateb tebyg ym mrawddegau llythrennol-trosiadol i'r amlwg yn L1.

Canlyniadau ERP

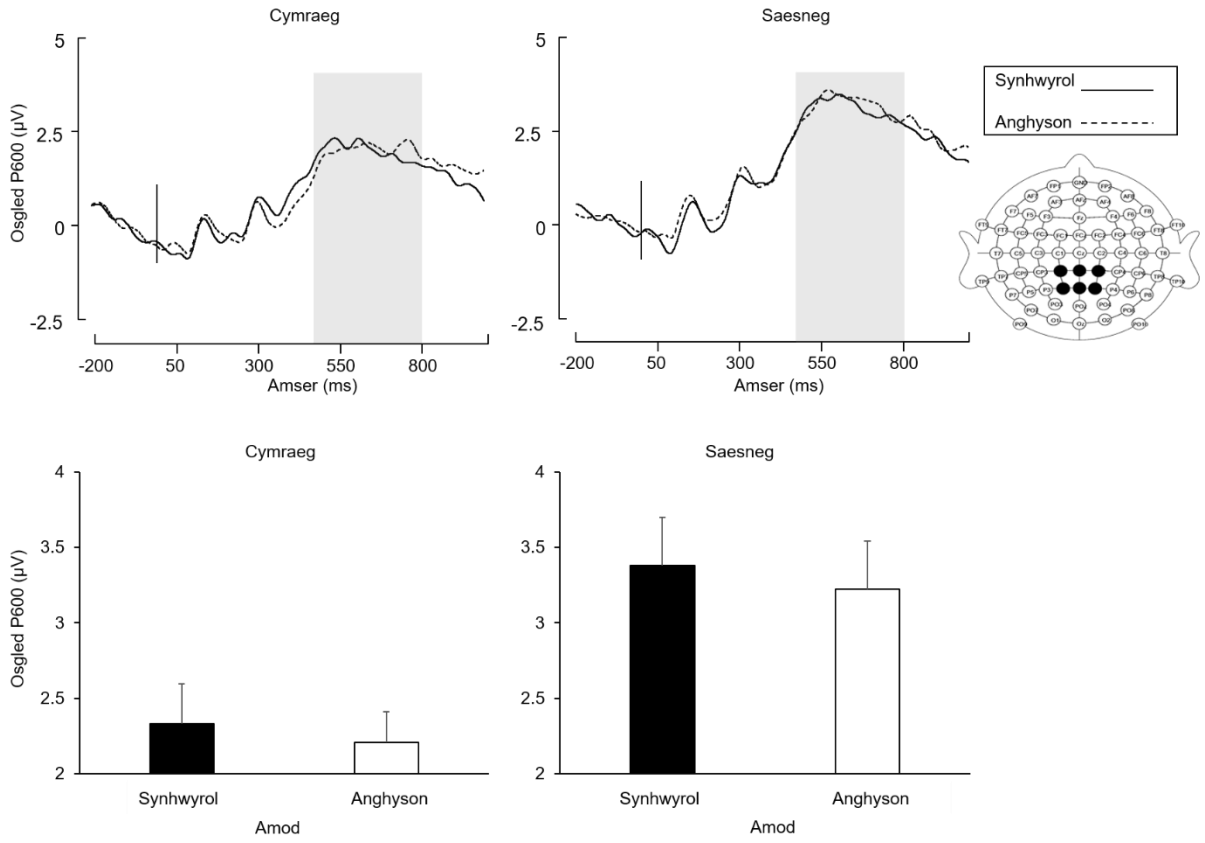
Roedd y prif ddadansoddiad yn cynnwys dadansoddiad o amrywiant (ANOVA) mesuriad ailadroddus 3-ffordd gyda'r ffactorau annibynnol, iaith (Cymraeg, Saesneg) ffigurol (llythrennol, trosiadol) a synwyrusrwydd (synhwyrol, anghyson). Yna, gan ystyried y gwahaniaeth dibwys rhwng brawddegau ‘llythrennol’ a ‘metafforaidd’ yn y cyflwr anghyson, archwiliodd ail ddadansoddiad effaith rhyngweithiad iaith a ffigurol ar gyfer brawddegau synhwyrol yn unig,

N400. Mae osgledau ERP dros 6 safle electrod (FC1 FC2 FCZ C1 C2 CZ CP1 CP2 CPZ) sy'n nodweddiadol yn cynhyrchu modiwleiddiad o'r N400 (Kutas & Hillyard, 1980; 1984; Thierry & Wu, 2007; Kutas & Federmeier, 2000; Kuiper, van Koningsbruggen, Thierry Dadansoddwyd Lau, Phillips, Poppel, 2008; Barber, Donamayor, Kuta, & Munte, 2010; West & Holcomb, 2002). Yn y ffenestr amser 300-500ms, darganfuwyd dwy brif effaith arwyddocaol o iaith (F (1, 19) = 6.15, p = .023, ηp2 = .24) a synwyrusrwydd (F (1, 19) = 14.48, p = .001, $\eta p2$ = .43). Datgelodd osgledau'r N400 ostyngiad mewn ymateb i frawddegau Saesneg L2 (M = .04, SE = .38, o gymharu â brawddegau Cymraeg L1: M = -. 48, SE = .33) a brawddegau synhwyrol (M = .27, SE = .33, o'i gymharu â brawddegau anghyson: M = -. 17, SE = .01). Nid oedd unrhyw brif effaith o ffigurol (p = .39). Datgelodd rhyngweithiad dwyffordd (a oedd bron yn arwyddoacol) rhwng iaith a synwyrusrwydd (F (1, 19) = 3.715, p = .06, $\eta p2$ = .164), bod effeithiau N400 llai i frawddegau synhwyrol (M = --24, SE = .33) o gymharu â brawddegau anghyson (M = -.72, SE = 33) yn Gymraeg, tra yn Saesneg, roedd brawddegau synhwyrol ac anghyson yn ennyn effeithiau N400 tebyg (M = .09, SE = .41 a M = -. 017, SE = 334). Ni welwyd unrhyw ryngweithiad arwyddocaol arall (p > .05). Gweler Ffigwr 11.



*Ffigwr 11***.** Osgled cymedrig (µV) effaith N400 ar gyfer brawddegau synhwyrol ac anghyson, Cymraeg a Saesneg. Mae'r bariau gwallau yn cynrychioli'r gwallau safonol.

P600. Yna gwnaethom ddadansoddi osgledau P600 dros 6 electrod '*Centro-parietal'* (CP1 CP2 CPZ P1 P2 PZ) yn y ffenestr amser 500-800ms (Tanner, Grey, Van Hell, 2017; Tanner et al., 2014). Datgelodd y canlyniadau brif effaith arwyddocaol o iaith (F (1, 19) = 21.22, p <.001, $\eta p2$ = .25) lle roedd osgledau P6 mwy i'r Saesneg (M = .3.3, SE = .302) o'i gymharu â brawddegau Cymraeg (M = 2.27, SE = .220). Ni welwyd unrhyw brif effeithiau ffigurol na synwyrusrwydd (p = .79), na rhyngweithiad arwydddocaol (p > .05).



Ffigwr 12. Osgled cymedrig (µV) effaith P600 ar gyfer brawddegau synhwyrol / anghyson Cymreig a Saesneg, gydag ystyron llythrennol / trosiadol. Mae’r bariau gwallau yn cynrychioli'r gwallau safonol.

I grynhoi canlyniadau Arbrawf 1a, gwelsom fod y grŵp dwyieithog Gymraeg-Saesneg yn dangos mwy o gywirdeb ymddygiadol cyffredinol ac amseroedd ymateb cyflymach yn eu hail iaith, Saesneg yn hytrach na'r iaith frodorol, Gymraeg. Mewn geiriau eraill, mae pobl ddwyieithog yn dangos perfformiad L2 gwell o ran eu hymatebion i ystyr brawddeg; y gwrthwyneb i'n rhagfynegiad gwreiddiol. Fodd bynnag, os edrychwn ar y pwynt cynharaf o integreiddio semantig wrth ddarllen brawddegau, tua 400 ms ar ôl dechrau'r gair targed, rydym yn dod o hyd i dystiolaeth o brosesu semantig

ar-lein - a nodir trwy ganfod brawddegau synhwyrol yn erbyn anghyson - yn yr iaith frodorol, sy'n absennol yn yr ail iaith – a nodir gan ddiffyg gwahaniaethiad rhwng brawddegau synhwyrol a llythrennol yn y ddwy ffenestr amser. Felly, mae'n ymddangos bod daduniad yn digwydd rhwng ein mesurau ymddygiadol ac ymhlyg, lle mae pobl ddwyieithog yn dangos sensitifrwydd cynharach i ystyr brawddeg yn L1, sy'n absennol yn L2; nodir fod hyn ddim yn awgrymu dealltwriaeth, ond fod chwiliad semantig yn digwydd yn gynt yn L1 na L2. Fodd bynnag, nid yw'r duedd hon yn trosi i ddangos perfformiad ymddygiadol L1 gwell gan fod y cyfranogwyr yn gynt ac yn fwy cywir yn L2, a awgrymir fod yr ystyr hefyd wedi ei gaffael yn yr L2, er ei fod yn diwgydd yn ystod cyfnodau hwyrach o brosesu.

Rydym yn ystyried ffactorau y gwyddwn i gydberthyn yn gymedrol â chywirdeb, megis hunanhyder cyfranogwyr (Kleitman, & Stankov, 2007; Harvey, 1997; Keren, 1991; Stankov, 1999), ac a allai hyder yn y L1 fod wedi dylanwadu ar yr ymatebion ymddygiadol. Yn ôl Llywodraeth Cymru (2018) dim ond 68% o siaradwyr Cymraeg sydd yn teimlo’n hyderus yn ei siarad, ac mae pryderon am ba mor dda y maent yn ei siarad yn poeni 21% o siaradwyr rhugl. Fodd bynnag, mae ymchwil yn dangos bod y rhai sy'n siarad Cymraeg gartref ac sy'n cael eu haddysgu yn Gymraeg yn bennaf, yn hyderus yn eu galluoedd siarad, darllen ac ysgrifennu ac yn adrodd eu bod yn gwneud ychydig iawn o gamgymeriadau yn y Gymraeg (Morris, 2014), sy'n gyson â'r canfyddiad bod cydberthynas gref rhwng hyder a rhuglder (Llywodraeth Cymru, 2018). Gan fod ein sampl ddwyieithog yn dod o gartrefi Cymreig yn unig, rydym yn awgrymu bod yr esboniad hwn yn annhebygol; byddai mesur penodol o'r ffactorau hyn wedi caniatáu pennu maint y dylanwadau hyn yn fwy cywir fodd bynnag.

Mae ein mesur ymhlyg o brosesu semantig ar y llaw arall, yn gyson â chyfrif lle gellir integreiddio gwybodaeth gysyniadol yn haws yn yr iaith frodorol, hyd yn oed mewn pobl ddwyieithog hyfedr iawn (Ardal, Donald, Meuter, & Muldrew, 1990; Kutas & Kluender, 1994; Weber -Fox & Neville, 1996; Hahne & Friederici, 2001; Moreno & Kutas, 2005). Rydym yn gadael trafodaeth bellach, gan gynnwys sut i gysoni ein canfyddiadau sy'n deillio o fesurau ymhlyg ac ymddygiadol i'r adran drafodaeth gyffredinol, ac yn awr yn canolbwyntio ar brosesu brawddegau llythrennol yn erbyn trosiadol mewn ddwyieithrwydd.

Er gwaethaf sensitifrwydd clir y cyfranogwyr i ystyr ffigurol, a welir yng nghywirdeb ymddygiadol cyffredinol ac amseroedd ymateb, ni welsom unrhyw dystiolaeth yn yr arbrawf hwn bod pobl ddwyieithog yn gwahaniaethu ystyron llythrennol a throsiadol ar lefel ymhlyg, ac na chafodd ffigurolrwydd ei fodiwleiddio yn ôl iaith. Mae hyn yn groes i ganfyddiadau blaenorol yn y llenyddiaeth uniaith (Arzouan et al., 2007; Coulson & Van Petten, 2002, 2007; De Grauwe et al., 2010; Goldstein et al., 2012; Lai et al., 2009; Pynte et al., 1996; Tartter et al., 2002), a'n rhagfynegiadau, lle roeddem yn rhagweld y byddai ystyron trosiadol yn haws i’w prosesu yn L1.

Rydym yn tybio bod cynnwys brawddegau anghyson yn Arbrawf 1a - er ei fod yn addysgiadol wrth ddatgelu gwahaniaethau L1-L2 mewn prosesu semantig ar gyfer synnwyr – yn gyfrifol am y canlyniad nwl ar ein ffactor ffigurol. Yn benodol, roedd y cyfranogwyr yn debygol o gael eu preimio i ganfod anghysondeb brawddegau, a allai o bosibl olygu bod gwahaniaethau mewn ystyr rhwng brawddegau llythrennol a throsiadol yn llai amlwg, ac felly'n lleihau gwahaniaethau yn N400 rhwng y lefelau hyn o'r ffactor ffigurol. Er mwyn profi'r rhagdybiaeth hon, gwnaethom gynnal ail arbrawf, bron yn

union yr un fath â'r cyntaf ond yn cynnwys eitemau synhwyrol yn unig (gan hepgor pob eitem anghyson). Roedd hyn yn golygu bod angen cynnwys tasg ymddygiadol wahanol a ddisgrifir yn yr adran nesaf.

Arbrawf 1b

Yn arbrawf 1b, gwnaethom archwilio unwaith eto os yw pobl ddwyieithog yn gallu mapio gwybodaeth ar lefel gysyniadol yn gyflym yn L1, gan arwain at ddeall iaith drosiadol yn haws nag yn L2. I gyflawni hyn, bu i sampl newydd o bobl ddwyieithog Gymraeg-Saesneg ddarllen yr un brawddegau Cymraeg a Saesneg wedi'u trin am ystyr lythrennol a throsiadol. Gwnaethom ragweld y byddai prosesu trosiad haws yn L1 yn amlygu mewn N400 ar gyfer brawddegau trosiadol, sy'n absennol yn L2 (ond sy'n bresennol yn y P600). Dylai dealltwriaeth haws o drosiad amlygu mewn N400 ar gyfer trosiad yn y ddwy iaith ond dylid ei leihau yn L1.

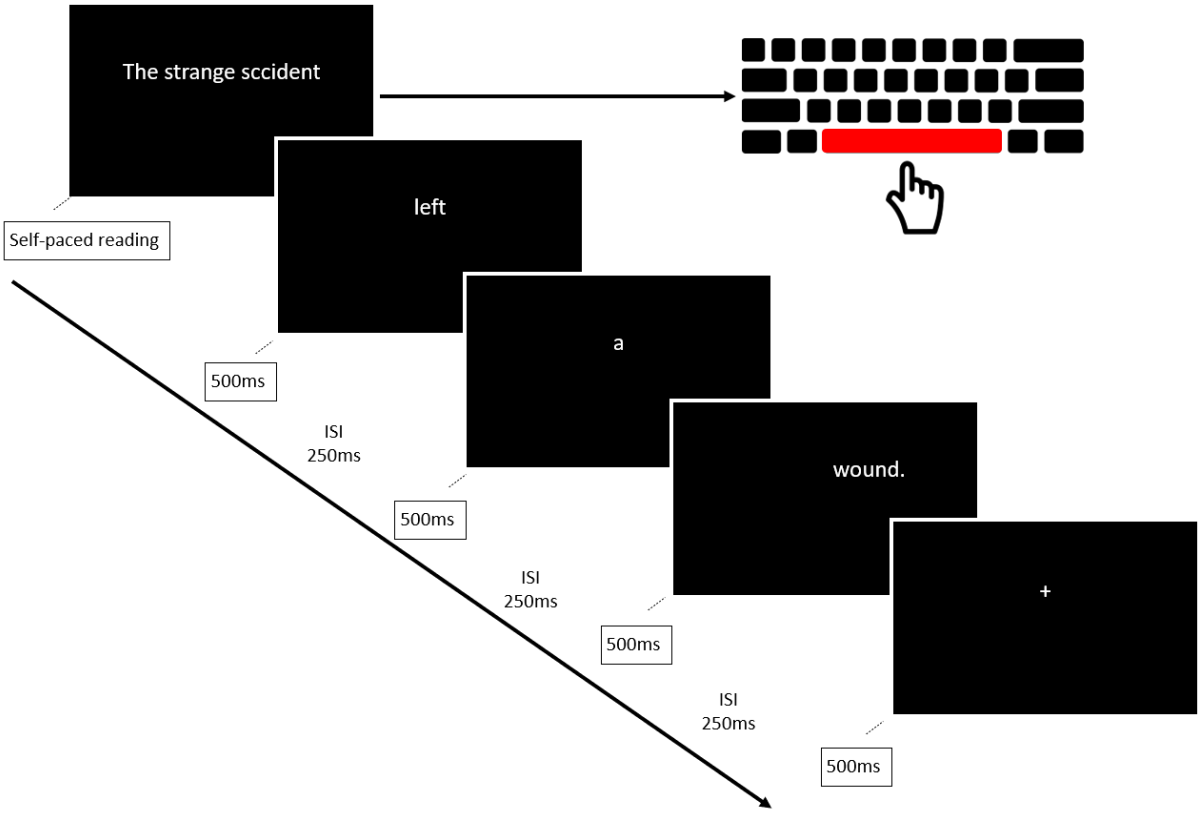
Dull

Cyfranogwyr Recriwtiwyd sampl newydd o bobl ddwyieithog Gymraeg-Saesneg ddwyieithog, a oedd serch hynny â phroffil demograffig union yr un fath â'r rhai a gafodd eu recriwtio i Arbrawf 1a (*N* = 21, 16 benyw, 5 dyn, *M* oed = 21.8, *SD* = 3.5). Cafodd wyth cyfranogwr arall eu gwahardd oherwydd ansawdd data isel. Bu i’r pobl ddwyieithog hyn adrodd eu bod wedi caffael y Gymraeg o enedigaeth ar Holiadur Hanes Iaith, a chaffael Saesneg fel ail iaith yn ifanc (*M* = 3.8, *SD* = 2.11). Fe wnaethant hefyd adrodd defnydd (*M* = 74%, *SD* = 15.91) a hyfedredd Cymraeg uwch (*M* = 9.7, *SD* = 0.23) o'i gymharu â defnydd (*M* = 26%, *SD* = 15.91) a hyfedredd Saesneg (*M* = 9.11, *SD* = 0.29).

Datgelodd yr holiadur MEIM (Phinney, 1992; Roberts, Phinney, Masse, Chen, Roberts & Romero, 1999) hunaniaeth ddiwylliannol Gymraeg gryf gyda Chymru (*M* = 3.38, *SD* = 0.28).

Deunyddiau, Dylunio a Threfn. Roedd y brawddegau a ddefnyddiwyd yn union yr un fath â'r brawddegau llythrennol a throsiadol a ddefnyddwyd yn arbrawf 1a (ar ôl dileu'r brawddegau anghyson). Felly, roedd y set yn cynnwys brawddegau llythrennol Cymraeg a Saesneg (cyfwerthoedd cyfieithiad, *n* = 160) a brawddegau trosiadol Cymraeg a Saesneg (cyfwerthoedd cyfieithiad, *n* = 160). Roedd brawddegau o bob set yn cael eu gwrthbwyso ar draws cyfranogwyr, fel bod pob cyfranogwr yn gweld unrhyw frawddeg benodol yn Saesneg neu yn Gymraeg yn unig. Cyflwynwyd y brawddegau mewn pedwar bloc o 40 treial.

Mewn un treial, cyflwynwyd brawddegau gan ddefnyddio gweithdrefn hunan-gyflymdra ar gyfer y tesun cyntaf, ac yna cyflwyniad cyfresol o eiriau ar gyfer y 3-5 gair olaf, gan arwain at y gair targed, mewn gweithdrefn union yr un fath ag Arbrawf 1a. Fodd bynnag, o gofio bod brawddegau yn 1b i gyd a ystyr synhwyrol, roedd angen newid y dasg. Er mwyn ennyn sylw â ffocws a sicrhau bod dedfrydau'n cael eu prosesu yn semantig, cyflwynwyd cwestiwn deallusrwydd yn dilyn eitemau llenwi (‘*filler items’*) ar 30% o'r holl dreialon a gyflwynwyd yn yr arbrawf. Roedd eitemau llenwi yn cynnwys brawddegau trosiadol a llythrennol i sicrhau nad oedd ystyron llythrennol neu drosiadol yn cael eu gorgynrychioli yn yr arbrawf. Gweler ffigwr 13 am sgematig o’r weithdrefn yma.

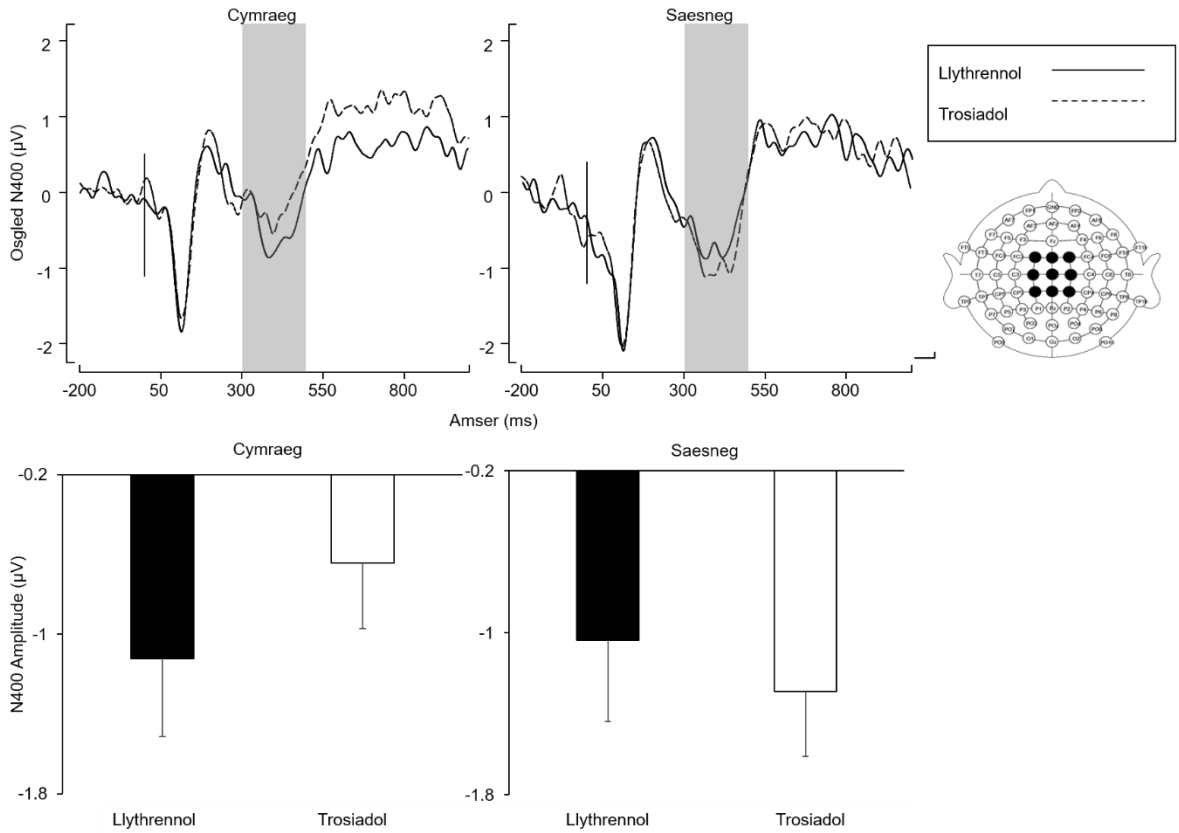


Ffigwr 13. Sgematig o'r weithdrefn arbrofol a ddefnyddir yn arbrawf 1b.

Canlyniadau a Thrafodaeth

N400. Dadansoddwyd osgledau ERP dros naw electrod blaen-ganolog, canolog a chanolog-parietal (‘*fronto-central, central, and central-parietal electrodes’*, FC1 FCZ FC2 C1 CZ C2 CP1 CPZ CP2) yn y ffenestr amser N400 glasurol (300-500ms). Er na ddaeth unrhyw brif effaith arwyddocaol o iaith (F (1, 20, 1) = .79, p = .39) na ffigurol (F (1, 20) = .04, p = .82) i'r amlwg, darganfuwyd rhyngwaithiad iaith * ffigurol arwyddocaol (F (1, 20) = 4.35, p = .04, $\eta p2$ = .172) gyda brawddegau llythrennol yn y Gymraeg yn ennyn osgledau N400 mwy (M = -.48, SE = .3) na brawddegau trosiadol (M = -.13, SE = .27), tra yn Saesneg, roedd brawddegau llythrennol (M = -.322, SE = .3) yn ennyn

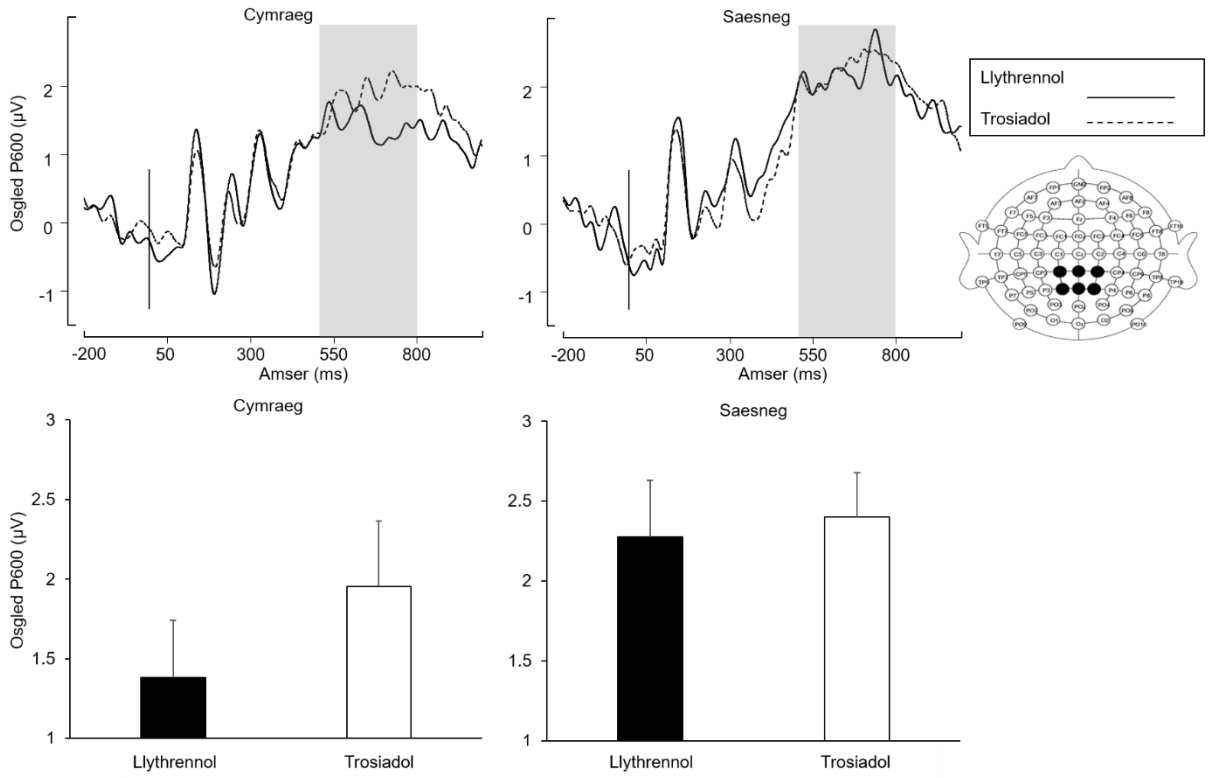
effeithiau N400 llai o gymharu â brawddegau trosiadol (*M* = -.61, *SE* = .25; gweler ffigwr 6).



Ffigwr 14. Cymedr osgled (µV) yr effaith N400 ar gyfer brawddegau llythrennol / trosiadol Cymraeg a Saesneg. Mae'r bariau gwallau yn cynrychioli'r gwallau safonol.

P600. Yna gwnaethom ddadansoddi'r ffenestr amser P600 (600-800ms) dros 6 electrod parietal canolog ('*central parietal'*, CP1 CPZ CP2 P1 PZ P2). Daeth prif effaith arwyddocaol i iaith i'r amlwg (*F* (1, 20) 6.70, *p* = .01, *ηp2* = .251) gyda osgledau P600 llai i frawddegau Cymraeg (*M* = 1.67, *SE* = .35) o gymharu â brawddegau Saesneg (*M* = 2.34, *SE* = 28; gweler ffigur X). Ni ddaeth unrhyw brif effaith arwyddocaol o ffigurol (*F*

(1, 20) = 1.05, *p* = .32) na rhyngweithiad ffigurol*iaith arwyddocaol (*F* (1, 20) = 1.05, *p* = .32) i'r amlwg (gweler ffigur 7).



Ffigwr 15. Cymedr osgled (µV) yr effaith P600 ar gyfer brawddegau llythrennol / trosiadol Cymraeg a Saesneg. Mae’r bariau gwallau yn cynrychioli'r gwallau safonol.

Yn Arbrawf 1b, gwnaethom geisio cynyddu sensitifrwydd i wahaniaethau llythrennol-trosiadol wrth fodiwleiddio'r don N400, trwy gael gwared ar frawddegau anghyson. Gwnaethom ddangos, yn gyffredinol (ar gyfer brawddegau llythrennol a throsiadol), bod pobl ddwyieithog Gymraeg-Saesneg rhugl yn dangos mwy o brosesu semantig (llai o N400 a P600) yn L1 o'i gymharu â L2. Gwnaethom hefyd ddangos bod yr unigolion dwyieithog yn gwahaniaethu brawddegau llythrennol a throsiadol yn y

Gymraeg L1, ond nid yn y Saesneg L2 (a amlygir yn osgledau N400 gwahaniaethol i lythrennol a throsiadol yn L1 ond nid yn L2). Mae'r ddau ganfyddiad yn gyson â chyfrif o integreiddio semantig mwy effeithlon yn L1 (Ardal, Donald, Meuter, & Muldrew, 1990; Kutas & Kluender, 1994; Weber-Fox & Neville, 1996; Hahne & Friederici, 2001; Moreno & Kutas, 2005), ac a chanlyniadau Arbrawf 1a, lle y canfuwyd anghysondeb yn L1 yn unig. Fodd bynnag, nid oedd y rhyngweithiad a arsylwyd yn Arbrawf 1b yn unol â'n rhagdybiaethau: Er bod brawddegau llythrennol yn arwain at fodiwleiddio tebyg o'r N400 yn L1 a L2, ac roedd brawddegau trosiadol yn arwain at N400s llai yn L1 o gymharu a L2 (Beck & Webber, 2016; Cieslicka, 2006; Jankowiak, Rataj & Naskrecki, 2017), *o fewn L1, roedd y brawddegau trosiadol hefyd yn ennyn N400 llai - sy'n awgrymu integreiddiad semantig haws - o gymharu â brawddegau llythrennol.*

Mae ein dehongliad o'r canfyddiad rhyfeddol hwn o reidrwydd yn ôl-hoc, ac yn anodd i’w adrodd, o ystyried rheolaeth lem iawn ein brawddegau. Cofiwch bod y geiriau targed wedi'u cylchdroi yn llawn ar draws amodau, gan ganiatáu ychydig iawn o gyfle i gael effeithiau geirfaol allanol. Yr unig wahaniaeth canfyddadwy rhwng y brawddegau llythrennol a throsiadol yn ein setiau oedd gair pwnc yn y frawddeg, a oedd yn penderfynu a oedd ystyr gyffredinol y frawddeg yn llythrennol neu'n drosiadol. Ar ôl eu harolygu, roedd y geiriau hyn yn tueddu i fod yn fwy haniaethol mewn brawddegau trosiadol nag mewn brawddegau llythrennol (gweler y bennod Dulliau, lle gwnaethom benderfynu bod brawddegau trosiadol trwy ddiffiniad yn cynnwys cysyniadau mwy haniaethol), a allai fod wedi cyflwyno mwy o amwysedd i ystyr y frawddeg. Fodd bynnag, roedd y geiriau pwnc hyn yn anghytbwys ar draws yr amodau llythrennol a throsiadol, felly os yw'r rhagdybiaeth hon yn gywir byddem wedi arsylwi effaith debyg

yn y cyflwr anghyson. Gan na ddarganfuwyd unrhyw effeithiau ni all hyn fod yn esboniad dilys.

Esboniad arall yr ydym yn ei ystyried yw’r amwysedd cystrawennol a gyflwynwyd trwy greu ysgogiad ar draws ieithoedd sydd ddim yn rhannu’r un strwythyr gystrawenol (Deuchar, 2006). Er enghraifft, efallai bod y strwythur cystrawennol wedi bod yn fwy derbyniol mewn un iaith gan arwain at brosesu gwahaniaethol ar-lein. Fodd bynnag, mae'r esboniad hwn hefyd yn ddigymell am ddau reswm. Yn gyntaf, fel yr eglurwyd uchod, oherwydd y cylchdro brawddegau a'r gweithdrefnau gwrthbwyso a berfformiwyd, byddem wedi arsylwi yr un effeithiau ar draws amodau, - ni welom hynny. Yn olaf, mae'n annhebygol y bydd unrhyw amwysedd semantig wedi ennyn yr N400 a byddai'n fwy tebygol o fod wedi ennyn cydrannau fel y Left Anterior Negativity (LAN; sydd yn cyrraedd uchafbwynt tua 180ms mewn safleoedd electrod blaen ar y chwith; Coulson, King & Kutas, 1998; Friederici, Pfeifer, & Hahne, 1993).

Yn y Drafodaeth Gyffredinol, rwyf bellach yn syntheseiddio canlyniadau Arbrofion 1a a b, ac rwy'n cynnig dau ddehongliad posibl ar gyfer ein data, sydd wedyn yn cael eu profi yn Arbrawf 2.

Trafodaeth Gyffredinol

Mewn dau arbrawf, gwnaethom archwilio prosesu cysyniadol ddwyieithwyr rhugl yn L1 yn erbyn L2. Yn Arbrawf 1a, gwnaethom ddangos bod pobl ddwyieithog yn fwy sensitif i anghysondeb brawddeg yn y Gymraeg nag yn Saesneg. Yn wir, prin iawn oedd y dystiolaeth o fodiwleiddio N400 fel swyddogaeth anghysondeb brawddeg neu drosiad yn L2. Ar y llaw arall, nid yw’n ymddangos bod y ‘fantais’ L1 hon ar lefel prosesu

semantig ar-lein yn trosi’n fantais ymddygiadol (h.y. ymatebion cynt a chywirdeb uwch). Yn hytrach, yn ystod prosesu echbyg, roedd L2 yn arddangos mwy o fantais o ran cywirdeb ac amseroedd ymateb. Yna archwiliodd arbrawf 1b os allem arsylwi effaith fwy cynnil o drosiad yn L1 (ond nid yn L2; h.y., yn cyfateb i'r effaith anghysondeb yn Arbrawf 1a). Dangosodd ein canlyniadau brosesu semantig haws yn gyffredinol yn L1 ynghyd ac effaith trosiad yn L1. Fodd bynnag, yn groes i'n disgwyliadau, roedd brawddegau trosiadol yn arwain at N400 llai na brawddegau llythrennol yn L1. Yn gyffredinol, er bod ein patrwm cyffredinol o ganlyniadau ar lefel prosesu semantig ar-lein yn awgrymu mwy o sensitifrwydd i wahaniaethau mewn gofynion mapio cysyniadol, nid yw cyfeiriad y canfyddiadau hyn yn gwbl gyson â'n disgwyliadau. Rwyf nawr yn trafod ein dau brif ganfyddiad yn eu tro.

Prosesu semantig ar-lein o anghysondeb brawddegau yn L1 a L2

Ar y cyfan, mae ein canfyddiadau yn awgrymu nad yw pobl ddwyieithog rhugl L1 a L2 yn ymgysylltu â’r un prosesau yn ystod deall ar-lein. Er bod y cyfranogwyr hyn a hyfedr uchel iawn yn yr ail iaith, ymddengys bod anghymesuredd L1-L2 yn parhau (Model BIA, van Heuven & Dijkstra, 2010; RHM, Kroll a Stewart, 1994), lle mae L1 yn galluogi prosesu lefel semantig yn haws, wedi'i ddangos mewn mwy o sensitifrwydd i anghysondeb brawddeg. Mae'r canfyddiadau hyn i raddau helaeth yn cyd-fynd ag astudiaethau blaenorol, gan ddangos oedi wrth brosesu cysyniadol yn L2 er gwaethaf lefelau rhuglder uchel (Moreno & Kutas, 2005; Ardal, Donald, Meuter, Muldrew, Luce, 1990; Hahne & Friederici, 2001). Tybir bod yr anghymesuredd hwn yn annibynnol o hyfedredd, ac yn hytrach yn digwydd o ganlyniad i brofiad ieithyddol gwannach (van

Heuven & Dijkstra, 2010; Kroll a Stewart, 1994; Moreno & Kutas, 2005; Ardal, Donald, Meuter, Muldrew, Luce, 1990 ; Hahne & Friederici, 2001). Yn wir, roedd ein sampl dwyieithog yn adrodd magwraeth mewn cartrefi Cymraeg, derbyn addysg gynradd ac uwchradd Cymraeg yn bennaf (yn unol â pholisi iaith Gwynedd (Gwynedd Council, 2016), a defnydd dyddiol uwch o'r Gymraeg. Fodd bynnag, roeddem yn disgwyl arsylwi effaith N400 llai amlwg i frawddegau yn L1 nag yn L2 (fel yr arsylwyd o'r blaen) ond yn lle hynny gwelsom yr effaith gyferbyniol (N400 llai a P600 mwy yn L2) sy'n awgrymu bod prosesu semantig yn L2 yn fwy agored i oediad na'r disgwyl blaenorol.

Er bod y canfyddiadau hyn yn cyd-fynd yn gyffredinol â modelau dwyieithrwydd cyfredol (Kroll & Stewart, 1994; Dijkstra a Van Heuven, 2002; Finkbeiner et al, 2004), rydym yn cynnig bod ein defnydd o frawddegau i brofi'r cysylltiadau hyn hefyd yn awgrymu y gall cyd-destun ieithyddol (yma, brawddegau) hefyd ragfarnu'r system iaith i gydnabod a chynhyrchu geiriau mewn ffordd iaith-benodol (Bultena, Dijkstra, & van Hell, 2014; Schwanenflugel & Shoben, 1985; Foucart, Martin, Moreno, & Costa, 2014; Schwartz & Van Hell, 2012; Van Hell & De Groot, 2008, Schwartz & Kroll, 2006; Duyck et al, 2007). Golygai hyn y gallai prosesau rhagfynegol mewn prosesu semantig fod yn fwy effeithlon yn L1 nag yn L2. Yn y Cyflwyniad Cyffredinol i'r traethawd ymchwil hwn, cynigiais fod canfyddiadau o'r fath yn y llenyddiaeth ddwyieithrwydd yn gyson â'r tebygolrwyddau trosiannol ('*transitional probabilities'*) a ddisgrifir mewn modelau dysgu iaith (ee, Elman, 1990; Dell & Chang, 2014), lle mae actifiant o linynnau geirfaol penodol dro ar ôl tro yn galluogi'r unigolyn i wneud rhagfynegiadau effeithlon ynghylch geiriau dilynol.

Felly, hyd yn oed pan fo rhuglder L2 yn uchel, tybir fod L1 yn cynnwys set gyfoethocach o eiriau a chysylltiadau geirfaol-semantig cryfach (Kroll & Stewart, 1994; Luo, Cheung, Bel, Li, Chen, & Mo, 2013; Finkbeiner, Forster, Nicol & Nakamura, 2004). Mewn cyferbyniad, mae gan yr iaith anfrodorol gysylltiadau geirfaol-semantig gwannach a rhwydweithiau rhyng-gysyniadol cyfyngedig (Finkbeiner, Forster, Nicol, Nakamura, 2004). Yn ôl y modelau hyn, mae cysylltiadau a phrofiadau israddol yn L2 yn arwain at oediad ac ymdrech mwy mewn prosesu ein hastudiaethau. Yn ein hymchwil, mae'n debyg y gwelir yr effaith hwn mewn modyliad lleiaf posib o'r N400 i anghysondeb a throsiad yn y Saesneg L2, ac ail-ddadansoddi uwch i frawddegau Saesneg yn y ddau arbrawf.

Un ffordd arall o egluro'r canfyddiad cyfredol yw trwy fframwaith o ddeall iaith 'digon da' ('good enough' Ferreira et al, 2002). Mae'r model hwn yn disgrifio ffenomen camddehongli brawddegau mewn achosion fel *"The authorities had to bury the survivors*" (Barton & Sanford, 1993), lle mae'r ystyr yn annhebygol, ac eto mae'r anghysondeb yn aml yn cael ei anwybyddu yn ystod camau cychwynnol y prosesu, a'i gydnabod yn ystod ail-ddadansoddi. Mae hygrededd cyd-ddigwyddiadau y cysyniadau hyn ('*authorities, bury, survival'),* yn golygu bod gan y darllenydd gynrychiolaeth 'digon da' o'r ystyr, nes pwyso am ddadansoddiad llawn (Christianson, 2016). Ar y lefel niwral, yn nodweddiadol nid yw brawddegau o'r fath yn ennyn modyliad y don N400, sydd yn mynd yn groes i'r effeithiau a geir fel arfer mewn anghysondeb brawddeg; yn hytrach, mae effeithiau i'w gweld yn y don P600, sy'n arwydd o ail-ddadansoddiad (ee, Brouwer, Fitz, & Hoecks, 2012; Osterhout & Holcomb 1992; Osterhout & Mobley 1995; van

Berkum et al. 2005; Kim & Osterhout 2005; Van Herten et al, 2005). Yn gyffredinol, mae darllenwyr sydd â gallu cof gwannach – darllenwyr gwan (Hannon & Daneman, 2004) ac oedolion hŷn (Christianson, Williams, Zacks, & Ferreira, 2010) - yn nodweddiadol yn fwy agored i gamddehongliadau prosesu digon da. Er ei fod yn betrus, gall mecanwaith tebyg fod yn sail i brosesu dwyieithog ’L2, lle mae cysylltiadau geiriadurol-semantig gwannach yn creu arddull brosesu semantig gychwynnol yn seiliedig ar ddulliau hewristig yn hytrach na dadansoddiad semantig ar-lein. Yn ddiddorol, nid ydym yn dod o hyd i gost i ddilysu semantig oddi ar lein, gan awgrymu nad yw dadansoddiad semantig hwyrach yn peryglu gweithredoedd L2 ar lefel ymddygiadol.

Prosesu semantig ar-lein o frawddeg trosiadol yn L1 a L2

Er na ddatgelodd Arbrawf 1a unrhyw sensitifrwydd ar-lein i drosiad, yn Arbrawf 1b, dangosodd pobl ddwyieithog ymatebion N400 llai i ystyron trosiadol yn L1, gan awgrymu yn arwynebol bod prosesu trosiad yn L1 yn haws na phrosesu iaith lythrennol. Awgrymaf ddau esboniad post-hoc am y canfyddiad annisgwyl hwn, a gaiff eu archwilio ymhellach yn Arbrawf 2.

Yn gyntaf, efallai bod y rhai dwyieithog hyn wedi bod yn agored i ‘rhith semantig’ (‘*semantic illusion’*) yn ystod prosesu trosiad cychwynnol yn L1, i ddechrau heb fod yn ymwybodol o’r ystyr anghonfensiynol / trosiadol. Mae'r effaith hon wedi'i mynegi gan N400 gostyngedig sydd yn awgrymu, bod trosiad yn ennyn mwy o ymdrech ail-ddadansoddi (sydd yn amlwg yn y ffenest P600) er nad oedd adalw'r ystyr o'r cof tymor hir yn anodd (sydd ddim yn syndod o ystyried mai hon yw'r iaith frodorol; sydd yn

amlwg mewn N400 llai). Felly, cafodd y frawddeg ei phrosesu'n llawnach ar gyfer ystyr yn ystod ffenestr amser hwyrach, sydd yn gysylltiedig yn nodweddiadol ag ail-ddadansoddi ystyr (Brouwer, Fitz, & Hoeks, 2012; Hoeks et al, 2004) ac awgrymu bod integreiddio ystyr yng nghyd-destun mwy'r frawddeg yn fwy anodd (Rataj et al 2018; Brouwer, Fitz, & Hoeks, 2012; Hoeks et al, 2004).

Er bod llawer o astudiaethau sy'n ymchwilio i brosesu trosiadol wedi arsylwi modiwleiddiadau o'r gydran P600 mae'r canlyniadau ychydig yn anghyson; gyda rhai astudiaethau'n canfod mwy o osgledau i drosiadau (Coulson & Van Petten, 2002; De Grauwe et al, 2010) tra bod eraill yn canfod yr effaith groes (Arzouan et al, 2007; Goldstein et al, 2012). Mae'r mater hwn yn cael ei ddrysu ymhellach gan fethiant llawer o astudiaethau i archwilio'r gydran yn gyfan gwbl (Rataj, Przekoracka-Krawczyk, & van der Lubbe, 2018). Felly, mae dod i gasgliadau pendant ynghylch y berthynas rhwng yr N400 a P600 yma (ac yn wir wrth brosesu trosiad cyffredinol) yn betrus. Rhaid inni hefyd ofyn pam na ddangosodd y rhai dwyieithog hyn yr un effaith yn L2 (fel y gwelwyd yn arbrawf 1a)? Felly, er bod yr esboniad hwn yn ddiriaethol yn ddamcaniaethol, mae'n gwrth-ddweud yn uniongyrchol gasgliadau arbrawf 1a (bod prosesu bas yn digwydd yn L2). Er iddo gael ei drafod o fewn y llenyddiaeth drosiadol (Rataj et al 2018) mae rhith semantig (wedi'i fynegi gan N400 gostyngedig) yn ganfyddiad newydd yn y llenyddiaeth drosiadol. Fodd bynnag, mae'n effaith sydd wedi’i sefydlu’n gryf mewn prosesu anghysondebau (Brouwer, Fitz, & Hoeks, 2012), ac mae'n rhaid i ni felly, ystyried esboniadau amgen a chynnal ymchwiliadau pellach (arbrawf 2) i egluro'r mater.

Yr ail esboniad, sydd yn fwy hapfasnachol, am y canfyddiad hwn yw bod y tebygolrwydd ystadegol o ddod ar draws iaith drosiadol yn uwch yn y Gymraeg na'r

Saesneg. Mae iaith drosiadol yn ddyfais farddonol a ddefnyddir yn aml mewn llenyddiaeth Gymraeg, a bydd pob plentyn sy'n derbyn addysg Gymraeg yn derbyn hyfforddiant benodol ar sut i ddehongli iaith o'r fath (yn benodol yn ystod eu TGAU a Lefel A (WJEC/CBAC, 2020. WJEC GCSE in Welsh Literature; WJEC/CBAC, 2020. WJEC GCE AS/A LEVEL in Welsh (first language); WJEC/CBAC, 2020. WJEC GCSE English Language); Jones, 2016; Trefor, 2014). Yn wir, caiff feistroli dehongliadau dyfeisiau fel trosiadau eu hystyried i fod yn hanfodol wrth ddeall ystyr testun cyffredinol llenyddiaeth Gymraeg (Rowlands, 2015). Felly, mae ein cyfranogwyr wedi derbyn mwy o gyfarwyddyd a phrofiad wrth brosesu iaith drosiadol yn Gymraeg ac efallai bod y profiad, yr hyfforddiant, a'r wybodaeth hon wedi hwyluso dealltwriaeth o drosiad yn Gymraeg.

Casgliadau

I grynhoi, mae’r astudiaethau cyfredol yn datgelu mwy o wahaniaethu ystyr yn L1 yn ystod camau prosesu semantig ar-lein o ddeall brawddegau, ond nad yw’n arwain at fantais ymddygiadol (Arbrawf 1a). Yn Arbrawf 2, rydym yn archwilio os yw'r effeithiau trosiad a welir yn L1 (Arbrawf 1b) wedi'u cysylltu'n wirioneddol â'r iaith frodorol. Felly, byddwn yn recriwtio pobl ddwyieithog frodorol Saesneg-Gymraeg, gan ddefnyddio patrwm union yr un fath, i ddarganfod os ellir dod o hyd i effeithiau tebyg pan fyddant yn Saesneg L1.

Pennod 4

Dwyieithrwyr yn gwneud synnwyr (II):

Gall prosesu semantig ar-lein o ystyr ffigurol ddibynnu ar gyd-destun iaith, nid statws L1

Cydnabyddiaethau: Hoffwn ddiolch i Yang Lee, Jen Lewendon a Laurie Mortimore am eu cymorth wrth ffitio'r cap EEG.

Crynodeb

Mae cyfrifon cyfredol o brosesu iaith ffigurol ar-lein yn awgrymu y ceir iaith lythrennol ei hintegreiddio'n haws nag iaith drosiadol, fel eu mynegir gan osgleddau N400 mwy. Yn arbrawf 1b, fodd bynnag, canfuom fod brawddegau trosiadol yn ennyn osgleddau N400 llai yn y Gymraeg mewn unigolion brodorol Cymraeg-Saesneg, er fod strwythyr y brawddegau llythrennol a throsiadol yr un fath, Yn ogystal, ni ddarganfuwyd unrhyw dystiolaeth o brosesu gwahaniaethol yn yr iaith anfrodorol (Saesneg). Yma, ein nod oedd egluro'r canfyddiadau hyn. Ymgymerodd unigoloion dwyieithog brodorol Saesneg - Cymraeg (h.y., gwrthdroi L1-L2) dasg union yr un fath â'r un a ddisgrifir yn Arbrawf 1b: Cofnodwyd data potensial cysylltiedig â digwyddiadau (ERP) wrth i'r cyfranogwyr ddarllen brawddegau Saesneg a Chymraeg gydag ystyron llythrennol a throsiadol. Darganfuwyd bod dim gwahanieuthau mewn osgleddau’r N400 rhwng brawddegau llythrennol a throsiadol yn L1 (Saesneg), gan gefnogi cyfrifon blaenorol o fynediad uniongyrchol i iaith drosiadol. Fodd bynnag, yn L2 (Cymraeg), cafodd brawddegau trosiadol eu prosesu yn haws na brawddegau llythrennol (wedi'u mynegi gan N400 gostyngedig i drosiad), yn gyson â chanfyddiadau Arbrawf 1b. Ar y cyfan, mae ein canfyddiadau yn awgrymu y gallai priodweddau ieithyddol effeithio ar brosesu iaith ffigurol.

Yn arbrofion 1a ac 1b, archwilwyd fapio cysyniadol unigolion rhugl Cymraeg-Saesneg yn L1 a L2. Yn Arbrawf 1a, cyflwynwyd brawddegau Cymraeg a Saesneg, a gafodd eu trin ar gyfer synnwyr (brawddegau synhwyrol yn erbyn brawddegau anghyson) a ffigurol (brawddegau llythrennol yn erbyn brawddegau trosiadol). Dangosodd ein canlyniadau fod prosesu semantig ar-lein yn wir yn wahanol rhwng L1 a L2. Yn yr iaith anfrodorol, dangosodd ein unigolion ddwyieithog fwy o ymdrech wrth brosesu brawddegau anghyson yn L1, ond ni ddaeth unrhyw wahaniaeth o'r fath i'r amlwg yn L2. Ein nod oedd archwilio gwahaniaethau mewn dadansoddi gwybodaeth semantig (canfod tramgwydd llawn yn achos brawddegau anghyson, neu fwy o anhawster yn achos trosiad) rhwng L1 a L2. Daethom i'r casgliad bod ystyr ar gael yn gynharach yn L1 nag yn L2 – fel y nodir gan chwiliad semantig cynharach yn L1, yn ddifater o synwyrusrwydd semanteg y frawddeg. Hynny yw, er fod yr ystyr efallai yn Newydd neu yn anghyson, roedd chwiliad semantig yn digwydd yn L1 (a nodir gan fodyliad N400). Nid oedd hyn fodd bynnag, yn trosi i hwyluso perfformiad ymddygiadol mewn tasg dyfarnu semantig (Arbrawf 1a).

Er mwyn archwilio achos trosiad yn fwy manwl, cynhalwyd ail arbrawf a oedd yn eithrio'r brawddegau anghyson (Arbrawf 1b). Unwaith eto, roedd prosesu yn L2 yn gymharol ar gyfer brawddegau llythrennol a throsiadol. Yn yr iaith frodorol (Cymraeg) fodd bynnag, roedd osgled yr N400 ar gyfer brawddegau llythrennol a throsiadol yn ymwahanu, yn rhyfeddol gyda brawddegau trosiadol yn cael eu prosesu yn haws na brawddegau llythrennol. Mae'r canlyniadau hyn yn gwrth-ddweud canfyddiadau sy'n

awgrymu ei bod yn anoddach cyrchu ystyr trosiadol (Pynte, Besson, Robichon & Poli, 1996; Coulson & Van Petten, 2002; 2007; Lai et al, 2009).

Cynnigiom ddau reswm posibl dros y canfyddiad hwn. Yn gyntaf, mae prosesu semantig yn L1 yn fwy agored i brosesu ‘digon da’, fel bod ystyron trosiadol yn cael eu gwerthuso'n fras yn ystod y cyfnod N400 a'u prosesu yn fwy manwl yn nes ymlaen. Yn ail, ac yn fwy dyfaliadol, yw fod y tebygolrwydd ystadegol o ddod ar draws trosiad yn uwch yn y gymraeg, ynghyd a phrofiad uwch â dyfeisiadau barddol, gan arwain at fantais o brosesu trosiad yn y Gymraeg. Er eu bod yn ddyfaliadol, cofiwch fod ein data normio wedi dangos bod brawddegau llythrennol a throsiadol Cymreig yn cael eu graddio yn ‘ffigurol’ yn yr un modd o gymharu â’r gwahanieth mwy yn y graddfeydd ar gyfer brawddegau Saesneg.

I brofi'r rhagdybiaethau cystadleuol hyn, ymgymerodd grŵp o bobl ddwyieithog Saesneg-Gymraeg rhugl (h.y., Saesneg L1) weithdrefn union yr un fath â'r un a ddefnyddiwyd yn arbrawf 1b. Yn seiliedig ar yr esboniadau a gyflwynwyd ym Mhennod 1, roedd ganddom ddau brif ragfynegiad:

1. O dan gyfrif prosesu ’digon da’, bydd osgleddau i frawddegau llythrennol Saesneg yn fwy na brawddegau trosiadol Saesneg (L1). Mae brawddegau trosiadol yn debygol o gael eu prosesu yn ddiweddarach gan ymddangos mewn osgleddau P600 mwy. Ni fydd gwahaniaeth rhwng brawddegau llythrennol a throsiadol yn y Gymraeg (L2).

2. Fodd bynnag, os yw mynediad at drosiad yn uniongyrchol a bod y gostyngiad yn osgledd yr N400 i frawddegau trosiadol Cymreig i'w briodoli i briodweddau'r

Gymraeg, rydym yn disgwyl i'r un canlyniadau ddigwydd waeth beth yw statws brodorol y Gymraeg. Hynny yw, yn Gymraeg rydym yn disgwyl i frawddegau trosiadol gael eu prosesu yn haws na brawddegau llythrennol (wedi'u mynegi gan osgled N400 gostyngedig i drosiad). Yn ogystal, byddai osgleddau tebyg i frawddegau llythrennol a throsiadol Saesneg yn cefnogi'r rhagdybiaeth o fynediad uniongyrchol at ystyr drosiadol.

Dulliau

Cyfranogwyr

Bu recrwtio pedwar ar hugain o bobl dwyieithog Saesneg-Gymraeg (*N* = 24; 18 benyw, 6 gwryw; *M* oed = 24.6) gan ddefnyddio dulliau samplu pel-eira a chyfleus (fel arbrawf 1). Dysgodd y cyfranogwyr hyn Gymraeg yn ifanc iawn (*M* = 2.6, *SD* = 1.76); yn fengach na’r cyfranogwyr Cymraeg iaith gyntaf (arbrawf 1), yn uniol a’r oedran y bydd addysg Cymraeg gynnar yn dechrau (e.e. ysgolion meithrin). Ystyrir unrhyw gyfranogwyr a adroddodd dderbyn Saesneg a Chymraeg yn y cartref yn ddwyieithwyr cydamserol ac felly bu eu diddymu cyn y dadansoddiad. Cafodd un cyfranogwr ychwnaegol ei eithrio o'r sampl derfynol oherwydd data o ansawdd isel. Datgelodd mesurau hunan-adrodd gan gynnwys holiadur hanes iaith a’r ‘Multi-Group Ethnic Identity Measure’ (gweler Pennod 2 ac Atodiad A & B am adolygiad llawn) fod hyfedredd a defnydd Saesneg y cyfranogwyr (*M* = 9.6, *SD* = 0.14; 62.75% yn cael ei ddefnyddio bob dydd) yn uwch na'u hyfedredd a'u defnydd o’r Gymraeg (*M* = 7.96, *SD* = 0.55; 37.25% o ddefnydd dyddiol). Bu i’r cyfranogwyr hunan-nodi eu bod yn

ddiwylliannol Gymraeg neu Brydeinig (*n* = 20; *n* = 4). Cafwyd cymeradwyaeth foesegol gan yr Ysgol Seicoleg, prifysgol Bangor a rhoddodd y cyfranogwyr ganiatâd gwybodus cyn cymryd rhan.

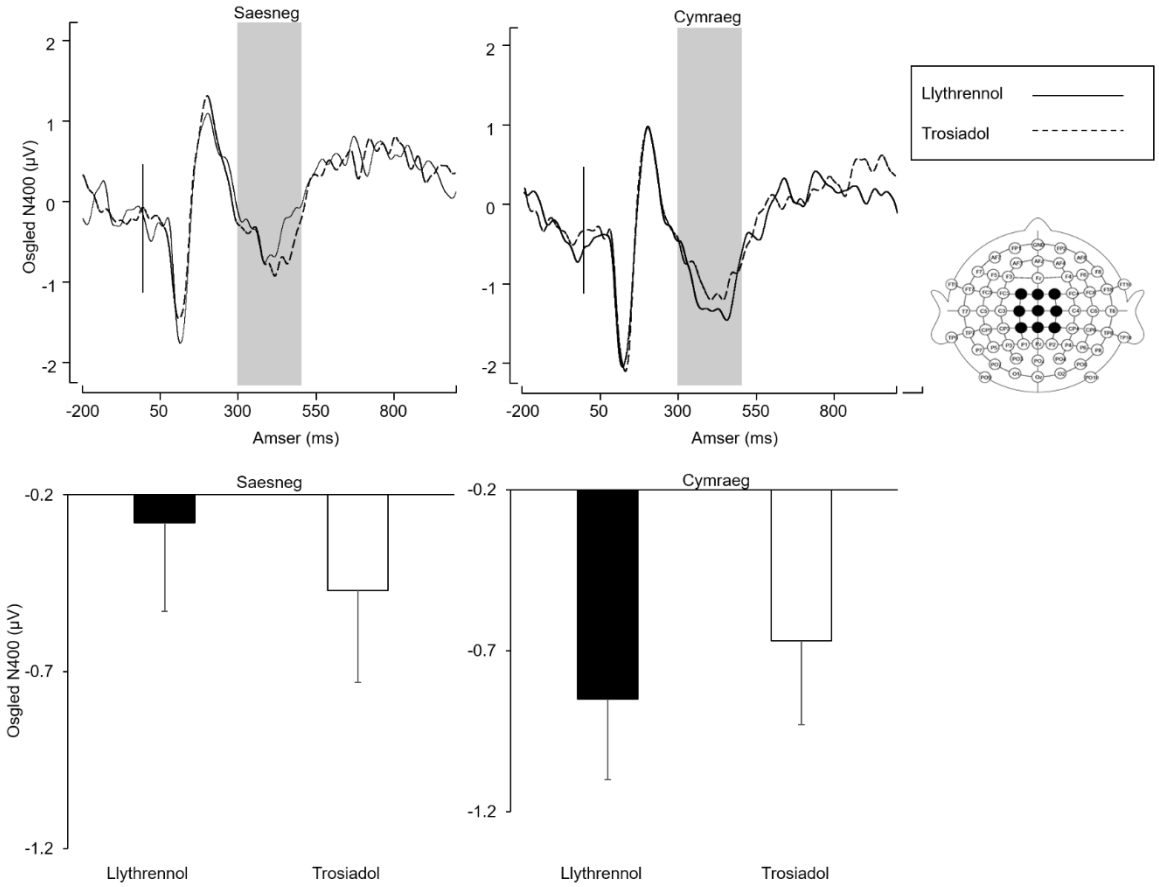
Deunyddiau, dyluniad a threfn

Roedd y deunyddiau, y dyluniad a'r gweithdrefnau a ddefnyddiwyd yn yr arbrawf hwn yn union yr un fath â'r rhai a ddefnyddiwyd yn arbrawf 1b (gweler pennod 3).

Canlyniadau

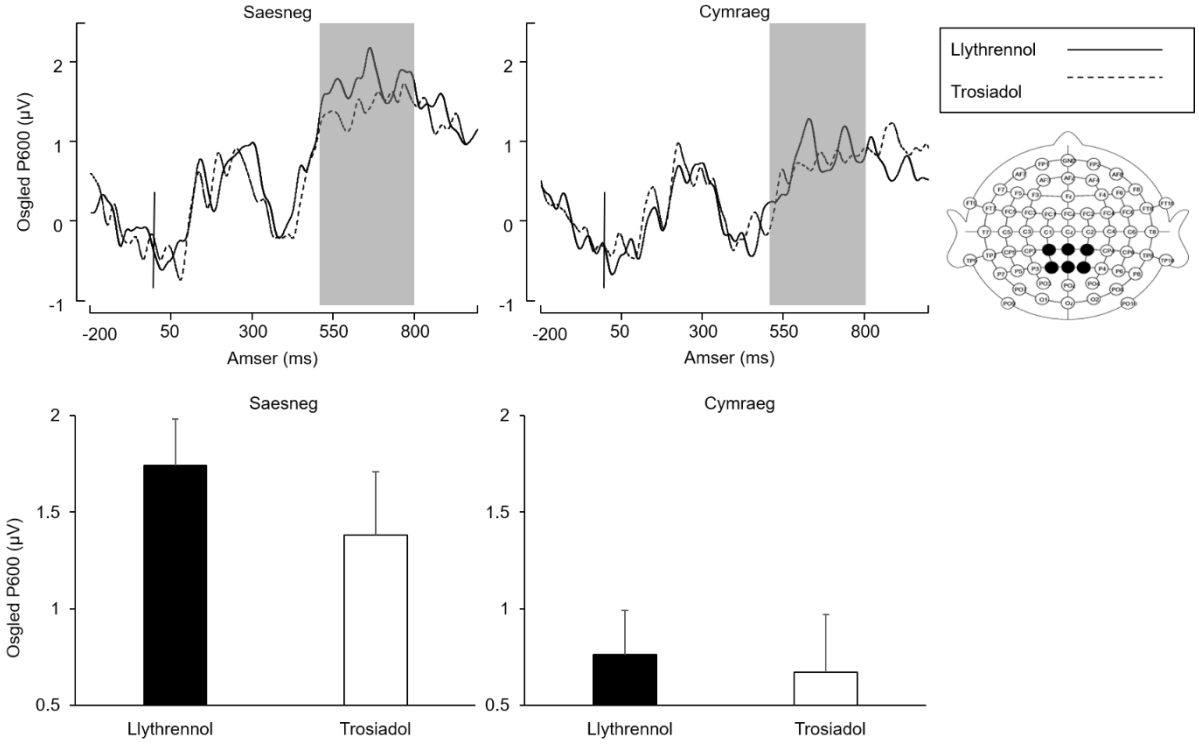
Defnyddwyd dadansoddiad o amrywiant dwy-ffordd (ANOVA) gan ddenfyddio cynllun mesuriadau ailadroddus, a'r ffactorau annibynnol o iaith (Saesneg, Cymraeg) a ffigurol (llythrennol, trosiadol).

N400. Yn ffenestr amser yr N400 (300 - 500 ms), dadansoddwyd osgleddau ERP dros 9 safle electrod blaen-ganolog, canolog a chanolog-parwydol (*'fronto-central, central, central-parietal'*, FC1 FC2 FCZ C1 C2 CZ CP1 CP2 CPZ). Darganfunwyd prif effaith arwyddocaol o iaith (F (1, 23) = 6.91, p = .02) gyda brawddegau Saesneg yn arddangos osgleddau llai o'r N400 (M = -38, SE = .23) o gymharu â brawddegau Cymraeg (M = -. 76, SE = .21, ηp2 = .23). Ni ddaeth unrhyw brif effaith ffigurol (F (1, 23) = .002, p = .96, ηp2 = .0) nac unrhyw ryngweithiad iaith * arwyddocaol i'r amlwg (F (1, 23) = 1.58, p = .22, ηp2 = .06).



Ffigwr 16. Osgled cymedrig (µV) yr N400 ar gyfer brawddegau llythrennol a throsiadol mewn Saesneg a Chymraeg. Mae’r bariau gwall yn cynrychioli'r gwallau safonol.

P600. Yn ffenestr amser y P600 (500 - 800 ms), dadansoddwyd amplitudes ERP dros 6 electrod parwydol (‘*pariatal*’, CP1 CPZ CP2 P1 PZ P2). Darganfuwyd prif effaith arwyddocaol o iaith (F (1, 23) = 8.88, *p* = .007, ηp2 = .27) gyda brawddegau Saesneg yn arddangos osgledau P600 uwch (*M* = 1.56, *SE* = .25) na brawddegau Cymraeg (*M* = .71, *SE* = .24). Ni ddaeth unrhyw brif effaith arwyddocaol o ffigurol (*F* (1, 23) = 1.595, *p* = .22, ηp2 = .07) na rhyngweithiad iaith*ffigurol i'r amlwg (*F* (1, 23) = .43, *p* = .52, ηp2 = .03).



Ffigwr 17. Osgled cymedrig (µV) y gydran P600 ar gyfer brawddegau llythrennol a throsiadol yn Saesneg a Chymraeg. Mae’r bariau gwallau yn cynrychioli'r gwallau safonol.

Trafodaeth

Nod yr astudiaeth hon oedd taflu goleuni ar ganfyddiadau annisgwyl arbrawf 1b, lle canfuwyd mwy o sensitifrwydd i iaith lythrennol yn erbyn iaith drosiadol yn L1 (Cymraeg), ond i gyfeiriad annisgwyl (cynhyrchodd trosiad osgleddau llai o gymharu ag iaith lythrennol). Felly, roedd Arbrawf 2 yn cynnwys patrwm union yr un fath ag Arbrawf 1b; yr unig newid yw'r boblogaeth a astudiwyd. Gwnaethom recriwtio pobl ddwyieithog Saesneg (L1) - Gymraeg (L2) er mwyn canfod os oedd ein canfyddiadau yn

adlewyrchu prosesu ‘digon da’ yn L2 (effaith samplu ddwyieithog). Pe bai hyn yn wir, roeddem yn disgwyl y byddai pobl ddwyieithog Saesneg-Cymraeg yn dangos prosesu bas i drosiad (ac osgleddau N400 llai i drosiad) yn Saesneg, ond yn Gymraeg nid oeddem yn disgwyl unrhyw wahaniaethau rhwng amodau. Neu, os yw gwahaniaethu a phrosesu trosiad ar bwynt cynharach yn adlewyrchu priodweddau naturiol y Gymraeg. Os felly, yna rydym yn disgwyl ailadrodd y duedd a welwyd yn Arbrawf 1b (byddai trosiad Cymru yn ennyn N400 llai o'i gymharu â brawddegau llythrennol Cymraeg).

Ar y cyfan, mae'r data'n awgrymu bod yr unigolion ddwyieithog Saesneg-Gymraeg wedi cael mwy o anhawster wrth brosesu'r Gymraeg o gymharu â brawddegau Saesneg (fel y'u mynegwyd gan osgleddau N400 mwy i frawddegau Cymraeg). Mae'r canfyddiad hwn yn gyson â'n canfyddiadau ein hunain (gweler arbrofion 1a ac 1b) a'r llenyddiaeth ddwyieithog (Ardal, Donald, Meuter & Muldrew, 1990; Kutas & Kluender, 1994; Weber-Fox & Neville 1996). Fodd bynnag, yn ystod y ffenestri amser diweddarach sy'n arwydd o ail-ddadansoddi, gwelsom brosesu mwy ymdrechgar i'r Saesneg o'i gymharu â brawddegau Cymraeg. ‘Rwyf nawr am drafod y canfyddiadau hyn yn eu tro.

Mynediad uniongyrchol i iaith ffigurol

Yn gyferbyn ag arbrawf 1b (ond yn unol ag arbrawf 1a fodd bynnnag) ni welsom unrhyw effeithiau arwyddocaol o drosiad yn yr iaith frodorol (neu anfrodorol). Yn seiliedig ar y canlyniadau hyn rydym yn tybio bod diffyg gwahaniaeth rhwng brawddegau llythrennol a throsiadol ar draws y tair astudiaeth, yn awgrymu bod y cyfranogwyr hyn wedi cyrchu'r ystyr trosiadol yn uniongyrchol - neu o leiaf ar y cyd â'r

brawddegau llythrennol tebygolrwydd isel - gan gefnogi'r rhagdybiaeth mynediad uniongyrchol (de Grauwe et al., 2010; Iakimova, Passerieux, Laurent, Hardy-Bayle, 2005). Gweler atodiad G am ddarlun o osgleddau N400 yr effaith hwn ar draws y dair arbrawf.

Mae'r canlyniadau hyn yn gwrthddweud y rhai a arsylwyd o'r blaen sydd wedi canfod osgleddau mwy i drosiadol o gymharu â brawddegau llythrennol. Mae modelau niwrowybyddol yn cynnig dau fodel cystadleuol i ddisgrifio dealltwriaeth trosiadau. Mae'r model hierarchaidd gwreiddiol (The original hierarchical model; Grice 1975; Searle 1979) yn cynnig y bydd darllenydd / gwrandäwr yn chwilio am ystyr lythrennol y brawddegau i ddechrau; unwaith y bydd y dehongliad hwn wedi'i ddatgan yn ddiystyr, bydd yn dechrau chwilio am ystyr trosiadol. Yn wrthgyferbyniol, mae'r rhagdybiaeth mynediad uniongyrchol (the direct access hypothesis; Gibbs & Gerrig 1989; Gibbs 2002) yn rhagdybio nad yw mynediad at ystyr trosiadol brawddeg yn dilyn chwiliad am ystyr llythrennol, ond yn hytrach, gellir ei gyrchu ar y cyd ar yr amod bod y cyd-destun yn cefnogi dehongliad trosiadol.

Mae canlyniadau arbrofion ymddygiadol yn cefnogi'r rhagdybiaeth mynediad uniongyrchol yn bennaf, gan nodi bod deall brawddegau llythrennol a throsiadol yr un mor hawdd (e.e. McElree & Nordlie 1999; Hoffman & Kemper 1987; gweler Glucksberg 2003 am drosolwg). Yn benodol, ceir amseroedd ymateb hirach ar gyfer brawddegau trosiadol i gymharu a brawddegau anghyson, ei ddehongli fel bod ystyron trosiadol a llythrennol yn cael eu cyrchu ar y cyd (Glucksberg, Gildea & Bookin 1982; Faust & Weisper 2000). Yn astudiaeth Glucksberg, Gildea & Bookin’s (1982) roedd y cyfranogwyr yn sylweddol arafach i ymateb i frawddegau trosiadol pan ofynnwyd iddynt

lunio barn ynglun a pha mor llythrennol oeddent mewn gwirionedd. Awgrymai hyn bod y dehongliad trosiadol ar gael ar unwaith ac yn anodd i'w anwybyddu.

Felly, er bod llawer o astudiaethau wedi canfod osgledau N400 cynyddol i frawddegau trosiadol mewn perthynas â brawddegau llythrennol (e.e. Pynte, Besson, Robichon & Poli, 1996) nid yw o reidrwydd yn cefnogi'r model hierarchaidd (h.y. bod dehongliad trosiadol yn cael ei gyrchu ar ôl mynediad llythrennol). Mewn gwirionedd, byddai cyfrif prosesu hierarchaidd neu gyfresol hefyd yn ennyn y cydran P600 sy'n arwydd o ail-ddadansoddiad (De Grauwe, Swain, Holcomb, Ditman, & Kuperberg, 2010). Fodd bynnag, os cyrchir at y dehongliad trosiadol ar y cyd â'r ystyr lythrennol, a'i fod yr un mor hawdd i'w ddehongli, pam felly fod astudiaethau'n parhau i arsylwi osgleddau N400 mwy?

Un ffactor y gwyddys i ddylanwadu ar osgled yr N400 yw hygrydedd ('*plausibility*') a '*cloze probability'* (gweler y bennod dulliau ar gyfer adolygiad llawn). Ymchwiliodd Coulson, & van Petten, 2007 effeithiau '*cloze probability'* ar brosesu iaith trosiadol v llythrennol. Er bod brawddegau llythrennol sydd a '*cloze probability'* isel yn ennyn ogledau mwy o gymharu a brawddegau llythrennol a '*cloze probability'* isel yn eu hymchwil, roeddent hefyd yn ennyn ogledau llai na brawddegau trosiadol. Mae hyn yn awgrymu bod prosesu trosiadau yn semantig yn anoddach na phrosesu brawddegau llythrennol a '*cloze probability'* isel. Fodd bynnag, er i'r awduron ddarganfod sgoriau tebygolrwydd cyfannu gan ddefnyddio tasg a oedd yn ymofyn i gwblhau brawddeg, ni chynhaliwyd normio pellach i ddarganfod graddfeydd ar gyfer tebygolrwydd a pha mor ffigurol oedd y frawddeg (i enwi ychydig yn unig). Ar ben hynny, er bod y geiriau targed wedi'u cylchdroi fel eu bod yn ymddangos mewn amodau llythrennol a throsiadol, ni

chylchdrowyd y brawddegau a oedd yn arwain at y geiriau terfynol (ee llythrennol – '*They ended the year with a huge party that everyone remembered as the orgy*'; trosiadol – '*Unfortunately, what started as mere flirtation with the stock market has become an orgy'*). Felly, ni allwn fod yn sicr bod unrhyw effeithiau a ddarganfuwyd yn astudiaeth Coulson a van Petten i'w priodoli i'r gwahaniaeth llythrennol / trosiadol yn unig. Gall gwahaniaethau mewn pethau fel credadwyedd hefyd fod yn gyrru'r effeithiau a ddarganwyd.

Hyd eithaf ein gwybodaeth, mae ein hastudiaethau yn cynrychioli'r ymgais gyntaf i gyfateb brawddegau llythrennol a throsiadol ar eu hygrededd, '*cloze probability'*, ac amlder geiriau, ynghyd a llwyddo i gylchdroi ar lefel y frawddeg a'r gair targed. Dyluniwyd y brawddegau llythrennol yn fwriadol i fod yn isel o ran '*cloze probability'* fel bod y rhain yn cyfateb i'w cymar trosiadol ar raddau credadwyedd. Fel y nodwyd gan Cardillo et al, gall sicrhau cydraddoldeb rhwng brawddegau llythrennol a throsiadol aflunio ystyr trosiadol y frawddeg. Felly, mae ymchwil flaenorol wedi caniatáu rhai gwahaniaethau ansoddol rhwng ysgogiadau llythrennol a throsiadol. Mae ychydig yn aneglur os yw brawddegau llythrennol a throsiadol yn cyfatebol ar eu gymhlethdod a'u strwythur (ee Coulson & Van Petten 2002, 2007; Iakimova et al. 2005; Laurent et al. 2006) ac nid yw geiriau targed yn cael eu rheoli ar gyfer newidynnau megis amlder, '*concreteness*' a delweddadwyedd (ee Laurent et al. 2006; Tartter et al. 2002). Wrth gadw'r ystyron trosiadol, mae'n debygol iawn bod ffactorau o'r fath sydd heb eu rheoli wedi arwain at y gwahanol ganfyddiadau a adroddir yn y llenyddiaeth ar brosesu trosiadau. Credwn ein bod wedi llwyddo i reoli'r setiau brawddegau a ddefnyddir yma'n

dda, gyda’r brawddegau trosiadol hefyd yn cael eu graddio’n fwy ‘ffigurol’ na brawddegau llythrennol.

Yn y cyd-destun hwn, mae ein canfyddiadau'n dangos yn gyson bod modd canfod trosiad yn ystod prosesu semantig ar-lein, ond eto i gyfeiriad - trosiadau sy'n cynhyrchu llai o N400 o gymharu â brawddegau llythrennol – sydd yn groes i lenyddiaeth flaenorol. At hynny, nid L1 yw'r iaith sydd yn angenrheidiol yn canfod y trosiad yn ystod ffenestr yr N400; yn hytrach, gwnaethom ddangos bod canfod trosiad ar-lein yn dibynnu i raddau helaeth ar gyd-destun iaith. Fe af ymlaen i drafod yr effaith hwn yn awr.

Gall priodweddau sy'n perthyn i'r Gymraeg hwyluso prosesu trosiad

Mewn dau arbrawf, gwelsom fod trosiad yn ymddangos yn haws i'w brosesu nag iaith lythrennol pan gyflwynir ef yn Gymraeg (fel y'i mynegeiwyd gan N400 gostyngedig i drosiad). Yn arbrawf 1b, gwnaethom gynnig dau esboniad posibl: Yn gyntaf, gwnaethom ddyfalu bod cyfranogwyr yn agored i ‘rhith semantig’ - gan nad oeddent yn ymwybodol dros dro o ystyr anuniongred y frawddeg.

Gwnaethom ddamcaniaethu bod N400 gostyngedig i drosiad yn yr iaith frodorol yn mynegi rhwyddineb adfer ystyr y gair targed o’r cof tymor hir, ond awgrymodd P600 uwch bod integreiddio’r ystyr i gyd destyn y frawddeg yn achosi anhawster (Rataj et al 2018; Brouwer, Fitz , & Hoeks, 2012; Hoeks et al, 2004). O ystyried bod y patrwm hwn yn amlwg ymhlith cyfranogwyr Cymraeg brodorol a Chymraeg ail iaith, gall statws brodorol neu hyfedredd yr iaith fod yn amherthnasol. Golygai hyn bod yr esboniad hwn yn wallus. Fodd bynnag, y ffactor cyffredin ar draws yr arbrofion hyn yw'r cyd-destun

iaith: darganfuwyd yr effaith mewn brawddegau Cymraeg ond nid mewn brawddegau Saesneg. Felly, mae’n debyg y gellir priodoli'r effeithiau i nodweddion sy'n perthyn i'r Gymraeg sy'n ei gwneud hi'n haws prosesu trosiad. Er ei fod yn arbrofol iawn, mae'r esboniad hwn yn haeddu ymchwiliad pellach.

Un nodwedd ddiddorol o'r Gymraeg yw ei bod yn gwyro i ddwy iaith wahanol: Cymraeg Llenyddol a Chymraeg llafar (Fife, 1986). Mae Cymraeg Llenyddol yn deillio o Gymraeg hanesyddol a gellir dod ar ei draws ar ffurf farddonol. Bydd felly yn cynnwys amryw ddyfeisiau arddull gan gynnwys trosiad, odl, cynghanedd (ailadrodd a / neu rigymau mewnol sy'n dilyn patrymau straen penodol; Greene, 2012; Vaughan-Evans et al, 2016), personoli (priodoli nodweddion dynol i wrthrychau) ymhlith eraill (gweler tabl 9 am enghreifftiau). Mae trosiadau, felly, yn gyffredin iawn mewn Cymraeg llenyddol. Mae Jones (2016) yn esbonio sut mae meddwl llenyddwr o Gymru wrth lunio trosiad heddiw o’r un meddylfryd â llenyddwr ddwy ganrif yn ôl. Ar ben hynny, mae Rowlands (2015) yn awgrymu bod cyffredinrwydd trosiadau yn llenyddiaeth Cymru yn arwain at ddehongliadau trosiadol ar gyfer rhai geiriau (e.e. glaw a nos) fod mor amlwg â'u dehongliadau llythrennol.

Addysgir plant sy'n derbyn addysg gyfrwng Cymraeg i ddarllen llenyddiaeth trwy ganolbwyntio ar y dyfeisiau a amlinellir yn nhabl 1 (Rowlands, 2015), ac i fynd i'r afael ag ystyr mewn testun newydd gan ddefnyddio’r un dulliau (Jones 2016). Yn wir, credir bod nodi arddulliau trosiadol yn allweddol i ddeall ystyr gyffredinol testun (Rowlands, 2015). Er enghraifft, mae’r elfen farddoniaeth y pwnc TGAU Llenyddiaeth Gymraeg yn cynnwys 10 cerdd gorfodol i'w dysgu (WJEC / CBAC, 2020. TGAU WJEC mewn Llenyddiaeth Gymraeg). Mae'r cerddi hyn yn cael eu hastudio, eu trafod a'u dehongli'n

ofalus er mwyn adnabod themâu a dyfeisiau barddonol (megis trosiad), cyn cael eu cyferbynnu â cherddi newydd, sydd hefyd yn cael eu trafod a'u harchwilio ar gyfer dyfeisiau barddonol. Ar ben hynny, yn ystod addysg bellach a Lefel A Cymraeg, cyflwynir 12 cerdd newydd i fyfyrwyr a disgwylir iddynt eto ystyried a dehongli themâu, dyfeisiau, ac arddulliau barddonol (WJEC / CBAC, 2020. TAG WJEC AS / LEFEL A yn Gymraeg (iaith gyntaf)). Yn ystod yr arholiadau terfynol, disgwylir i fyfyrwyr adlaw'r cerddi o’r cof er mwyn eu trafod (TGAU = 1 cerdd orfodol; Lefel = 3 cerdd orfodol) a chyferbynnu â cherddi nofel. Ni roddir pwyslais o'r fath ar ddyfeisiau barddonol fel hyn mewn pynciau TGAU a Lefel A Saesneg ar y llaw arall. Rhoddir y ffocws yn hytrach, ar destunau megis llythyrau, erthyglau, taflenni ffeithiau, blogiau, taflenni, e-byst ac adroddiadau (WJEC / CBAC, 2020. WJEC GCSE English Language).

Yn ogystal, yn achos darllenwyr llai galluog a hyderus, defnyddir y dyfeisiau barddonol hyn fel offer addysgol i hwyluso dealltwriaeth (Rowlands, 2015). Yn wir, mae ymchwil yn dangos bod hyd yn oed y rhai sy'n credu na fyddent yn gallu deall llenyddiaeth ysgrifenedig (fel siaradwyr Cymraeg ail iaith), mewn gwirionedd yn gallu deall Cymraeg llenyddol yn hawdd (Trefor, 2014). Y rheswm am hyn yw bod llenyddiaeth Gymraeg yn fwy amlwg yn y gymdeithas nag y buasai rhywun feddwl, ac er eu bod yn hollol anymwybodol, mae darllenwyr yn agored i iaith o'r fath bron yn ddyddiol (mewn papurau newydd ac erthyglau ar-lein er enghraifft). Felly, efallai nad yw llenyddiaeth Gymraeg ffurfiol mor newydd na heriol i siaradwyr hyfedr, a hyd yn oed yn llai felly i siaradwyr trech / bob dydd.

Felly, yn ogystal â bod yn gyffredin mewn addysg gyfrwng Cymraeg (gorfodol tan 16 oed), deuir ar draws trosiadau a Chymraeg llenyddol yn aml y tu allan i'r cyd-

destun llenyddol. Mewn geiriaduron Cymraeg er enghraifft, cynhwysir dehongliadau llythrennol a throsiadol; disgrifir y term llew, fel anifail, fel dyn cryf, ac yn olaf, fel temtasiwn (Hawke, 2014). Mae defnydd ffigurol o iaith hefyd yn gyffredin mewn cymunedau Cymreig: Mae'r Eisteddfod er enghraifft (gŵyl genedlaethol Gymreig gyda chystadlaethau amrywiol) yn cynnal Gŵyl Lenyddiaeth Gymraeg sydd yn wythnos o hyd i blant ac oedolion. Fodd bynnag, ychydig iawn o dystiolaeth empeiraidd sydd ar gael i ddangos sut mae llenyddiaeth Gymraeg a'i dyfeisiau'n cael eu prosesu o fewn poblogaeth Cymru, na sut mae'r pwyslais ar drosiad yn y Gymraeg yn cymharu â'i ddefnydd mewn Saesneg.

Mae un astudiaeth sy'n bodoli wedi archwilio effeithiau niwrowybyddol barddoniaeth wrth brosesu brawddegau Cymraeg (Vaughan-Evans et al, 2016). Roedd y brawddegau naill ai'n gyson â rheolau rhythmig a chyflythrennol cynghanedd, (ee *Y rheol brwd ger y bryn*) neu'n torri cynghanedd (ee *Y ddiogel brwd ger y bont* - Torri cytseiniol; *Y cyhoeddus brwd ger y ffin* - Torri straen; *Y cyfrifoldeb brwd ger y clawdd* - Torri dwbl). Er eu bod yn siaradwyr brodorol Cymraeg, nid oedd gan y cyfranogwyr unrhyw wybodaeth flaenorol am ffurfiau traddodiadol cynghanedd. Defnyddiwyd sampl o gyfranogwyr di-gymraeg fel cymhariaeth. Darganfuwyd osgledau uwch o’r P3b (sy'n arwydd o ganfod targedau) i’r brawddegau a oedd yn cydymffurfio a rheolau cynghanedd yn y brodorion dibrofiad Cymreig. Golygai hyn fod y siaradwyr Cymraeg naïf hyn wedi canfod y ffurf farddonol o gynghanedd yn ymhlyg, gan awgrymu bod dyfeisiau a phatrymau barddonol ar gael cyn ystyried ystyr lythrennol, a bod barddoniaeth yn cael ei phrosesu yn ymhlyg ac yn annibynnol ar ystyr.

Gan ystyried (a) bod geiriau trosiadol yn hynod gyffredin o fewn llenyddiaeth Gymraeg a (b) bod pob siaradwr Cymraeg yn cael ei ddysgu i ddefnyddio dyfeisiau fel trosiadau fel allweddi i ddeall yr ystyr gyffredinol, rydym yn cynnig bod profiad blaenorol y cyfranogwyr o drosiad yn y Gymraeg wedi hwyluso dealltwriaeth. Derbyniodd y ddau grŵp addysg Gymraeg yn ifanc, ac er bod y siaradwyr ail iaith yn defnyddio Saesneg yn amlach, fe wnaethant adrodd eu bod yn defnyddio Cymraeg yn gymedrol (37%). Ar ben hynny, roedd yr holl gyfranogwyr yn byw yng Nghymru, ac felly, byddent yn agored i'r Gymraeg yn ddyddiol, hyd yn oed pe bai ond ar lefel anymwybodol. Yn wir, mae ymchwil yn dangos bod unigolion sydd yn byw mewn cymunedau fel Gwynedd (ble mae mwy na 30% o'r boblogaeth yn siarad Cymraeg), ddwy waith yn fwy tebygol o ddefnyddio'r iaith eu hunnain; mae'r ffigwr hwn yn cynyddu bedair Gwaith mewn cymunedau ble mae mwy na 60% yn siarad yr iaith (Jones, 2008).

Tabl 9. Enghreifftiau o ddyfeisiau llenyddol a gymerwyd o ddarnau llenyddol a addysgir ar gwricwlwm addysgol Cymru.

Dyfais	*Enghraifft*	*Teitl ac Awdur*
Personoli	*Siopau'n agor llygaid*	Prifddinas Caerdydd yn dihuno, Mihangel Morgan
	Pan fydd y niwl yn gwisgo'r bryniau draw	Y Sbectol Hud, Mererid Hopwood
Trosiad	*Mae popty'r Hydref wedi'u rhostio*	Walkers Wood, Myrddin ap Dafydd
	Treiddiodd dart trwy hedd y dŵr	Glas y dorlan, Rhys Dafis
Cynghanedd	*Gwerth cynnydd yw gwarth cenedl*	Etifeddiaeth, Gerallt Lloyd Owen

	Cawsom wlad i'w chadw, darn o dir yn dyst	Etifeddiaeth, Gerallt Lloyd Owen
cyf lythrennu	*Hen, hen yw murmur llawer man*	Eifionydd, R. Williams Parry
	Dilynem ddartiau gwyn y gwylain aflonydd yn trywanu targed y creigiau -	Glas, Bryan Martin Davies
Ansoddair	*Y ferch lwyd*	Gail fu Farw, Nesta Wyn Jones
	Yr ugeinfed yw'r fwyaf barbaraidd ohonynt hwy i gyd	Y Coed, Gwenallt

Rydym hefyd yn ystyried y gallai natur ein samplau dwyieithog gyfrannu at y canfyddiadau hyn. Trafodir o fewn y llenyddiaeth fod dwyieithrwydd yn sbectrwm o wybodaeth a phrofiadau (DeLuca, Rothman, Bialystock a Pliatsikas, 2019), lle nad oes unrhyw ddau unigolyn dwyieithog yn cael eu hystyried yr un fath (De Bruin, 2019). Yn wir, mae pobl ddwyieithog yn amrywio'n sylweddol yng nghyd-destun defnydd iaith, addysg ac agwedd tuag at ddwyieithrwydd (Bak, 2016). Felly, er bod ein mesurau hunan-adroddol wedi caniatáu i ni gasglu rhywfaint o wybodaeth ddiddorol ynglŷn â'n samplau dwyieithog, mae'r wybodaeth a gawsom yn hynod arwynebol o ystyried cymhlethdod dwyieithrwydd (byddef yn trafod y mater hwn ymhellach ym mhennod 6). Ar gyfer y canlyniadau hyn yn benodol, byddai angen mwy o wybodaeth arnom ynglŷn â chyd-destun defnyddio iaith ar draws eu hoes (Bak, 2016). O ystyried yr esboniad uchod, byddai gwybodaeth benodol am gyfranogwyr addysg bellach ac uwch (gan gynnwys cyfrwng pwnc ac iaith), ynghyd â chymryd rhan mewn gwyliau Cymreig (fel yr Eisteddfod), wedi bod yn fuddiol i fesur maint yr amlygiad a'r defnydd o'r Gymraeg a Llenyddiaeth Gymraeg. Mae'n anodd gwybod sut y byddai gwahaniaethau ieithyddol rhwng y cyfranogwyr hyn wedi effeithio ar y data. Fodd bynnag, wrth edrych ar hanes

ieithyddol cyfranogwyr yn fanylach, gwelwn nad oedd y samplau a ddefnyddiwyd ar draws yr arbrofion hyn yn union yr un fath; yn enwedig wrth gymharu L1 Cymraeg yn erbyn Saesneg L1 (gweler tabl 10), O ystyried bod yr effaith yn gryfach yn y Gymraeg L1 mae'n debygol iawn y gallai amlygiad, defnydd a gwybodaeth mwy fod wedi hwyluso dealltwriaeth ymhellach.

Tabl 10. Oedran caffael iaith, hyfedredd a defnydd cyfranogwyr yn arbrofion 1a, 1b, a 2.

	Oedran Caffaeliad		Hyfrydedd		Defnydd	
	Cymraeg	Saesneg	Cymraeg	Saesneg	Cymraeg	Saesneg
Arbrawf 1a	Birth	4.7	9.78	8.3	74%	26%
Arbrawf 1b	Birth	3.8	9.7	9.1	74%	26%
Arbrawf 2	2.6	Birth	7.9	9.6	37%	63%

Mae hefyd yn anodd pennu maint yr effaith hon yn ein samplau oherwydd y pŵer arbrofol isel sy'n debygol o ddeillio o feintiau sampl annigonol. Er bod y meintiau sampl a ddefnyddiwyd yma yn nodweddiadol iawn o arbrofion ERP iaith, mae Button, Loannidis, Mokrysz, Nosek, Flint, Robinson a Munafo (2013) yn awgrymu bod y meintiau sampl nodweddiadol a ddefnyddir mewn niwrowyddoniaeth yn rhy isel, ac yn arwain at fethu effeithiau dilys. Mae'r meintiau effaith (effect sizes) ar draws yr arbrofion

hyn yn awgrymu y gallai’r effaith fodoli, fodd bynnag, mae maint ein sampl yn rhy fach i bennu gwir faint yr effaith hon. Dychwelaf at y drafodaeth hon ym mhennod 6.

Casgliadau

I grynhoi Rhan 1 o'r traethawd ymchwil hwn, rydym yn dod i dri phrif gasgliad. Yn gyntaf, ymddengys bod canfod anghysondeb yn mynd yn ei flaen yn fwy effeithlon yn L1 o'i gymharu â L2. Fodd bynnag, ymddengys bod canfod trosiad yn gysylltiedig â chyd-destun iaith yn hytrach na statws L1 / L2. Byddaf yn trafod y pwyntiau hyn yn y Drafodaeth Gyffredinol (Pennod 6), ond i arddel fy nadl, awgrymaf fod brawddegau anghyson yn cynrychioli iaith gyffredinol, ond gall trosiad fod yn fwy dibynnol ar ffactorau iaith-benodol.

Pennod 5

Rhan 2

Mapio rhyng-synnwyr mewn pobl ddwyieithog

Cydnabyddiaethau: Hoffwn ddiolch i Yang Lee, Jen Lewendon a Lurie Mortimore am eu cymorth wrth ffitio'r cap EEG. Diolch hefyd i Manon Jones, Awel Vaughan-Evans a Guillaume Thierry am eu hadborth a'u cymorth wrth lunio'r ysgogiadau arbrofol.

Trosolwg o'r Bennod

Ym mhenodau 3 a 4 gwnaethom ymchwilio i weld a yw pobl ddwyieithog Cymraeg-Saesneg rhugl yn dangos gwahaniaethau mewn prosesu cysyniadol o fewn iaith (mapio o fewn synnwyr). Mae ein canfyddiadau yn cynnig tystiolaeth o ganfod anomali semantig yn gynharach yn L1, er bod gwahaniaethau o ran canfod iaith lythrennol yn erbyn iaith ffigurol ychydig yn fwy cynnil. Yn y bennod hon, edrychwn os yw cynrychioliadau cysyniadol rhwng ieithoedd (mapio rhyng-synnwyr) yn gydweithredol. Yn benodol, yw cynrychioliadau sy'n unigryw i un iaith ar gael ar yr un pryd i'r iaith ddigyswllt. I gyflawni hyn, gwnaethom gyflwyno brawddegau Saesneg i bobl ddwyieithog Cymraeg-Saesneg ynghyd a phobl Saesneg uniaith, a oedd yn cynnwys brawddeg idiomatig Gymraeg (wedi'i chyfieithu) (‘*She thought the woman was an old hat’*), brawddeg anghyson yn semantig (‘*He walked to the shop with the wind in his hat’*), neu frawddeg dderbyniol yn semantig (*'He was criticised by his friend for being a front hat’*). Er na chanfuom unrhyw wahaniaethau rhwng grwpiau ar lefel ymddygiadol, mae ymatebion ERP yn awgrymu bod pobl ddwyieithog Gymraeg-Saesneg yn cyrchu ystyr semantig idiomau Cymraeg mor hawdd â’r brawddegau derbyniol; wedi’i fynegi gan osgledau N400 a P600 gostyngedig i idiom Gymraeg a’r brawddegau derbyniol mewn cymhariaeth â brawddegau anghyson. Fodd bynnag, yn yr unigolion uniaith Saesneg, gwelsom fod yr idiom Gymraeg yn cyflwyno anhawster sy'n debyg i frawddegau anghyson; wedi’i fynegi gan ogledau N400 a P600 mwy i’r idiom Gymraeg a’r brawddegau anghyson o’u cymharu a’r brawddegau derbyniol. Mae'r canlyniadau hyn yn dangos bod ein cyfranogwyr dwyieithog Cymraeg-Saesneg wedi cyrchu yr ystyr iaith-benodol hyd yn

oed drwy’r iaith anghydweddol, sy’n awgrymu bod cyd-actifadu iaith hefyd yn digwydd ar lefel semantig.

Mae llawer o ymdrech ymchwil wedi canolbwyntio ar p'un a yw pobl ddwyieithog yn actifadu un iaith neu'r ddwy iaith yn gyfochrog yn ystod dealltwriaeth ieithyddol (Kroll & De Groot, 2005; Thierry & Wu, 2004; 2007; Schwartz & Van Hell, 2012; Gollan, Froster & Frost 1997; Hoshino & Kroll, 2008; Starreveld, De Groot, Rossmark, & Van Hell, 2014; Schoonbaert, Duyck, Brysbaert, & Hartsuiker, 2009; Hartsuiker, Pickering, & Veltkamp, 2004; Vaughan-Evans, Kuipers, Thierry, Jones, 2014 ; Van Hell & Dijkstra, 2002; van Hell & de Groot, 2008; Dijkstra, van Jaarsveld, & Brinkle, 1998; Brysbaert, van Dyck, & van de Poel, 1999; Costa, Caramazza, & Sebastia´n-Galle's. 2000; Costa, Miozzo, & Caramazza, 1999; de Groot, Delmaar, & Lupker, 2000; Dijkstra, Grainger, & van Heuven, 1999; Dijkstra, van Jaarsveld, & ten Brinke, 1998; Jared & Kroll, 2001; van Heuven, Dijkstra, & Grainger, 1998; Von Studnitz & Green, 2002). Mae'r dystiolaeth gyfredol yn awgrymu bod pobl ddwyieithog yn cyfieithu'n ddigymell o un iaith i'r llall, gan gyrchu'r ddwy eirfa (Thierry & Wu, 2007; 2012; Kroll & Sholl, 1992; Tzelgov & Eben-Ezra, 1992; Keatley et al., 1994; Beauvillain & Grainger , 1987; McClelland & Rumelhart, 1981) a gwybodaeth gystrawennol (Vaughan-Evans et al., 2013; Hartsuiker, Pickering, & Veltkamp, 2004) o'r ddwy iaith. Yr hyn sy'n llai adnabyddus ar hyn o bryd yw os ydyn nhw hefyd yn cyrchu gwybodaeth yn y ddwy iaith ar y cyd ar lefel semantig. Hynny yw, a yw actifadu synhwyrau sy'n unigryw i un iaith yn bosibl trwy'r iaith arall. Yma, gwnaethom archwilio a oes gan bobl ddwyieithog rhugl, fynediad uniongyrchol i synhwyrau sydd yn unigryw i'r L1, trwy L2 (lle mae'r wybodaeth yn ddisynnwyr i siaradwr uniaith).

Camsyniad cyffredin yw bod geiriau o un iaith yn cyfieithu'n syml i ieithoedd eraill (Jakobson, 2000; Panou, 2013), pan fydd ieithoedd mewn gwirionedd, yn amrywio

o fod â nodweddion sy’n gorgyffwrdd yn helaeth, i nodweddion sy’n gorgyffwrdd yn rhannol; ac mewn rhai achosion, nodweddion cwbl annibynnol (h.y., nid oes gan yr ystyr mewn un iaith gyfwerth yn yr iaith arall). Mewn achos o ddwyieithrwydd, mae cymhlethdod ychwanegol yn ymwneud ag achos ‘polysemy’, lle gellir rhannu gwybodaeth semantig ymhlith dwy iaith y rhai dwyieithog (RHM, Kroll a Stewart, 1994; BIA, Dijkstra, Van Heuven, & Grainger, 1998); BIA +, van Heuven, & Dijkstra, 2010), ond gyda nodweddion ychwanegol nad ydynt yn gorgyffwrdd (Jarvis a Pavlenko, 2008; Malt et al., 2015; Gathercole & Moawad, 2010). Er enghraifft, er bod cywerth cyfieithiadau megis ‘*hat*’ a ‘*het*’ yn gallu gorgyffwrdd yn llwyr ar draws ieithoedd (ee mae'r gair Saesneg '*hat*' a'r gair Cymraeg '*het*' yn rhannu'r gynrychiolaeth semantig o '*ddillad*'), mae gan '*het*' synhwyrau lluosog yn Gymraeg, yn dibynnu ar y cyd-destun (h.y. nodweddion semantig ychwanegol '*dynes wirion'*; Taylor, Devereux, & Tyler, 2011; Finkbeiner et al, 2004).

O dan gyfrif dewisol iaith, dim ond ymgeiswyr geiriau sy'n perthyn i'r iaith weithredu fydd yn cael eu hactifadu, ond o dan y farn ddetholus iaith, dylai ymgeiswyr o'r ddwy iaith fod yn weithredol ar y cyd. Ar y lefelau geirfaol a chystrawennol, mae cryn dipyn o dystiolaeth bellach yn cefnogi'r farn ddetholus iaith (Thierry & Wu, 2004, 2007; Wu & Thierry, 2012; Kroll and Sholl, 1992; Tzelgov & Eben-Ezra, 1992; Keatley et al., 1994; Beauvillain & Grainger, 1987; McClelland & Rumelhart, 1981; Vaughan-Evans et al., 2013; Kroll & De Groot, 2005; Schwartz & Van Hell, 2012; Gollan, Forster & Frost, 1997; Hoshino & Kroll, 2008; Starreveld, De Groot, Rossmark, & Van Hell, 2014; Schoonbaert, Duyck, Brysbaert, & Hartsuiker, 2009; Hartsuiker, Pickering, & Veltkamp, 2004; Vaughan-Evans, Kuipers, Thierry, & Jones, 2014; Van Hell & Dijkstra, 2002; van

Hell & de Groot, 2008; Dijkstra, van Jaarsveld, & Brinkle, 1998; Brysbaert, van Dyck, & van de Poel, 1999; Costa, Caramazza, & Sebastia´n-Galle´ s, 2000; Costa, Miozzo, & Caramazza, 1999; de Groot, Delmaar, & Lupker, 2000; Dijkstra, Grainger, & van Heuven, 1999; Jared & Kroll, 2000; Von Studnitz & Green, 2002).

Yn ogystal, mae ychydig iawn o dystiolaeth bod mynediad semantig dwyieithog yn ddetholus. Mewn dau arbrawf ERP, cyflwynodd Martin, Dering, Thomas & Thierry (2009) barau o eiriau i unigolion dwyieithog Cymraeg-Saesneg rhugl, wedi'u trin yn ôl perthnasedd semantig ac iaith preimio / darged (targedau Saesneg wedi'u dilyn gan gyfnodau Cymraeg neu dargedau Cymraeg ac yna cyfnodau Saesneg) . Gofynnwyd i'r cyfranogwyr wneud penderfyniadau ynglŷn â hyd y gair targed a gyflwynwyd yn yr iaith 'weithredol', wrth anwybyddu'r preim a gyflwynir yn yr iaith 'anweithredol'. Darganfuwyd fod parau â chysylltiad semantig yn arwain at effeithiau preimio ar gyfer geiriau Saesneg a Chymraeg, fel eu mynegwyd gan N400 llai i barau â chysylltiad semantig, hyd yn oed pan oedd iaith y parau targed-preim yn anghydnaws. Awgrymai'r awduron fod pobl ddwyieithog yn cyrchu cynrychioliadau semantig yn ddigymell yn eu dwy iaith, hyd yn oed pan ofynnir iddynt anwybyddu un iaith.

Mae canfyddiadau o'r fath yn cyd-fynd yn fras â thybiaethau'r modelau BIA a BIA +, lle mae cynrychioliadau orthograffig o'r L1 a L2 yn cael eu cyd-actifadu (Dijkstra, Van Heuven, & Grainger, 1998; van Heuven, & Dijkstra, 2010), ac yn arwain at fynediad cyfochrog i gynrychioliadau lefel ffonolegol a semantig mewn system gwbl ryngweithiol. Er y gall modelau fel y BIA + roi cyfrif syml am gyfwerth cyfieithiadau mewn unigolion dwyieithog, maent ar hyn o bryd yn darparu llai o fanylion ynglŷn â phrosesu semantig dwyieithog yn achos synhwyrau iaith-benodol. Mewn gwirionedd,

mae prosesu semantig dwyieithog yn bwnc cymharol isel yn y maes (Dijkstra et a., 2019), ac un o'r ychydig fodelau sydd wedi ceisio amlinellu'r system semantig ddwyieithog yw'r Sense Model (Finkbeiner Forster, Nicol & Nakamura, 2004). Yn ôl y model hwn, mae'r synhwyrau semantig sy'n gysylltiedig â chynrychioliadau geirfaol yn amlochrog, gan gynnwys nodweddion iaith-benodol ac amhenodol. Mae synhwyrau lluosog yn fwy tebygol o fod yn nodweddiadol o'r L1 o gymharu â'r iaith anfrodorol oherwydd hyfedredd a defnydd uwch (Finkbeiner et al, 2004).

Fodd bynnag, nid yw synhwyrau unigryw wedi'u cyfyngu i eiriau unigol; gallant hefyd ymddangos ar lefel y frawddeg, fel sy'n wir mewn iaith idiomatig, wedi'i nodweddu gan ymadroddion lle mae ystyr ffigurol yn ychwanegol i'w ystyr lythrennol. Er enghraifft, gellir dehongli'r ymadrodd Saesneg '*in hot water'* fel bod mewn dŵr yn llythrennol, neu fel bod mewn trafferth (Beck & Weber, 2016). Mae'r canfyddiadau cyfredol yn awgrymu bod mynediad at yr ystyr lythrennol o gymharu ag idiomatig yn cael ei bennu gan amlygrwydd, neu amlder, gydag ystyron ffigurol yn cael eu cyrchu'n uniongyrchol pan fydd yr idiom yn gyfarwydd (Ortony et al., 1978; Swinney & Cutler, 1979; Cacciari & Tabossi, 1988); yn benodol pan fo ei ystyr yn amlwg i gymharu ag idiomau anghyfarwydd a rheolaethau llythrennol (Giora 1997; 2002; Cacciari & Tabossi, 1988; Conklin & Schmitt, 2008; Libben & Titone, 2008; Rommers, Dijkstra & Bastiaansen, 2013; Tabossi , Fanari & Wolf, 2009).

Mae iaith idiomatig - ystyriwch eto 'mewn dŵr poeth' - hefyd yn tueddu i fod yn iaith-benodol, neu o leiaf yn rhagfarnllyd o ran iaith, ac mae ymadrodd ffigurol y frawddeg hon yn ddiystyr mewn ieithoedd eraill. Felly, byddai cyflwyno idiom mewn iaith wahanol yn debygol o ennyn anhawster prosesu, sy'n cyfateb i'r anhawster a

ddangosir pan fo angen i brosesu idiom anghyfarwydd (Carrol, Conklin & Gyllstad, 2016; Carrol & Conklin, 2016; Beck & Weber, 2016; Cieslicka & Heredia, 2017). Yna mae'r cwestiwn yn codi: A all unigolyn dwyieithog sydd yn gyfarwydd ag idiom synhwyrol mewn un iaith, gael gafael ar ei ystyr yn yr iaith arall (lle mae'n ffurf an-idiomatig yn ôl pob golwg)? I brofi'r rhagdybiaeth hon, cyflwynodd Carrol a Conklin (2016) idiomau Tsieineaidd i siaradwyr Tsieineaidd ond yn L2 (Saesneg), gan ddefnyddio dulliau olrhain llygaid i fynegi anhawster prosesu. Er bod cydnabyddiaeth yn arafach nag ar gyfer ystyr testun llythrennol, darganfuwyd fod modd adnabod ffurfiau idiomatig L1 hyd yn oed pan ddaethpwyd ar eu traws yn L2. Awgrymai hyn y gallai’r cyfieithiad idiomau ar-lein i'r Tsieinëeg L1 fod wedi arwain at actifadu'r ystyr idiomatig yn awtomatig.

Yma, rydym yn archwilio os all pobl ddwyieithog gyrchu ystyron idiomatig L1 unigryw, trwy L2. Ac ymhellach, p'un a yw mynediad yn uniongyrchol (ar lefel prosesu semantig ar-lein), neu'n anuniongyrchol (yn hytrach ar lefel ail-ddadansoddi brawddegau). I gyflawni hyn, cyflwynwyd unigolion brodorol Cymraeg-Saesneg ynghyd a grŵp rheoli o siaradwyr Saesneg uniaith, gyda brawddegau Saesneg wrth i ni recordio ymatebion ERP. Lluniwyd brawddegau fel bod eu hystyr gyffredinol (a bennir gan air targed a oedd yn frawddeg-derfynol) yn cynnwys ystyr lythrennol dderbyniol semantig, ystyr anghyson semantig, ac ystyr idiomatig Cymreig. Roedd brawddegau wedi ei chwblhau gyda’r cwblhad ‘gorau’ hefyd yn caniatáu inni gydbwyso’r arbrawf o ran brawddegau semantig dderbyniol ac anghyson. Cyfarwyddwyd y cyfranogwyr i farnu os oedd y frawddeg yn gorffen yn y cwblhad semantig gorau posibl (y gair targed). Yn ôl semanteg y frawddeg mewn Saesneg, dylai ystyron anghyson ac idiomau Cymraeg ennyn

ymateb ‘no’, tra dylai derbyniadau derbyniol a gorau ennyn ymateb ‘yes’. Yn hanfodol, roedd ein defnydd o gynllun uniaith caeth (dim ond yn Saesneg y cyflwynwyd brawddegau) yn golygu ein bod yn cyfyngu unrhyw groes-halogiad o'r iaith ‘arall’.

Byddai mynediad uniongyrchol i’r ystyr idiomatig Gymraeg drwy L2 (Saesneg) yn gysylltiedig â N400 gostyngedig i’r brawddegau ‘idiom Gymraeg’ yn y grŵp dwyieithog ond nid yn y grŵp uniaith. Ar y llaw arall, byddai mynediad anuniongyrchol i idiom Cymraeg yn cael effaith debyg ond yn ystod y cyfnod ail-ddadansoddi (llai o effaith P600 yn y grŵp dwyieithog, ond nid y grŵp uniaith). Ar gyfer y cyfranogwyr uniaith Saesneg, dylai brawddegau idiomatig Cymraeg fod yn anghyson, gan arwain at osgled N400 a P600 cyfatebol i'r brawddegau anghyson. Yn seiliedig ar ganfyddiadau Carrol a Conklin (2016), gallem hefyd ddisgwyl i ymatebion ymddygiadol y grŵp Cymraeg-Saesneg fod yn arafach mewn ymateb i’r idiom nag i frawddegau semantig dderbyniol a semanitg anghyson. Ar ben hynny, os yw pobl ddwyieithog yn adfer yr ystyr idiomatig, rydym yn disgwyl y byddant yn fwy tueddol o wneud camgymeriadau wrth farnu’r brawddegau idiomatig o'u cymharu â phobl uniaith.

Dulliau

Cyfranogwyr

Grŵp dwyieithog: Roedd cyfanswm o N = 21 unigolion dwyieithog brodorol Cymraeg-Saesneg (4 gwryw, 17 benyw M oed = 22, SD = 4.3) yn gynwysedig yn y dadansoddiad terfynol (gwaharddwyd un cyfranogwr arall oherwydd data o ansawdd isel). Roedd Holiadur Hanes Iaith (gweler atodiad A), sy’n asesu hyfedredd a phrofiad L1 a L2, yn

tystio caffaeliad y Gymraeg o enedigaeth, a chaffaeliad a'r Saesneg yn ifanc (M = 3.3, SD = 2.37). Nododd y cyfranogwyr hefyd ddefnydd dyddiol uwch o'r Gymraeg na Saesneg (M = 68%, SD = 20.98; M = 32%, SD = 20.98). Yn ogystal, roedd hunan-raddfeydd o ddarllen, ysgrifennu, siarad a deall ar raddfa o 1 (ddim yn iawn llythrennog) i 10 (llythrennog iawn), yn uchel ar gyfer Cymraeg a Saesneg (M = 9.54, SD = 0.27; M = 9.25, SD = 0.14). Datgelodd The Multigroup Ethnic Identity Measure (MEIM; Phinney, 1992; Roberts, Phinney, Masse, Chen, Roberts & Romero, 1999; gweler atodiad B), sy'n mesur perthyn diwylliannol i raddfa 1 (difater) i 4 (ymdeimlad cryf o berthyn), hunaniaeth ddiwylliannol gryf a Chymru (M = 3.33, SE = 0.26).

Grŵp uniaith: Recriwtwyd siaradwyr uniaith Saesneg hefyd (N = 19, gwrywod = 7, benywod = 12, M oed = 21, SD = 4.9), nad oedd wedi dysgu'r Gymraeg nac wedi byw yng Nghymru am gyfnod a oedd yn fwy na tair blynedd, er mwyn dileu effeithiau amlygiad. Cafwyd cymeradwyaeth foesegol gan bwyllgor moeseg Prifysgol Bangor. Rhoddodd y cyfranogwyr gydsyniad gwybodus ymlaen llaw a chawsant iawndal am eu cyfranogiad.

Ysgogiadau

Lluniwyd cyfanswm o 59 set o frawddegau Saesneg. Roedd pob set yn cynnwys pedair brawddeg gan gynnwys cyfieithiad o fynegiant idiomatig Cymraeg, cyflwr semantig derbyniol, cyflwr semantig anghyson, a chyflwr cwblhad semantig ‘gorau’ (roedd y cyflwr olaf yn llenwad (filler), a gafodd ei gynnwys i greu cydraddoldeb rhwng

synnwyr ac anghysondeb yn unig). Roedd y brawddegau yn union yr un fath, hyd at y gair targed. Cafodd y geiriau targed eu cylchdroi ar draws setiau ymhlith y brawddegau Cymraeg, derbyniol ac anghyson, fel y byddai'r diweddglo ar gyfer brawddegau idiom Cymraeg hefyd yn ymddangos ar gyfer brawddegau derbyniol ac anghyson. Roedd y brawddegau 'gorau' hefyd yr un fath ond nid oeddent yn cynnwys y gair targed.. Er mwyn llunio'r brawddegau hyn, dewiswyd y geiriau targed yn seiliedig ar ganlyniadau astudiaeth 'cloze probability'; dewiswyd y trydydd diweddglo mwyaf cyffredin (gweler tabl 10 am enghraifft o set o frawddegau; gweler Tabl 12 am enghraifft o gylchdroi geiriau targed). Cynhaliwyd cylchdro yn ofalus ar lefel y frawddeg yn hytrach na lefel yr eitem er mwyn uchafu ystyron derbyniol ac anghyson pob brawddeg

Tabl 11. Dyluniad arbrofol ac enghraifft un set o frawddegau.

Amod	*Brawddeg*	*Gair Targed*
Idiom	She came out of the store smiling like a	Gate
Derbyniol	She came out of the store smiling like a	Goblin
Anghyson	She came out of the store smiling like a	Sandwich
Gorau	She came out of the store smiling like a	Cat

Tabl 12. Enghraifft o gylchdroi geiriau Targed.

Amod	*Brawddeg*	*Gair Targed*
Idiom	She came out of the store smiling like a	Gate

Derbyniol	The car thieves managed to pass the	Gate
Anghyson	He was told off by his father for being a	Gate

Normio

Gofynnwyd i *N* = 14 o bobl ddwyieithog frodorol Gymraeg-Saesneg, na chymerodd ran yn yr arbrawf, farnu os oedd rhestr o 91 o frawddegau Cymraeg yn idiomau Cymreig ai peidio. Yn y setiau terfynol, cynhwyswyd dedfrydau a farnwyd yn idiomatig gan dros 65% o'r rhai dwyieithog. Er fod yr holl frawddegau yn idiomau Cymreig (fel a nodwyd gan 3 siaradwyr Cymraeg brodorol) darganfuwyd for cynefindra yn amrywio o un ardal i’r llall. Felly, er mwyn ceisio llunio set ble oedd y nifer o dreialau hanfodol mewn arbrawf ERP (30-50; Luck, 2014) yn gyfrwydd i pob cyfranogwr, llunwyd 59 o setiau brawddegau (h.y. roedd pob cyfranogwr yn debygol iawn o fod yn gyfarwydd a oleiaf 30-50 o’r idiomau). Byddai unrhyw halogiad o gyflwyno un neu ddau o idiomau anghyfarwydd felly, yn cael eu lleuhau yn ystod y broses o gyfartalu.

Yn dilyn hynny, cyflwynwyd y brawddegau hyn i siaradwyr uniaith Saesneg (N = 15) ynghyd â brawddegau semantig derbyniol a semantig anghyson. Sgoriodd hwy dderbynioldeb semantig (semantic *acceptabiltiy*) pob brawddeg ar raddfa o -2 (annerbyniol) i +2 (derbyniol). Datgelodd y canlyniadau fod y cyflwr gorau yn cael ei raddio fel y mwyaf derbyniol yn semantig (*M* = 1.57, *SE* = .06), yna'r amod semantig derbyniol (M = .52, *SE* = .13), y cyflwr idiom Cymraeg (*M* = -.53, *SE* = .11), ac yn olaf y cyflwr semantig anghyson (*M* = -1.14, *SE* = .0.94). Rydym o'r farn bod y graddio o ymadroddion idiomatig yn fwy derbyniol nag anghyson yn dderbyniol, gan fod gwneud casgliadau am ystyr y brawddegau hyn yn debygol o fod yn haws nag ar gyfer

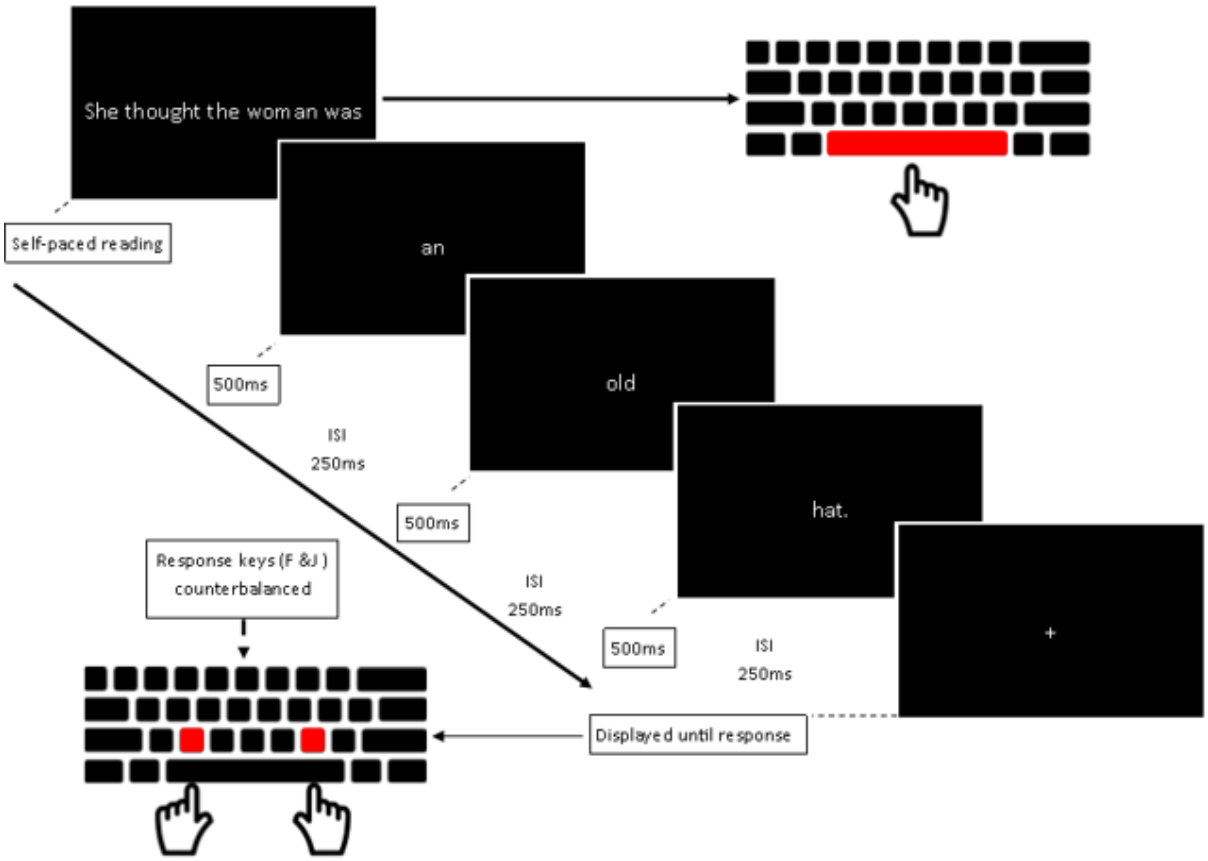
brawddegau anghyson amlwg. Dylem felly weld patrwm tebyg yn ymatebion ERP y cyfranogwyr uniaith; er, i raddau llai. Caniataodd canlyniadau o astudiaeth *'cloze probability'*, hefyd o'r grŵp hwn, i ni dynnu brawddegau â sgôr *'cloze probability'* o >40% o'r rhestr derfynol, a chreu brawddegau llenwi (fillers) ar gyfer ein cyflwr gorau. Yn ogystal, diddymwyd unrhyw frawddegau a nodwyd i fod yn dderbyniol ac yn uchel mewn cloze-probability gan y siaradwyr uniaith Saesneg er mwyn lleihau halogiad gan idiomau Saesneg neu idiomau cyffredinol byd-eang.Arweiniodd canlyniadau'r astudiaethau normio at gyfanswm terfynol o 236 brawddeg (59 eitem).

Gweithdrefn

Yn gyntaf, cwblhaodd y cyfranogwyr 6 treial ymarfer, ac yna'r arbrawf a oedd yn cynnwys 6 bloc arbrofol: 4 bloc o 39 treial a 2 floc o 40 treial. Cafodd y brawddegau eu trefnu ar hap fel mai dim ond un frawddeg o bob set a ymddangosai ym mhob bloc.

Cyflwynwyd y frawddeg yn weledol, mewn ffont arian ar gefndir du. Cyflwynwyd hanner gyntaf y frawddeg fel testun parhaus, gyda'r cyfranogwyr yn darllen ar eu cyflymdra eu hunain, ac yna cyflwynwyd gweddill y frawddeg fesul gair (amser cyflwyno: 500ms; ISI: 250ms). Ar ôl cyflwyniad o groes sefydlogiad, gofynnwyd i'r cyfranogwyr ymateb i'r cwestiwn: '*Was this the best completion of the sentence*?' Gwnaed ymatebion '*Yes*' a '*No*' gan ddefnyddio'r bysellau F a J, a gafwyd eu gwrthgytbwys ar draws y cyfranogwyr. Codwyd ymatebion cywir yn ôl eu dehongliad

Saesneg. Hynny yw, codwyd ymatebion '*No*' i idiomau Cymraeg a brawddegau anghyson fel rhai cywir, tra bod ymatebion '*Yes*' i frawddegau derbyniol a 'gorau' yn cael eu codio fel rhai cywir.



Ffigwr 18. Sgematig o'r weithdrefn arbrofol.

Cofnodi Electroffisiolegol

Cofnodwyd gweithgaredd electroffisiolegol o 64 electrod a osodwyd ar groen y pen ar gyfradd o 1 kHz, gan ddefnyddio'r electrod CZ fel cyfeirnod. Digwyddodd hidlo ar-lein ('*online filtering'*) gan ddefnyddio hidlydd band-pasio ('*band-pass filter'*) rhwng 0.1 a 200 Hz, yn ogystal â hidlo oddi ar-lein gan ddefnyddio hidlydd sero-sifft pasio isel

(‘*low-pass zero-shift filter’*) wedi'i dorri i ffwrdd ar 20 Hz. Cafodd arteffactau o’r llygaid (*‘eye-artefacts’*) eu modelu a'u cywiro yn fathemategol. Tynnwyd yr arteffactau sy'n weddill â llaw gan ddefnyddio meddalwedd NeuroScan 4.4. Tynnwyd y cyfnod (*‘epoch’*) rhwng -200 a 1000ms ar ôl cyflwyniad y gair targed, gydag o leiaf 30 cyfnod (*‘epoch’*) fesul cyflwr ar gyfer pob cyfranogwr. Roedd gweithgareddau sy'n fwy na + _75Uv yn cael eu taflu'n awtomatig. Cynhaliwyd gweithdrefn cywiro llinell sylfaen (‘*baseline correction’*).

Canlyniadau

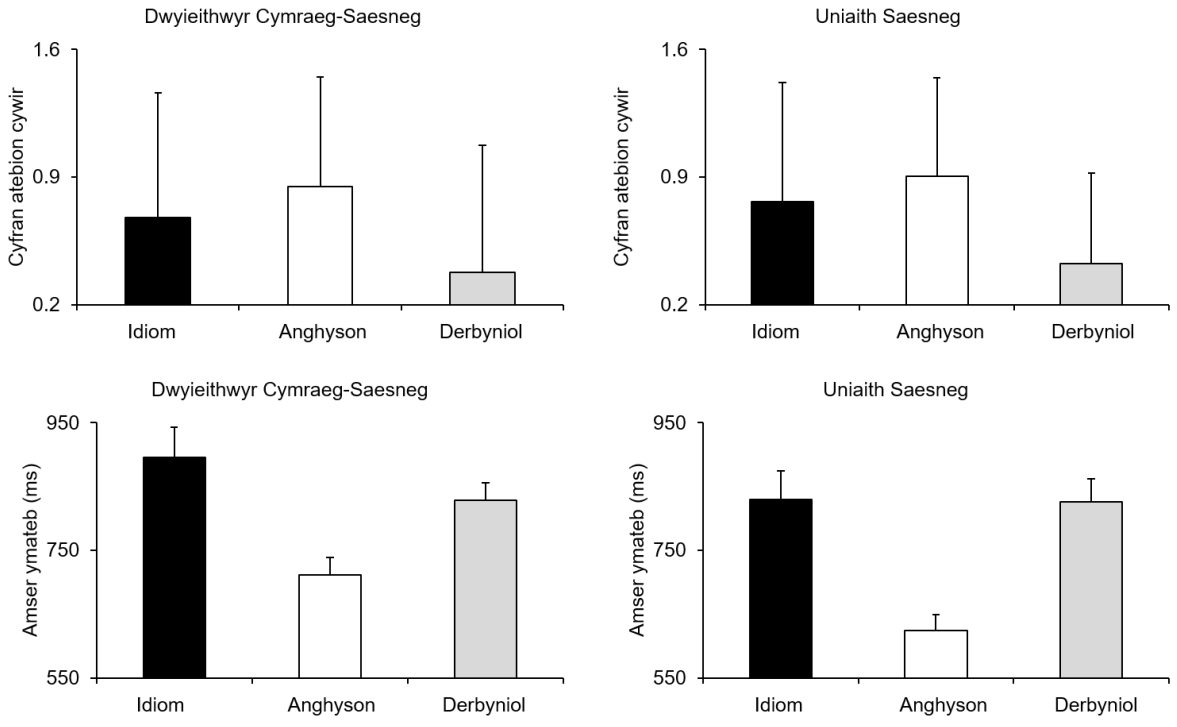
Canlyniadau Ymddygiadol

Modelwyd data cywirdeb ac amseroedd ymateb gydag un ffactor rhwng grwpiau: Grŵp (Dwyieithog, Uniaith), ac un ffactor o fewn grwpiau: Cyflwr (Cymraeg, Derbyniol ac Anghyson). Cafodd y ddau factor eu canoli (*‘centred’*) ar gyfer y dadansoddiadau i leihau gwrth linoledd (‘*collinearity’*). Cyflwynwyd data cywirdeb i fodel effeithiau cymysg cyffredinol (‘*Generalized mixed-effects model’* - swyddogaeth *glmer* yn lme4; Bates, Mächler, Bolker, & Walker, 2014), lle gwnaethom fodelu'r effaith ar hap fwyaf posibl (‘*maximal random effects*’), gan gynnwys rhyngdoriadau a llethrau o frawddeg (yn ôl grŵp) a phwnc (yn ôl cyflwr) nes i'r model gydgyfeirio (Barr, Levy, Scheepers, & Tily, 2013). Nodir bod cywirdeb i'r cwestiwn *'Was this the best completion of the sentence*?' wedi'i godio yn ôl ystyr y frawddeg Saesneg (h.y., codwyd ymateb '*no*' i amodau idiom anghyson a Chymraeg yn gywir, tra bod ymateb '*yes*' i codwyd yr amodau derbyniol a'r gorau fel rhai cywir). Trawsnewidiwyd (‘*log transformation’*) data amser

ymateb i gyflawni dosbarthiad normal a'i gyflwyno i fodel effeithiau cymysg llinol *('linear mixed effects model'*; swyddogaeth LMER yn lme4), eto gyda'r effeithiau ar hap mwyaf posibl gan gynnwys rhyngdoriad a llethrau brawddeg (yn ôl grŵp) a phwnc (yn ôl cyflwr) nes i'r model gydgyfeirio . Dim ond treialon cywir a ddadansoddwyd yn y dadansoddiad RT.

Datgelodd dadansoddiad cywirdeb effaith arwyddocaol o gyflwr, lle'r oedd y cyfranogwyr yn fwy cywir wrth ganfod brawddegau anghyson (b = 2.53, SE = 0.31, z = 8.15, p <.001) o gymharu â'r Gymraeg idiomau (b = 1.99, SE = 0.33, z = 6.03), ac yn llai cywir wrth ganfod brawddeg dderbyniol (b = -2.76, SE = 0.37, z = -7.47, p <.001) o gymharu ag idiomau Cymru. Ni ddaeth unrhyw effaith arwyddocaol o grŵp (b = 0.91, SE = 0.6, z = 1.51, p = 0.13) na rhyngweithiad rhwng cyflwr * grwp i'r amlwg (DwyieithogIdiom * UniaithDerbyniol b = -0.3, SE = 0.63, z = -0.49, p = 0.62 ; DwyieithogIdiom * UniaithAnghyson b = -0.18, SE = 0.49, z = -0.37, p = 0.72).

Datgelodd dadansoddiad o amseroedd ymateb y cyfranogwyr effaith arwyddocaol o gyflwr, lle roedd ymatebion yn gyflymach i frawddegau anghyson (b = -0.04, SE = 0.01, df = 101.19, t = -3.68, p = .01) nag i idiomau Cymru (b = 6.13, SE = 0.03, df = 47.53, t = 216.11), ac yn arafach i frawddegau derbyniol (b = 0.07, SE = 0.02, df = 79.41, t = 3.39, p = .01) na brawddegau Cymraeg. Ni ddaeth unrhyw effaith arwyddocaol o grŵp (b = -0.00, SE = 0.05, df = 40.4, t = -0.1, p = 0.91) na rhyngweithiad rhwng cyflwr * grŵp i'r amlwg (DwyieithogIdiom * UniaithDerbyniol b = 0.01, SE = 0.03, df = 32.08 , t = 0.37, p = 0.71; DwyieithogIdiom * UniaithAnghyson b = -0.01, SE = 0.01, df = 36.41, t = 0.46, p = 0.64).



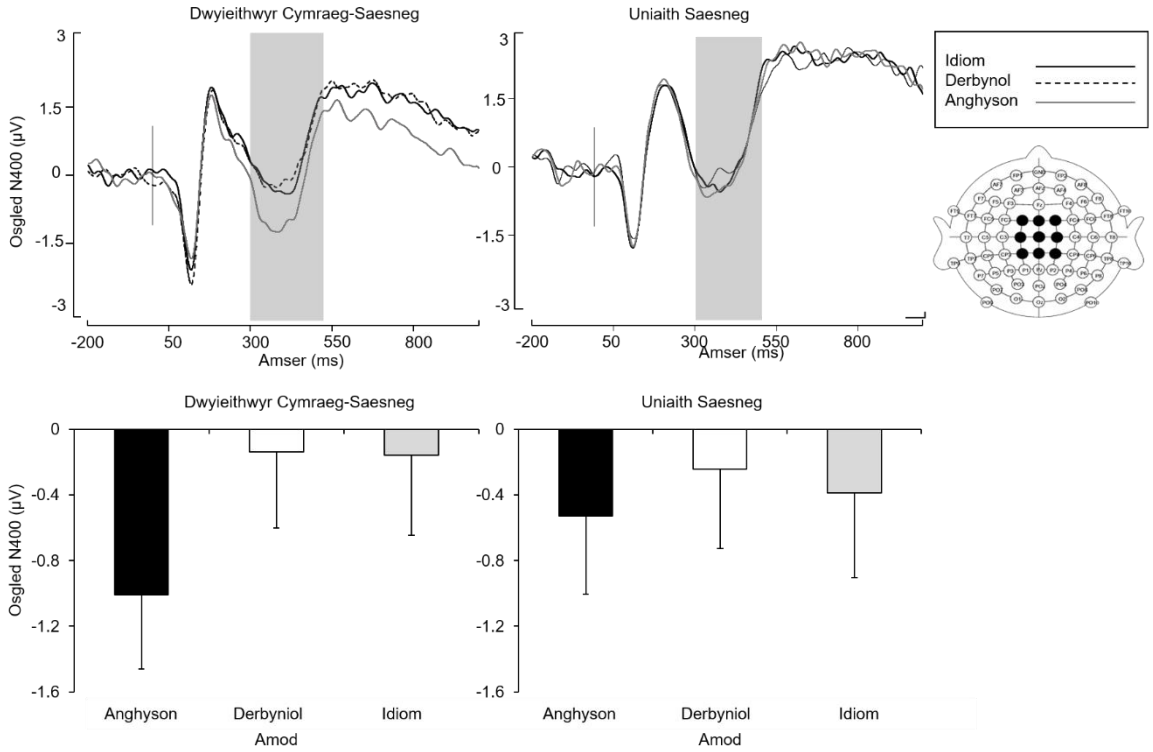
Ffigwr 19. Cymedr cywirdeb (cyfran yr ymatebion cywir) ac amseroedd ymateb (ms) i ymadroddion idiomatig Cymraeg, brawddegau derbyniol ac anghyson, ar gyfer y cyfranogwyr dwyieithog Cymraeg-Saesneg a Saesneg uniaith. Mae’r bariau gwallau yn cynrychioli'r gwallau safonol.

Canlyniadau ERP

Cynhaliwyd dadansoddiad o amrywiant (ANOVA) 2x3 a chynllun ail-adrodd mesurau, gyda grŵp (Saesneg Cymraeg yn ddwyieithog, uniaith Saesneg) fel y newidyn rhyng-gyfranwyr, a'r cyflwr (idiom Cymraeg, anghyson, derbyniol) fel y newidyn mewn-gyfranwyr.

N400. Yn y ffenestr amser 300-500ms (N400), gwelsom brif effaith arwyddocaol o gyflwr (F (2, 37) = 5.16, p = .008, ηp2 = .2) dros 6 safle electrod blaen-ganolog, canolog a chanolog-parietal (*fronto-central, central and centro-parietal;* FC1 FC2 FCZ C1 C2 CZ CP1 CP2 CPZ). Datgelodd cymariaethau post hoc Bonferroni fod brawddegau anghyson (M = .09 SE = .3) yn fwy negyddol na brawddegau derbyniol (M = .5, SE = .28) a brawddegau idiomatig Cymreig (M = .4, SE = 31).

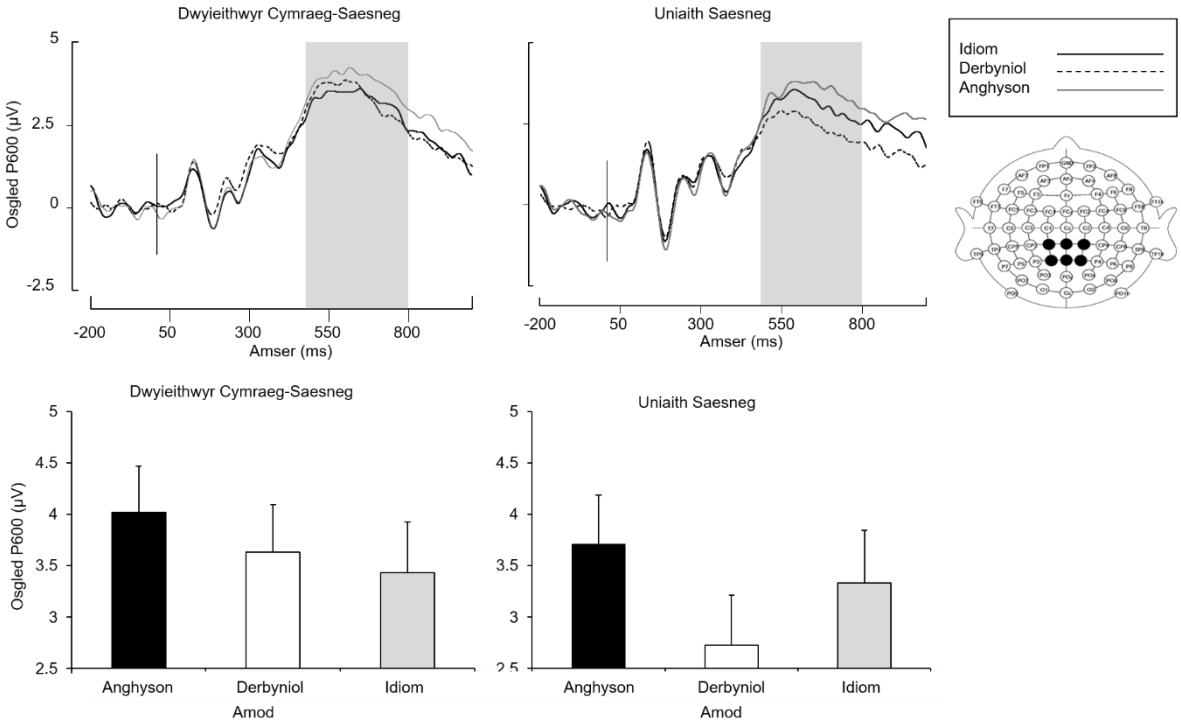
Hefyd, canfuwyd tuedd a oedd yn agos at ryngweithiad arwyddocaol rhwng cyflwr a grŵp (F (2, 37) = 2.48, p = .09, ηp2 = .13). Ar gyfer y rhai dwyieithog Cymraeg-Saesneg, dangosodd y brawddegau derbyniol (M = .57, SE = .38) a'r ymadroddion idiomatig Cymraeg (M = .43, SE = .43) osgledau tebyg, gyda'r brawddegau anghyson yn dangos negyddiaeth uwch (M = -1.21, SE = .42). Fodd bynnag, yn y cyfranogwyr uniaith Saesneg, roedd yr osgledau yn debyg rhwng y brawddegau derbyniol (M = .43, SE = .4), yr ymadroddion idiomatig Cymraeg (M = .37, SE = .46), a'r brawddegau anghyson (M = .3, SE = .47).



Ffigwr 20. Cymedrau osgled (µV) yr N400 ar gyfer yr idiom Cymraeg, brawddegau derbyniol a'r brawddegau anghyson, ar gyfer y bobl ddwyieithog Gymraeg-Saesneg ac uniaith Saesneg. Mae'r bariau gwallau yn cynrychioli'r gwallau safonol.

P600. Yn y ffenestr amser 500 – 700ms (P600) gwelsom brif effaith arwyddocaol o gyflwr (F (1, 38) = 7.06, p <.001, ηp2 = .43) dros 6 safle electrod canolog-parietal (*central-parietal*; CP1 CPZ CP2 P1 PZ P2). Datgelodd cymhariaeth post-hoc Bonferroni mai brawddegau anghyson (M = 4.15, SE = .30) a ddangosodd osgledau P600 mwyaf, yna'r ymadroddion idiomatig Cymraeg (M = 3.71, SE = .33), a'r brawddeg dderbyniol (M = 3.47, SE = .31).

Ni ddarganfuwyd rhyngweithiad arwyddocaol rhwng grŵp a chyflwr (F (1, 38) = 1.90, p = .133, ηp2 =1.3)



Ffigwr 21. Cymedr osgled (µV) y P600 ar gyfer brawddegau anghyson, brawddegau derbyniol ac ymadroddion idiomatig Cymraeg, ar gyfer pobl ddwyieithog Gymraeg ac uniaith Saesneg. Mae’r bariau gwallau yn cynrychioli'r gwallau safonol.

Trafodaeth

Yma, fe wnaethon ymwchilio os yw pobl ddwyieithog Gymraeg-Saesneg, yn actifadu synhwyrau Cymraeg-benodol yn ddigymell mewn tasg ddarllen uniaith Saesneg. Fe wnaethom fesur ymatebion ymddygiadol ac ERP mewn pobl ddwyieithog Gymraeg-

Saesneg ac uniaith Saesneg wrth iddynt ddarllen brawddegau a gafodd eu trin i fod yn dderbyniol, yn anghyson neu'n idiom Gymraeg (anghyson yn Saesneg). Er, ni ddangosodd y data ymddygiadol unrhyw wahaniaethau rhwng y grwpiau, gwelsom fod y cyfranogwyr yn gyffredinol yn gyflymach ac yn fwy cywir wrth ymateb i frawddegau anghyson a ddilynwyd gan idiomau Cymraeg a brawddegau derbyniol. Roedd tueddiadau yn nata'r ERP yn awgrymu bod prosesu dwyieithog Cymraeg-Saesneg o frawddegau idiomatig Cymraeg a brawddegau synhwyrol yn gymharol yn ffenestri amser yr N400 a P600. Ar gyfer pobl uniaith Saesneg ar y llaw arall, roedd prosesu idiomau Cymraeg yn debycach i frawddegau anghyson. Mae ein canfyddiadau yn awgrymu bod cynrychiolaeth semantig yr idiom ar gael yn uniongyrchol, hyd yn oed yn yr iaith idiom-anghydweddol.

Ni ddangosodd ein canlyniadau ymddygiadol ar y llaw arall, unrhyw wahaniaethau rhwng prosesu uniaith a dwyieithog. Mae anghysondebau o'r fath yng nghanlyniadau ymddygiadol a'r N400 yn gydnaws â chanfyddiadau blaenorol, ac mae'n adlewyrchu bod yr N400 - sy'n mynegi mecanwaith chwilio semantig - yn eithaf gwahanol i ymatebion ymddygiadol (Kutas & Federmeier, 2011). Yma, er ei bod yn ymddangos bod pobl ddwyieithog yn cyd-actifadu'r ystyr idiomatig yn ymhlyg (cf. dim arwydd ar y lefel niwral yr ystyriwyd bod brawddegau idiomatig 'Cymraeg' yn annerbyniol), roeddent yn barnu derbynioldeb gair olaf y frawddeg mor gyflym a chywir â'r uniaith; gan ddynodi bod brawddegau idiomatig 'Cymraeg', yn wir, yn annerbyniol. Awgrymwn felly, fod y brawddegau anghyson yn wahanol i'r grŵp dwyieithog ar-lein oherwydd argaeledd ystyr ar gyfer pob brawddeg arall. Pan ofynnwyd iddynt yn benodol farnu pob brawddeg, fodd bynnag, roedd y cyfranogwyr hyn yn atal yr ystyr Gymraeg penodol ac yn ymateb yn ôl y dehongliad Saesneg. Mewn cyferbyniad â'r rhai

dwyieithog, nid oedd yn ymddangos bod y cyfranogwyr uniaith Saesneg yn gwahaniaethu rhwng y brawddegau o ran ymdrech brosesu semantig ar-lein (effaith N400), er eu bod yn dangos sensitifrwydd clir yn ymddygiadol. Awgrymwn y gallai cynnwys brawddegau a chwblhad ‘gorau’ fod wedi newid eu prosesu o’r brawddegau ‘derbyniol’ ac ‘anghyson’, gan greu llai o wahaniaeth rhwng y ddwy na fyddai wedi bod pe bai brawddegau ‘gorau’ wedi’u heithrio. Mae’n debyg nad oedd y brawddegau gorau wedi bod mor amlwg i'r grŵp dwyieithog oherwydd bod y broses ragfynegi yn ystod darllen yn llai effeithlon yn L2 (Martin et al 2013). Byddai fersiwn o’r astudiaeth hon yn y dyfodol yn eithrio brawddegau a chwblhad ‘gorau’ o’r arbrawf.

Mae ein data yn darparu rhywfaint o dystiolaeth bod cysylltiadau lexico-semantig L2 yn ymestyn i synhwyrau L1 unigryw. Hynny yw, yn y frawddeg Saesneg: *she thought the old woman was a hat*, gallai *hat* arwain at ledaeniad o actifiant o bob synnwyr o *hat* a'i gyfieithiad (translation equivalent), *het*, gan arwain at fynediad uniongyrchol i'r ystyr Gymraeg-benodol. Felly mae ein canlyniadau'n gyson ag adroddiadau blaenorol sy’n honni y gall pobl ddwyieithog gael mynediad i gynrychioliadau semanteg trwy'r ddwy iaith (Martin et al., 2013), a chefnogi'r rhagdybiaeth ganolog o fodelau adnabod geiriau gweledol fel y BIA a’r BIA + (Dijkstra, Van Heuven, & Grainger, 1998; van Heuven, & Dijkstra, 2010), sy'n honni system gwbl ryngweithiol a chydweithredol. Gall y canfyddiadau cyfredol hefyd awgrymu fod rhyngweithiad mwy nag a nodwyd yn flaenorol gan y modelau sy'n bodoli: Mae'n debyg y gall ieithoedd gyrchu ystyron semantic sydd yn anghydweddol hyd yn oed, heb fawr o gost prosesu semantig.

Felly bydd ein canfyddiadau - wedi iddynt gael eu cadarnhau drwy ddyblygiad - yn ddefnyddiol wrth ddiweddaru gweithrediadau modelau dwyieithog yn y dyfodol (cf.

Dijkstra et al., 2019), ac awgrymu y dylai addasu modelau fel y *Sense Model* (Finkbeiner et al., 2004) i gynnwys cysylltiadau rhwng synhwyrau iaith unigryw a'r iaith anghydweddol.

Mae’n rhaid nodi bod rhai o'r casgliadau hyn yn seiliedig ar ganlyniadau sydd bron yn arwyddocaol. Trafodir yn y lenyddiaeth os yw canlyniad arwyddocaol (neu an-arwyddocaol) mewn niwrowyddoniaeth yn adlewyrchu gwir effaith mewn gwirionedd (Botwm, Loannidis, Mokrysz, Nosek, Fflint, Robinson, & Munafo, 2013). Mae'r broblem hon yn ganlyniad o bŵer ystadegol isel oherwydd ffactorau fel maint sampl bach. Awgrymwn nad oedd maint y samplau a gafodd eu recriwtio yn ddigonol i arsylwi y gwir effaith. Dychwelaf at y drafodaeth hon ym Mhennod 6.

Casgliadau

I grynhoi, mae ein canfyddiadau cyfredol yn awgrymu bod lefel y cyd-actifadu a’r rhyngweithiad yn system iaith ddwyieithog, hyd yn oed yn fwy nag a dybiwyd yn flaenorol. Mae ein data yn cefnogi'r syniad bod cynrychioliadau semanteg ar gael ar-lein, hyd yn oed mewn iaith sydd â chysylltiadau geirfa-semanteg anghydweddol

Pennod 6

Trafodaeth Gyffredinol

6.0 Trosolwg o’r bennod

Prif nod y traethawd ymchwil hwn oedd ymchwilio strwythur swyddogaethol y system (au) semantig dwyieithog. Roedd fy nodau yn ddeublyg:

1. Yn Rhan 1 ymchwiliais i fapio cysyniadol yn L1 a L2 (mapio o fewn synnwyr) ac os yw cysylltiadau geiriadurol-semantig cryfach yn L1 (fel y nodir mewn modelau deall dwyieithog) yn arwain at lai o ymdrech brosesu i gael mynediad at ystyr.

2. Ymchwiliodd Rhan 2 i fapio cysyniadol ar draws L1 a L2 (mapio rhyng-synnwyr) ac os yw cyd-actifadu iaith ymhlyg yn digwydd ar y lefel gysyniadol.

Yn y bennod hon, rwy'n adolygu canfyddiadau pedair astudiaeth empeiraidd a geisiodd fynd i'r afael â'r nodau hyn. Byddaf yn trafod goblygiadau'r canfyddiadau hyn yng nghyd-destun ymchwil gyfredol ar ddwyieithrwydd ac yn cynnig cyfarwyddiadau ar gyfer ymchwil yn y dyfodol.

6.1 Rhan 1: Mapio Mewn-Synnwyr yn L1 a L2

Er mwyn profi'r rhagdybiaeth bod prosesu geirfa-semantig L1 yn ymwneud a llai o ymdrech, gwnaethom archwilio prosesu brawddegau L1 yn erbyn L2 gan ddefnyddio triniaeth o (a) torri synnwyr (Arbrawf 1a) a (b) ffigurol (Arbrofion 1b a 2), o gymharu â phrosesu brawddegau llythrennol sylfaenol. Felly, (a) caniatawyd archwilio prosesu semantig L1 yn erbyn L2 yng nghyd-destun anghysondeb hynod eglur, tra bod (b) wedi galluogi archwilio prosesu semantig L1 yn erbyn L2 yng nghyd-destun mwy cynnil

mynediad anuniongyrchol at ystyr (wrth gadw synnwyr). Cofiwch ein bod wedi archwilio mynediad dwyieithog i ystyr brawddeg ar-lein (~ 400 ms ar ôl dechreuad y gair targed) gan ddefnyddio ERP ym mhob un o'r tri arbrawf.

6.1.1 Prosesu semantig ar-lein o anghysondeb brawddegau yn L1 a L2

Fe wnaethom ragweld y byddai pobl ddwyieithog yn canfod anghysondeb brawddegau yn L1 yn haws, wedi'i fynegi gan osgledau N400 llai i frawddegau synhwyrol yn L1 yn erbyn L2. Yn Arbrawf 1a, darllenodd pobl ddwyieithog Gymraeg-Saesneg frawddegau yn gorffen mewn geiriau targed a oedd yn golygu bod y frawddeg gyffredinol ac ystyr naill ai synhwyrol (llythrennol / synhwyrol - *Gadawodd y ddamwain ryfedd friw*; trosiadol / synhwyrol - *Gadawodd y datganiad rhyfedd friw*) neu'n anghyson. (llythrennol / anghyson - *Gadawodd y ddamwain ryfedd newyn*; trosiadol / anghyson - *Gadawodd y datganiad rhyfedd newyn*). Roedd y rhai dwyieithog hyn yn gwahaniaethu brawddegau synhwyrol ac anghyson ar lefel prosesu semantig ar-lein yn y Gymraeg L1, yn amlwg mewn N400 mwy negyddol ar gyfer brawddegau anghyson dros synhwyrol. Yn ddiddorol (ac yn groes i'n rhagfynegiadau), roedd y rhai dwyieithog hyn hefyd yn dangos N400 llai a P600 uwch i frawddegau Saesneg yn gyffredinol, gan awgrymu prosesu mwy arwynebol yn y cam semantig ar-lein a mwy o wahaniaethu yn ddiweddarach. Yn hanfodol, fodd bynnag, er bod yr unigolion hyn yn arddangos sensitifrwydd cynharach i ystyr brawddegau ar-lein, darganfuwyd dim tystiolaeth o berfformiad ymddygiadol L1 uwchraddol yn yr unigolion hyn (cywirdeb ac amseroedd ymateb). Ymhelaethaf yn awr ar y canfyddiadau hyn.

Wrth ddarllen neu wrando ar iaith, rydym yn cynhyrchu rhagfynegiadau am eiriau sydd ar fin ymddangos, sydd yn caniatáu integreiddio semantig rhwydd; po fwyaf rhagweladwy yw'r gair, y cyflymaf y bydd yn cael ei brosesu (Foucart, Martin, Moreno & Costa, 2014; Pickering & Garrod, 2007; Wicha, Morena & Kutas, 2004; DeLong et al, 2005; Neely, 1977; Morton & Long, 1976; Ardoll, 2008). Mae ymchwil yn awgrymu, fodd bynnag, efallai na fydd y broses ragfynegol hon yn gweithredu'n gymharol ar draws ieithoedd (Martin et al 2013). Yn ogystal, mae modelau iaith yn nodi y bydd dod ar draws llinynnau ieithyddol penodol yn aml, yn arwain at actifiant haws o'r llinynnau hyn (*'transitional probability'*; Elman, 1990), a gaiff ei fodylu gan wybodaeth ac amlygiad ieithyddol (Dell & Chang, 2014). Wedi ei gymhwyso i ddwyieithrwydd, byddai llai o amlygiad i L2 yn arwain at actifadu mwy ymdrechgar ac arafach (Francis, Arteaga, Liano, & Taylor, 2020; Whitford & Titone, 2017; Diependaele, Lemhofer, & Brysbaert, 2012; Duyck, Vanderelst, Desmet & Hartsuiker , 2008), sy'n cyd-fynd â chanfyddiadau integreiddio cysyniadol mwy ymdrechgar wrth brosesu brawddegau L2 (Hahne, 2001; Hahne & Friederici, 2001), ac oedi cyn cydnabod troseddau (Moreno & Kutas, 2005; Moreno, Rodriguez-Fornells, & Laine, 2008; Ardal, Donald, Meuter, & Muldrew, 1990; Kutas & Kluender, 1994; Weber-Fox & Neville, 1996). Mae cysylltiadau geirfa-semantig gwannach yn L2 hefyd i'w gweld mewn modelau dwyieithrwydd (Kroll & Stewart, 1994; Dijkstra a Van Heuven, 2002; Finkbeiner et al, 2004).

Er i ni ddarganfod gwahaniaethiad mwy wrth brosesu ystyr brawddegau L1 ar lefel prosesu semantig ar-lein, roedd brawddegau L2 yn achosi modyliad llai o'r N400 yn gyffredinol. Er bod hyn yn syndod i ddechrau, efallai ei fod ychydig yn llai rhyfeddol wrth ystyried bod y cyd-destun iaith yn llai cyfarwydd neu yn arwynebol, ac felly yn fwy

agored i oediad neu strategaeth brosesu ‘ddigon da’ (Ferreira et al, 2002; Barton & Sanford, 1993; Christianson, 2016). Yn hynny o beth, cafodd ein pobl ddwyieithog ymatebion N400 llai, ond osgledau P600 mwy (yn ddiddorol fodd bynnag, nid ydynt yn gwahaniaethu brawddegau synhwyrol yn erbyn anghyson ar hyn o bryd). Felly gall y canfyddiadau hyn fod yn gyson â damcaniaethu dwyieithog, lle mae gan L2 gysylltiadau geirfa-semantig gwannach (Kroll & Stewart, 1994), sydd yn achosi oedi amserol (Dijstra & Van Heuven, 2002; Grainger & Dijkstra, 1992, Dijkstra & Van Heuven , 1998), mynediad at nifer llai o gynrychioliadau semantig (Finkbeiner, Forster, Nicol & Nakamura, 2004), ac yn cyrchu cynrychioliadau cysyniadol trwy lwybr gwahanol i'r L1 (de Groot, 1992). Mae'r goblygiadau hyn yn drawiadol wrth ystyried lefel hyfedredd uchel iawn y rhai dwyieithog hyn. Yn hanfodol, er y credir bod mynediad yn gwella gyda mwy o hyfedredd, tybir hefyd y bydd anghymesuredd yn parhau oherwydd profiad uwch yn L1 (Kroll & Stewart, 1994; Finkbeiner, Forster, Nicol & Nakamura, 2004), a gaiff ei arddangos yn ein hastudiaeth o ystyried hyfedredd L2 uchel iawn ein grŵp dwyieithog.

Yn wir, pan ystyriwn ganlyniadau ymddygiadol Arbrawf 1a, mae'n amlwg, er bod dadansoddiad cynnar gwahanol wrth brosesu brawddegau L1 ag L2, nid yw'r sensitifrwydd cychwynnol i ystyr yn L1 o reidrwydd yn arwain at fantais ymddygiadol mewn tasg barnu ystyr semantig. Mewn gwirionedd, dangosodd ein pobl ddwyieithog fwy o gywirdeb ymddygiadol ac amseroedd ymateb cyflymach yn eu hail iaith o gymharu â'r iaith frodorol. Felly, mae ein canfyddiadau yn awgrymu y gallai L1 alluogi canfod synnwyr yn gynharach, ond mae hyfedredd uchel yn L2 yn caniatáu i bobl ddwyieithog ‘ddal i fyny’ yn gyflym yn ddiweddarach, gan alluogi perfformiad tebyg os nad uwch ar y lefel ymddygiadol.

Nid yw'r anghysondeb hwn rhwng y mesurau ar-lein (ERP) ac all-lein (ymddygiadol) yn syndod o ystyried bod ymatebion N400 ac ymddygiadol yn nodweddiadol wahanol (Kutas & Federmeier, 2011). Mae’r cydrannau ERP unigol yn adlewyrchu is-set fechan iawn yn unig o'r prosesu cyffredinol sy'n cyfrannu at ymatebion ymddygiadol diweddarach, felly nid yw'r gwahaniaeth a geir yma o reidrwydd yn syndod. Mewn gwirionedd, mae'r canfyddiadau hyn yn cyd-fynd i raddau helaeth â chyfrifon blaenorol sy'n awgrymu bod amseroedd ymateb yn hirach mewn ymateb i iaith drosiadol oherwydd argaeledd nifer o ddehongliadau cystadleuol (Glucksberg, Gildea & Bookin 1982; Faust & Weisper 2000). Yn yr un modd, cynigiaf y gellir priodoli'r oediad L1 a ddarganfuwyd yn arbrawf 1a i argaeledd dehongliadau lluosog, neu o leiaf actifadu synhwyrau lluosog, yn L1 o'i gymharu â L2. Os yw'r L1 yn elwa o fapio cysyniadol llai ymdrechgar a mynediad at fwy o gynrychioliadau, yna mae'n rhesymol tybio bod L1 yn gallu llunio sawl ystyr yn well. Yn L2 ar y llaw arall, bydd mapio cysyniadol mwy ymdrechgar a mynediad at lai o gynrychioliadau ar gael yn arwain at gynhyrchu dehongliadau cyfyngedig. Felly ni fydd yn ofynnol i L2 wahaniaethu rhwng cynrychiolaethau lluosog sy'n amlygu mewn mantais amser ymateb L2.

6.1.2 Mapio nifer o gynrychioliadau cysyniadol yn L1 a L2

Gwnaethom ragweld y byddai pobl ddwyieithog yn gallu cyflawni mapio synnwyr lluosog yn gyflymach ac yn haws yn L1, gan alluogi mwy o sensitifrwydd i frawddegau ffigurol. Gwnaethom ragweld ymhellach y byddai'r effaith hon yn amlwg mewn gwahaniaeth N400 llai rhwng brawddegau llythrennol a throsiadol yn L1 o'i gymharu â L2. I brofi'r rhagdybiaethau hyn yn Arbrofion 1a, 1b a 2, mae pobl

ddwyieithog Gymraeg-Saesneg hyfedr iawn, yn darllen brawddegau lle'r oedd y gair olaf (targed) yn golygu bod y frawddeg yn naill ai'n llythrennol (*Gadawodd y ddamwain ryfedd friw*) neu'n ffigurol (*Gadawodd y datganiad rhyfedd friw*; cofiwch fod yr ystyr hon yn Arbrawf 1a, yn orthogonal ag anghysondeb brawddeg; yn y ddau arbrawf arall, gollyngwyd anghysondeb). Ni chafwyd unrhyw effaith ffigurol yn arbrawf 1a (yn debygol oherwydd effaith anghysondeb brawddeg o bosibl, gan achosi i sensitifrwydd i'r broses ffigurol fwy cynnil fod yn llai canfyddadwy). Yn arbrawf 1b, gwnaethom felly ddileu'r brawddegau anghyson i archwilio effaith ffigurol yn unig. Er bod pobl ddwyieithog yn gwahaniaethu brawddegau llythrennol a throsiadol ar y lefel semantig ar-lein yn L1, er syndod, canfuwyd bod trosiad yn haws i'w brosesu nag iaith lythrennol. Ni welwyd unrhyw wahaniaethu o'r fath yn L2. Yn Arbrawf 2 felly, gwnaethom recriwtio pobl ddwyieithog frodorol Saesneg-Gymraeg, i archwilio a fyddem yn dod o hyd i'r patrwm iaith wrthwynebol (mwy o wahaniaethu yn Saesneg L1, a dim gwahaniaethu yn L2 Cymraeg), a fyddai'n awgrymu fod statws L1 yn gyfrifol am effeithiau Arbrawf 1b. Yn rhyfeddol, roedd ein canfyddiadau mewn gwirionedd yn efelychu Arbrawf 1b. Roedd y Gymraeg (er yn L2 yn y cyd-destun hwn), yn golygu mwy o sensitifrwydd i ffigurol i'r un cyfeiriad ag Arbrawf 1b, lle cynhyrchodd trosiad osgledau N400 llai o gymharu â brawddegau llythrennol. Daethom i'r casgliad fod gan rai ieithoedd (e.e. Cymraeg) o bosib, briodweddau ystadegol, megis digwyddiadau naturiol uwch o drosiad mewn addysg (WJEC/CBAC, 2020. WJEC GCSE in Welsh Literature; WJEC/CBAC, 2020. WJEC GCE AS/A LEVEL in Welsh (first language); WJEC/CBAC, 2020. WJEC GCSE English Language), sy'n golygu bod canfod trosiad yn haws na chanfod ystyr sydd â cloze-probability isel yn yr iaith honno (Jones, 2016; Rowlands, 2015; Trefor, 2014;

Pyrs, 2014; gweler atodiad G am ddarlun o'r effaith hon dros ein tri arbrawf). Mae ein hastudiaeth normio (gweler Pennod 2) yn gyson â'r dehongliad hwn, o gofio bod brawddegau llythrennol yn tueddu i gael eu graddio'n fwy ffigurol na'r un brawddegau a gyflwynir yn Saesneg.

6.1.3 Casgliadau dros dro ar fapio dwyieithog o fewn synnwyr

Yn Arbrawf 1a, canfuom fod **canfod anghysondeb yn digwydd yn gynharach, yn ystod cyfnod prosesu semantig ar-lein yn L1**. Yn Arbrofion 1b a 2, gwelsom y gall **mynediad at brosesu trosiad fod yn uniongyrchol (er gwaetha statws brodorol iaith).** Mae'r casgliad hwn yn seiliedig ar brosesu N400 cymharol yn y ffenestr prosesu semantig ar-lein ar gyfer trosiad o gymharu â brawddegau llythrennol, ac yn gyson â'r rhesymeg a ddangoswyd mewn astudiaethau blaenorol, lle tybir bod osgledau N400 tebyg ar gyfer ystyr lythrennol a throsiadol yn dynodi mynediad semantig tebyg (uniongyrchol; cf. Gibbs, 1994, 2002). Fodd bynnag, efallai y gellir defnyddio ein canfyddiadau hefyd i feirniadu'r rhesymeg hon: Fel y dangosir yn Arbrawf 1a, gall sensitifrwydd i drosiad fod yn agored i amodau'r arbrawf (yn yr achos hwn, presenoldeb anghysondeb brawddeg, gan roi dim effaith trosiad), a hefyd y cyd-destun iaith (Arbrofion 1b a 2). Felly, amlygir peryglon dod i gasgliadau o ganfyddiad effaith nwl (dim gwahaniaeth ym modiwleiddio N400 rhwng prosesu llythrennol a throsiadol). Mae ein canfyddiadau hefyd yn awgrymu y gallai **mynediad i drosiad gael ei ddylanwadu gan briodweddau iaith-benodol**: Mae trosiad yn y Gymraeg yn ennyn olgledau N400 llai, er gwaethaf statws brodorol y Gymraeg, gan awgrymu y gallai’r tebygolrwydd uchel o drosiad yn y Gymraeg ddylanwadu ar ganfyddiad o a phrosesu trosiad cychwynnol. Mae'r canfyddiad hwn yn

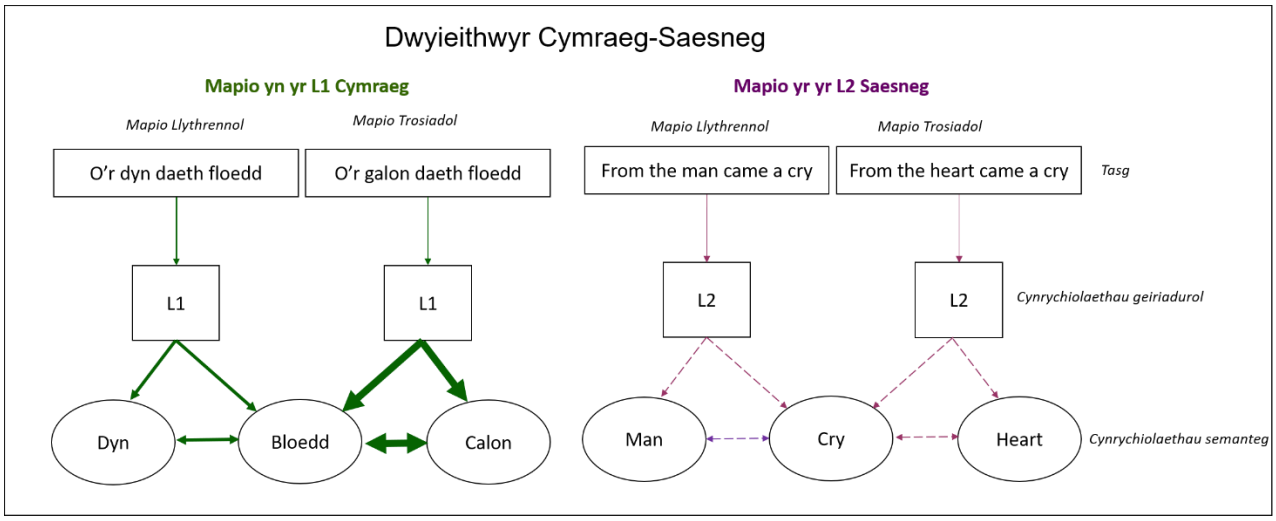
cyd-fynd â'r syniad o berthnasedd ieithyddol (‘*linguistic relativity’*), lle mae gwybyddiaeth a chanfyddiad yn cael ei ddylanwadu gan briodweddau ieithyddol (cf. Flecken, Athnosopoulos, Kuipers, Thierry, 2015; Thierry & Wu, 2009; Boutonnet, Athanasopoulos & Thierry, 2012). Yn ddiweddar, dangosodd Ellis, Kuipers, Thierry, Lovett, Turnbull a Jones (2015) fod angen prosesu gwybyddol llawer llai i hwyluso dealltwriaeth pan fydd cysylltiad rhwng gwybodaeth ddiwylliannol a'r iaith y mae'n cael ei gyflwyno ynddo. Yma, ‘rydym hefyd yn gweld bod deallusrwydd yn cael ei hwyluso pan fydd y wybodaeth a gyflwynir yn gydnaws â'r iaith y mae gan y cyfranogwr brofiad uwch a throsiad. Ar ben hynny, er bod effeithiau'n gryfach yn yr iaith frodorol (gan gyrraedd arwyddocâd yn arbrawf 1b), rydym yn nodi fod y patrwm cyffredinol a welir yng nghanlyniadau arbrawf 2 yn awgrymu bod yr effaith hon yn digwydd hefyd yn yr ail iaith mewn pobl ddwyieithog hyfedr (er i raddfa lai - wedi'i fynegi gan ddiffyg canlyniad arwyddocaol).

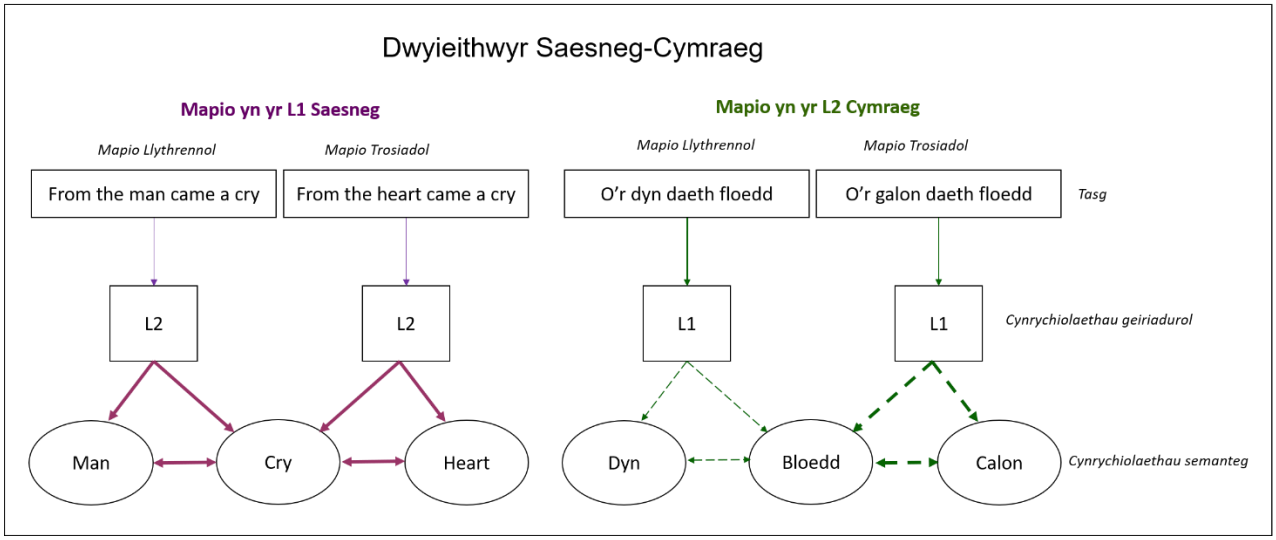
6.1.5 Sgematig o fapio mewn synnwyr mewn pobl ddwyieithog

Gyda’i gilydd, mae canlyniadau Rhan 1 yn awgrymu bod mynediad dwyieithog i ystyr yn ystod prosesu semantig ar-lein yn haws yn L1 nag yn L2. Ac eto, nid oes unrhyw fudd amlwg ar y lefel ymddygiadol. Mae'r canfyddiadau hyn yn unol â thybiaethau'r RHM, sy'n rhagdybio bod cysylltiadau dwyochrog cryf rhwng cysyniadau geirfaol-semantig a mynediad uniongyrchol at gysyniadau yn cael eu sefydlu gyda hyfedredd L2 uwch (Kroll a Stewart, 1994; Kroll, van Hell, Tokowicz & Green, 2010). Felly, er bod gan L1 fantais brosesu, mae L2 yn wir yn elwa o fynediad mewn modd tebyg. Trof yn awr i gyflwyno darlun o'r effaith hon ynghyd â'n canfyddiadau eraill.

Mae Ffigwr 22 yn cyflwyno darlun o'r prosesu semantig ar-lein o iaith lythrennol a ffigurol a welwyd yn L1 a L2 ar gyfer y rhai dwyieithog Cymraeg-Saesneg a'r rhai dwyieithog Saesneg-Cymraeg.

Yn debyg ar gyfer L1 a L2, tybir bod cyrraedd at ddehongliad llythrennol a ffigurol yn dilyn patrwm union yr un fath; fel y mynegeiwyd gan osgledau N400 a P600 tebyg i frawddegau llythrennol a throsiadol yn Gymraeg a Saesneg. Hynny yw, yn L1 a L2 mae mapio brawddegau llythrennol (mapio '*dyn*' a '*cry*') a brawddegau trosiadol (mapio '*cry*' a '*heart*') yn uniongyrchol. Canfuom fod L1 fodd bynnag, yn elwa o fantais brosesu (oherwydd cysylltiadau geiriadurol-semantig cryfach a ragdybir ar sail modelau seicoieithyddol) gan amlygu mewn mwy o sensitifrwydd i ystyr brawddeg (synnwyr) yn ystod ffenestr amser integreiddio semantig (N400) a llai o angen am ail-ddadansoddi. (P600). Cynrychiolir hyn yn y model gan linellau solid rhwng cysyniadau semantig yn L1. Yn L2 ar y llaw arall, gwelsom integreiddiad semantig 'digon da' a gohiriedig (N400) a phrosesu mwy ymdrechgar gyda mwy o angen am ail-ddadansoddi (P600). Cynrychiolir yr effaith hon yn y model gan linellau toredig rhwng cysyniadau semantig yn L2. O bosibl ein canfyddiad mwyaf rhyfeddol oedd bod deall trosiad yn cael ei hwyluso yn y Gymraeg gan achlysuron a phrofiad uwch, yn ddifater o beth oedd eu brodorol rwydd,. Ar ben hynny, canfuwyd bod yr effaith hon yn gryfach ymhlith siaradwyr brodorol Cymraeg (wedi'i mynegi gan ganlyniad arwyddocaol yn L1 a thuedd gyffredinol yn L2) ac felly fe'i cynrychiolir gan linellau mwy grymus ar gyfer trosiad Cymraeg L1 o'i gymharu â throsiad Cymraeg L2.





Ffigwr 22. Darlun o ganfyddiadau penodau 3 a 4.

6.2 Rhan 2: Mapio rhyng-synnwyr mewn pobl ddwyieithog

Yn flaenorol, canfuwyd cyd-actifadu ieithoedd ar y cyd ar y lefelau geirfaol a chystrawennol. Ym mhennod 5, ymchwiliais os yw cyd-actifadu iaith o'r fath hefyd yn digwydd ar y lefel semantig. I'r perwyl hwn, cynhaliais arbrawf ERP a archwiliodd sut y

gellir cyrchu cynrychioliadau cysyniadol sy'n benodol i'r iaith frodorol trwy'r iaith anfrodorol. Yn fwy penodol, cyflwynais ymadroddion idiomatig Cymraeg i bobl ddwyieithog Gymraeg-Saesneg a siaradwyr uniaith Saesneg yn yr iaith idiom-anghydweddol (hy Saesneg -(‘*She thought the woman was a hat’* - lle mae'r ystyr yn nonsensical) ynghyd ag anghyson (‘*He was criticised by his friend for being a front hat’)* a thebygolrwydd isel tebygolrwydd (‘*He walked to the shop with the wind in his hat’*) brawddegau.

O dan gyfrif dethol iaith, lle mai dim ond ymgeiswyr gair sy'n gyfath â'r iaith weithredol fyddai'n cael eu hactifadu, ni fyddai wedi bod yn bosibl i'r rhai dwyieithog hyn gael mynediad at y gynrychiolaeth semantig iaith benodol yn ystod prosesu semantig ar-lein. Pe bai'r cyfrif hwn yn gywir, yna byddai deallusrwydd yn gyntaf yn gofyn iddynt wrthod y dehongliad anghyson Saesneg a'i gyfieithu yn ddiweddarach i'r Gymraeg. Felly byddai'r effeithiau'n ymddangos yn nes ymlaen (yn ystod ffenestr amser P600). Fodd bynnag, mae ein canlyniadau'n cefnogi'r safbwynt cyferbyniol, y cyfrif iaith an-ddetholus. Canfuom fod yr idiom Gymraeg yn cael ei phrosesu yn rhwydd yn ystod y ffenestri amser sy'n gysylltiedig ag integreiddio semantig ac ail-ddadansoddi (a nodwyd gan osgledau N400 a P600 llai i idiomau Cymraeg a brawddegau derbyniol o gymharu â brawddegau anghyson). Fodd bynnag, yn y siaradwyr uniaith Saesneg, roedd prosesu semantig ac ail-ddadansoddi mwy ymdrechgar (a nodwyd gan osgledau N400 a P600 mwy i idiomau Cymraeg a brawddegau anghyson o gymharu â brawddegau derbyniol). Felly, er bod y rhai uniaith Saesneg yn trin yr idiom fel brawddeg semantig anghyson (fel yn wir y dylent), roedd y bobl ddwyieithog Gymraeg-Saesneg yn prosesu'r idiom mewn ffordd debyg i frawddeg semantig derbyniol. Fodd bynnag, datgelodd ein canlyniadau

ymddygiadol fod ymatebion y ddau grŵp yn gyflymach ac yn fwy cywir i frawddegau anghyson a ddilynwyd gan idiomau Cymraeg a brawddegau derbyniol, yn ddifater o aelodaeth y grŵp.

Gyda'i gilydd, mae'r canlyniadau hyn yn awgrymu, er bod ystyr benodol Gymraeg yr idiom ar gael ar unwaith i'r rhai dwyieithog Cymraeg-Saesneg, pan ofynnwyd yn benodol iddynt farnu pa mor dderbyniol oedd y brawddegau, roeddent yn gallu atal yr ystyr Cymraeg-benodol. Felly, nid oedd dealltwriaeth yn cael ei bennu gan gyfatebiaeth rhwng iaith y cyflwyniad ac aelodaeth iaith y cysyniad. Mewn gwirionedd, ar ôl i ymgeiswyr geirfaol gael eu hactifadu, actifadwyd yr holl gynrychiolwyr semantig cysylltiedig. Felly, awgrymaf fod lledaeniad o actifadu yn digwydd lle mae ymgeiswyr geirfaol yn actifadu'r holl gynrychiolwyr cyfatebol yn awtomatig, yn ddifater o'r gorgyffyrddiad iaith rhwng y mewnbwn geirfaol a'r gynrychiolaeth yn y storfa semantig. Golygai hyn bod hyd yn oed gwybodaeth iaith-benodol yn gysylltiedig nid yn unig â chynrychioliadau geirfaol o'r un iaith, ond hefyd â'r iaith anghysylltiedig (Kroll & Stewart; Dijstra & Van Heuven, 2002; Dijstra & Van Heuven 1998; Grainjer & Dijstra, 1992).

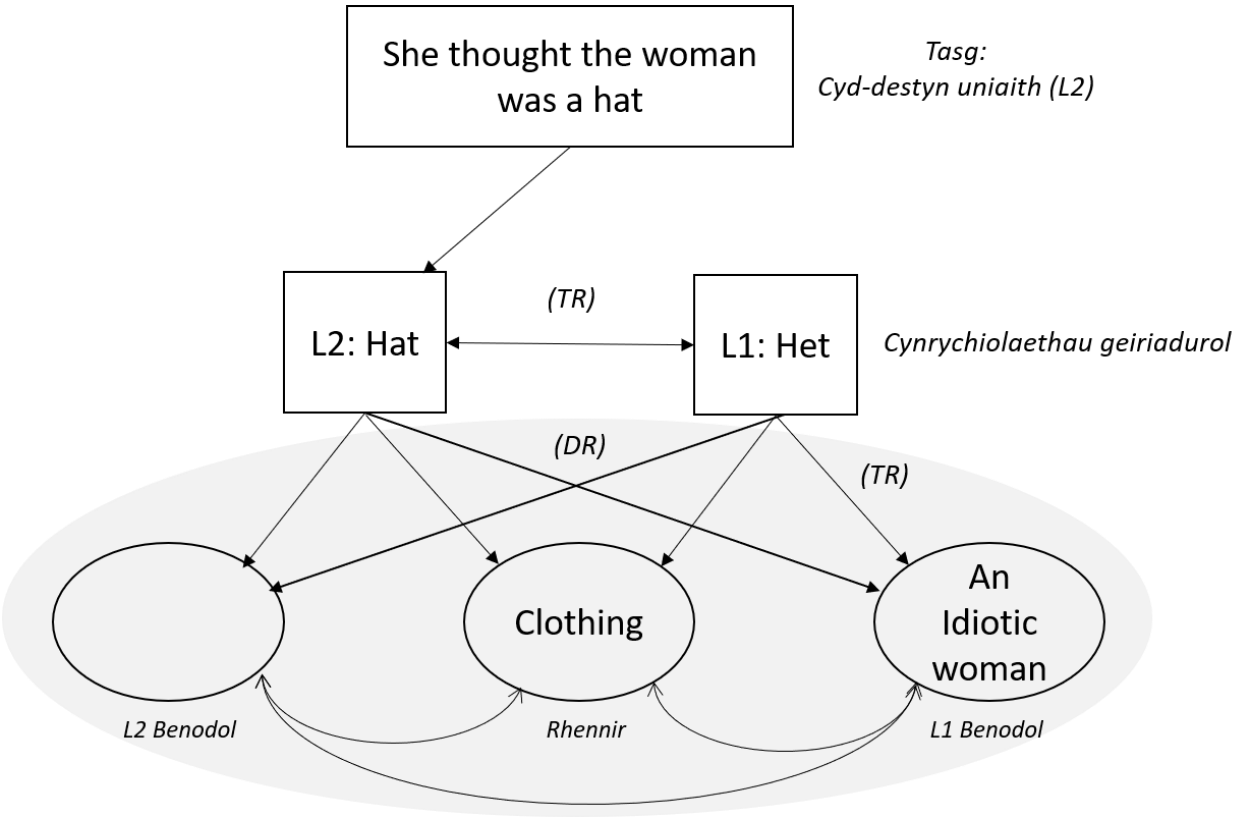
Gyda hyn mewn golwg, awgrymaf fod natur y rhwydwaith semantig dwyieithog yn llawer mwy cymhleth na'r hyn a ddisgrifir ar hyn o bryd gan fodelau seicoieithyddol fel y '*Sense Model'*, sy'n tybio bod cynrychioliadau'n perthyn i'r ddwy iaith (cynrychioliadau craidd) neu i un iaith (iaith- cynrychioliadau penodol; Finkbeiner, et al 2004). Mae ein canlyniadau'n awgrymu nad yw sylwadau'n perthyn i un iaith yn unig ac yn cael eu gweithredu gan yr iaith honno, ond yn hytrach maent yn cael eu rhannu a'u gweithredu gan yr holl ymgeiswyr geirfaol cysylltiedig. Dyma'r dystiolaeth gyntaf bod

pobl ddwyieithog mewn gwirionedd yn cyd-actifadu cynrychioliadau cysyniadol o'r ddwy iaith wrth ddarllen brawddegau (iaith an-ddewisiol). Yn unol â chyfrifon blaenorol o actifadu geirfaol a chystrawennol (Dijkstra, Van Heuven, & Grainger, 1998; van Heuven, Dijkstra, 2010), mae cynrychioliadau cysyniadol o'r ddwy iaith yn cael eu cyd-actifadu yn ystod deall brawddegau, ac mae'r storfa gysyniadol ddwyieithog yn system hynod o ryngweithiol, ac nid yw actifadu yn dibynnu ar actifadu cyfwerthoedd cyfieithiad. Ar hyn o bryd, mae'r rhyngweithiad cymhleth hwn wedi'i orsymleiddio'n fawr o fewn modelau seicoieithyddol. Mae hyn felly'n tynnu sylw at yr angen i fodelau newydd fel yr Multilink (Dijkstra et al., 2019) ymgorffori'r rhwydweithiau cymhleth hyn. Mae methu â gwneud hynny yn cyfyngu'n dealltwriaeth yn sylweddol o sut mae'r system gysyniadol ddwyieithog yn gweithredu mewn gwirionedd.

6.2.1 Sgematig o fapio mewn synnwyr mewn pobl ddwyieithog

Mae Ffigwr 23 yn ddarlun o ganfyddiadau’r astudiaeth mapio rhyng-synnwyr ym Mhennod 5. Mae'r ardal lwyd yn cynrychioli'r storfa semantig ac mae'r saethau'n cynrychioli cysylltiadau geirfa-semantig a chysylltiadau rhwng cysyniadau. Pan gyflwynir â’r frawddeg Saesneg ‘*She thought the woman was a hat’*, actifadir y gynrychiolaeth eirfaol gyfatebol *‘hat’*. Petae cysyniadau semantig o'r iaith anweithredol ddim yn cael eu hactifadu ar yr un pryd (gan gefnogi'r farn ddethol iaith o gyd-actifiant semanteg) byddai mynediad wedi digwydd trwy'r llwybr cyfieithu (TR) - gan arwain at N400 a P600 cynyddol i’r idiom. Fodd bynnag, dangosodd y canfyddiadau fod ogledau N400 a P600 tebyg i’r idiom a’r brawddegau derbyniol, a oedd yn llai o gymharu â brawddegau anghyson. Mae'r canlyniadau hyn yn awgrymu bod yr holl gynrychiolwyr

semantig sy'n gysylltiedig â'r gair targed wedi'u hactifadu (hyd yn oed cynrychioliadau iaith-benodol) gan gefnogi’r farn an-ddetholus iaith o gyd-actifiant ar y lefel semanteg. Arweiniodd yr actifiant hwn at fynediad trwy'r llwybr uniongyrchol (DR). Felly, mae'r L1 a L2 yn cyflawni mynediad at gysyniadau semantig, yn ddifater o beth yw'r iaith y mae cysyniadau'n cyfateb iddi.



Ffigwr 23. Darlun o gyd-actifadu cysyniadol mewn cyd-destun uniaith - mapio rhwng-iaith o fewn cysyniadau.

6.3 Cyfyngiadau’r Thesis

6.3.1 Safon a dadansoddiad y data

Rydym yn nodi sawl cyfyngiad ar yr astudiaeth hon. Yn gyntaf, mae'r data ERP a gasglwyd yn arbrawf 1b a 2 yn cynnwys halogiad tonnau alffa (‘*alpha wave’*) sylweddol, a effeithiodd ar y mwyafrif o’r cyfranogwyr, ac felly ni ellid ei wella trwy hidlo neu wahardd cyfranogwyr. Yn ôl pob tebyg, cododd lefel yr alffa o'r dasg arbrofol, a oedd yn ymofyn ymateb ar 30% o'r holl dreialon yn unig. Byddai angen i waith yn y dyfodol gynnwys tasg sy'n gofyn am ymateb ar fwyafrif y treialon er mwyn osgoi effaith o'r fath ar y data.

Mae ail gyfyngiad yn ymwneud â'r diffyg pŵer ystadegol (fel y nodwyd ym mhenodau 4 a 5). Pan edrychwn ar feintiau effaith ein data sydd yn an-arwyddocaol, gwelwn fod tuedd yn y data, ac rydym yn gyson yn dod o hyd i feintiau effaith (effect sizes) bach i gymedrol. Yn wir, gwelwyd maint effaith ar bob achlysur ond un (Arbrawf 2, N400 phrif effaith an-arwyddocaol ar gyfer ffigurol, maint effaith = .0). Felly, mae'r meintiau effaith hyn yn awgrymu ein bod yn methu ag arsylwi gwir effeithiau. Mae'n bosibl bod ein maint sampl cyfredol, ynghyd ag effeithiau halogiad alffa, yn golygu na allwn arsylwi gwir effeithiau a phenderfynu ba raddau mae’r effeithiau hyn bodoli yn y boblogaeth

Er bod dadansoddiad pŵer yn dod yn fwy a mwy poblogaidd mewn astudiaethau seicolegol (Brysbaert & Stevens, 2018) mae'n ymddangos nad yw astudiaethau ERP wedi mabwysiadu'r dull hwn o amcangyfrif pŵer a'r maint sampl gofynnol cyn ei brofi (Fields, & Kuperberg, 2020). Mewn gwirionedd, mae'r pŵer ystadegol cyfartalog mewn niwrowyddoniaeth yn isel iawn (Botwm, Loannidis, Mokrysz, Nosek, Y Fflint, Robinson, & Munafo, 2013). Byddai dadansoddiad pŵer a priori wedi ein galluogi i benderfynu ar y

nifer o gyfranogwyr sy'n ofynnol i ddarganfod os yw unrhyw effaith a welwyd mewn gwirionedd yn effaith wirioneddol. Felly, mae'n hanfodol bod fersiynau o'r arbrawf hwn yn y dyfodol yn defnyddio technegau dadansoddi pŵer a priori i benderfynu ar faint y sampl sy'n ofynnol, a thrwy estyniad cynyddu'r pŵer ystadegol.

6.3.2 Ysgogiadau arbrofol

Er bod defnyddio cyd-destun brawddeg yn fwy cynrychioliadol o brosesu iaith naturiol, mae llunio brawddegau sy'n ystyrlon yn semanteg ac yn ramadegol yn y ddwy iaith yn heriol. Crëwyd pob set o frawddegau yn y ddwy iaith ar y cyd (yn hytrach na'u cyfieithu) er mwyn osgoi effeithiau cyfieithu. Fodd bynnag, gallai hyn fod wedi arwain at strwythur gramadegol rhyfedd (ond nid anghyson) mewn rhai brawddegau. Ar ben hynny, o gofio bod gan eiriau penodol ystyron trosiadol a / neu idiomatig mewn rhai ieithoedd, efallai bod gan rai geiriau pwnc neu darged ystyron ychwanegol i rai unigolion (h.y., defnyddir het yn aml yn yr idiom Saesneg ‘talking through your hat’).

Fel y nodwyd ym mhennod 5, gwnaethom geisio lleihau effeithiau'r cyfyngderau hyn trwy gynnwys cyfanswm nifer y treialon a oedd yn fwy na'r disgwyl gan arbrofion ERP. At hynny, cynhaliwyd astudiaethau normaleiddio ar wahân ar bob set nes y cyflawnwyd cywerthedd (a diffyg cywerthedd lle bo'n briodol). Yn ogystal, er mwyn ymchwilio i effeithiau ffactorau fel strwythurau gramadegol anuniongred defnyddiwyd dull cylchdroi brawddegau a geiriau targed. Felly, pe bai ffactorau o'r fath wedi effeithio ar y canlyniadau, byddai effaith wedi'i gweld ar draws amodau (er enghraifft, mewn amodau semanteg dderbyniol ac anghyson yn arbrawf 1 a 2). Gan na arsylwyd ar hyn,

fodd bynnag, rydym yn dod i'r casgliad nad oedd strwythurau gramadegol y brawddegau hyn (a allai fod yn anghonfensiynol mewn rhai achosion) wedi dylanwadu ar ganlyniadau cyffredinol yr ERP.

Ychwanegiad diddorol i'r mesurau hyn fyddai astudiaeth ar wahân yn ymchwilio i dderbynioldeb cystrawennol y brawddegau hyn. Byddai hyn wedi caniatáu inni bennu i ba raddau y mae'r brawddegau hyn yn anuniongred, a phenderfynu a oes unrhyw wahaniaethau rhyngweithiol yn bodoli rhwng cystrawen y brawddegau hyn ar draws ieithoedd. Efallai bod y brawddegau Cymraeg yn fwy anuniongred na'u cymheiriaid Saesneg, neu, o ystyried yr hyblygrwydd gramadegol yn y Gymraeg (Deuchar, 2006) a bod yr ysgogiadau wedi'u creu gan siaradwyr brodorol-Gymraeg, efallai bod y gystrawen Saesneg yn fwy anuniongred. Byddai astudiaeth normio yn edrych ar strwythur cystrawennol yn benodol wedi caniatáu inni ymchwilio'r gwahaniaethau posibl hyn.

6.3.3 Dewisiad Cyfranogwyr

Rydym yn defnyddio'r term dwyieithog (gan gynnwys cydamserol, cynnar a hwyr) i gategoreiddio unigolion ar gyfer ymchwil. Un o ddryswch mawr fodd bynnag, yw ‘nad oes unrhyw ddau ddwyieithog yr un fath’ (de Bruin, 2019) ac nid yw dwyieithrwydd yn newidyn categorïaidd (Luk & Bialystok, 2013). Hyd yn oed o fewn y categorïau hyn, bydd pobl ddwyieithog yn amrywio yn sylweddol yn eu hoedran caffael, hyfedredd, defnydd, ac arferion newid iaith, a hyd yn oed pan gyflawnir cydraddoldeb ar ambell ddimensiwn (oedran caffael a hyfedredd er enghraifft), gall eraill (megis defnydd

iaith) fod yn sylweddol wahanol (de Briun, 2019). Am y rheswm hwn, mae'n hynod anodd cael samplau sy'n cyfateb ar yr holl newidynnau demograffig ac ieithyddol.

Er bod creu mesur mesuradwy o brofiad pob unigolyn yn heriol, mae mesur dwyieithrwydd gan ddefnyddio mesurau goddrychol (fel yr holiaduron a ddefnyddir yn y traethawd ymchwil cyfredol) yn broblemus gan fod cyfranogwyr yn aml yn goramcangyfrif neu'n tanamcangyfrif galluoedd megis eu lefelau hyfedredd. Ar ben hynny, mae'n anodd archwilio defnydd ac amlygiad iaith o ystyried bod cyd-destun yn ffactor hanfodol sy'n cael ei danamcangyfrif yn fawr gan fesurau goddrychol (gan gynnwys y rhai a ddefnyddir yma). Serch hynny, mae mesurau o’r fath yn rhoi mewnwelediad gwerthfawr i wahanol agweddau o ddwyieithrwydd ac felly ni ddylid eu diystyru'n llwyr (de Bruin, 2014). Dull mwy cadarn byddai ddefnyddio dulliau goddrychol a gwrthrychol fel deall iaith, hyfedredd a thasgau treiglo mewn cyd-destun Cymraeg (yn unol â Vaughan-Evans, Kuipers, Thierry & Jones, 2014).

Gan ystyried fod ffactorau megis cyd-destun yn cael ei anwybyddu, dylai fesurau goddrychol geisio bod yr un mor gynhwysfawr â phosibl. Er enghraifft, dylid archwilio amlygiad a defnydd iaith yn ôl cyd-destun (cartref a theulu, cyfoedion, cymuned, ysgol, prifysgol, gwaith, hamdden, cyfryngau) yn hytrach na chanran gyffredinol (yn unol ag Anderson, Mak, Chahi, & Bialystok, 2018). Yma efallai, efallai bod profiad dwyieithog fel maes astudio, cymryd rhan mewn gweithgareddau cyfrwng Cymraeg fel yr Eisteddfod, maint y cyfarwyddyd Cymraeg ffurfiol (hy TGAU, Safon Uwch, cwrs Prifysgol, cwrs cyfrwng Prifysgol) wedi cael ei ystyried yn gyfraniad pwysig ffactor. Er mwyn osgoi meini prawf cynhwysiant mwy llym a ‘cherry picking’ yn seiliedig ar

nodweddion penodol (de Bruin, 2019) byddai sicrhau mesur o’r profiadau hyn wedi caniatáu cynnwys y ffactorau hyn fel cyd-newidyn yn y dadansoddiad terfynol.

Yn wir, roedd ein meini prawf cynhwysiant yn llym ar y gorau, gan gynnwys addysg i lefel Prifysgol, o gartrefi Cymraeg yn unig, 18-35 oed, a dim anableddau dysgu hysbys. Er i’r dulliau samplu a ddefnyddir (pel-eira a chyfleustra gan ddefnyddio’r Cyfryngau Cymdeithasol, fforymau Prifysgol, a hysbysfyrddau Llyfrgell) wedi caniatáu inni dargedu ein demograffig arfaethedig, fe wnaethant arwain at greu sampl ychydig yn rhwystredig. Felly, mae'n anodd cyffredinoli'r canlyniadau hyn i'r boblogaeth ddwyieithog gyfan. Fodd bynnag, gallai caniatáu mwy o amrywiad mewn gwahaniaethau unigol i'n sampl fod wedi cael effaith niweidiol ar ein cydrannau ERP gan olygu bod unrhyw ganlyniadau'n annibynadwy ac yn annealladwy (Luck, 2005; Woodman, 2010). Caniataodd ein sampl gyfyngedig i ni reoli am rai gwahaniaethau unigol y gwyddys eu bod yn modiwleiddio cydran yr N400 megis lefel darllen a deall, yn ogystal â chynhyrchiad alffa.

Mae cyfyngiad ychwanegol yn ymwneud â'r poblogaethau dwyieithog a samplwyd yn Arbrawf 1b (brodorol Cymraeg-Saesneg) a 2 (Saesneg-Cymraeg brodorol), a'r tebygolrwydd na chyflawnwyd dwyochredd llawn mewn hyfedredd (Gass, 1984; Pham, Donovan, Dam, & Contant , 2018). Er y gwnaed pob ymdrech i recriwtio pobl ddwyieithog â lefelau hyfedredd cyfatebol ac oedran caffael yn y L1 / L2 ar draws grwpiau, gall pob grŵp gael ei nodweddu gan broffil iaith unigryw. Er enghraifft, er bod y ddau grŵp wedi derbyn addysg Gymraeg, mae oedran ac amlder yr amlygiad i'r ail iaith (Cymraeg) yn uwch ymhlith y siaradwyr brodorol Saesneg. At hynny, mae newid iaith yn rheolaidd yn ofyniad mwy cyffredin i bobl ddwyieithog Gymraeg brodorol o'i gymharu â

siaradwyr Saesneg brodorol (hy, mae siaradwr brodorol Saesneg yn llai tebygol o newid i'w Gymraeg L2, o'i gymharu â siaradwr brodorol y mae newid i Saesneg L2 yn gyffredin iddo).

Yn olaf, ar draws yr holl arbrofion, roedd y mwyafrif o’r cyfranogwyr yn ferched. Mae canfyddiadau o wahaniaethau rhyw yn y llenyddiaeth prosesu iaith yn anghyson. Er nad yw rhai ymchwilwyr wedi darganfod unrhyw wahaniaeth rhwng y rhywiau (Frost et al, 1999; Sommer et al, 2004, Weiss et al, 2003) mae eraill wedi canfod gwahaniaethau mewn lleoliad prosesu (localizarion) dynion a merched (Kaiser et al, 2007; Baxter et al, 2003). Yn wir, mae ymchwil i brosesu iaith ffigurol hefyd wedi canfod gwahaniaethau rhyw wrth brosesu. Yn eu hymchwiliad fMRI o ddealltwriaeth lythrennol ac idiomatig, darganfuwyd fwy o actifadu ymysg menywod i frawddegau llythrennol ac idiomatig, sy’n awgrymu bod merched yn prosesu iaith ar lefel fwy eang (*global*; Kana et al, 2012). Efallai nad yw hyn yn wir fodd bynnag, ar gyfer yr astudiaeth gyfredol gan fod y dechneg ERP ddatrysiad gofodol gwael, ac felly, nid yw'n ymwneud â lleoliad prosesu (localization; Luck, 2014). Ar ben hynny, hyd eithaf ein gwybodaeth nid oes unrhyw wahaniaethau rhyw wedi eu darganfod yn y llenyddiaeth N400 gweledol-ieithyddol, ac felly, mae'n annhebygol fod yr anghydbwysedd rhwng y rhywiau yma wedi dylanwadu ar y data.

6.4 Cyfarwyddiadau ar gyfer ymchwil yn y dyfodol

Trof yn awr i gynnig cyfeiriad ar gyfer ymchwil yn y dyfodol sy'n ofynnol i ymchwilio i'r cwestiynau empirig sy'n dilyn casgliadau cyffredinol y traethawd ymchwil

hwn. Y ffocws yma yw sut mae mynediad at wybodaeth semantig yn cael ei sicrhau gan yr iaith frodorol ac anfrodorol (o fewn synnwyr) a sut mae cysylltiadau semantig yn rhyngweithio ar draws ieithoedd (rhyng-synnwyr).

6.4.1 Mapio o fewn synnwyr

Ym Mhennod 2, cyflwynais set o frawddegau a oedd yn cynnwys ffactor diwylliannol na chafodd eu defnyddio yn yr astudiaethau ERP diweddarach. Penderfynais fod y ffactor diwylliannol ychwanegol yn rhy gymhleth fel man cychwyn i sefydlu dealltwriaeth o'r prosesau sylfaenol sy'n gysylltiedig â deall iaith lythrennol yn erbyn trosiadol, ac felly tynnwyd y ffactor hwn o'r ymchwiliadau. Nawr bod gennym sylfaen i ymestyn yr ymholiad hwn ohoni, cynigiaf y byddai'r ffactor diwylliannol penodol yn darparu dull diddorol i ymestyn canfyddiadau arbrofion 1 a 2. Yn benodol, byddai ymchwiliad o'r fath yn caniatáu mewnwelediad pellach i ddylanwad profiad a gwybodaeth ieithyddol ar brosesu semantig. Yn ôl y rhagdybiaeth perthnasedd ieithyddol (‘*linguistic relativity*’) pan fydd y wybodaeth gyd-destunol yn cyfateb yn unol ag iaith y cyflwyniad - brawddegau trosiadol sy'n cynnwys gwybodaeth ddiwylliannol berthnasol i Gymru - dylid hwyluso mynediad semantig a deallusrwydd trosiadol ymhellach (Ellis et al, 2015). Estyniad diddorol o'r arbrawf arfaethedig hwn fyddai ymchwilio eto i siaradwyr brodorol ac anfrodorol Cymraeg i bennu maint y cysylltiadau iaith-diwylliant hyn, gan dddefnyddio’r ysgogiad a greuwyd ym mhenod 2 a’r weithdrefn a ddefnyddwyd ym mhenod 3 a 4.

6.4.2 Mapio rhyng-synnwyr

Mae canlyniadau Arbrawf 3 yn darparu, hyd eithaf ein gwybodaeth, y dystiolaeth gyntaf o gyd-actifadu cysyniadol dwyieithog. Gyda hyn mewn golwg, mae angen i ni ymchwilio i'r effaith hon ymhellach er mwyn sefydlu gwell dealltwriaeth o strwythur y rhwydweithiau semantig, a'r prosesau y maent yn gweithredu trwyddynt. I gyflawni hyn, mae'n hanfodol defnyddio dulliau amrywiol megis prosesu '*polysemy*' fel enghraifft. Yn bwysicach fyth, serch hynny, dylem geisio ymchwilio i ddefnyddio paradeimau y daw mwyafrif y dystiolaeth i gefnogi modelau dwyieithog ohonynt fel '*masked priming'*.

Felly, er ei fod yn gam i'r cyfeiriad cywir, mae'r traethawd ymchwil hwn yn gadael llawer o gwestiynau heb eu hateb ynghylch natur cysylltiadau semantig dwyieithog. Er enghraifft, os yw cynrychioliadau semantig iaith-benodol ar gael ar unwaith pan wyrdroir y cyfeiriad? Hynny yw, yw cynrychioliadau cysyniadol penodol L2 yn hygyrch pan gânt eu cyflwyno yn L1? Fodd bynnag, mae ymchwil yn awgrymu nad yw unigolion yn gyfarwydd ag ystyr estynedig yn L2, gan gynnwys ystyron polysemous ac idiomatig (Finkbeiner et al, 2004). Felly, gallai ymchwilio i gyd-actifadu cysyniadol gan ddefnyddio ystyr iaith-benodol i'r cyfeiriad hwn fod yn heriol. Cwestiwn hyfyw arall, a mwy gwerth chweil efallai, fyddai gofyn pryd yn ystod caffael ail iaith y mae'r system semantig yn cael ei hintegreiddio'n llawn ar draws ieithoedd? Mae modelau dwyieithog cyfredol yn cynnig y daw cysylltiadau cryfach rhwng cynrychioliadau geirfaol-semantig gyda mwy o hyfedredd. Yma, dim ond pobl ddwyieithog rhugl iawn y gwnaethom eu profi; byddai profi pobl ddwyieithog o lefelau hyfedredd amrywiol yn cynnig mewnwelediad i dafl-wybr y system semantig gael ei hintegreiddio'n llawn rhwng L1 a L2.

Mae ymchwiliad pellach i'r effeithiau hyn yn hanfodol ar gyfer esblygiad modelau dwyieithog traddodiadol, sydd ar hyn o bryd yn disgrifio'r storfa semantig fel unedol. Er bod y modelau hyn yn disgrifio system eirfaol ryngweithiol lawn, maent yn methu ag ystyried y rhyngweithiad cymhleth sydd hefyd yn digwydd yn y storfa gysyniadol. At hynny, ar hyn o bryd mae cynrychiolaethau'n cael eu dosbarthu fel unedau sengl tra eu bod mewn gwirionedd yn cynnwys amryw o ystyron a chynodiadau.

6.5 Sylwadau Terfynol

Nod y traethawd ymchwil hwn oedd ymchwilio i'r system semantig ddwyieithog a goblygiadau'r strwythur hwn ar gyfer prosesu iaith. I'r perwyl hwn, fe wnes i gategoreiddio'r system semantig yn mapio o fewn synnwyr, h.y., o fewn L1 a L2, a mapio rhyng-synnwyr, h.y., rhwng L1 a L2. Ymchwiliodd Rhan 1 o'r traethawd ymchwil i fapio mewn-synnwyr, lle cynhaliais dri arbrawf (penodau 3 a 4) gan archwilio sut mae pobl ddwyieithog yn prosesu 1) iaith anghyson, a 2) iaith ffigurol. Yn seiliedig ar ganlyniadau Rhan 1, gwnaf dri phrif gasgliad. Yn gyntaf, er bod L1 yn elwa o fwy o sensitifrwydd i synnwyr a phrosesu llai, llai ymdrechgar, mae L2 yn arddangos prosesu mwy bas, gohiriedig ac ymdrechgar. Yn ail, rydym yn canfod bod mynediad at ystyr trosiadol yn uniongyrchol ac yn cael ei gyrchu ar y cyd ag ystyr lythrennol yn L1 a L2 (er eto yn fwy ymdrechgar yn L2). Yn olaf, mae mynediad i iaith drosiadol yn cael ei fodiwleiddio gan briodweddau ystadegol yr iaith. Er bod yr effaith yn gryfach yn yr iaith frodorol, roedd tueddiadau hefyd yn awgrymu bod priodweddau iaith hefyd yn modiwleiddio mynediad yn yr iaith anfrodorol. Ymchwiliodd Rhan 2 o'r traethawd ymchwil i fapio rhyng-synnwyr. Er mwyn mynd i’r afael â’r cwestiwn hwn, ymchwiliais i gyd-actifadu semantig

trwy archwilio sut mae gwybodaeth semantig sy'n unigryw i'r iaith frodorol yn cael ei phrosesu yn yr iaith - anghydweddol - arall. Ym mhennod 5, darganfyddais fod cyd-actifadu iaith hefyd yn digwydd ar y lefel semantig, gan awgrymu bod natur y rhwydwaith semantig dwyieithog yn fwy rhyngweithiol nag a dybiwyd yn flaenorol.

References/ Cyfeiriadau

Abel, B. (2003). English idioms in the first language and second language lexicon: A dual representation approach. *Second Language Research,* 19(4), 329-358

Aguinis, H., & Stone-Romero, E. F., (1997). Methodological Artefacts in Moderated Multiple Regression and Their Effects on Statistical Power. *Journal of Applied Psychology,* 82 (1), 192-206

Alday PM. 2019. How much baseline correction do we need in ERP research? Extended GLM model can replace baseline correction while lifting its limits. *Psychophysiology* 94(1):206

Altarriba, J., Kroll, J. F., Sholl, A., & Rayner, K., (1996). The influence of lexical and conceptual constraints on reading mixed-language sentences: Evidence from eye fixations and naming times. *Memory and Cognition,* 24, 477-492

Anderson, J.A.; Mak, L.; Chahi, A.K.; Bialystok, E. (2018). *The language and social background questionnaire: Assessing degree of bilingualism in a diverse population.* Behaviour Research Methods, 50, 250–263.

Ardal, S., Donald, M. W., Meuter, R., Muldrew, S., & Luce, M., (1990). Brain responses to semantic incongruity in bilinguals. *Brain Language,* 39, 187–205

Arzouan, Y., Goldstein, A., Faust, M., (2007). Brainwaves are stethoscopes: ERP correlates of novel metaphor comprehension. *Brain Research* 1160, 69–81. https://doi.org/10.1016/j.brainres.2007.05.034

Arzouan, Y., Goldstein, A., Faust, M., (2007). Dynamics of hemispheric activity during metaphor comprehension: electrophysiological measures. *Neuroimage* 36 (1), 222–231. https://doi.org/10.1016/j.neuroimage.2007.02.015

Athanasopoulos, P., Bylund, E., Montero-Melis, G., Damjanovic, L., Schartner, A., Kibbe, A., Riches, N., & Thierry, G., (2015). Two languages, two minds: flexible cognitive processing driven by language of operation. *Psychological Science*, 26 (4), 518-526

Bak, T., (2016), 'Cooking pasta in La Paz: bilingualism, bias and the replication crisis', *Linguistic Approaches to Bilingualism*, 6 (5), 699-717

Bambini, V., Bertini, C., Schaeken, W., Stella, A., & Di Russo, F. (2016). Disentangling metaphor from context: An ERP study. *Frontiers in Psychology*, 7, 559. doi:10.3389/fpsyg.2016.00559

Bambini, V., Canal, P., Resta, D., & Grimaldi, M. (2018). Time course and neurophysiological underpinnings of metaphor in literary context. *Discourse Processes.* Advance online publication. doi:10.1080/0163853X.2017.1401876

Barber, H.A., Donamayor, N., Kutas, M., Munte, T., (2010). Parafoveal N400 effect during sentence reading. *Neuroscience Letters*, 479, 152-156.

Barr, D. J., Levy, R., Scheepers, C., & Tily, H. J., (2013). Random effects structure for confirmatory hypothesis testing: keep it maximal. *Journal of Memory and Language*, 68 (3),

Barton, S. B., & Sanford, A. J., (1993). A case study of anomaly detection: Shallow semantic processing and cohesion establishment. *Memory & Cognition* 21, 477–487

Basnight-Brown, D. M., & Altarriba, J. (2007). Differences in semantic and translation priming across languages: The role of language direction and language dominance. *Memory & Cognition*, 35, 953–965.

Bates, D., Mächler, M., Bolker, B., & Walker, S., (2014). Fitting linear mixed-effects models using lme4. *Journal of statistical software*, 67

Beauvillain, C., & Grainger, J. (1987). Accessing interlexical homographs: Some limitations of a language-selective access. *Journal of Memory and Language, 26*(6), 658-672.

Baxter, L.C., Saykin, A.J., Flashman, L.A., Johnson, S.C., Guerin, S.J.,Babcock, D.R., Wishart, H.A., (2003). Sex differences in semantic language processing: a functional MRI study. Brain and Language 84,264–272.

Beck, S. D., & Weber, A., (2016). Bilingual and Monolingual Idiom Processing Is Cut from the Same Cloth: The Role of the L1 in Literal and Figurative Meaning Activation. *Frontiers in Psychology*, 7, 1350

Bobrow, S. A., & Bell, S. M. (1973). On catching on to idiomatic expressions. *Memory & Cognition, 1*, 342-346.

Bolognesi, M., (2016). Modeling Semantic Similarity between Metaphor Terms of Visual vs. Linguistic Metaphors through Flickr Tag Distributions. *Frontiers in Communication,*

Bonthoux, F., and Kalénine, S. (2007). Preschoolers' superordinate taxonomic categorization as a function of individual processing of visual vs. contextual/functional information and object domain. *Cogniţie Creier Comportament, 11*(4), 713–731.

Boutonnet, B., Athanasopoulos, P., Thierry, G. (2012). Unconscious effects of grammatical gender during object categorisation. *Brain Research,* 1479, 72-79

Brake, P., & ap Myrddin, M., (1999). *Welsh in Three Months*. London, Dorling Kindersley Ltd.

Brouwer, H., Fitz, H., Hoeks, J., (2012). Getting real about Semantic Illusions: Rethinking the functional role of the P600 in language comprehension. *Brain Research,* 1446, 127 – 143

Brownell HH, Simpson TL, Bihrle AM, Potter HH, Gardner H. Appreciation of metaphoric alternative word meanings by left and right brain-damaged patients. *Neuropsychologia,* 28 (4), 375-383

Brysbaert, M., & Duyck, W. (2010). Is it time to leave behind the Revised Hierarchical Model of bilingual language processing after fifteen years of service? *Bilingualism: Language, and Cognition,* 13, 359–371.

Brysbaert, M., & Stevens, M., (2018. Power analysis and effect size in mixed effects models: a tutorial. Journal of Cognition, 1 (1), 9

Brysbaert, M., Van Dyck, G., & Van de Poel, M. (1999). Visual word recognition in bilinguals: Evidence from masked phonological priming. *Journal of Experimental Psychology: Human Perception and Performance,* 25(1), 137–148.

Bultena, S., Dijkstra, T., & van Hell, J. G. (2014). Cognate effects in sentence context depend on word class, L2 proficiency, and task. *Quarterly Journal of Experimental Psychology,* 67, 1214–1241. http://dx.doi.org/10.1080/17470218.2013.853090.

Burkhardt, P., 2006. Inferential bridging relations reveal distinct neural mechanisms: evidence from event-related brain potentials. *Brain and Language* 98, 159–168.

Button, K. S., Loannidis, J. P. A., Mokrysz, C., Nosek, B. A., Flint, J., Robinson, E. S. J., & Munafo, M. R., (2013). *Power failure: why small sample size undermines the reliability of neuroscience*. Neuroscience, 14

Cacciari, C., & Tabossi, P. (1988). The comprehension of idioms. *Journal of Memory and Language,* 27,668–683. doi: 10.1016/0749-596X(88)90014-9

Caillies, S., & Butcher, K. (2007). Processing of idiomatic expressions: Evidence for a new hybrid view. *Metaphor and Symbol, 22(1),* 79-108.

Cardillo, E. R., Schmidt, G. L., Kranjec, A., & Chatterjee, A. (2010). Stimulus design is an obstacle course: 560 matched literal and metaphorical sentences for testing neural hypotheses about metaphor. *Behaviour Research Methods,* 42, 651–664. doi:10.3758/BRM.42.3.651

Carrol, G., & Conklin, K. (2014). Getting your wires crossed: Evidence for fast processing of L1 idioms in an L2. *Bilingualism: Language and Cognition,* 17, 784-797. doi:10.1017/S1366728913000795

Carrol, G., & Conklin, K., (2017). Cross language lexical priming extends to formulaic units: Evidence from eye-tracking suggests that this idea 'has legs'. *Bilingualism: Language & Cognition*, 20 (2), 299-317

Carrol, G., Conklin, K., & Gyllstad, H., (2016). Found in Translation: The Influence of the L1 on the Reading of Idioms in a L2. *Studies in Second Language Acquisition*, 4-41

Chen, B., Zhou, H., Gao, Y., & Dunlap, S. (2014). Cross language translation priming asymmetry with Chinese–English bilinguals: a test of the sense model. *Journal of psycholinguistic research*, 43, 225–240

Chou, C., Huang, H., Lee, C. , Lee, C., (2014). Effects of semantic constraint and cloze probability on Chinese classifier-noun agreement. *Journal of Neurolinguistics*, 31, 42-54

Christianson, K., (2016). When language comprehension goes wrong for the right reasons: Good-enough, underspecified, or shallow language processing. T*he Quarterly Journal of Experimental Psychology,* 69 (5), 817-828

Christianson, K., Williams, C. C., Zacks, R. T., & F Ferreira (2010). Effects of plausibility on structural priming. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 36 (2), 538,

Christoffels, I. K., De Groot, A. M. B., & Kroll, J.F. (2006). Memory and language skills in simultaneous interpreters: The role of expertise and language proficiency. *Journal of Memory and Language,* 54, 324–345.

Cieślicka, A. (2006). Literal salience in on-line processing of idiomatic expressions by L2 speakers. *Second Language Research,* 22,115-144.

Cieslicka, A. B., & Heredia, R. R., (2017). How to save your skin when processing L2 idioms: an eye movement analysis of idiom transparency and cross-language similarity among bilinguals. *Iranian Journal of Language Teaching Research,* 5 (3), 81 – 107

Citron, F. M. M., Cacciari, C., Kucharski, M., Beck, L., Conrad, M., & Jacobs, A. M., (2016). When emotions are expressed figuratively: psycholinguistic and affective norms of 619 idioms for German (PANIG). *Behaviour Research Methods,* 48, 91-111

Conklin, K., & Schmitt, N. (2008). Formulaic sequences: are they processed more quickly than nonformulaic language by native and non-native speakers? *Applied Linguistics,* 29,72–89

Coolican, H., (2009). *Research Methods and Statistics in Psychology,* 5th Edition. Hodder Education, London

Costa, A., Caramazza, A., & Sebastian-Galles, N. (2000). The cognate facilitation effect: Implications for models of lexical access. *Journal of Experimental Psychology: Learning, Memory, and Cognition,* 26(5), 1283–1296.

Costa, A., Miozzo, M, & Caramazza, A. (1999). Lexical selection in bilinguals: Do words in the bilingual's two lexicons compete for selection? *Journal of Memory and Language,* 41, 365-397

Coulson, S., King, J. W., & Kutas, M., (1998). Expect the unexpected: event-related brain response to morphosyntactic violations

Coulson, A., Urbach, T. P., & Kutas, M., (2006). Looking back: joke comprehension and the space structuring model. *Humour,* 19 (13), 229

Coulson, S., & Van Petten, C., (2002). Conceptual integration and metaphor: an event-related potential study. *Memory and Cognition 30* (6), 958–968

Coulson, S., & Van Petten, C., (2007). A special role for the right hemisphere in metaphor comprehension? ERP evidence from hemifield presentation. *Brain Research* 1146, 128–145. https://doi.org/10.1016/j.brainres.2007.03.008

Coulson, S., Urbach, T. P., & Kutas, M. (2006). Looking back: Joke comprehension and the space structuring model. *Humor–International Journal of Humor Research*, *19*(3), 229-250.

Coulson, S.,& Van-Petten, (2002). Conceptual integration and metaphor: an event-related potential study. *Memory and Cognition,* 30 (6), 958-968

Cutting, J. C., & Bock, K. (1997). That’s the way the cookie bounces: Syntactic and semantic components of experimentally elicited idiom blends. *Memory & Cognition, 25*, 57-71

De Bruin, A., (2019). *Not all bilinguals are the same: A call for more detailed assessments and descriptions of bilingual experiences.* Behavioural Sciences, 9 (33)

De Grauwe, S., Swain, A., Holcomb, P.J., Ditman, T., Kuperberg, G.R., (2010). Electrophysiological insights into the processing of nominal metaphors. *Neuropsychologia* 48 (7), 1965–1984. https://doi.org/10.1016/j. neuropsychologia.2010.03.017

De Groot, A. M. B. (1992). *Bilingual lexical representation: A closer look at conceptual representations.* In R. Frost & L. Katz (Eds.), Orthography, phonology, morphology, and meaning (pp. 389–412). Amsterdam: Elsevier.

De Groot, A. M. B. (1995). Determinants of bilingual lexicosemantic organization. *Computer Assisted Language Learning*, 8, 151–180.

De Groot, A. M. B., & Nas, G. L. J. (1991). Lexical representation of cognates and noncognates in compound bilinguals. *Journal of Memory and Language*, 30, 90–123.

De Groot, A. M. B., Dannenburg, L. & Van Hell, J. G. (1994). Forward and backward word translation by bilinguals. *Journal of Memory and Language*, 33, 600–629.

de Groot, A. M. B., Delmaar, P., & Lupker, S. J., (2000). The Processing of Interlexical Homographs in Translation Recognition and Lexical Decision: Support for Non-Selective Access to Bilingual Memory. *Quarterly Journal of Experimental Psychology*, 53 (2)

De Houwer, A . (1990). *The acquisition of two languages from birth: A case study.* Cambridge, UK: Cambridge University Press.

De Houwer, A . (2009*). Bilingual first language acquisition.* Bristol, UK: Multilingual Matters.

De Luca, V., Rothman, J., Bialystok, E., & Pliatsikas, C., (2019). Redefining bilingualism as a spectrum of experiences that differentially affects brain structure and function. *PNAS*, 116 (15), 7565 - 7574

DeBonis, M., Epelbaum, C., Deffez, V., & Feline, A., (1997). The comprehension of metaphors in schizophrenia. *Psychopathology,* 30, 149-154

Dell, G. S., & Chang, F., (2014). The P-chain: relating sentence production and its disorders to comprehension and acquisition. *Biological Sciences,* 369 (1634)

DeLong, K. A., Urbach, T. P., & Kutas, M. (2005). Probabilistic word pre-activation during language comprehension inferred from electrical brain activity. *Nature Neuroscience,* 8, 1117–1121. doi:10.1038/nn1504

Deuchar, M., (2006). Welsh-English code-switching and the matrix language frame model. *Lingua,* 116, 1986 - 2011

Diem, K. G., (2002). *A Step-by-Step Guide to Developing Effective Questionnaires and Survey Procedures for Program Evaluation & Research*. Rutgers Cooperative Research & Extension, NJAES, Rutgers, The State University of New Jersey

Dijkstra, A., & Van Heuven, W. J. B., (1998). *The BIA model and bilingual word recognition.* In J. Grainger & A. Jacobs (Eds.), Localist Connectionist

Approaches to Human Cognition (pp. 189–225). Hillsdale, NJ: Lawrence Erlbaum Associates.

Dijkstra, A., Timmermans, M., & Schriefers, H. (2000). On being blinded by your other language: Effects of task demands and language intermixing. *Journal of Memory and Language*, 42, 445–464.

Dijkstra, T. (2005). *Bilingual visual word recognition and lexical access.* In J. F. Kroll & A. M. B. de Groot (Eds.), Handbook of bilingualism: Psycholinguistic approaches (pp. 179 –201). New York: Oxford University Press.

Dijkstra, T., & Van Heuven, W., (2002). The architecture of the bilingual word recognition system: from identification to decision. *Bilingualism: Language and Cognition*, 5 (3), 175-197

Dijkstra, T., Grainger, J., & van Heuven, W. J. B. (1999). Recognition of cognates and interlingual homographs: The neglected role of phonology. *Journal of Memory and Language*, 41(4), 496–518.

Dijkstra, T., Van Hell, J., & Brenders, P., (2015). Sentence context effects in bilingual word recognition: Cognate status, sentence language, and semantic constraint. *Bilingualism: Language and Cognition*, 1-17. doi:10.1017/S1366728914000388

Dijkstra, T., Van Heuven, W.J.B., & Grainger, J. (1998). Simulating cross-language competition with the bilingual interactive activation model. *Psychologica Belgica*, 38, 177–196

Dijkstra, T., Van Jaarsveld, H., & Brinke, S. T., (1998). Interlingual homograph recognition: Effects of task demands and language intermixing. *Bilingualism: Language and Cognition* 1, 51-66.

Dijkstra, T., Wahl, A., Buytenhuijs, F., Van Halem, N., Al-Jibouri, Z., De Korte, M., Rekke, S., (2019). Multilink: a computational model for bilingual word recognition and translation. *Bilingualism: Language and Cognition, 22* (4), 657-679

Dufour, R., & Kroll, J. F. (1995). Matching words to concepts in two languages: A test of the concept mediation model of bilingual representation. *Memory and Cognition,* 23, 166–180.

Duncan, C. C., Barry, R. J., Connolly, J. F. Fischer, C., Michie, P. T., & Nätäänen, R., (2009). Event-related potentials in clinical research: guidelines for eliciting, recording, and quantifying mismatch negativity, P300, and N400. *Clinical Neurophysiology,* 120, 1883-1908

Durand, C. P., (2013). Does Raising Type 1 Error Rate Improve Power to Detect Interactions in Linear Regression Models? A Simulation Study. *PLOS One,* 8 (8),

Duyck W., Assche, E. V., Drieghe, D., & Hartsuiker, R., (2007). Visual Word Recognition by Bilinguals in a Sentence Context: Evidence for Nonselective Lexical Access. *Journal of Experimental Psychology Learning Memory and Cognition* 33, (4), 663-79

Duyck, W. & Warlop, N., (2009). Translation priming between the native language and a second language: New evidence from Dutch–French bilinguals. *Experimental Psychology,* 56, 173–179.

Egan, C., Oppenheim, G. M., Saville, C., Moll, K., Jones, M. W., (2019). Bilinguals apply language-specific grain sizes during sentence reading. *Cognition,* 193

Ellis, C., Kuipers, J. R., Thierry, G., Lovett, V., Turnbull, O. & Jones, M. W., (2015). Language and culture modulate online semantic processing. *Social Cognitive and Affective Neuroscience,* 10, 10, 1392-1396

Ellis, C., Thierry, G., Vaughan-Evans, A. & Jones, M. W., (2017). Languages flex cultural thinking: cultural perception in bilinguals. *Bilingualism: Language and Cognition, 21 (2), 219-227*

Ellis, N. C., O'Dochartaigh, C., Hicks, W., Morgan, M., & Laporte, N. (2001). Cronfa Electroneg o Gymraeg (CEG): A 1 million word lexical database and frequency count for Welsh. Retrieved from: https://www.bangor.ac.uk/canolfanbedwyr/ceg.php.en

Elman, J. L. (1990). Finding Structure in Time. *Cognitive Science,* 14 (2), 179-211

Faust, M., Weisper, S., (2000). Understanding metaphoric sentences in the two cerebral hemispheres. *Brain & Cognition,* 43, 186–191.

Federmeier, K. D., & Laszlo, S., (2009). Time for meaning: Electrophysiology provides insights into the dynamics of representation and processing in semantic memory. *Psychology of Learning and Motivation,* 51, 1–44.

Federmeier, K.D., (2007). Thinking ahead: The role and roots of prediction in language comprehension. *Psychophysiology,* 44, 491–505.

Ferreira, F. & Patson, N. D., (2007). The 'Good Enough' Approach to Language Comprehension. *Language and Linguistics Compass* 1, 71-83

Ferreira, F., (2003). The misinterpretation of noncanonical sentences. *Cognitive Psychology,* 47 (2), 164-203

Ferreira, F., Bailey, K. G. D., & Ferraro, V., (2002). Good-enough representations in language comprehension. *Current Directions in Psychological Science,* 11 (1), 11-15

Ferreira, F., Christianson, K., & Hollingworth, (2001). Misinterpretations of Garden-Path Sentences: Implications for Models of Sentence Processing and Reanalysis. *Journal of Psycholinguistic Research, 30, 3-20*

Field, A., (2011). *Discovering Statistics Using SPSS, 3rd edition.* SAGE Publications Ltd, London

Fields, E. C., & Kuperberg, G. R., (2020). Having your cake and eating it too: flexibility and power with mass univariate statistics for ERP data. Psychophysiology, 57 (2)

Fife, J. (1986). Literary vs. Colloquial Welsh: Problems of definition. *Word,* 37:3, 141-151, DOI: 10.1080/00437956.1986.11435773

Finkbeiner, M. (2002). Bilingual lexical memory: Towards a psycholinguistic model of adult L2 lexical acquisition, representation, and processing. *Unpublished doctoral dissertation,* University of Arizona, Tucson, AZ.

Finkbeiner, M., & Nicol, J. (2003) Semantic category effects in second language word learning. *Applied Psycholinguistics,* 24, 369−383.

Finkbeiner, M., Forster, K., Nicol J., & Nakamura, K., (2004). The role of polysemy in masked semantic and translation priming. *Journal of Memory and Language, 51* (1), 1-22

Firth, J.R. 1935. *The technique of semantics.* Papers in Linguistics 1934-1951, by J.R. Firth. 7-33. London: Oxford University Press

Fischer-Baum, S., & Dickson, D. S., & Federmeier, K. D., (2014). Frequency and regularity effects in reading are task dependent: evidence from ERPs. *Language, Cognition and Neuroscience,* 29,1342–1355.

Fischer-Baum, S., Dickson, D. S., Federmeier, K. D., (2014). Frequency and regularity effects in reading are task dependent: evidence from ERPs. *Language, Cognition and Neuroscience*, 29, 1342–1355

Foucart, A., Martin, C. D., Moreno, E. M., & Costa, A. (2014, May 5). Can Bilinguals See It Coming? Word Anticipation in L2 Sentence Reading. *Journal of Experimental Psychology: Learning, Memory, and Cognition,* 40 (5),

Francis, W. S., (2018). Shared core meanings and shared associations in bilingual semantic memory: evidence from research on implicit memory. *International Journal of Bilingualism, 1*-14

Friederici, A. D., Pfeifer, E., & Hahne, A. (1993). Event-related brain potentials during natural speech processing: Effects of semantic, morphological and syntactic violations. *Cognitive Brain Research,* 1, 183192

Frost, J.A., Binder, J.R., Springer, J.A., Hammeke, T.A., Bellgowan,P.S.F., Rao, S.M., Cox, R.W., (1999). Language processing is strongly left lateralized in both sexes: evidence from functional MRI. *Brain 1*22, 199–208.

Gass, S., (1984). A review of interlanguage syntax: language transfer and language universals. *Language earning* 34 (2), 115-132

Gathercole, V. C. M. (2007). Miami and North Wales, so far and yet so near: A constructivist account of morphosyntactic development in bilingual children. *International Journal of Bilingual Education and Bilingualism,* 10 (3)

Gathercole, V. C. M. (ed.). (2007a). Language Transmission in Bilingual Families in Wales. Cardiff: Welsh Language Board.

Gathercole, V. C. M., & Moawad, R. A. (2010). Semantic interaction in early and late bilinguals: all words are not created equal. *Bilingualism: Language and Cognition,* 13, 385-408

Gathercole, V. C. M., Stadthagen-Gonzalez, H., Perez-Tattam, R., Yava, F., (2016). Semantic and conceptual factors in Spanish–English bilinguals' processing of lexical categories in their two languages. *Second Language Research,* 32 (4), 537-562

Gibbs, R. W. (1980). Spilling the beans on understanding and memory for idioms in conversation. *Memory & Cognition,* 8, 149-156.

Gibbs, R. W. (1985). On the process of understanding idioms. *Journal of Psycholinguistic Research,* 14, 465-472

Gibbs, R. W. (2002). A new look at literal meaning in understanding what is said and implicated. *Journal of Pragmatics,* 34, 457–486

Gibbs, R. W., & Colston H. L., (2006*). Figurative language*. Handbook of psycholinguistics, Second edition, Pages 835-861

Gibbs, R. W., & Gerrig, R. J., (1989). How context makes metaphor comprehensions seem "special". *Metaphor and Symbolic Activity,* 4, 145–158.

Giora, R. (1997). Understanding figurative and literal language: the graded salience hypothesis. *Cognitive Linguistics* 8, 183–206. doi: 10.1515/cogl.1997.8.3.183

Giora, R. (2002). Literal vs. figurative language: Different or equal? *Journal of Pragmatics*, 34, 487- 506.

Giora, R. (2003). *On our mind: Salience, context, and figurative language*. Oxford, England: Oxford University Press

Glucksberg, S. (2003). The psycholinguistics of metaphor. *Trends in Cognitive Sciences,* 7(2), 92–96.

Glucksberg, S., Gildea, P., Bookin, M. B., (1982). On understanding nonliteral speech: Can people ignore metaphors? *Journal of Verbal Learning & Verbal Behavior,* 21, 85–98.

Glucksbers, S., (2003). The psycholinguistics of metaphor. *Trends in Cognitive Sciences*, 7 (2), 92-96

Goldstein, A., Arzouan, Y., Faust, M., (2012). Killing a novel metaphor and reviving a dead one: ERP correlates of metaphor conventionalization. *Brain and Language* 123 (2), 137–142

Gollan, T., Forster, K. L. & Frost, R. (1997). Translation priming with different scripts: Masked priming with cognates and noncognates in Hebrew–English bilinguals. *Journal of Experimental Psychology: Learning, Memory, and Cognition,* 23, 1122–1139.

Gomes, H., Ritter, W., Tartter, V. C., Vaughan, H. G. Jr, Rosen, J. J., (1997). Lexical processing of visually and auditorily presented nouns and verbs: Evidence from reaction time and N400 priming data. *Cognitive Brain Research*, 6, 121–34.

Gouvea, A. C., Phillips, C., Kazanina, N., Poppel, D., (2010). The linguistic processes underlying the P600. *Language and Cognitive Process,* 25 (2), 149-188

Grainger, J., & Dijkstra, A. (1992). *On the representation and use of language information in bilinguals.* In R. J. Harris (Ed.), Cognitive processing in bilinguals, 207–220. Amsterdam: Elsevier

Gratton, G., Coles, M. G. H., & Donchin, E. (1983). A new method for off-line removal of ocular artefact. *Electroencephalography and Clinical Neurophysiology*, 55, 468-484.

Greene, R. (2012). *The Princeton Encyclopaedia of Poetry and Poetics.* Princeton, NY: Princeton University Press

Grice, H. P., (1975). *Logic and Conversation*. In: Cole, P.; Morgan, J., editors. Speech Acts Syntax and Semantics. Vol. 3. New York: Academic Press, p. 41-58.

Gwynedd Council, (2016). Gwynedd Council Welsh *Language Policy 2016*. < https://www.gwynedd.llyw.cymru/en/Council/Documents---Council/Strategies-and-policies/Language-Standards-and-Policy/Language-Policy-2016.pdf > [. Accessed 27th January, 2021.

Gwynedd Council (2017). Welsh in Education Strategic Plan 2017-2020: Gwynedd Council. https://www.gwynedd.llyw.cymru/en/Council/Documents---Council/Strategies-and-policies/Welsh-in-Education-Strategic-Plan.pdf. Accessed February 3rd, 2021

Hagoort, P., Brown, C. M., & Groothusen, J. (1993). The syntactic positive shift as an ERP measure of syntactic processing. *Language and Cognitive Processes,* 8, 439483.

Hahne, A., & Friederici, A. D. (1999). Electrophysiological evidence for two steps in syntactic analysis: Early automatic and late con-trolled processes. *Journal of Cognitive Neuroscience,* 11(2), 194–205.

Hahne, A., & Friederici, A. D., (2001). Processing a second language: late learners' comprehension mechanisms as revealed by event-related brain potentials. *Bilingualism: Language and Cognition,* 4 (2), 123-114.

Hahne, A., (2001). What's different in second-language processing? Evidence from event-related potentials. *Journal of Psycholinguistic Research,* 30, (3), 251-266

Hannon, B., & Daneman, M., (2004). Shallow Semantic Processing of Text: An Individual-Differences Account. *Discourse Processes,* 37 (3), 187-204

Harris, R., (1967). Semantics and translation. *Proceedings of the Tenth International Congress of Linguists*, 2, 465-469

Harris, R., (1970). B. Harris 1Deviance and Citation1, *Journal of Linguistics*, 6

Hartsuiker, R. J., Pickering, M. J., & Veltkamp, E., (2004). Is Syntax Separate or Shared Between Languages?: Cross-Linguistic Syntactic Priming in Spanish-English Bilinguals. *Psychological Science,* 15 (6), 409-414

Harvey, N. (1997). Confidence in judgment. *Trends in Cognitive Sciences*, 1, 78−82.

Hawke, A., (2014). Geiriadur Prifysgol Cymru: Ar seiliau cadarn? Geiriaduron hanesyddol, disgrifiadol a rhagnodol. Cyfres digidol y Coleg Cymraeg: https://llyfrgell.porth.ac.uk/View.aspx?id=2106~4j~J2Mgk3uy

Heredia, R. R. (2008*). Mental models of bilingual memory*. In J. A. Altarriba & R. R. Heredia (eds.), An introduction to bilingualism: Principles and processes, pp. 39–67. New York: Lawrence Erlbaum

Hoeks, J. C. J., Stowe, L. A., Doedens, G., (2004). Seeing words in context: the interaction of lexical and sentence level information during reading. *Cognitive Brain Research* 19, 59–73.

Hoffman, R. R., & Kemper, S. (1987). What could reaction-time studies be telling us about metaphor comprehension? *Metaphor & Symbolic Activity,* 2(3), 149-186

Hoshino, N., & Kroll, J. F. (2008). Cognate effects in picture naming: Does cross-language activation survive a change of script? *Cognition,* 106, 501–511.

Iakimova, G., Passerieux, C., Laurent, J.P., & Hardy-Bayle, M. C., (2005). ERPs of metaphoric, literal, and in congruous semantic processing in schizophrenia. *Psychophysiology*, 42, 380–390.

Jakobson,R.(2000). *On linguistics aspects of translation*. In Venuti, L. (ed.) (2000). The Translation Studies Reader. London and New York: Routledge, 113-118.

Jankowiak, K., Rataj K., & Naskrecki, R., (2017). To electrify bilingualism: Electrophysiological insights into bilingual metaphor comprehension. *PLoS ONE* 12(4)

Jared, D. & Kroll, J. F. (2001). Do bilinguals activate phonological representations in one or both of their languages when naming words? *Journal of Memory and Language*, 44, 2–31

Jarvis, S., & Pavlenko, A., (2008). *Crosslinguistic influence in language and cognition*. New York: Routledge

Jiang, N. & Forster, K. I. (2001). Cross-language priming asymmetries in lexical decision and episodic recognition. *Journal of Memory and Language*, 44, 32–51.

Jiang, N. (2000). Lexical representation and development in a second language. *Applied Linguistics*, 21, 47–77.

Jones, H. M., (2008). The changing social context of Welsh: A review of statistical trends. *International Journal of Bilingual Education and Bilingualism*, 11 (5), 541–557

Jones, R. M., (2016). Seiliau Berniadaeth. Sglefrio ar eiriau. Cyfres digidol y Coleg Cymraeg: https://llyfrgell.porth.ac.uk/View.aspx?id=2106~4j~J2Mgk3uy

Kaiser, A., Kuenzli, E., Zappatore, D., Nitsch, C., (2007). On females' and males' bilateral activation during language production: a fMRI study. International Journal of Psychophysiology 63, 192–198

Kalénine S., Peryrin, C., Pichat, C., Segebarth, C., Bonthoux, F., Baciu, M., (2009) The sensory-motor specificity of taxonomic and thematic conceptual relations: A behavioral and fMRI study. *Neuroimag*e 44, 1152–1162.

Kalénine, S., Peyrin, C., Pichat, C., Segebarth, C., Bonthoux, F., and Baciu, M. (2009). The sensory-motor specificity of taxonomic and thematic conceptual relations: a behavioral and fMRI study. *Neuroimage* 44, 1152–1162.

Kana, R. K., Murdaugh, D. L., Wolfe, K. R., & Kumar, S. L. (2012). Brain responses mediating idiom comprehension: gender and hemispheric differences. *Brain Research,* 1467, 18-26

Kann, E. Harris, A., Gibson E., & Holcomb, P., (2000). The P600 as an index of syntactic integration difficulty. *Language and Cognitive Process,* 15 (2), 159-201

Katz, A. N., Paivio, A., Marschark, M., Clark, J. M., (1988). Norms for 204 Literary and 260 Nonliterary Metaphors on 10 Psychological Dimensions. *Metaphor and Symbol,* 3 (4): 191.

Keatley, C., Spinks, J., and De Gelder, B. (1994). Asymmetrical semantic facilitation between languages. *Memory and Cognition* 22, 70–84.

Kecskes, I. (2000). A cognitive-pragmatic approach to situation-bound utterances. *Journal of Pragmatics,* 32, 605-625.

Keren, G. (1991). Calibration and probability judgments: Conceptual and methodological issues. *Acta Psychologica,* 77, 217−273.

Kiefer, M., Schuch, S., Schenck, W., & Fiedler, K. (2007). Mood states modulate activity in semantic brain areas during emotional word encoding. *Cerebral Cortex,* 17, 1516 – 1530

Kim, A., & Osterhout, L. (2005). The independence of combinatory se-mantic processing: Evidence from event-related potentials. *Journal of Memory and Language*, 52(2), 205–225

King, G., (1993). *Modern Welsh: A Comprehensive Grammar*. London and New York: Routledge, 1993. Print.

Kleitman, S., & Stankov, L., (2007). *Self-confidence and metacognitive processes.* Learning and Individual Differences, 17, 161 - 173

Kroll, J. F., & de Groot, A. M. B. (Eds.). (2005). *Handbook of bilingualism: Psycholinguistic approaches*. Oxford University Press.

Kroll, J. F., & Sholl, A. (1992). *Lexical and conceptual memory in fluent and nonfluent bilinguals*. In *Cognitive Processing in Bilinguals*, ed R. J. Harris (Amsterdam: Elsevier), 191–204.

Kroll, J. F., & Stewart, E., (1994). Category interference in translation and picture naming: Evidence for asymmetric connections between bilingual memory representations. *Journal of Memory and Language*, 33, 149–174.

Kroll, J. F., Van Hell, J. G., Tokowicz, N., & Green, D. W. (2010). The Revised Hierarchical Model: A critical review and assessment. *Bilingualism: Language and Cognition*, 13, 373–381.

Kuhn, L. J., Wiloughby, M. T., Wilbourn, M. P., Vernon-Feagans, L., & Blair, C. B., (2014). Early communicative gestures prospectively predict language development and executive function in early childhood. *Child Development,* 85 (5), 1898-1914

Kuipers, J. R., van Koningsbruggen, M., & Thierry, G., (2013). Semantic priming in the motor cortex; evidence from combined rTMS and ERPs. *NeuroReport,* 24 (12), 646 – 651

Kutas M, & Federmeier K. D., (2000). Electrophysiology reveals semantic memory use in language comprehension. *Trends in Cognitive Science*, 4, 463-470.

Kutas M., & Kluender, R., (1994). What Is Who Violating? A Reconsideration of Linguistic Violations in Light of Event-Related Brain Potentials. *Cognitive Electrophysiology,* 183-210

Kutas, M., & Federmeier, K. D., (2011). Thirty years and counting: finding meaning in the N400 component of the event-related brain potential (ERP). *Annual Review of Psychology,* 62, 621- 647

Kutas, M., & Hillyard, S. A. (1980). Event-related brain potentials to semantically inappropriate and surprisingly large words. *Biological Psychology,* 11, 99e116.

Kutas, M., & Hillyard, S. A. (1980). Reading senseless sentences: brain potentials reflect semantic incongruity. *Science,* 207, 203205.

Kutas, M., & Hillyard, S. A. (1984). Brain potentials during reading reflect word expectancy and semantic association. *Nature,* 307, 161-163.

Kutas, M., Van Petten, C., (1994). Psycholinguistics Electrified. Handbook of Psycholinguistics. 1994:83–143.

Labov, W., (1973). The Linguistic Consequences of Being a Lame. *Language in Society,* 2 (1), 81-115

Lai, V.T., Curran, T., & Menn, L., (2009). Comprehending conventional and novel metaphors: an ERP study. *Brain Research* 1284, 145–155.

Lakoff, G., & Johnson, M., (1980). *Metaphors we live by.* Chicago, IL: The University of Chicago Press.

Lakoff, G., (1987). *Women fire and dangerous things.* Chicago, IL: The University of Chicago Press

Landau, M. J., Meier, B. P., & Keefer, L. A. (2010). A metaphor-enriched social cognition. *Psychological Bulletin, 136* (6), 1045–1067

Lau, E. F., Phillips, C., & Poppel, D., (2008). A cortical network for semantics: (de)constructing the N400. *Nature Reviews in Neuroscience,* 9 (12), 920 - 933

Laurent, J. P., Denhieres, G., Passerieux, C., Iakimova, G., Hardy-Bayle, M. C., (2006). On understanding idiomatic language: The salience hypothesis assessed by ERPs. *Brain Research*, 1068, 151–160.

Leon, A. C., & Heo, M., (2009). Sample sizes required to detect interactions between two binary fixed-effects in a mixed-effects linear regression model. *Computational Statistics & Data Analysis,* 53 (3), 603-608

Levy, R., (2008). Expectation-based syntactic comprehension. *Cognition* 106, 1126 – 1177.

Libben, M. R., & Titone, D. A. (2008). The multidetermined nature of idiom processing. *Memory & Cognition, 36,* 1103-1121.

Libben, M. R., & Titone, D. A., (2009). Bilingual lexical access in context: evidence from eye-movements during reading. *Journal of Experimental Psychology: Learning, Memory and Cognition,* 35 (2), 381-390

Libben, M., & Titone, D. (2008). The multidetermined nature of idiom processing. *Memory and Cognition,* 36,1103–1121

Liontas, J. I., (2002). *Context and idiom understanding in second languages*. In S. H. FosterCohen, T. Ruthenberg, & M.-L. Poschen (Eds.), EUROSLA Yearbook: Annual conference of the European Second Language Association (pp. 155-185). Amsterdam/Philadelphia: John Benjamins Publishing Company

Luck, S. J., (2005). *An introduction to the event-related potential technique.* MIT Press; Cambridge, MA

Luck, S. J. (2014). *An introduction to the event-related potential technique* (2nd ed.). MIT Press; Cambridge, MA

Luck, S. J. & Kappenman, E. S., (2011). *Oxford Handbook of Event-Related Potential Components.* Oxford University Press, Oxford.

Luk, G., & Bialystok, E., (2013). *Bilingualism is not a categorical variable: Interaction between language proficiency and usage*. Journal of Cognitive Psychology, 25 (5), 605 - 621

Luo, X., Cheung, H., Bel, D., Li, L., Chen, L., & Mo, L., (3013). The Roles of Semantic Sense and Form-Meaning Connection in Translation Priming. *Psychological Record* 63, 193–208

Macnamara, J., & Kushnir, S. (1971). Linguistic independence of bilinguals: The input switch. *Journal of Verbal Learning and Verbal Behaviour,* 10, 480–487.

Malt, B. C., Gennari, S., Imai, M., Ameel, E., Saji, N., & Majid, A., (2015) *Where are the concepts? What words can and can't reveal*. In: Margolis E and Laurence S (eds) The conceptual mind: New directions in the study of concepts. Cambridge, MA: MIT Press, pp. 291–326.

Martin CD, Thierry G, Kuipers JR, Boutonnet B, Foucart A, & Costa A. (2013). Bilinguals reading in their second language do not predict upcoming words as native readers do. *Journal of Memory and Language*, 69 (4):574–588.

Martin, C. D., Dering, B., Thomas, E. M., & Thierry, G., (2009). Brain potentials reveal semantic priming in both the active and the non-attended language of early bilinguals. *Neuroimage,* 47, 326-333

McClelland, James L. and David E. Rumelhart (198 I), "An Interactive Activation Model of the Effect of Context in Perception, Part I. An Account of Basic Findings," *Psychological Review,* 88 (September), 375-407.

Mcelree, B., Nordlie, J., (1999). Literal and figurative interpretations are computed in equal time. *Psychonomic Bulletin & Review* 6, 486–494

McGlone, M., Glucksberg, S., & Cacciari, C. (1994). Semantic productivity and idiom comprehension. *Discourse Processes,* 17,167–190

Mirman, D., Landrigan, J, Britt, A. E., (2017). Taxonomic and Thematic Semantic Systems. *Psychological Bulletin,* 143 (5), 499-520

Mitchel, J., & Lapata, M., (2010). Composition in Distributional Models of Semantics. *Cognitive Science,* 34, 1388-1429

Moreno, E. M., & Kutas, M., (2005). Processing semantic anomalies in two languages: An electrophysiological exploration in both languages of Spanish-English bilinguals. *Cognitive Brain Research,* 22 (2), 205-220

Moreno, E. M., Rodriguez-Fornells, A., & Laine, M., (2008). Event-related potentials (ERPs) in the study of bilingual language processing. *Journal of Neurolinguistics,* 21 (6), 477-508

Morris, J., (2014). The influence of social factors on minority language engagement amongst young people: an investigation of Welsh-English bilinguals in North Wales. *International Journal of the Sociology of Language*, 230, 65-89.

Morton, J., Long, J., (1976). Effect of word transitional probability on phoneme identification. *Journal of Verbal Learning and Verbal Behaviour*, 15, 43 – 51.

Neely, J. H. (1977). Semantic priming and retrieval from lexical memory: roles of inhibitionless spreading activation and limited-capacity attention. *Journal of Experimental Psychology: General*, 106, 226 –254.

Neville, H. J., Nicol, J. L., Barss, A., Forster, K. I., & Garrett, M. F. (1991). Syntactically based sentence processing classes: Evidence from event-related brain potentials. *Journal of Cognitive Neuroscience*, 3, 151165.

Nordman, E., & Jambazova, 2017. Normative data for idiomatic expressions. *Behaviour Research Methods*, 49, 198-215

Office for National Statistics. (2012*). Language in England and Wales*, 2011. London

Ortony, A., Schallert, D. L., Reynolds, R. E., & Antos, S. J. (1978). Interpreting metaphors and idioms: some effects of context on comprehension. *Journal of Verbal Learning and Verbal Behaviour* 17, 465–477.

Osterhout, L., & Holcomb, P. J. (1992). Event-related brain potentials elicited by syntactic anomaly. *Journal of Memory and Language*, 31, 785806.

Osterhout, L., & Mobley, L. A. (1995). Event-related brain potentials elicited by failure to agree. *Journal of Memory and Language*, 34(6), 739–773.

Osterhout, L., Holcomb, P. J., & Swinney, D. A. (1994). Brain potentials elicited by garden-path sentences: Evidence of the application of verb information during parsing. *Journal of Experimental Psychology: Learning, Memory and Cognition,* 20, 786803

Panou, D (2013). Equivalence in translation studies: a critical evaluation. *Theory and Practice in Language Studies,* 3 (1), 1-6

Papagno, C., (2001). Comprehension of metaphors and idioms in patients with Alzheimer's disease: a longitudinal study. *Brain,* 124, 1450-1460

Payne, B. R., Lee, C., & Federmeier, K. D., (2015). Revisiting the incremental effects of context on word processing: evidence from single-word event-related brain potentials. *Psychophysiology,* 52 (11), 1456–1469

Pham, G., Donovan, D., Dam, Q., & Contant, A., (2018). Learning Words and Definitions in Two Languages: What Promotes Cross-Language Transfer? *Language Learning, 68* (1), 206-233

Phinney, J. (1992). The Multigroup Ethnic Identity Measure: A new scale for use with adolescents and young adults from diverse groups. *Journal of Adolescent Research*, 7, 156-176.

Pickering, M. J. & Garrod, S. (2007) Do people use language production to make predictions during comprehension? *Trends in Cognitive Sciences*, 11, 105–110.

Pollio H., Barlow, J. Fine H., & Polio, M. (1977) *Psychology and the poetics of growth.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Pruijn, L., Peacock, J., & Dijkstra, A. (in preparation). Mechanisms of word translation production: Empirical and simulation data.

Prys, D., (2014). Ysgrifiau ar ieithyddiaeth a geiriaduraeth Cymraeg. Cyfres digidol y Coleg Cymraeg https://llyfrgell.porth.ac.uk/View.aspx?id=1782~4s~tatfzEqh

Pynte, J., Besson, M., Robichon, F.H., & Poli, J., (1996). The time-course of metaphor comprehension: an event-related potential study. *Brain and Language* 55 (3), 293–316. https://doi.org/10.1006/brln.1996.0107

R. Harald Baayen, R. H., Piepenbrock, R., & Gulikers. L., (1995). *The CELEX lexical database (release 2).* CDROM. Linguistic Data Consortium, University of Pennsylvania, Pennsylvania, USA.

Rapp, A. M., Leube, D. T., Erb, M., Grodd, W., Kircher, T. T. J., (2004). Neural correlates of metaphor processing. *Cognitive Brain Research*, 20 (3). 395–402

Rataj, K., Przekoracka-Krawczykcd, A., van der Lubbebe, R. H. J., (2018). On understanding creative language: The late positive complex and novel metaphor comprehension. *Brain Research*, 1678, 231-244

Regel, S., Gunter, T. D., Friederici, S. D., (2011). Isn't it ironic? An electrophysiological exploration of figurative language processing. *Journal of Cognitive Neuroscience, 23 (2), 277 - 93*

Roberts, R., Phinney, J., Masse, L., Chen, Y., Roberts, C., & Romero, A. (1999). The structure of ethnic identity in young adolescents from diverse ethnocultural groups. *Journal of Early Adolescence*, 19, 301-322.

Rommers, J., Dijkstra, T., & Bastiaansen, M. (2013). Context-dependent semantic processing in the human brain: evidence from idiom comprehension. *Journal of Cognitive Neuroscience*, 25,762–76

Rosch, E., (1975). Cognitive representations of semantic categories. *Journal of Experimental Psychology: General* 104: 192–233.

Rotaru, A. S., Vigliocco, G., & Frank, S. L., (2018). Modelling the structure and dynamics of semantic processing. *Cognitive Science,* 42 (8), 2890-2917

Rowlands, J., (2015). Sglefrio ar eiriau. Cyfres digidol y coleg Cymraeg https://llyfrgell.porth.ac.uk/View.aspx?id=1756~4t~UWIQjABH

Scheele, A. F., Leseman, P.P. M., & Mayo, A. Y. (2010). The home language environment of monolingual and bilingual children and their language proficiency. *Applied Psycholinguistics,* 31, 117-140

Schirmer, A., & Kotz, S. A. (2003). ERP evidence for asex-specific Stroop effect in emotional speech. *Journal of Cognitive Neuroscience*, 15, 1135 – 1148

Schirmer, A., Kotz, S. A., & Friederici, A. D. (2005). On the role of attention for the processing of emotions in speech: Sex differences revisited. *Cognitive Brain Research*, 24, 442 – 452.

Schneider, S., Rapp, A.M., Haeußinger, F.B., Ernst, L.H., Hamm, F., Fallgatter, A.J., et al., 2014. Beyond the N400: complementary access to early neural correlates of novel metaphor comprehension using combined electrophysiological and haemodynamic measurements. *Cortex* 53, 45–59

Schoonbaert, S., Duyck, W., Brysbaert,M., & Hartsuiker,R. J., (2009). Semantic and translation priming from a first language to a second and back: making sense of the findings. *Memory and Cognition,* 37, 569-586

Schwanenflugel P. J., & Shoben, E. J., (1985). The influence of sentence constraint on the scope of facilitation for upcoming words. *Journal of Memory and Language,* 24 (2), 232-252

Schwartz A. I., & Kroll, J. F., (2006). Bilingual lexical activation in sentence context. *Journal of Memory and Language,* 55 (2), 197 – 242

Schwartz, A. I., & Van Hell, J., (2012). *Bilingual visual word recognition in sentence context. Visual Word Recognition* (Vol. 2), Psychology Pess

Schweigert, W. (1986). The comprehension of familiar and less familiar idioms. *Journal of Psycholinguistic Research*, 15, 33–45.

Schweigert, W. (1991). The muddy waters of idiom comprehension. *Journal of Psycholinguistic Research*, 20,305–314

Scorolli, C., Binkofski, F., Buccino, G., Nicoletti, R., Riggio, L., & Borghi, A. M., (2011). Abstract and concrete sentences, embodiment, and languages. F*rontiers in Psychology,* 2, 1-11

Searle, J. (1979). *Expression and meaning.* Cambridge, England. University Press

Silverberg, S., & Samuel, A. G. (2003). *The effects of age of acquisition and fluency on processing second language words: Translation or direct conceptual access?* Unpublished manuscript, State University of New York at Stony Brook, NY

Siyanova-Chanturia, A., Conklin, K., & Schmitt, N. (2011). Adding more fuel to the fire: An eye-tracking study of idiom processing by native and non-native speakers. *Second Language Research,* 27, 251–272.

Sommer, I. E. C., Aleman, A., Bouma, A., Kahn, R. S., (2004). Do women really have more bilateral language representation than men? A meta-analysis of functional imaging studies. *Brain* 127, 1845–1852

Sprenger, S., Levelt, W., & Kempen, G. (2006). Lexical access during the production of idiomatic phrases. *Journal of Memory and Language,* 54,161–184

Stankov, L. (1999). *Mining on the "no man's land" between intelligence and personality.* In P. L. Ackerman, P. C. Kyllonen, & R. D. Roberts (Eds.), Learning and individual differences: Process, trait, and content determinants (pp. 315−337). Washington, DC: American Psychological Association.

Starreveld, P. A., De Groot, A. M. B., Rossmark, B. M. M., & Van Hell, J. G., (2014). Parallel language activation during word processing in bilinguals: evidence from word production in sentence context. *Bilingualism Language and Cognition,* 17 (2), 528-576

Steinhauer, K., (2014). Event-related potentials (ERPs) in second language research: a brief introduction to the technique, a selected review, and an invitation to reconsider critical periods in L2. *Applied Linguistics,* 35 (4), 393 - 417

Stemmer, B., & Whitaker, H. A., (2008). *Handbook of the neuroscience of language*. San Diego, CA: Academic Press.

Swinney, D. A., and Cutler, A. (1979). The access and processing of idiomatic expressions. *Journal of Verbal Learning and Verbal Behaviour* 18, 523–534.

Tabossi, P., Fanari, R., & Wolf, K. (2009). Why are idioms recognized fast? *Memory and Cognition, 37*, 529–40

Tanner, D., Grey, S., Van Hell, J., (2017). Dissociating retrieval interference and reanalysis in the P600 during sentence comprehension. *Psychophysiology*, 54 (2), 248-259

Tanner, D., Nicol, J., & Brehm, L. (2014). The time-course of feature interference in agreement comprehension: Multiple mechanisms and asymmetrical attraction. *Journal of Memory and Language,* 76, 195–215.

Tanner, D., Norton, J. J., Morgan-Short, K., & Luck, S. J. (2016). On high-pass filter artifacts (they're real) and baseline correction (it's a good idea) in ERP/ERMF analysis. *Journal of Neuroscience Methods,* 266, 166–170.

Tartter, V. C., Gomes, H., Dubrovsky, B., Molholm S., & Stewart, R. V., (2002). Novel metaphors appear anomalous at least momentarily: Evidence from N400. *Brain and Language* 80. 488-509.

Tartter, V.C., Gomes, H., Dubrovsky, B., Molholm, S., Stewart, R.V., (2002). Novel metaphors appear anomalous at least momentarily: evidence from N400. *Brain and Language* 80 (3), 488–509

Taylor, K. I., Devereux B. J., & Tyler, L. K., (2011): Conceptual structure: Towards an integrated neurocognitive account. *Language and Cognitive Processes,* 26:9, 1368-1401

Taylor, W. L. (1953). “Cloze Procedure”: a new tool for measuring readability. *Journalism Quarterly*, 30, 415-433.

Thierry, G., & Wu, Y. J., (2007). Brain potentials reveal unconscious translation during foreign-language comprehension. *Proceedings of the National Academy of Sciences of the United States of America*, 104 (30) 12530-12535

Thierry, G., Wu, Y.J., 2004. Electrophysiological evidence for language interference in late bilinguals. *Neurorepor,t* 15 (10), 1555–1558.

Titone, D. A., & Connine, C. M. (1999). On the compositional and non-compositional nature of idiomatic expressions. *Journal of Pragmatics*, 31, 1655-1674.

Titone, D., Columbus, G., Whitford, V., Mercier, J., & Libben. M. (2015). *Contrasting bilingual and monolingual idiom processing.* In R. R. Heredia & A. B. Cieślicka (Eds.), Bilingual figurative language processing (pp. 171-207). New York, NY: Cambridge University Press.

Tokowicz, N. & Kroll, J. F. (2007). Number of meanings and concreteness: Consequences of ambiguity within and across languages. *Language and Cognitive Processes*, 22, 727–779.

Tokowicz, N. (2000). *Meaning representation within and across languages.* Unpublished doctoral dissertation, Pennsylvania State University.

Torreano, L. A., Cacciari, C., Glucksberg, S., (2005). When dogs can fly: Level of abstraction as a cue to metaphorical use of verbs. *Metaphor and Symbol*, 20 (4), 259.

Trefor, R., (2014). Problemau gyda Safoni a Chywair. Ysgrifau ar Ieithyddiaeth a Geiriaduraeth Gymraeg

Tzelgov, J., and Eben-Ezra, S. (1992). Components of the between-language semantic priming effect. *European Journal of Cognitive Psychology.* 4, 253–272.

Van Assche, E., Duyck, W., & Hartsuiker, R . J., (2016). *Context Effects in Bilingual Sentence Processing: Task Specificity.* Methods in Bilingual Reading Comprehension Research. Springer Science + Buisness Media, New York

van Berkum, J. J. A., (2009). *The neuropragmatics of 'simple' utterance comprehension: An ERP review.* In: Sauerland, U.; Yatsushiro, K., editors. Semantics and Pragmatics: From Experiment to Theory. Basingstoke: Palgrave Macmillan; 276-316.

Van Berkum, J. J. A., Brown, C. M., Zwitserlood, P., Kooijman, V., & Hagoort, P. (2005). Anticipating Upcoming Words in Discourse: Evidence From ERPs and Reading Times. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 31(3), 443–467.

van Berkum, J. J., Hagoort, P., & Brown, C. M. (1999). Semantic integration in sentences and discourse: evidence from the N400. *Journal of Cognitive Neuroscience,* 11, 657-671.

Van de Putte, E., De Baene, W., Brass, M., & Duyck, W., (2017). Neural overlap of L1 and L2 semantic representations in speech: A decoding approach. *NeuroImage,* 162, 106-116

Van Hell, J. G. & de Groot, A. M. B. (1998). Conceptual representation in bilingual memory: Effects of concreteness and cognate status in word association. *Bilingualism: Language and Cognition,* 3, 193–211.

Van Hell, J. G., & Dijkstra, T., (2002). Foreign language knowledge can influence native language performance in exclusively native contexts. *Psychonomic Bulletin & Review,* 9 (4), 780-789

Van Hell, J. G., & Tanner, D. T. (2012). Second language proficiency and cross-language lexical activation. *Language Learning 62* (2), 148-171

Van Hell, J., & de Groot, A., M., B., (2008). Sentence context modulates visual word recognition and translation in bilinguals. *Acta Psychologica,* 128, 431–451

Van Hell, J., (2002). Bilingual word recognition beyond orthography: On meaning, linguistic context, and individual differences. *Bilingualism Language & Cognition, 5 (3)*

Van Hell, J., (2019). Words only go so far: Linguistic context affects bilingual word processing. *Bilingualism: Language and Cognition* 22 (4), 689-690

van Herten, M., Kolk, H. H. J., Chwilla, D. J. (2005). An ERP study of P600 effects elicited by semantic anomalies. *Cognitive Brian Research,* 22, 241-255

Van Heuven, W. J. B., & Dijkstra, T., (2010). Language comprehension in the bilingual brain: fMRI and ERP support for psycholinguistic models. *Brain Research Reviews,* 54 (1), 104-122

van Heuven, W. J. B., Schriefers, H., Dijkstra, T. & Hagoort, P. (2008). Language conflict in the bilingual brain. *Cerebral Cortex,* 18, 2706–2716.

Van Heuven, W., & Wen, Y., (2019). The need for a universal computational model of bilingual word recognition and word translation. *Bilingualism: Language and Cognition,* 22 (4), 695-696

Van Heuven, W.J.B., Dijkstra, T., & Grainger, J. (1998). Orthographic neighbourhood effects in bilingual word recognition. *Journal of Memory and Language,* 39, 458–483

Van Lancker Sidtis, D. (2004). When novel sentences spoken or heard for the first time in the history of the universe are not enough. *International Journal of Language Communication Disorders,* 39(1), 1–44.

Van Lancker Sidtis, D. (2012). *Two-track mind: Formulaic and novel language support a dual process model.* In M. Faust (Ed.), The handbook of the neuropsychology of language (pp. 342– 367). Chichester, England: Wiley-Blackwell.

Van Lancker Sidtis, D., Cameron, K., Bridges, K., & Sidtis, J. J. (2015). The formulaic schema in the minds of two generations of native speakers. *Ampersand,* 2, 39–48.

Van Lancker, D., Canter, G. J., & Terbeek, D. (1981). Disambiguation of ditropic sentences: Acoustic and phonetic cues. *Journal of Speech and Hearing Research, 24*, 330–335

Van Petten C, & Kutas M., (1990). Interactions between sentence context and word frequency in event-related brain potentials. *Memory & Cognition,* 18, 380–393.

Van Petten, C., & Kutas, M. (1991). Influences of semantic and syntactic context on open- and closed-class words. *Memory and Cognition*, 19, 95-112.

Vaughan-Evans, A., Trefor, R., Jones, L., Lynch, P., Jones, M. W., & Thierry, G., (2016). Implicit Detection of Poetic Harmony by the Naïve Brain. *Frontiers in Psychology*, 7, 1859

Vaughan-Evans,A., Kuipers, J. R., Thierry G., & Jones, M. J. (2014). Anomalous Transfer of Syntax between Languages. *Journal of Neuroscience*, 34 (24) 8333-8335

Vecchi, E. M., Marelli, M., Zamparelli, R., & Baroni, M., (2017). Spicy adjectives and nominal donkeys: capturing semantic deviance using compositionality in distributional spaces. *Cognitive Science*, 41, 102-136

Von Studnitz, R. E., & Green, D. (2002). Interlingual homograph interference in German–English bilinguals: Its modulation and locus of control. *Bilingualism: Language and Cognition*, 5, 1–23.

Weber-Fox C., & Neville, H. J., (1996). Maturational constraints on functional pecializations for language processing: ERP and behavioural evidence in bilingual speakers. *Journal of Cognitive Neuroscience*, 8 (3), 231–256.

Weiss, E. M., Siedentopf, C., Hofer, A., Deisenhammer, E. A., Hoptman, M. J., Kremser, C., Golaszewski, S., Felber, S.,Fleischhacker, W. W., Delazer, M., (2003). Brain activation pattern during a verbal fluency test in healthy male andfemale

volunteers: a functional magnetic resonance imaging study. *Neuroscience Letters*, 352, 191–194

Welsh Government (2018). National Survey for Wales, 2017-18. Welsh Language: Confidence and attitudes. https://gov.wales/sites/default/files/statistics-and-research/2019-01/national-survey-wales-welsh-language-confidence-attitudes-2017-18.pdf. Accessed 29th January, 2021

Welsh Government, (2019/20). Schools by local authority region and Welsh medium type. https://statswales.gov.wales/Catalogue/Education-and-Skills/Schools-and-Teachers/Schools-Census/Pupil-Level-Annual-School-Census/Welsh-Language/Schools-by-LocalAuthorityRegion-WelshMediumType

West, W. C., & Holcomb, P. J., (2002). Event-related potentials during discourse-level semantic integration of complex pictures. *Cognitive Brain Research*, 13 (3), 363-375

Wicha, N. Y. Y., Moreno, E. M., & Kutas, M. (2004). Anticipating words and their gender: An event-related brain potential study of semantic integration, gender expectancy, and gender agreement in Spanish sentence reading. *Journal of Cognitive Neuroscience*, 16, 1272–1288.

Winner, E., Gardner, H., (1977). The comprehension of metaphor in brain-damaged patients. *Brain: A Journal of Neurology.* 100 (4), 717–729

Wittgenstein, L., (1958). *The Blue and Brown Books.* Oxford: Blackwell.

WJEC/CBAC (2020). *WJEC GCSE in Welsh Literature.* https://www.wjec.co.uk/media/nawo2ern/wjec-gcse-welsh-literature-spec-from-2015-e-03-12-2020.pdf. Accessed 27 January 2020

WJEC/CBAC (2020). *WJEC GCE AS/A LEVEL in Welsh (first language)).* https://www.wjec.co.uk/media/jbhnh54j/wjec-gce-welsh-first-language-spec-from-2015-s.pdf. Accessed 27 January 2020

WJEC/CBAC (2020). *WJEC GCSE English Language.* https://www.wjec.co.uk/media/krviytuc/wjec-gcse-english-language-specification-2015-24-10-14-branded.pdf. Accessed 27 January 2020

Wlotko, E. W., & Federmeier, K. D. (2013). Two sides of meaning: The scalp-recorded N400 reflects distinct contributions from the cerebral hemispheres. *Frontiers in Psychology,* 4, 181.

Woodman, G. F., (2010). A brief introduction to the use of Event-Related Potentials (ERPs) in studies of perception and attention. *Attention, Perception & Psychophysics* 72 (8)

Wray, A. (2002). *Formulaic Language and the Lexicon.* Cambridge, Cambridge University Press.

Wray, A., & Perkins, M. (2000). The functions of formulaic language: an integrated model. *Language and Communication,* 20,1–28

Yang, F. G., Bradley, K., Huq, M., Wu, D., & Krawczyk, D., (2013). Contextual effects on conceptual blending in metaphors: An event-related potential study. *Journal of Neurolinguistics, 26*, 312-326

Yee, E., Jones, M. N., & McRae, K. (2017). *Semantic Memory.* In J. T. Wixted & S. Thompson-Schill (Eds.), The Stevens' Handbook of Experimental Psychology and Cognitive Neuroscience (4th Edition, Volume 3: Language and Thought). New York: Wiley

Appendix A

Language History Questionnaire used in experimental chapters

Atodiad A

Holiadur Hanes Iaith a ddefnyddir yn y penodau arbrofol

Participant # _____ Date _____

Language History Questionnaire

This questionnaire is designed to give us a better understanding of your language experience. We ask that you be as accurate as possible when answering the following questions.

1. Gender
   - ☐ Female
   - ☐ Male

2. Age: _____ years

3. Do you have any known visual or hearing problems (corrected or uncorrected)?
   - ☐ No
   - ☐ Yes [Please explain]

   _____

4. Native Country: _____

5. Native/First Language (languages first spoken): _____

6. What languages were spoken in your home and school while you were a child?

_____
_____

_____
_____

7. When did you start learning English? Age:_____

8. How long have you lived in Wales in total? _____years_____months

9. List below, from most fluent to least fluent, all of the languages you know. Also specify the age at which you began to learn the language and the context in which you learned it. For example, "English, birth, home," "English, age 13, school and study abroad," or "English, age 7, living abroad and school."

Please remember to list your native language.

Language	Age	Learning Situation

10. Please rate your **Welsh** reading proficiency on a ten-point scale.

1 2 3 4 5 6 7 8 9 10
not literate very literate

11. Please rate your **Welsh** writing proficiency on a ten-point scale.

1 2 3 4 5 6 7 8 9 10
not literate very literate

12. Please rate your **Welsh** conversational fluency on a ten-point scale.

1 2 3 4 5 6 7 8 9 10
not fluent very fluent

13. Please rate your **Welsh** speech comprehension ability on a ten-point scale.

1 2 3 4 5 6 7 8 9 10
unable to understand conversation perfectly able to understand conversation

14. Please rate your **other language** reading proficiency on a ten-point scale.

1 2 3 4 5 6 7 8 9 10
not literate very literate

15. Please rate your **other language** writing proficiency on a ten-point scale.

1 2 3 4 5 6 7 8 9 10
not literate very literate

16. Please rate your **other language** conversational fluency on a ten-point scale.

1 2 3 4 5 6 7 8 9 10
not fluent very fluent

17. Please rate your **other language** speech comprehension ability on a ten-point scale.

1	2	3	4	5	6	7	8	9	10
unable to understand conversation									perfectly able to understand conversation

18. What percentage of the time do you spend using **Welsh**—reading, writing, speaking, and listening? ____%

19. What percentage of the time do you spend using **your other language**—reading, writing, speaking and listening? ____%

** Please make sure that the addition of Q18 & Q19 is 100 %.*

20. How often do you read **in Welsh**?

1 2 3 4 5 6 7 8 9 10
not at all rarely sometimes often always

21. How often do you read **in your other language**?

1 2 3 4 5 6 7 8 9 10
not at all rarely sometimes often always

22. How often do you write **in Welsh**?

1 2 3 4 5 6 7 8 9 10
not at all rarely sometimes often always

23. How often do you write **in your other language**?

1 2 3 4 5 6 7 8 9 10
not at all rarely sometimes often always

24. How often do you speak **in Welsh**?

1 2 3 4 5 6 7 8 9 10
not at all rarely sometimes often always

25. How often do you speak **in your other language**?

1 2 3 4 5 6 7 8 9 10
not at all rarely sometimes often always

26. How often do you watch TV programs/movies or listen to lectures/radio/conversations **in Welsh**?

1 2 3 4 5 6 7 8 9 10
not at all rarely sometimes often always

27. How often do you watch TV programs/movies or listen to lectures/radio/conversations **in your other language**?

1 2 3 4 5 6 7 8 9 10
not at all rarely sometimes often always

28. Is there anything else about your language background that you would like to comment on? Please feel free to make comments about things that were not covered on this questionnaire.

Appendix B

Multi Group Ethnic Identity Measure used in experimental chapters

Atodiad B

Mesur Hunaniaeth Ethnig Aml-Grŵp a ddefnyddir yn y penodau arbrofol

Please fill in: In terms of cultural group, I consider myself to be _____

Use the numbers below to indicate how much you agree or disagree with each statement.

(4) Strongly agree (3) Agree (2) Disagree (1) Strongly disagree

1- I have spent time trying to find out more about my cultural group, such as its history, traditions, and customs.
2- I am active in organizations or social groups that include mostly members of my own cultural group.
3- I have a clear sense of my ethnic background and what it means for me.
4- I think a lot about how my life will be affected by my cultural group membership.
5- I am happy that I am a member of the group I belong to.
6- I have a strong sense of belonging to my own cultural group.
7- I understand pretty well what my cultural group membership means to me.
8- In order to learn more about my cultural background, I have often talked to other people about my ethnic group.
9- I have a lot of pride in my cultural group.
10- I participate in cultural practices of my own group, such as special food, music, or customs.
11- I feel a strong attachment towards my own cultural group.
12- I feel good about my cultural background.

13- My ethnicity is
(1) Asian or Asian American, including Chinese, Japanese, and others
(2) Black or African American
(3) Hispanic or Latino, including Mexican American, Central American, and others

(4) White, Caucasian, Anglo, European American; not Hispanic
(5) American Indian/Native American
(6) Mixed; Parents are from two different groups
(7) Other (write in): _____

14- My father's ethnicity is (use numbers above)
15- My mother's ethnicity is (use numbers above)

Appendix C

Experimental stimuli used in chapter 2 norming study

Atodiad C.

Ysgogiadau arbrofol a ddefnyddir yn astudiaeth normio pennod 2

English sentences / Brawddegau Saesneg

Item	Sentence	English Sentences	Figurativeness	Culture
1	1	The harmful crash left a wound.	Literal	General
1	2	The harmful relationship left a wound.	Metaphorical	General
1	3	The red dragon's bite left a wound.	literal	Specific
1	4	The red dragon's failure left a wound.	Metaphorical	Specific
2	5	The awkward fall left a scab.	literal	General
2	6	The awkward defeat left a scab.	Metaphorical	General
2	7	Gelert's wound left a scab.	literal	Specific
2	8	Gelert's tale left a scab.	Metaphorical	Specific
3	9	His hard hammer left a bruise.	literal	General
3	10	His hard words left a bruise.	Metaphorical	General
3	11	Neil Jenkins' tackle left a bruise.	literal	Specific
3	12	Neil Jenkins' retirement left a bruise.	Metaphorical	Specific
4	13	Her view of the concert was hazy.	literal	General
4	14	Her memory of the concert was hazy.	Metaphorical	General
4	15	Her view of St David was hazy.	literal	Specific
4	16	Her memory of St David was hazy.	Metaphorical	Specific
5	17	The secretary's wine was sweet.	literal	General
5	18	The secretary's complement was sweet.	Metaphorical	General
5	19	Grandmother's lobsgows was sweet.	literal	Specific
5	20	Grandmother's family tale was sweet.	Metaphorical	Specific
6	21	The early man is cheerful.	literal	General
6	22	The early sun is cheerful.	Metaphorical	General
6	23	The early quarryman is cheerful.	literal	Specific
6	24	The early daffodil is cheerful.	Metaphorical	Specific
7	25	The hotel cleaner is happy.	literal	General
7	26	The hotel's atmosphere is happy.	Metaphorical	General
7	27	Nant Gwyrtheyrn's learner is happy.	literal	Specific
7	28	Nant Gwyrtheyrn's atmosphere is happy.	Metaphorical	Specific
8	29	The car's surface was smooth.	literal	General
8	30	The car's journey was smooth.	Metaphorical	General
8	31	The harp's pedal is smooth.	literal	Specific
8	32	The harp's tone is smooth.	Metaphorical	Specific
9	33	The workman's hands were rough.	literal	General
9	34	The workman's years were rough.	Metaphorical	General
9	35	The sheep dog's tongue was rough.	literal	Specific
9	36	The sheep dog's journey was rough.	Metaphorical	Specific
10	37	The biggest star was bright.	literal	General
10	38	The biggest smile was bright.	Metaphorical	General

10	39	The rugby stadium was bright.	literal	Specific
10	40	The rugby win was bright.	Metaphorical	Specific
11	41	The dark statue was still.	literal	General
11	42	The dark night was still.	Metaphorical	General
11	43	The Welsh lamb was still.	literal	Specific
11	44	The Welsh nation was still.	Metaphorical	Specific
12	45	The cupboard she investigated was dark.	literal	General
12	46	The secret she investigated was dark.	Metaphorical	General
12	47	The Aberfan mine was dark.	literal	Specific
12	48	The Aberfan accident was dark.	Metaphorical	Specific
13	49	Her morning porridge was cold.	literal	General
13	50	Her morning expression was cold.	Metaphorical	General
13	51	Arthur Picton's morning porridge was cold.	literal	Specific
13	52	Arthur Picton's morning expression was cold.	Metaphorical	Specific
14	53	The author's street is silent.	literal	General
14	54	The author's mind is silent.	Metaphorical	General
14	55	The streets of Tryweryn are silent.	literal	Specific
14	56	The heart of Tryweryn is silent.	Metaphorical	Specific
15	57	The disco girl danced to the beat.	literal	General
15	58	The disco lights danced to the beat.	Metaphorical	General
15	59	The Celtic warrior danced to the beat.	literal	Specific
15	60	The Celtic soul danced to the beat.	Metaphorical	Specific
16	61	The reflex hammer caused a jolt.	literal	General
16	62	The bad news caused a jolt.	Metaphorical	General
16	63	The tractor accident caused a jolt.	literal	Specific
16	64	News of the tractor accident caused a jolt.	Metaphorical	Specific
17	65	The young horse is at a gallop.	literal	General
17	66	The young woman is at a gallop.	Metaphorical	General
17	67	Twm Sion Cati rode at a gallop.	literal	Specific
17	68	Twm Sion Cati ran at a gallop.	Metaphorical	Specific
18	69	From the thin man came a shout.	literal	General
18	70	From the thin pamphlet came a shout.	Metaphorical	General
18	71	From the Eisteddfod's presenter came a shout.	literal	Specific
18	72	From the Eisteddfod's programme came a shout.	Metaphorical	Specific
19	73	The man's race was a marathon.	literal	General
19	74	The man's task was a marathon.	Metaphorical	General
19	75	The Llanberis race was a marathon.	literal	Specific
19	76	The Noson Lawen was a marathon.	Metaphorical	Specific
20	77	The girl sang in her dream.	literal	General
20	78	The girl accomplised her dream.	Metaphorical	General
20	79	Cerys Matthews sang in her dream.	literal	Specific
20	80	Cerys Matthews accomplised her dream.	Metaphorical	Specific
21	81	The Olympic boxer caused a blow.	literal	General

21	82	The Olympic refusal caused a blow.	Metaphorical	General
21	83	The Penyberth explosion caused a blow.	literal	Specific
21	84	The Penyberth plans caused a blow.	Metaphorical	Specific
22	85	His children are restless.	literal	General
22	86	His nerves are restless.	Metaphorical	General
22	87	The Welsh flag is restless.	literal	Specific
22	88	The Welsh city is restless.	Metaphorical	Specific
23	89	The quiet sound was a whisper.	literal	General
23	90	The quiet wind was a whisper.	Metaphorical	General
23	91	Beddgelert's quiet visitors whisper.	literal	Specific
23	92	Beddgelert's quiet trees whisper.	Metaphorical	Specific
24	93	The frightful accident left a scar.	literal	General
24	94	The frightful divorce left a scar.	Metaphorical	General
24	95	Glyndwr's frightful sword left a scar.	literal	Specific
24	96	Glyndwr's frightful longing left a scar.	Metaphorical	Specific
25	97	From the lonely man came a cry.	literal	General
25	98	From the lonely heart came a cry.	Metaphorical	General
25	99	From Llewelyn's battle came a cry.	literal	Specific
25	100	From Llewelyn's soul came a cry.	Metaphorical	Specific
26	101	The little lion was roaring.	literal	General
26	102	The little car was roaring.	Metaphorical	General
26	103	The Newport Dragons were roaring.	literal	Specific
26	104	The Newport stadium was roaring.	Metaphorical	Specific
27	105	The girl on the left gave a screech.	literal	General
27	106	The wheel on the left gave a screech.	Metaphorical	General
27	107	The Swansea Ospreys gave a screech.	literal	Specific
27	108	The history of Swansea castle was a screech.	Metaphorical	Specific
28	109	The angry boy caused a thump.	literal	General
28	110	The angry comment caused a thump.	Metaphorical	General
28	111	The rugby tackle caused a thump.	literal	Specific
28	112	The rugby loss caused a thump.	Metaphorical	Specific
29	113	From the lonely dog came a howl.	literal	General
29	114	From the lonely soul came a howl.	Metaphorical	General
29	115	From the Cantre'r Gwaelod dog came a howl.	literal	Specific
29	116	From the Cantre'r Gwaelod soul came a howl.	Metaphorical	Specific
30	117	Her active cat was awake.	literal	General
30	118	Her active mind was awake.	Metaphorical	General
30	119	The Land of My Fathers singer was awake.	literal	Specific
30	120	The Land of My Fathers message was awake.	Metaphorical	Specific
31	121	The hands of the girl were waving.	literal	General
31	122	The leaves on the tree were waving.	Metaphorical	General
31	123	The hands of Cilmeri visitors were waving.	literal	Specific
31	124	The leaves on the Cilmeri tree were waving.	Metaphorical	Specific

32	125	The man was soaked in lots of sweat.	literal	General
32	126	The man was soaked in buckets of sweat.	Metaphorical	General
32	127	Dewi Pws was soaked in lots of sweat.	literal	Specific
32	128	Dewi Pws was soaked in buckets of sweat.	Metaphorical	Specific
33	129	The noisy lightning was over with a flash.	literal	General
33	130	The noisy visit was over in a flash.	Metaphorical	General
33	131	The Caernarfon fireworks were over with a flash.	literal	Specific
33	132	The visit to Caernarfon was over in a flash.	Metaphorical	Specific
34	133	The vague figure was cast in shadow.	literal	General
34	134	The vague memory was cast in shadow.	Metaphorical	General
34	135	Llyn Tryweryn lies in shadow.	literal	Specific
34	136	Llyn Tryweryn carries a shadow.	Metaphorical	Specific
35	137	The awful noise gave a fright.	literal	General
35	138	The awful speech was a fright.	Metaphorical	General
35	139	Hedd Wyn's haunting poetry gave a fright.	literal	Specific
35	140	Hedd Wyn's haunting death was a fright.	Metaphorical	Specific
36	141	The boy made the triangle ring.	literal	General
36	142	The trianle made her head ring.	Metaphorical	General
36	143	Elin Fflur made the triangle ring.	literal	Specific
36	144	Elin Fflur made her head ring.	Metaphorical	Specific
37	145	The school girl's comment was a spite.	literal	General
37	146	The girl's school was filled with spite.	Metaphorical	General
37	147	The Plaid Cymru statement was a spite.	literal	Specific
37	148	The Plaid Cymru office was filled with spite.	Metaphorical	Specific
38	149	From the gentle boy came a caress.	literal	General
38	150	From the gentle breeze came a caress.	Metaphorical	General
38	151	From the swimmer in Llyn Tegid came a caress.	literal	Specific
38	152	From the waves of Llyn Tegid came a caress.	Metaphorical	Specific
39	153	The persistent dog had an itch.	literal	General
39	154	The persistent thought was an itch.	Metaphorical	General
39	155	Tom Jones' jumper caused an itch.	literal	Specific
39	156	Tom Jones' ambition caused an itch.	Metaphorical	Specific
40	157	The industrial fumes caused suffocation.	literal	General
40	158	The industrial speech caused suffocation.	Metaphorical	General
40	159	The holiday house fires caused suffocation.	literal	Specific
40	160	The holiday houses caused suffocation.	Metaphorical	Specific
41	161	The difficult rocks caused a slip.	literal	General
41	162	The difficult words caused a slip.	Metaphorical	General
41	163	The Portmeirion rocks caused a slip.	literal	Specific
41	164	The Portmeirion respectability caused a slip.	Metaphorical	Specific
42	165	Defeating the destructive boxer was a fight.	literal	General
42	166	Defeating the destructive disease was a fight.	Metaphorical	General
42	167	Defeating the Cardiff boxer was a fight.	literal	Specific

42	168	Defeating the Cardiff cold was a fight.	Metaphorical	Specific
43	169	On the surface, the big ball made a splash.	literal	General
43	170	On the cover, the big story made a splash.	Metaphorical	General
43	171	On the muddy pitch, Welsh feet made a splash.	literal	Specific
43	172	On the pitch, Welsh football made a splash.	Metaphorical	Specific
44	173	The tricky stairs caused a fall.	literal	General
44	174	The tricky exam caused a fall.	Metaphorical	General
44	175	Bangor University hill caused a fall.	literal	Specific
44	176	Bangor University exam caused a fall.	Metaphorical	Specific
45	177	Her awkwardly placed chair made her stumble.	literal	General
45	178	Her awkwardly placed words made her stumble.	Metaphorical	General
45	179	The awkward rocks on the Lôn Goed made her stumble.	literal	Specific
45	180	The awkward rhyme in the Lôn Goed made her stumble.	Metaphorical	Specific
46	181	The unexpected crash made his car slide.	literal	General
46	182	The unexpected crash made his confidence slide.	Metaphorical	General
46	183	The folk dance made her foot slide.	literal	Specific
46	184	The folk dance made her mind slide.	Metaphorical	Specific
47	185	The long path was a hike.	literal	General
47	186	The long day was a hike.	Metaphorical	General
47	187	Walking Menai Bridge was a hike.	literal	Specific
47	188	Building Menai Bridge was a hike.	Metaphorical	Specific
48	189	He dressed in a hurry and his trousers were a squeeze.	literal	General
48	190	He dressed in a hurry and time was a squeeze.	Metaphorical	General
48	191	Meinir was lost as the tree was a squeeze.	literal	Specific
48	192	Meinir was lost and Rhys' longing was a squeeze.	Metaphorical	Specific
49	193	The beautiful violin produced a tune.	literal	General
49	194	The beautiful waterfall produced a tune.	Metaphorical	General
49	195	The birds above Teifi River produced a tune.	literal	Specific
49	196	The flow of Teifi river produced a tune.	Metaphorical	Specific
50	197	From the gushing mother came a laugh.	literal	General
50	198	From the gushing stream came a laugh.	Metaphorical	General
50	199	From the child in Llandudno came a laugh.	literal	Specific
50	200	From the seagull in Llandudno came a laugh.	Metaphorical	Specific
51	201	From the old man's mouse came a squeal.	literal	General
51	202	From the old man's hip came a squeal.	Metaphorical	General
51	203	From Ceridwen's baby came a squeal.	literal	Specific
51	204	From Ceridwen's Cauldron came a squeal.	Metaphorical	Specific
52	205	His careful work received praise.	literal	General
52	206	His careful work demanded praise.	Metaphorical	General
52	207	The Glanaethwy performance received praise.	literal	Specific
52	208	The Glanaethwy performance demanded praise.	Metaphorical	Specific
53	209	From the distant phone came a voice.	literal	General
53	210	From the distant wind came a voice.	Metaphorical	General

53	211	From Snowdon's café came a voice.	literal	Specific
53	212	From Snowdon's roots came a voice.	Metaphorical	Specific
54	213	In the dark lake was a reflection.	literal	General
54	214	In the dark portrait was a reflection.	Metaphorical	General
54	215	In the surface of Llyn Padarn was a reflection.	literal	Specific
54	216	In the depth of Llyn Padarn was a reflection.	Metaphorical	Specific
55	217	From the mean girl she received a push.	literal	General
55	218	From the mean letter she received a push.	Metaphorical	General
55	219	From a member of Meibion Glyndwr she felt a push.	literal	Specific
55	220	From the action of Meibion Glyndwr she felt a push.	Metaphorical	Specific
56	221	His quick dog was in the race.	literal	General
56	222	His quick mind was in the race.	Metaphorical	General
56	223	The Welsh Cob was in the race.	literal	Specific
56	224	The Welsh heart was in the race.	Metaphorical	Specific
57	225	The loose screws caused a collapse.	literal	General
57	226	His loose screws caused his collapse.	Metaphorical	General
57	227	Eirias Park's loose screws caused a collapse.	literal	Specific
57	228	Rhys Ifans' loose screws caused his collapse.	Metaphorical	Specific
58	229	From the beautiful room came a light.	literal	General
58	230	From the beautiful baby came a light.	Metaphorical	General
58	231	From Llanddwyn Island's lighthouse came a light.	literal	Specific
58	232	From Llanddwyn Island's spirit came a light.	Metaphorical	Specific
59	233	His loud tool was a drill.	literal	General
59	234	His loud voice was a drill.	Metaphorical	General
59	235	Bryn Terfel's tool was a drill.	literal	Specific
59	236	Bryn Terfel's voice was a drill.	Metaphorical	Specific
60	237	The large wall began to crack.	literal	General
60	238	The large man began to crack.	Metaphorical	General
60	239	The Conwy castle keep began to crack.	literal	Specific
60	240	The Conwy castle soldier began to crack.	Metaphorical	Specific
61	241	The University sink was full of vomit.	literal	General
61	242	The University essay was full of vomit.	Metaphorical	General
61	243	Stereophonics sink was full of vomit.	literal	Specific
61	244	Stereophonics' song was full of vomit.	Metaphorical	Specific
62	245	His revolting medicine was hard to swallow.	literal	General
62	246	His revolting comment was hard to swallow.	Metaphorical	General
62	247	Ysbyty Gwynedd's food was hard to swallow.	literal	Specific
62	248	Ysbyty Gwynedd's news was hard to swallow.	Metaphorical	Specific
63	249	Changing her domestic lightbulb was a stretch.	literal	General
63	250	Changing her domestic lifestyle was a stretch.	Metaphorical	General
63	251	Reaching the Cerdd Dant book was a stretch.	literal	Specific
63	252	Reaching the Cerdd Dant note was a stretch.	Metaphorical	Specific
64	253	After the fall her head was swollen.	literal	General

64	254	After the comment her head was swollen.	Metaphorical	General
64	255	After the bad tackle Shane Williams' head was swollen.	literal	Specific
64	256	After the comment Shane Williams' head was swollen.	Metaphorical	Specific
65	257	Her strong curry was boiling.	literal	General
65	258	Her strong temper was boiling.	Metaphorical	General
65	259	Dudley's strong broth was boiling.	literal	Specific
65	260	Dudley's strong temper was boiling.	Metaphorical	Specific
66	261	Their love for chocolate was a craving.	literal	General
66	262	Their love for each other was a craving.	Metaphorical	General
66	263	Lleu's love for broth was a craving.	literal	Specific
66	264	Lleu's love for Blodeuwedd was a craving.	Metaphorical	Specific
67	265	After a long day he went to sleep.	literal	General
67	266	After a long life he went to sleep.	Metaphorical	General
67	267	After a long day T. Llew Jones went to sleep.	literal	Specific
67	268	After a long life T. Llew Jones went to sleep.	Metaphorical	Specific
68	269	From his dirty bag came a stink.	literal	General
68	270	From his dirty excuse came a stink.	Metaphorical	General
68	271	From the Welsh Government office came a stink.	literal	Specific
68	272	From the Welsh Government excuse came a stink.	Metaphorical	Specific
69	273	The ancient swaying man was exhausted.	literal	General
69	274	The ancient swaying tree was exhausted.	Metaphorical	General
69	275	The cow on Tryfan is exhausted.	literal	Specific
69	276	The Snowdrop on Tryfan is exhausted.	Metaphorical	Specific
70	277	The punishment she received for talking was a whip.	literal	General
70	278	The scolding she received for talking was a whip.	Metaphorical	General
70	279	The punishment received for the 'Welsh Not' was a whip.	literal	Specific
70	280	The judgement received for the 'Welsh Not' was a whip.	Metaphorical	Specific
71	281	The slow flock ran with a limp.	literal	General
71	282	The slow computer ran with a limp.	Metaphorical	General
71	283	The Anglesey athlete ran with a limp.	literal	Specific
71	284	The Anglesey show ran with a limp.	Metaphorical	Specific
72	285	Her soft tune was a song.	literal	General
72	286	Her soft charm was a song.	Metaphorical	General
72	287	Katherine Jenkins' soft tune was a song.	literal	Specific
72	288	Katherine Jenkins' soft charm was a song.	Metaphorical	Specific
73	289	Her husband's breath was a sigh.	literal	General
73	290	The love for her husband was a sigh.	Metaphorical	General
73	291	Bryn Fôn's breath was a sigh.	literal	Specific
73	292	Bryn Fôn's love for Wales was a sigh.	Metaphorical	Specific
74	293	The singer's voice made her shiver.	literal	General
74	294	The singer's voice made the stadium shiver.	Metaphorical	General
74	295	Dafydd Iwan's voice made her shiver.	literal	Specific
74	296	Dafydd Iwan's voice made the valley shiver.	Metaphorical	Specific

75	297	The emotional moment caused a blink.	literal	General
75	298	The emotional moment was over in a blink.	Metaphorical	General
75	299	The Cardiff city lights went off with a blink.	literal	Specific
75	300	The Cardiff city goalkeeper went off in a blink.	Metaphorical	Specific
76	301	Her need for cake was a hunger.	literal	General
76	302	Her need for knowledge was a hunger.	Metaphorical	General
76	303	Her need for Welsh cakes is a hunger.	literal	Specific
76	304	Her need for Welsh independence is a hunger.	Metaphorical	Specific
77	305	The girl and her aunt had a row.	literal	General
77	306	The girl and her conscience had a row.	Metaphorical	General
77	307	Llywelyn and Gelert had a row.	literal	Specific
77	308	Llywelyn and his conscience had a row.	Metaphorical	Specific
78	309	The dog gave him a kiss.	literal	General
78	310	The breeze gave him a kiss.	Metaphorical	General
78	311	To Gavin, Stacey gave a kiss.	literal	Specific
78	312	To Gavin, Stacey's smile was a kiss.	Metaphorical	Specific
79	313	The sharp nail made him bleed.	literal	General
79	314	The sharp cry made him bleed.	Metaphorical	General
79	315	Bendigeidfran's sword made them bleed.	literal	Specific
79	316	Bendigeidfran's cry made them bleed.	Metaphorical	Specific
80	317	A little walk caused a thirst.	literal	General
80	318	A little knowledge caused a thirst.	Metaphorical	General
80	319	The Sain Ffagan trip caused a thirst.	literal	Specific
80	320	The Sain Ffagan history caused a thirst.	Metaphorical	Specific

Welsh sentences / Brawddegau Cymraeg

Item	Sentence	Welsh sentences	Figurativeness	Culture
81	321	Gadawodd y ddamwain niweidiol friw.	Literal	General
81	322	Gadawodd y berthynas niweidiol friw.	Metaphorical	General
81	323	Gadawodd frathiad y ddraig goch friw.	literal	Specific
81	324	Gadawodd fethiant y ddraig goch friw.	Metaphorical	Specific
82	325	Gadawodd y codwm chwithig grachen.	literal	General
82	326	Gadawodd y trechiad chwithig grachen.	Metaphorical	General
82	327	Gadawodd friw Gelert grachen.	literal	Specific
82	328	Gadawodd stori Gelert grachen.	Metaphorical	Specific
83	329	Gadawodd ei forthwyl caled glais.	literal	General
83	330	Gadawodd ei eiriau caled glais.	Metaphorical	General
83	331	Gadawodd dacl Neil Jenkins glais.	literal	Specific

83	332	Gadawodd ymddeoliad Neil Jenkins glais.	Metaphorical	Specific
84	333	Roedd ei golwg o'r cyngerdd yn niwlog.	literal	General
84	334	Roedd ei chof o'r cyngerdd yn niwlog.	Metaphorical	General
84	335	Roedd ei golwg o Dewi Sant yn niwlog.	literal	Specific
84	336	Roedd ei chof o Dewi Sant yn niwlog.	Metaphorical	Specific
85	337	Roedd gwin yr ysgrifenyddes yn felys.	literal	General
85	338	Roedd canmoliaeth yr ysgrifenyddes yn felys.	Metaphorical	General
85	339	Roedd lobsgows nain yn felys.	literal	Specific
85	340	Roedd chwedl teulu nain yn felys.	Metaphorical	Specific
86	341	Mae'r dyn cynnar yn llon.	literal	General
86	342	Mae'r haul cynnar yn llon.	Metaphorical	General
86	343	Mae'r chwarelwr cynnar yn llon.	literal	Specific
86	344	Mae'r cennin Pedr cynnar yn llon.	Metaphorical	Specific
87	345	Mae glanhawr y gwesty yn hapus.	literal	General
87	346	Mae awyrgylch y gwesty yn hapus.	Metaphorical	General
87	347	Mae dysgwr Nant Gwrtheyrn yn hapus.	literal	Specific
87	348	Mae awyrgylch Nant Gwrtheyrn yn hapus.	Metaphorical	Specific
88	349	Roedd wyneb y car yn llyfn.	literal	General
88	350	Roedd siwrne'r car yn llyfn.	Metaphorical	General
88	351	Mae pedal y delyn yn llyfn.	literal	Specific
88	352	Mae tôn y delyn yn llyfn.	Metaphorical	Specific
89	353	Roedd dwylo'r gweithiwr yn arw.	literal	General
89	354	Roedd blynyddoedd y gweithiwr yn arw.	Metaphorical	General
89	355	Roedd tafod y ci defaid yn arw.	literal	Specific
89	356	Roedd siwrne'r ci defaid yn arw.	Metaphorical	Specific
90	357	Roedd y seren fwyaf yn ddisglair.	literal	General
90	358	Roedd y wên fwyaf yn ddisglair.	Metaphorical	General
90	359	Roedd y stadiwm rygbi yn ddisglair.	literal	Specific
90	360	Roedd y fuddugoliaeth rygbi yn ddisglair.	Metaphorical	Specific
91	361	Roedd y ddelw dywyll yn llonydd.	literal	General
91	362	Roedd y noson dywyll yn llonydd.	Metaphorical	General
91	363	Roedd yr oen Cymreig yn llonydd.	literal	Specific
91	364	Roedd y genedl Gymreig yn llonydd.	Metaphorical	Specific
92	365	Roedd y cwpwrdd a archwiliodd yn dywyll.	literal	General
92	366	Roedd y gyfrinach a archwiliodd yn dywyll.	Metaphorical	General
92	367	Roedd chwarel Aberfan yn dywyll.	literal	Specific
92	368	Roedd damwain Aberfan yn dywyll.	Metaphorical	Specific
93	369	Roedd ei uwd boreol yn oer.	literal	General
93	370	Roedd ei mynegiant boreol yn oer.	Metaphorical	General
93	371	Roedd uwd boreol Arthur Picton yn oer.	literal	Specific
93	372	Roedd mynegiant boreol Arthur Picton yn oer.	Metaphorical	Specific
94	373	Mae stryd yr awdur yn dawel.	literal	General
94	374	Mae meddwl yr awdur yn dawel.	Metaphorical	General

94	375	Mae strydoedd Tryweryn yn dawel.	literal	Specific
94	376	Mae calon Tryweryn yn dawel.	Metaphorical	Specific
95	377	Dawnsiodd y ferch disgo i'r curiad.	literal	General
95	378	Dawnsiodd y goleuadau disgo i'r curiad.	Metaphorical	General
95	379	Dawnsiodd y rhyfelwr Celtaidd i'r curiad.	literal	Specific
95	380	Dawnsiodd yr enaid Celtaidd i'r curiad.	Metaphorical	Specific
96	381	Achosodd y morthwyl reflex ysgytiad.	literal	General
96	382	Achosodd y newyddion drwg ysgytiad.	Metaphorical	General
96	383	Achosodd y ddamwain tractor ysgytiad.	literal	Specific
96	384	Achosodd newyddion y ddamwain tractor ysgytiad.	Metaphorical	Specific
97	385	Mae'r ceffyl ifanc ar garlam.	literal	General
97	386	Mae'r ddynes ifanc ar garlam.	Metaphorical	General
97	387	Marchogodd Twm Siôn Cati ar garlam.	literal	Specific
97	388	Rhedodd Twm Siôn Cati ar garlam.	Metaphorical	Specific
98	389	O'r dyn tenau daeth floedd.	literal	General
98	390	O'r pamffled tenau daeth floedd.	Metaphorical	General
98	391	O gyflwynydd yr Eisteddfod daeth floedd.	literal	Specific
98	392	O raglen yr Eisteddfod daeth floedd.	Metaphorical	Specific
99	393	Roedd ras y dyn yn farathon.	literal	General
99	394	Roedd tasg y dyn yn farathon.	Metaphorical	General
99	395	Roedd ras Llanberis yn farathon.	literal	Specific
99	396	Roedd y Noson Lawen yn farathon.	Metaphorical	Specific
100	397	Canodd y ferch yn ei breuddwyd.	literal	General
100	398	Cyflawnodd y ferch ei breuddwyd.	Metaphorical	General
100	399	Cannodd Cerys Matthews yn ei breuddwyd.	literal	Specific
100	400	Cyflawnodd Cerys Matthews ei breuddwyd.	Metaphorical	Specific
101	401	Achosodd y bocsiwr Olympaidd ergyd.	literal	General
101	402	Achosodd y gwrthodiad Olympaidd ergyd.	Metaphorical	General
101	403	Achosodd ffrwydrad Penyberth ergyd.	literal	Specific
101	404	Achosodd gynllwynia Penyberth ergyd.	Metaphorical	Specific
102	405	Mae ei blant yn aflonydd.	literal	General
102	406	Mae ei nerfau yn aflonydd.	Metaphorical	General
102	407	Mae'r faner Gymreig yn aflonydd.	literal	Specific
102	408	Mae'r ddinas Gymreig yn aflonydd.	Metaphorical	Specific
103	409	Roedd y swn tawel yn sibrwd.	literal	General
103	410	Roedd y gwynt tawel yn sibrwd.	Metaphorical	General
103	411	Roedd ymwelwyr tawel Beddgelert yn sibrwd.	literal	Specific
103	412	Roedd coed tawel Beddgelert yn sibrwd.	Metaphorical	Specific
104	413	Gadawodd y ddamwain ddychrynllyd graith.	literal	General
104	414	Gadawodd yr ysgariad dychrynllyd graith.	Metaphorical	General
104	415	Gadawodd gleddyf dychrynllyd Glyndŵr graith.	literal	Specific
104	416	Gadawodd hiraeth dychrynllyd Glyndŵr graith.	Metaphorical	Specific
105	417	O'r dyn unig daeth waedd.	literal	General

105	418	O'r galon unig daeth waedd.	Metaphorical	General
105	419	O Frwydr Llewelyn daeth waedd.	literal	Specific
105	420	O enaid Llewelyn daeth waedd.	Metaphorical	Specific
106	421	Roedd y llew bach yn rhuo.	literal	General
106	422	Roedd y car bach yn rhuo.	Metaphorical	General
106	423	Roedd Dreigiau Casnewydd yn rhuo.	literal	Specific
106	424	Roedd stadiwm Casnewydd yn rhuo.	Metaphorical	Specific
107	425	Roddodd y ferch sgrech.	literal	General
107	426	Roddodd yr olwyn sgrech.	Metaphorical	General
107	427	Roddodd Gweilchion Abertawe sgrech.	literal	Specific
107	428	Roedd hanes castell Abertawe yn sgrech.	Metaphorical	Specific
108	429	Achosodd y bachgen blin bwniad.	literal	General
108	430	Achosodd y sylwad blin bwniad.	Metaphorical	General
108	431	Achosodd y dacl rygbi bwniad.	literal	Specific
108	432	Achosodd y golled rygbi bwniad.	Metaphorical	Specific
109	433	O'r ci unig daeth udiad.	literal	General
109	434	O'r enaid unig daeth udiad.	Metaphorical	General
109	435	O gi Cantre'r Gwaelod daeth udiad.	literal	Specific
109	436	O enaid Cantre'r Gwaleod daeth udiad.	Metaphorical	Specific
110	437	Roedd ei chath actif yn effro.	literal	General
110	438	Roedd ei meddwl actif yn effro.	Metaphorical	General
110	439	Roedd canwr Mae Hen Wlad fy Nhadau yn effro.	literal	Specific
110	440	Roedd neges Mae Hen Wlad fy Nhadau yn effro.	Metaphorical	Specific
111	441	Roedd dwylo'r ferch yn chwifio.	literal	General
111	442	Roedd y dail ar y goeden yn chwifio.	Metaphorical	General
111	443	Roedd dwylo ymwelwyr Cilmeri yn chwifio.	literal	Specific
111	444	Roedd y dail ar goeden Cilmeri yn chwifio.	Metaphorical	Specific
112	445	Roedd y dyn yn socian mewn lot o chwys.	literal	General
112	446	Roedd y dyn yn socian mewn bwcedi o chwys.	Metaphorical	General
112	447	Roedd Dewi Pws yn socian mewn lot o chwys.	literal	Specific
112	448	Roedd Dewi Pws yn socian mewn bwcedi o chwys.	Metaphorical	Specific
113	449	Roedd y mellt swnllyd drosodd gyda fflach.	literal	General
113	450	Roedd yr ymweliad swnllyd drosodd mewn fflach.	Metaphorical	General
113	451	Roedd tân gwyllt Caernarfon drosodd gyda fflach.	literal	Specific
113	452	Roedd yr ymweliad i Gaernarfon drosodd mewn fflach.	Metaphorical	Specific
114	453	Roedd y ffigwr amwys wedi ei orchuddio mewn cysgod.	literal	General
114	454	Roedd y cof amwys wedi ei orchuddio mewn cysgod.	Metaphorical	General
114	455	Mae Llyn Tryweryn yn gorwedd mewn cysgod.	literal	Specific
114	456	Mae Llyn Tryweryn yn cario cysgod.	Metaphorical	Specific
115	457	Rhoddodd y sŵn dychrynllyd fraw.	literal	General
115	458	Roedd yr araith ddychrynllyd yn fraw.	Metaphorical	General
115	459	Rhoddodd gerddi arswydus Hedd Wyn fraw.	literal	Specific
115	460	Roedd marwolaeth arswydus Hedd Wyn yn fraw.	Metaphorical	Specific

116	461	Gwnaeth y bachgen i’r triongl ganu.	literal	General
116	462	Gwnaeth y triongl i’w phen ganu.	Metaphorical	General
116	463	Gwnaeth Elin Fflur i'r triongl ganu.	literal	Specific
116	464	Gwnaeth Elin Fflur i'w phen ganu.	Metaphorical	Specific
117	465	Roedd sylwad y ferch ysgol yn sbeit.	literal	General
117	466	Roedd ysgol y ferch yn llawn sbeit.	Metaphorical	General
117	467	Roedd mynegiad Plaid Cymru yn sbeit.	literal	Specific
117	468	Roedd swyddfa Plaid Cymru yn llawn sbeit.	Metaphorical	Specific
118	469	O'r bachgen tyner daeth mwythau.	literal	General
118	470	O'r awel dyner daeth mwythau.	Metaphorical	General
118	471	O nofiwr tyner Llyn Tegid ddaeth mwythau.	literal	Specific
118	472	O donnau tyner Llyn Tegid ddaeth mwythau.	Metaphorical	Specific
119	473	Roedd gan y ci bywiog gosiad.	literal	General
119	474	Roedd y syniad parhaus yn gosiad.	Metaphorical	General
119	475	Achosodd siwmper Tom Jones gosiad.	literal	Specific
119	476	Achosodd uchelgais Tom Jones gosiad.	Metaphorical	Specific
120	477	Achosodd y mwg masnachol dagiad.	literal	General
120	478	Achosodd yr araith fasnachol dagiad.	Metaphorical	General
120	479	Achosodd danau'r tai haf dagiad.	literal	Specific
120	480	Achosodd y tai haf dagiad.	Metaphorical	Specific
121	481	Achosodd y cerrig anodd lithriad.	literal	General
121	482	Achosodd y geiriau anodd lithriad.	Metaphorical	General
121	483	Achosodd gerrig Portmeirion lithriad.	literal	Specific
121	484	Achosodd barchusrwydd Portmeirion lithriad.	Metaphorical	Specific
122	485	Roedd trechu'r bocsiwr dinistriol yn frwydr.	literal	General
122	486	Roedd trechu'r salwch dinistriol yn frwydr.	Metaphorical	General
122	487	Roedd trechu bocsiwr Caerdydd yn frwydr.	literal	Specific
122	488	Roedd trechu oerfel Caerdydd yn frwydr.	Metaphorical	Specific
123	489	Ar yr wyneb, gwnaeth y bel mawr sblash.	literal	General
123	490	Ar y clawr, gwnaeth y stori fawr sblash.	Metaphorical	General
123	491	Ar y cae mwdlyd, gwnaeth draed Cymreig sblash.	literal	Specific
123	492	Ar y cae, gwnaeth bêl-droed Cymreig sblash.	Metaphorical	Specific
124	493	Achosodd y grisiau cymhleth syrthiad.	literal	General
124	494	Achosodd yr arholiad cymhleth syrthiad.	Metaphorical	General
124	495	Achosodd allt Prifysgol Bangor syrthiad.	literal	Specific
124	496	Achosodd arholiad Prifysgol Bangor syrthiad.	Metaphorical	Specific
125	497	Gwnaeth lleoliad lletchwith ei chadair iddi faglu.	literal	General
125	498	Gwnaeth lleoliad lletchwith ei geiriau iddi faglu.	Metaphorical	General
125	499	Gwnaeth gerrig lletchwith y Lôn Goed iddi faglu.	literal	Specific
125	500	Gwnaeth odl letchwith y Lôn Goed iddi faglu.	Metaphorical	Specific
126	501	Gwnaeth y ddamwain annisgwyl i'w gar lithro.	literal	General
126	502	Gwnaeth y ddamwain annisgwyl i'w hyder lithro.	Metaphorical	General
126	503	Gwnaeth y ddawns gwerin ei throed lithro.	literal	Specific

126	504	Gwnaeth y ddawns gwerin ei meddwl lithro.	Metaphorical	Specific
127	505	Roedd y llwybr hir yn daith.	literal	General
127	506	Roedd y diwrnod hir yn daith.	Metaphorical	General
127	507	Roedd creded Pont Menai yn daith.	literal	Specific
127	508	Roedd adeiladu pont Menai yn daith.	Metaphorical	Specific
128	509	Gwisgodd mewn brys ac roedd ei drowsus yn gwasgu.	literal	General
128	510	Gwisgodd mewn brys ac roedd amser yn gwasgu.	Metaphorical	General
128	511	Roedd Meinir ar goll gan fod y goeden yn gwasgu.	literal	Specific
128	512	Roedd Meinir ar goll ac roedd hiraeth Rhys yn gwasgu.	Metaphorical	Specific
129	513	Cynhyrchodd y ffidil hardd alaw.	literal	General
129	514	Cynhyrchodd y rhaeadr hardd alaw.	Metaphorical	General
129	515	Cynhyrchodd adar uwchlaw afon Teifi alaw.	literal	Specific
129	516	Cynhyrchodd llif afon Teifi alaw.	Metaphorical	Specific
130	517	O'r fam fyrlymus daeth chwerthiniad.	literal	General
130	518	O'r nant fyrlymus daeth chwerthiniad.	Metaphorical	General
130	519	O'r plentyn yn Llandudno daeth chwerthiniad.	literal	Specific
130	520	O'r wylan yn Llandudno daeth chwerthiniad.	Metaphorical	Specific
131	521	O lygoden yr hen ddyn daeth gwich.	literal	General
131	522	O glun yr hen ddyn daeth gwich.	Metaphorical	General
131	523	O faban Ceridwen daeth gwich.	literal	Specific
131	524	O grochan Ceridwen daeth gwich.	Metaphorical	Specific
132	525	Derbyniodd ei waith gofalus glod.	literal	General
132	526	Mynnodd ei waith gofalus glod.	Metaphorical	General
132	527	Derbyniodd berfformiad Glanaethwy glod.	literal	Specific
132	528	Mynnodd berfformiad Glanaethwy glod.	Metaphorical	Specific
133	529	O'r ffon bell daeth llais.	literal	General
133	530	O'r gwynt pell daeth llais.	Metaphorical	General
133	531	O gaffi'r Wyddfa daeth llais.	literal	Specific
133	532	O wraidd yr Wyddfa daeth llais.	Metaphorical	Specific
134	533	Yn y llyn tywyll oedd adlewyrchiad.	literal	General
134	534	Yn y darlun tywyll oedd adlewyrchiad.	Metaphorical	General
134	535	Yn wyneb Llyn Padarn oedd adlewyrchiad.	literal	Specific
134	536	Yn nyfnder Llyn Padarn oedd adlewyrchiad.	Metaphorical	Specific
135	537	Gan y ferch gas derbyniodd wthiad.	literal	General
135	538	Gan y llythyr cas derbyniodd wthiad.	Metaphorical	General
135	539	Gan aelod Meibion Glyndŵr teimlodd wthiad.	literal	Specific
135	540	Gan weithred Meibion Glyndŵr teimlodd wthiad.	Metaphorical	Specific
136	541	Roedd ei gi cyflym yn y ras.	literal	General
136	542	Roedd ei feddwl cyflym yn y ras.	Metaphorical	General
136	543	Roedd y Cob Cymreig yn y ras.	literal	Specific
136	544	Roedd y galon Gymreig yn y ras.	Metaphorical	Specific
137	545	Achosodd y sgriwiau llac gwymp.	literal	General
137	546	Achosodd ei sgriwiau llac ei gwymp.	Metaphorical	General

137	547	Achosodd sgriwiau llac Parc Eirias gwymp.	literal	Specific
137	548	Achosodd sgriwiau llac Rhys Ifans ei gwymp.	Metaphorical	Specific
138	549	O'r ystafell brydferth daeth golau.	literal	General
138	550	O'r baban prydferth daeth golau.	Metaphorical	General
138	551	O oleudy Ynys Llanddwyn daeth golau.	literal	Specific
138	552	O ysbryd Ynys Llanddwyn daeth golau.	Metaphorical	Specific
139	553	Roedd ei offeryn uchel yn ddril.	literal	General
139	554	Roedd ei lais uchel yn ddril.	Metaphorical	General
139	555	Roedd offeryn Bryn Terfel yn ddril.	literal	Specific
139	556	Roedd llais Bryn Terfel yn ddril.	Metaphorical	Specific
140	557	Dechreuodd y wal fawr gracio.	literal	General
140	558	Dechreuodd y dyn mawr gracio.	Metaphorical	General
140	559	Dechreuodd orthwr castell Conwy gracio.	literal	Specific
140	560	Dechreuodd milwr castell Conwy gracio.	Metaphorical	Specific
141	561	Roedd sinc y Brifysgol yn llawn chwd.	literal	General
141	562	Roedd traethawd y brifysgol yn llawn chwd.	Metaphorical	General
141	563	Roedd sinc Stereophonics yn llawn chwd.	literal	Specific
141	564	Roedd cân Stereophonics yn llawn chwd.	Metaphorical	Specific
142	565	Roedd ei ffisig ffiaidd yn anodd i'w lyncu.	literal	General
142	566	Roedd ei sylw ffiaidd yn anodd i'w lyncu.	Metaphorical	General
142	567	Roedd bwyd Ysbyty Gwynedd yn anodd i'w lyncu.	literal	Specific
142	568	Roedd newyddion Ysbyty Gwynedd yn anodd i'w lyncu.	Metaphorical	Specific
143	569	Roedd newid ei bwlb domestig yn ymestyniad.	literal	General
143	570	Roedd newid ei ffordd o fyw domestig yn ymestyniad.	Metaphorical	General
143	571	Roedd cyrraedd llyfr y Gerdd Dant yn ymestyniad.	literal	Specific
143	572	Roedd cyrraedd nodyn y Gerdd Dant yn ymestyniad.	Metaphorical	Specific
144	573	Wedi'r ddamwain roedd ei phen wedi chwyddo.	literal	General
144	574	Wedi'r sylw roedd ei phen wedi chwyddo.	Metaphorical	General
144	575	Wedi'r dacl ddrwg roedd pen Shane Williams wedi chwyddo.	literal	Specific
144	576	Wedi'r sylw roedd pen Shane Williams wedi chwyddo.	Metaphorical	Specific
145	577	Roedd ei chyri cryf yn berwi.	literal	General
145	578	Roedd ei thempar cryf yn berwi.	Metaphorical	General
145	579	Roedd cawl cryf Dudley yn berwi.	literal	Specific
145	580	Roedd tempar cryf Dudley yn berwi.	Metaphorical	Specific
146	581	Roedd eu cariad at siocled yn chwant.	literal	General
146	582	Roedd eu cariad at ei gilydd yn chwant.	Metaphorical	General
146	583	Roedd cariad Lleu at gawl yn chwant.	literal	Specific
146	584	Roedd cariad Lleu at Blodeuwedd yn chwant.	Metaphorical	Specific
147	585	Wedi diwrnod hir fe aeth i gysgu.	literal	General
147	586	Wedi bywyd hir fe aeth i gysgu.	Metaphorical	General
147	587	Wedi diwrnod hir fe aeth T. Llew Jones i gysgu.	literal	Specific
147	588	Wedi bywyd hir fe aeth T. Llew Jones i gysgu.	Metaphorical	Specific
148	589	O'i fag budur daeth drewdod.	literal	General

148	590	O'i esgus budr daeth drewdod.	Metaphorical	General
148	591	O swyddfa llywodraeth Cymru daeth drewdod.	literal	Specific
148	592	O esgus llywodraeth Cymru daeth drewdod.	Metaphorical	Specific
149	593	Roedd yr hen ddyn sigledig wedi blino.	literal	General
149	594	Roedd yr hen goeden sigledig wedi blino.	Metaphorical	General
149	595	Mae'r fuwch ar Dryfan wedi blino.	literal	Specific
149	596	Mae'r lili wen fach ar Dryfan wedi blino.	Metaphorical	Specific
150	597	Y gosb a gafwyd hi am siarad oedd chwip.	literal	General
150	598	Roedd y ffrae a gafwyd hi am siarad yn chwip.	Metaphorical	General
150	599	Y gosb a gafwyd am yr 'Welsh Not' oedd chwip.	literal	Specific
150	600	Roedd y feirniadaeth a gafwyd am yr 'Welsh not' yn chwip.	Metaphorical	Specific
151	601	Rhedodd yr haid araf gyda herc.	literal	General
151	602	Rhedodd y cyfrifiadur araf gyda herc.	Metaphorical	General
151	603	Rhedodd athletwr Môn gyda herc.	literal	Specific
151	604	Rhedodd sioe Môn gyda herc.	Metaphorical	Specific
152	605	Roedd ei halaw lyfn yn gân.	literal	General
152	606	Roedd ei swyn llyfn yn gân.	Metaphorical	General
152	607	Roedd alaw lyfn Katherine Jenkins yn gân.	literal	Specific
152	608	Roedd swyn llyfn Katherine Jenkins' yn gân.	Metaphorical	Specific
153	609	Roedd anadl ei gwr yn ochenaid.	literal	General
153	610	Roedd ei chariad i’w gwr yn ochenaid.	Metaphorical	General
153	611	Roedd anadl Bryn Fôn yn ochenaid.	literal	Specific
153	612	Roedd cariad Bryn Fôn at Gymru yn ochenaid.	Metaphorical	Specific
154	613	Gwnaeth lais y canwr iddi grynu.	literal	General
154	614	Gwnaeth lais y canwr i'r stadiwm grynu.	Metaphorical	General
154	615	Gwnaeth lais Dafydd Iwan iddi grynu.	literal	Specific
154	616	Gwnaeth lais Dafydd Iwan i'r cwm grynu.	Metaphorical	Specific
155	617	Achosodd y foment emosiynol chwinciad.	literal	General
155	618	Gorffennodd y foment emosiynol mewn chwinciad.	Metaphorical	General
155	619	Aeth golau dinas Gaerdydd I ffwrdd gyda chwinciad.	literal	Specific
155	620	Aeth gôl-geidwad dinas Caerdydd i ffwrdd mewn chwinciad.	Metaphorical	Specific
156	621	Roedd ei hangen am gacen yn newyn.	literal	General
156	622	Roedd ei hangen am wybodaeth yn newyn.	Metaphorical	General
156	623	Roedd ei hangen am gacenni Cri Cymreig yn newyn.	literal	Specific
156	624	Roedd ei hangen am annibyniaeth Gymreig yn newyn.	Metaphorical	Specific
157	625	Cafodd y ferch a'i modryb ffrae.	literal	General
157	626	Cafodd y ferch a'i chydwybod ffrae.	Metaphorical	General
157	627	Cafodd Llywelyn a Gelert ffrae.	literal	Specific
157	628	Cafodd Llywelyn a'i gydwybod ffrae.	Metaphorical	Specific
158	629	Iddo ef, rhoddodd y ci sws.	literal	General
158	630	Iddo ef, rhoddodd yr awel sws.	Metaphorical	General
158	631	I Gavin, rhoddodd Stacey sws.	literal	Specific
158	632	I Gavin, roedd gwen Stacey yn sws.	Metaphorical	Specific

159	633	Gwnaeth yr hoelen finiog iddo waedu.	literal	General
159	634	Gwnaeth y waedd finiog iddo waedu.	Metaphorical	General
159	635	Gwnaeth gleddyf Bendigeidfran iddynt waedu.	literal	Specific
159	636	Gwnaeth waedd Bendigeidfran iddynt waedu.	Metaphorical	Specific
160	637	Achosodd ychydig o gerdded syched.	literal	General
160	638	Achosodd ychydig o wybodaeth syched.	Metaphorical	General
160	639	Achosodd daith Sain Ffagan syched.	literal	Specific
160	640	Achosodd hanes Sain Ffagan syched.	Metaphorical	Specific

Appendix D

Procedures used in chapter 2 norming study

Atodiad D

Gweithdrefnau a ddefnyddir yn astudiaeth normio pennod 2

Counterbalancing

Table 1. Counterbalanced versions of the norming lists. Note that 'scale' corresponds to each of the six rating scales (familiarity, imageability, cultural relevance, emotional valence, figurativeness, and plausibility). Each participant saw 320 sentences; 160 in the cloze condition and 160 in the ratings conditions.

List 1			*List 2*		
Version 1.1			*Version 2.1*		
V1.1.1	Cloze	Welsh specific	V2.1.1	Cloze	Welsh non-specific
V1.1.2	Cloze	English non-specific	V2.1.2	Cloze	English specific
V1.1.3	Scale	English specific	V2.1.3	Scale	English non-specific
V1.1.4	Scale	Welsh non-specific	V2.1.4	Scale	Welsh specific
Version 1.2			*Version 2.2*		
V1.2.1	Cloze	Welsh specific	V2.2.1	Cloze	Welsh non-specific
V1.2.2	Cloze	English non-specific	V2.2.2	Cloze	English specific
V1.2.3	Scale	English specific	V2.2.3	Scale	English non-specific
v.1.2.4	Scale	Welsh non-specific	V2.2.4	Scale	Welsh specific
Version 1.3			Version 2.3		
V1.3.1	Cloze	English non-specific	V2.3.1	Cloze	English specific
V1.3.2	Cloze	Welsh specific	V2.3.2	Cloze	Welsh non-specific
V1.3.3	Scale	Welsh non-specific	V2.3.3	Scale	Welsh specific
V1.3.4	Scale	English specific	V2.3.4	Scale	English non-specific
Version 1.4			***Version 2.4***		
V1.4.1	Cloze	English non-specific	V2.4.1	Cloze	English specific
V1.4.2	Cloze	Welsh specific	V2.4.2	Cloze	Welsh non-specific
V1.4.3	Scale	Welsh non-specific	V2.4.3	Scale	Welsh specific
V1.4.4	Scale	English specific	V2.4.4	Scale	English non-specific

Individual test procedures

Design

Words data. Data on length and frequency were collected for the subject of each sentence (e.g., crash vs relationship). Frequency for English sentences were obtained via the CELEX database (Baayen, Piepenbrock, & Gulikers. 1995), whilst frequency of Welsh words was obtained using the Cronfa database (Ellis, O'Dochartaigh, Hicks, Morgan, & Laporte, 2001).

Sentence data. Each of the 640 sentences created for Experiment 1 (320 in each language) was rated for familiarity, plausibility, imagability, figurativeness and for cloze probability. We then designed a counterbalancing procedure (see Table 1), in which any given participant would complete one 'version' of the experiment (e.g., Version 1.1). Each version comprised presentation of 320 sentences, which corresponded to every experimental sentence presented *either* in English or Welsh (i.e., a total of 160 sentence in English and 160 sentences in Welsh). Presentation of sentences was randomized. Although each participant only saw a quarter of all sentences (given the large volume of the total set), between group and mixed designs for norming literal/metaphorical sentences are found to be comparable with within-group designs (Libben & Titone, 2008; Titone & Connie, 1994; Nordmann & Jambazova, 2017).

Participants were first presented with detailed explanations of each rating scale and cloze probability question. For example; *In this study you will be presented with a series of sentences. We would like you to rate the semantic plausibility (or meaning) of each sentence. Please try to concentrate on* ***the meaning of the sentence*** *as a whole. Please note that there is no right or wrong answer.* Additionally, an example question and answer was given.

Rating scales

1. Familiarity

Ratings of familiarity and frequency were obtained in order to ascertain participants' experience with each literal and metaphorical sentence. In response to the question: "*How familiar is this sentence?"* participants responded by indicating its familiarity on a scale of 1 to 4. The explicit choice / instruction was as follows: "*1. I have never heard the expression before and the meaning is unfamiliar; 2. I have heard similar expressions once or twice before and feel the meaning is somewhat unfamiliar; 3. I have heard similar expressions occasionally before and feel the meaning in somewhat familiar; 4. I have heard similar expressions frequently before and the meaning is highly familiar".*

2. Plausibility

Ratings of plausibility or naturalness were also obtained and indicated on a scale of 1 to 4 . Participants were asked; How plausible is this sentence? Options included: "1. The sentence is very unnatural; 2. The sentence is somewhat unnatural; 3. The sentence is somewhat natural; 4. The sentence is very natural".

3. Imageability

Participants were asked how easily each sentence brought a visual/auditory image to mind on a scale of 1 to 4. Options included: *"1. The sentence brings no image to mind; 2. The sentence eventually brings a vague image to mind; 3. The sentence eventually*

brings a clear image to mind; 4. The sentence immediately brings a clear image to mind".

4. Figurativeness

Participants indicated the figurativeness of each sentence, again using a scale of 1 to 4, Options included: "1. The sentence is highly literal; 2. The sentence is somewhat literal; 3. The sentence is somewhat figurative; 4. The sentence is highly figurative".

Cloze probability

Each participant was presented with 160 sentences (80 in Welsh, and in 80 English); up to but not including the critical word, as per De Grauwe et al, 2010. Participants were instructed to type the first plausible word that came to mind in order to complete the sentence.

Gwrthbwyso

Tabl. Fersiynau gwrthgytbwys o'r rhestrau normio. Sylwch fod ‘graddfa’ yn cyfateb i bob un o’r chwe graddfa (cynefindra, delweddadwyedd, perthnasedd diwylliannol, falens emosiynol, ffigurol, a hygrededd). Gwelodd pob cyfranogwr 320 o frawddegau; 160 yn y cyflwr cloze a 160 yn yr amodau graddio.

Rhestr 1			*Rhestr 2*		
Fersiwn 1.1			*Fersiwn 2.1*		
V1.1.1	Cloze	Cymraeg benodol	V2.1.1	Cloze	Cymraeg cyffredinol
V1.1.2	Cloze	Saesneg cyffredinol	V2.1.2	Cloze	Saesneg benodol
V1.1.3	Graddfa	Saesneg benodol	V2.1.3	Graddfa	Saesneg cyffredinol
V1.1.4	Graddfa	Cymraeg cyffredinol	V2.1.4	Graddfa	Cymraeg benodol
Fersiwn 1.2			*Fersiwn 2.2*		
V1.2.1	Cloze	Cymraeg benodol	V2.2.1	Cloze	Cymraeg cyffredinol
V1.2.2	Cloze	Saesneg cyffredinol	V2.2.2	Cloze	Saesneg benodol
V1.2.3	Graddfa	Saesneg benodol	V2.2.3	Graddfa	Saesneg cyffredinol
v.1.2.4	Graddfa	Cymraeg cyffredinol	V2.2.4	Graddfa	Cymraeg benodol
Fersiwn 1.3			*Fersiwn* 2.3		
V1.3.1	Cloze	Saesneg cyffredinol	V2.3.1	Cloze	Saesneg benodol
V1.3.2	Cloze	Cymraeg benodol	V2.3.2	Cloze	Cymraeg cyffredinol
V1.3.3	Graddfa	Cymraeg cyffredinol	V2.3.3	Graddfa	Cymraeg benodol
V1.3.4	Graddfa	Saesneg benodol	V2.3.4	Graddfa	Saesneg cyffredinol
Fersiwn 1.4			*Fersiwn 2.4*		
V1.4.1	Cloze	Saesneg cyffredinol	V2.4.1	Cloze	Saesneg benodol
V1.4.2	Cloze	Cymraeg benodol	V2.4.2	Cloze	Cymraeg cyffredinol
V1.4.3	Graddfa	Cymraeg cyffredinol	V2.4.3	Graddfa	Cymraeg benodol
V1.4.4	Graddfa	Saesneg benodol	V2.4.4	Graddfa	Saesneg cyffredinol

Gweithdrefnau unigol

Cynllun

Data geiriau. Casglwyd data hyd ac amlder ar gyfer geiriau pwnc pob brawddeg (e.e., damwain yn erbyn perthynas). Cafwyd amledd ar gyfer brawddegau Saesneg trwy'r gronfa ddata CELEX (Baayen, Piepenbrock, & Gulikers. 1995), tra cafwyd amlder geiriau Cymraeg gan ddefnyddio cronfa ddata Cronfa (Ellis, O'Dochartaigh, Hicks, Morgan, & Laporte, 2001).

Data brawddegau. Cafodd pob un o'r 640 brawddeg a grëwyd ar gyfer Arbrawf 1 (320 ym mhob iaith) eu graddio am gynefindra, credadwyedd, delweddadwyedd, ffigurol ac am debygolrwydd cloze. Yna fe wnaethon ddylunio gweithdrefn gwrthbwyso (gweler Tabl 1), lle byddai unrhyw gyfranogwr penodol yn cwblhau un 'fersiwn' o'r arbrawf (e.e., Fersiwn 1.1). Roedd pob fersiwn yn cynnwys cyflwyniad o 320 o frawddegau, a oedd yn cyfateb i bob brawddeg arbrofol a gyflwynwyd naill ai yn Saesneg neu Gymraeg (h.y., cyfanswm o 160 brawddeg yn Saesneg a 160 brawddeg yn Gymraeg). Cyflwynwyd y brawddegau ar hap. Er mai dim ond chwarter o'r holl frawddegau a welodd pob cyfranogwr (gan ystyried maint y set gyfan), nodir bod cynlluniadau rhyng-grŵp a chynlluniau cymysg wrth mornio brawddegau llythrennol / trosiadol yn debyg i ddyluniadau o fewn grŵp (Libben & Titone, 2008; Titone & Connie, 1994; Nordmann & Jambazova, 2017).

Ar ddechrau'r astudiaeth, cyflwynwyd eglurhad manwl o'r cwestiynau graddfeydd graddio a'r cloze probability. Er engraifft; *Yn yr astudiaeth hon, cewch eich cyflwyno a cyfres o frawddegau. Hoffem I chi raddio credadwyedd semantig (neu ystyr) y brawddegau. Ceisiwch ganolbwyntio ar ystyr y frawddeg ar y cyfan os gwelwch yn dda.*

Nodwch fod dim ateb cywir nac anghywir. Yn ogystal a hyn, rhoddwyd gwestiwn ac ateb engreifftiol er mwyn eu cyfarwyddo a'r drefn ymateb.

Graddfeydd graddio

1. Cynefindra

Cafwyd graddfeydd o gynefindra ac amlder er mwyn canfod profiad cyfranogwyr gyda phob brawddeg lythrennol a throsiadol. Mewn ymateb i'r cwestiwn: *"Pa mor gyfarwydd yw'r frawddeg hon?"* ymatebodd cyfranogwyr trwy nodi ei gynefindra ar raddfa o 1 i 4. Roedd y dewis / cyfarwyddiadau penodol fel a ganlyn: "*1. Ni chlywais yr ymadrodd erioed o'r blaen ac mae'r ystyr yn anghyfarwydd; 2. Rwyf wedi clywed ymadroddion tebyg unwaith neu ddwy o'r blaen ac yn teimlo bod yr ystyr braidd yn anghyfarwydd; 3. Rwyf wedi clywed ymadroddion tebyg yn achlysurol o'r blaen ac yn teimlo'r ystyr mewn rhywbeth eithaf cyfarwydd; 4. Rwyf wedi clywed ymadroddion tebyg yn aml o'r blaen ac mae'r ystyr yn gyfarwydd iawn "*

2. Credadwyedd

Cafwyd graddfeydd credadwyedd neu naturioldeb hefyd eu nodi ar raddfa 1 i 4. Gofynnwyd: Pa mor gredadwy yw'r frawddeg? Ymhlith yr opsiynau oedd: "1. *Mae'r frawddeg yn annaturiol iawn; 2. Mae'r frawddeg braidd yn annaturiol; 3. Mae'r frawddeg yn eithaf naturiol; 4. Mae'r frawddeg yn naturiol iawn "*

3. Delweddadwyedd

Gofynnwyd i'r cyfranogwyr pa mor hawdd yr oedd pob brawddeg yn dod â delwedd weledol / clywedol i'r meddwl ar raddfa o 1 i 4. Roedd yr opsiynau'n cynnwys: "*1. Nid yw'r frawddeg yn dod â delwedd i'r meddwl; 2. Yn y diwedd, mae'r frawddeg yn dod â delwedd annelwig i'r meddwl; 3. Yn y diwedd, mae'r frawddeg yn dod â delwedd glir i'r meddwl; 4. Mae'r frawddeg yn dod â delwedd glir i'r meddwl ar unwaith ".*

Ffigurol

Gofynnwyd I'r cyfranogwyr nodi pa mor ffigurol oedd pob brawddeg, gan ddefnyddio graddfa 1 i 4. Roedd yr opsiynau'n cynnwys: *"1. Mae'r frawddeg yn hynod lythrennol; 2. Mae'r frawddeg ychydig yn llythrennol; 3. Mae'r frawddeg ychydig yn ffigurol; 4. Mae'r frawddeg yn ffigurol iawn ".*

Tebygolrwydd cloze

Cyflwynwyd 160 o frawddegau i bob cyfranogwr (80 yn Gymraeg, ac 80 mewn Saesneg) hyd at, ond heb gynnwys y gair targed, yn unol â De Grauwe et al, (2010). Cyfarwyddwyd hwy i deipio'r gair credadwy cyntaf a ddaeth i'r meddwl er mwyn cwblhau'r frawddeg.

Appendix E

Experimental stimuli used in chapters 3 & 4

Atodiad E

Ysgogiadau arbrofol a ddefnyddir ym mhenodau 3 a 4

English sentences / Brawddegau Saesneg

Item	Sentence	English sentences	Sensibility	Figurativeness
1	1	The strange accident left a wound.	Sensible	Literal
1	2	The strange statement left a wound.	Sensible	Metaphorical
1	3	The strange accident left a hunger.	Anomalous	Literal
1	4	The strange statement left a hunger.	Anomalous	Metaphorical
2	5	The awkward fall left a scab.	Sensible	Literal
2	6	The awkward defeat left a scab.	Sensible	Metaphorical
2	7	The awkward fall left a tune.	Anomalous	Literal
2	8	The awkward defeat left a tune.	Anomalous	Metaphorical
3	9	His hard grip left a bruise.	Sensible	Literal
3	10	His hard letter left a bruise.	Sensible	Metaphorical
3	11	His hard grip left a reflection.	Anomalous	Literal
3	12	His hard letter left a reflection.	Anomalous	Metaphorical
4	13	Her view of the concert was hazy.	Sensible	Literal
4	14	Her description of the concert was hazy.	Sensible	Metaphorical
4	15	Her view of the concert was light.	Anomalous	Literal
4	16	Her description of the concert was light.	Anomalous	Metaphorical
5	17	The secretary's grapes were sweet.	Sensible	Literal
5	18	The secretary's tooth was sweet.	Sensible	Metaphorical
5	19	The secretary's grapes were restless.	Anomalous	Literal
5	20	The secretary's tooth was restless.	Anomalous	Metaphorical
6	21	The early man is cheerful.	Sensible	Literal
6	22	The early sun is cheerful.	Sensible	Metaphorical
6	23	The early man is dark.	Anomalous	Literal
6	24	The early sun is dark.	Anomalous	Metaphorical
7	25	The script made the parent happy.	Sensible	Literal
7	26	The script made the novel happy.	Sensible	Metaphorical
7	27	The script made the parent hazy.	Anomalous	Literal
7	28	The script made the novel hazy.	Anomalous	Metaphorical
8	29	The car's engine surface was smooth.	Sensible	Literal
8	30	The car's engine performance was smooth.	Sensible	Metaphorical
8	31	The car's engine surface was happy.	Anomalous	Literal
8	32	The car's engine performance was happy.	Anomalous	Metaphorical
9	33	The workman's hair was rough.	Sensible	Literal
9	34	The workman's voice was rough.	Sensible	Metaphorical
9	35	The workman's hair was still.	Anomalous	Literal
9	36	The workman's voice was still.	Anomalous	Metaphorical
10	37	The biggest flame was bright.	Sensible	Literal

10	38	The biggest eyes were bright.	Sensible	Metaphorical
10	39	The biggest flame was silent.	Anomalous	Literal
10	40	The biggest eyes were silent.	Anomalous	Metaphorical
11	41	The dark statue was still.	Sensible	Literal
11	42	The dark night was still.	Sensible	Metaphorical
11	43	The dark statue was cheerful.	Anomalous	Literal
11	44	The dark night was cheerful.	Anomalous	Metaphorical
12	45	The stable she investigated was dark.	Sensible	Literal
12	46	The journal she investigated was dark.	Sensible	Metaphorical
12	47	The stable she investigated was boiling.	Anomalous	Literal
12	48	The journal she investigated was boiling.	Anomalous	Metaphorical
13	49	Her morning tea was cold.	Sensible	Literal
13	50	Her morning expression was cold.	Sensible	Metaphorical
13	51	Her morning tea was roaring.	Anomalous	Literal
13	52	Her morning expression was roaring.	Anomalous	Metaphorical
14	53	The author's street is silent.	Sensible	Literal
14	54	The author's pages are silent.	Sensible	Metaphorical
14	55	The author's street is swollen.	Anomalous	Literal
14	56	The author's pages are swollen.	Anomalous	Metaphorical
15	57	The disco singer moved to the beat.	Sensible	Literal
15	58	The disco lights moved to the beat.	Sensible	Metaphorical
15	59	The disco singer moved to the fright.	Anomalous	Literal
15	60	The disco lights moved to the fright.	Anomalous	Metaphorical
16	61	The bad accident caused a jolt.	Sensible	Literal
16	62	The bad news caused a jolt.	Sensible	Metaphorical
16	63	The bad accident caused a thirst.	Anomalous	Literal
16	64	The bad news caused a thirst.	Anomalous	Metaphorical
17	65	The young horse is at a gallop.	Sensible	Literal
17	66	The young woman is at a gallop.	Sensible	Metaphorical
17	67	The young horse is at a whisper.	Anomalous	Literal
17	68	The young woman is at a whisper.	Anomalous	Metaphorical
18	69	The colourful person finished with a shout.	Sensible	Literal
18	70	The colourful pamphlet finished with a shout.	Sensible	Metaphorical
18	71	The colourful person finished with a beat.	Anomalous	Literal
18	72	The colourful pamphlet finished with a beat.	Anomalous	Metaphorical
19	73	The man's race was a marathon.	Sensible	Literal
19	74	The man's day was a marathon.	Sensible	Metaphorical
19	75	The man's race was a voice.	Anomalous	Literal
19	76	The man's day was a voice.	Anomalous	Metaphorical
20	77	The girl fell in her dream.	Sensible	Literal
20	78	The girl accomplished her dream.	Sensible	Metaphorical
20	79	The girl fell in her vomit.	Anomalous	Literal
20	80	The girl accomplished her vomit.	Anomalous	Metaphorical

21	81	The clever politician caused a blow.	Sensible	Literal
21	82	The clever plan caused a blow.	Sensible	Metaphorical
21	83	The clever politician caused a marathon.	Anomalous	Literal
21	84	The clever plan caused a marathon.	Anomalous	Metaphorical
22	85	His snakes are restless.	Sensible	Literal
22	86	His nerves are restless.	Sensible	Metaphorical
22	87	His snakes are sweet.	Anomalous	Literal
22	88	His nerves are sweet.	Anomalous	Metaphorical
23	89	The quiet child let out a whisper.	Sensible	Literal
23	90	The quiet wind let out a whisper.	Sensible	Metaphorical
23	91	The quiet child let out a gallop.	Anomalous	Literal
23	92	The quiet wind let out a gallop.	Anomalous	Metaphorical
24	93	The frightful collision left a scar.	Sensible	Literal
24	94	The frightful separation left a scar.	Sensible	Metaphorical
24	95	The frightful collision left a song.	Anomalous	Literal
24	96	The frightful separation left a song.	Anomalous	Metaphorical
25	97	From the lonely doctor came a cry.	Sensible	Literal
25	98	From the lonely heart came a cry.	Sensible	Metaphorical
25	99	From the lonely doctor came a flash.	Anomalous	Literal
25	100	From the lonely heart came a flash.	Anomalous	Metaphorical
26	101	The little bear was roaring.	Sensible	Literal
26	102	The little car was roaring.	Sensible	Metaphorical
26	103	The little bear was exhausted.	Anomalous	Literal
26	104	The little car was exhausted.	Anomalous	Metaphorical
27	105	The mouse on the left gave a screech.	Sensible	Literal
27	106	The wheel on the left gave a screech.	Sensible	Metaphorical
27	107	The mouse on the left gave a caress.	Anomalous	Literal
27	108	The wheel on the left gave a caress.	Anomalous	Metaphorical
28	109	The fat guy caused a thump.	Sensible	Literal
28	110	The fat letter caused a thump.	Sensible	Metaphorical
28	111	The fat guy caused a hike.	Anomalous	Literal
28	112	The fat letter caused a hike.	Anomalous	Metaphorical
29	113	From his lonely monkey came a howl.	Sensible	Literal
29	114	From his lonely core came a howl.	Sensible	Metaphorical
29	115	From his lonely monkey came a drill.	Anomalous	Literal
29	116	From his lonely core came a drill.	Anomalous	Metaphorical
30	117	Her active snail was awake.	Sensible	Literal
30	118	Her active head was awake.	Sensible	Metaphorical
30	119	Her active snail was cold.	Anomalous	Literal
30	120	Her active head was cold.	Anomalous	Metaphorical
31	121	The hands of the patient were waving.	Sensible	Literal
31	122	The leaves on the tree were waving.	Sensible	Metaphorical
31	123	The hands of the patient were craving.	Anomalous	Literal

31	124	The leaves on the tree were craving.	Anomalous	Metaphorical
32	125	The man was soaked in lots of sweat.	Sensible	Literal
32	126	The man was soaked in buckets of sweat.	Sensible	Metaphorical
32	127	The man was soaked in lots of sleep.	Anomalous	Literal
32	128	The man was soaked in buckets of sleep.	Anomalous	Metaphorical
33	129	The noisy lightning was over with a flash.	Sensible	Literal
33	130	The noisy race was over in a flash.	Sensible	Metaphorical
33	131	The noisy lightning was over with a swallow.	Anomalous	Literal
33	132	The noisy race was over in a swallow.	Anomalous	Metaphorical
34	133	Their strong light cast a shadow.	Sensible	Literal
34	134	Their strong doubt cast a shadow.	Sensible	Metaphorical
34	135	Their strong light cast a sweat.	Anomalous	Literal
34	136	Their strong doubt cast a sweat.	Anomalous	Metaphorical
35	137	The long movie gave a fright.	Sensible	Literal
35	138	The long speech was a fright.	Sensible	Metaphorical
35	139	The long movie gave a kiss.	Anomalous	Literal
35	140	The long speech was a kiss.	Anomalous	Metaphorical
36	141	The boy made the triangle ring.	Sensible	Literal
36	142	The triangle made her head ring.	Sensible	Metaphorical
36	143	The boy made the triangle limp.	Anomalous	Literal
36	144	The triangle made her head limp.	Anomalous	Metaphorical
37	145	The school girl's remark was a spite.	Sensible	Literal
37	146	The girl's school was filled with spite.	Sensible	Metaphorical
37	147	The school girl's remark was a collapse.	Anomalous	Literal
37	148	The girl's school was filled with collapse.	Anomalous	Metaphorical
38	149	From the subtle husband came a caress.	Sensible	Literal
38	150	From the subtle smile came a caress.	Sensible	Metaphorical
38	151	From the subtle husband came a stumble.	Anomalous	Literal
38	152	From the subtle smile came a stumble.	Anomalous	Metaphorical
39	153	The lively dog had an itch.	Sensible	Literal
39	154	The lively boy was an itch.	Sensible	Metaphorical
39	155	The lively dog had a ring.	Anomalous	Literal
39	156	The lively boy was a ring.	Anomalous	Metaphorical
40	157	The industrial waste caused suffocation.	Sensible	Literal
40	158	The industrial speech caused suffocation.	Sensible	Metaphorical
40	159	The industrial waste caused waving.	Anomalous	Literal
40	160	The industrial speech caused waving.	Anomalous	Metaphorical
41	161	The difficult rubble caused a slip.	Sensible	Literal
41	162	The difficult discussion caused a slip.	Sensible	Metaphorical
41	163	The difficult rubble caused a dream.	Anomalous	Literal
41	164	The difficult discussion caused a dream.	Anomalous	Metaphorical
42	165	Defeating the destructive army was a fight.	Sensible	Literal
42	166	Defeating the destructive cancer was a fight.	Sensible	Metaphorical

42	167	Defeating the destructive army was a splash.	Anomalous	Literal
42	168	Defeating the destructive cancer was a splash.	Anomalous	Metaphorical
43	169	On the surface, the big ball made a splash.	Sensible	Literal
43	170	On the cover, the big singer made a splash.	Sensible	Metaphorical
43	171	On the surface, the big ball made a squeeze.	Anomalous	Literal
43	172	On the cover, the big singer made a squeeze.	Anomalous	Metaphorical
44	173	The tricky jump caused a fall.	Sensible	Literal
44	174	The tricky examination caused a fall.	Sensible	Metaphorical
44	175	The tricky jump caused a shadow.	Anomalous	Literal
44	176	The tricky examination caused a shadow.	Anomalous	Metaphorical
45	177	Her awkwardly placed stool made her stumble.	Sensible	Literal
45	178	Her awkwardly placed words made her stumble.	Sensible	Metaphorical
45	179	Her awkwardly placed stool made her whip.	Anomalous	Literal
45	180	Her awkwardly placed words made her whip.	Anomalous	Metaphorical
46	181	The unexpected crash made his car slide.	Sensible	Literal
46	182	The unexpected crash made his bank balance slide.	Sensible	Metaphorical
46	183	The unexpected crash made his car stink.	Anomalous	Literal
46	184	The unexpected crash made his bank balance stink.	Anomalous	Metaphorical
47	185	The long path was a hike.	Sensible	Literal
47	186	The long essay was a hike.	Sensible	Metaphorical
47	187	The long path was a screech.	Anomalous	Literal
47	188	The long essay was a screech.	Anomalous	Metaphorical
48	189	He dressed in a hurry and his trousers were a squeeze.	Sensible	Literal
48	190	He dressed in a hurry and time was a squeeze.	Sensible	Metaphorical
48	191	He dressed in a hurry and his trousers were a howl.	Anomalous	Literal
48	192	He dressed in a hurry and time was a howl.	Anomalous	Metaphorical
49	193	The shiny drum produced a tune.	Sensible	Literal
49	194	The shiny river produced a tune.	Sensible	Metaphorical
49	195	The shiny drum produced a scab.	Anomalous	Literal
49	196	The shiny river produced a scab.	Anomalous	Metaphorical
50	197	From the gushing mother came a laugh.	Sensible	Literal
50	198	From the gushing river came a laugh.	Sensible	Metaphorical
50	199	From the gushing mother came a bruise.	Anomalous	Literal
50	200	From the gushing river came a bruise.	Anomalous	Metaphorical
51	201	From the old man's mouse came a squeal.	Sensible	Literal
51	202	From the old man's hip came a squeal.	Sensible	Metaphorical
51	203	From the old man's mouse came a fight.	Anomalous	Literal
51	204	From the old man's hip came a fight.	Anomalous	Metaphorical
52	205	His rushed attempt received praise.	Sensible	Literal
52	206	His rushed attempt demanded praise.	Sensible	Metaphorical
52	207	His rushed attempt received spite.	Anomalous	Literal
52	208	His rushed attempt demanded spite.	Anomalous	Metaphorical
53	209	From the distant room came a voice.	Sensible	Literal

53	210	From the distant lake came a voice.	Sensible	Metaphorical
53	211	From the distant room came a blink.	Anomalous	Literal
53	212	From the distant lake came a blink.	Anomalous	Metaphorical
54	213	In the empty lake was a reflection.	Sensible	Literal
54	214	In the empty portrait was a reflection.	Sensible	Metaphorical
54	215	In the empty lake was a row.	Anomalous	Literal
54	216	In the empty portrait was a row.	Anomalous	Metaphorical
55	217	From the short student she received a push.	Sensible	Literal
55	218	From the short letter she received a push.	Sensible	Metaphorical
55	219	From the short student she received an itch.	Anomalous	Literal
55	220	From the short letter she received an itch.	Anomalous	Metaphorical
56	221	His quick dog was in the race.	Sensible	Literal
56	222	His quick mind was in the race.	Sensible	Metaphorical
56	223	His quick dog was in the shout.	Anomalous	Literal
56	224	His quick mind was in the shout.	Anomalous	Metaphorical
57	225	The loose screws caused a collapse.	Sensible	Literal
57	226	His loose screws caused his collapse.	Sensible	Metaphorical
57	227	The loose screws caused a sigh.	Anomalous	Literal
57	228	His loose screws caused his sigh.	Anomalous	Metaphorical
58	229	From the beautiful cinema came a light.	Sensible	Literal
58	230	From the beautiful baby came a light.	Sensible	Metaphorical
58	231	From the beautiful cinema came a crack.	Anomalous	Literal
58	232	From the beautiful baby came a crack.	Anomalous	Metaphorical
59	233	His loud tool was a drill.	Sensible	Literal
59	234	His loud wife was a drill.	Sensible	Metaphorical
59	235	His loud tool was a slide.	Anomalous	Literal
59	236	His loud wife was a slide.	Anomalous	Metaphorical
60	237	The large wall began to crack.	Sensible	Literal
60	238	The large man began to crack.	Sensible	Metaphorical
60	239	The large wall began to cry.	Anomalous	Literal
60	240	The large man began to cry.	Anomalous	Metaphorical
61	241	The University sink was full of vomit.	Sensible	Literal
61	242	The University essay was full of vomit.	Sensible	Metaphorical
61	243	The University sink was full of suffocation.	Anomalous	Literal
61	244	The University essay was full of suffocation.	Anomalous	Metaphorical
62	245	His final mixture was hard to swallow.	Sensible	Literal
62	246	His final smell was hard to swallow.	Sensible	Metaphorical
62	247	His final mixture was hard to bleed.	Anomalous	Literal
62	248	His final smell was hard to bleed.	Anomalous	Metaphorical
63	249	Changing her domestic lightbulb was a stretch.	Sensible	Literal
63	250	Changing her domestic lifestyle was a stretch.	Sensible	Metaphorical
63	251	Changing her domestic lightbulb was a shiver.	Anomalous	Literal
63	252	Changing her domestic lifestyle was a shiver.	Anomalous	Metaphorical

64	253	After the bump her head was swollen.	Sensible	Literal
64	254	After the comment her head was swollen.	Sensible	Metaphorical
64	255	After the bump her head was awake.	Anomalous	Literal
64	256	After the comment her head was awake.	Anomalous	Metaphorical
65	257	Her strong curry was boiling.	Sensible	Literal
65	258	Her strong temper was boiling.	Sensible	Metaphorical
65	259	Her strong curry was bright.	Anomalous	Literal
65	260	Her strong temper was bright.	Anomalous	Metaphorical
66	261	Their love for meat was a craving.	Sensible	Literal
66	262	Their love for each other was a craving.	Sensible	Metaphorical
66	263	Their love for meat was a stretch.	Anomalous	Literal
66	264	Their love for each other was a stretch.	Anomalous	Metaphorical
67	265	After a long opera he went to sleep.	Sensible	Literal
67	266	After a long life he went to sleep.	Sensible	Metaphorical
67	267	After a long opera he went to fall.	Anomalous	Literal
67	268	After a long life he went to fall.	Anomalous	Metaphorical
68	269	From her new purse came a stink.	Sensible	Literal
68	270	From his new story came a stink.	Sensible	Metaphorical
68	271	From her new purse came a wound.	Anomalous	Literal
68	272	From his new story came a wound.	Anomalous	Metaphorical
69	273	The ancient fireman was exhausted.	Sensible	Literal
69	274	The ancient tree was exhausted.	Sensible	Metaphorical
69	275	The ancient fireman was smooth.	Anomalous	Literal
69	276	The ancient tree was smooth.	Anomalous	Metaphorical
70	277	The punishment she received for talking was a whip.	Sensible	Literal
70	278	The scolding she received for talking was a whip.	Sensible	Metaphorical
70	279	The punishment she received for talking was a praise.	Anomalous	Literal
70	280	The scolding she received for talking was a praise.	Anomalous	Metaphorical
71	281	The slow flock ran with a limp.	Sensible	Literal
71	282	The slow brain ran with a limp.	Sensible	Metaphorical
71	283	The slow flock ran with a laugh.	Anomalous	Literal
71	284	The slow brain ran with a laugh.	Anomalous	Metaphorical
72	285	Her unusual harmony was a song.	Sensible	Literal
72	286	Her unusual charm was a song.	Sensible	Metaphorical
72	287	Her unusual harmony was a blow.	Anomalous	Literal
72	288	Her unusual charm was a blow.	Anomalous	Metaphorical
73	289	Her husband`s breath was a sigh.	Sensible	Literal
73	290	The love for her husband was a sigh.	Sensible	Metaphorical
73	291	Her husband`s breath was a jolt.	Anomalous	Literal
73	292	The love for her husband was a jolt.	Anomalous	Metaphorical
74	293	The singer's voice made her shiver.	Sensible	Literal
74	294	The singer's voice made the stadium shiver.	Sensible	Metaphorical
74	295	The singer's voice made her slip.	Anomalous	Literal

74	296	The singer's voice made the stadium slip.	Anomalous	Metaphorical
75	297	The emotional moment caused a blink.	Sensible	Literal
75	298	The emotional moment was over in a blink.	Sensible	Metaphorical
75	299	The emotional moment caused a push.	Anomalous	Literal
75	300	The emotional moment was over in a push.	Anomalous	Metaphorical
76	301	Her need for chocolate was a hunger.	Sensible	Literal
76	302	Her need for shoes was a hunger.	Sensible	Metaphorical
76	303	Her need for chocolate was a scar.	Anomalous	Literal
76	304	Her need for shoes was a scar.	Anomalous	Metaphorical
77	305	The butler and his master had a row.	Sensible	Literal
77	306	The butler and his head had a row.	Sensible	Metaphorical
77	307	The butler and his master had a thump.	Anomalous	Literal
77	308	The butler and his head had a thump.	Anomalous	Metaphorical
78	309	The spring lamb gave him a kiss.	Sensible	Literal
78	310	The spring breeze gave him a kiss.	Sensible	Metaphorical
78	311	The spring lamb gave him a race.	Anomalous	Literal
78	312	The spring breeze gave him a race.	Anomalous	Metaphorical
79	313	The sharp nail made him bleed.	Sensible	Literal
79	314	The sharp mouth made him bleed.	Sensible	Metaphorical
79	315	The sharp nail made him rough.	Anomalous	Literal
79	316	The sharp mouth made him rough.	Anomalous	Metaphorical
80	317	A little walk caused a thirst.	Sensible	Literal
80	318	A little book caused a thirst.	Sensible	Metaphorical
80	319	A little walk caused a squeal.	Anomalous	Literal
80	320	A little book caused a squeal.	Anomalous	Metaphorical

Welsh sentences / Brawddegau Cymraeg

Item	*Sentence*	*Welsh Sentences*	*Sensibility*	*Figurativeness*
81	321	Gadawodd y ddamwain ryfedd friw.	sensible	Literal
81	322	Gadawodd y datganiad rhyfedd friw.	sensible	Metaphorical
81	323	Gadawodd y ddamwain ryfedd newyn.	anomalous	Literal
81	324	Gadawodd y datganiad rhyfedd newyn.	anomalous	Metaphorical
82	325	Gadawodd y codwm chwithig grachen.	sensible	literal
82	326	Gadawodd y trechiad chwithig grachen.	sensible	Metaphorical
82	327	Gadawodd y codwm chwithig alaw.	anomalous	literal
82	328	Gadawodd y trechiad chwithig alaw.	anomalous	Metaphorical
83	329	Gadawodd ei afael caled glais.	sensible	literal
83	330	Gadawodd ei lythyrcaled glais.	sensible	Metaphorical
83	331	Gadawodd ei afael caled adlewyrchiad.	anomalous	literal

83	332	Gadawodd ei lythyr caled adlewyrchiad.	anomalous	Metaphorical
84	333	Roedd ei golwg o'r cyngerdd yn niwlog.	sensible	literal
84	334	Roedd ei disgrifiad o'r cyngerdd yn niwlog.	sensible	Metaphorical
84	335	Roedd ei golwg o'r cyngerdd yn olau.	anomalous	literal
84	336	Roedd ei disgrifiad o'r cyngerdd yn olau.	anomalous	Metaphorical
85	337	Roedd grawnwin yr ysgrifenyddes yn felys.	sensible	literal
85	338	Roedd dant yr ysgrifenyddes yn felys.	sensible	Metaphorical
85	339	Roedd grawnwin yr ysgrifenyddesyn aflonydd.	anomalous	literal
85	340	Roedd dant yr ysgrifenyddes yn aflonydd.	anomalous	Metaphorical
86	341	Mae'r dyn cynnaryn llon.	sensible	Literal
86	342	Mae'r haul cynnar yn llon.	sensible	Metaphorical
86	343	Mae'r dyn cynnar yn dywyll.	anomalous	Literal
86	344	Mae'r haul cynnaryn dywyll.	anomalous	Metaphorical
87	345	Gwnaeth y sgript y rhiant yn hapus.	sensible	literal
87	346	Gwnaeth y sgripty nofel yn hapus.	sensible	Metaphorical
87	347	Gwnaeth y sgript y rhiant yn niwlog.	anomalous	literal
87	348	Gwnaeth y sgript y nofel yn niwlog.	anomalous	Metaphorical
88	349	Roedd wyneb injan y car yn llyfn.	sensible	literal
88	350	Roedd perfformiad injan y car yn llyfn.	sensible	Metaphorical
88	351	Roedd wyneb injan y caryn hapus.	anomalous	literal
88	352	Roedd perfformiad injan y car yn hapus.	anomalous	Metaphorical
89	353	Roedd gwallt y gweithiwr yn arw.	sensible	literal
89	354	Roedd llais y gweithiwr yn arw.	sensible	Metaphorical
89	355	Roedd gwallt y gweithiwr yn llonydd.	anomalous	literal
89	356	Roedd llais y gweithiwr yn llonydd.	anomalous	Metaphorical
90	357	Roedd y fflam fwyaf yn ddisglair.	sensible	literal
90	358	Roedd y llygaid mwyaf yn ddisglair.	sensible	Metaphorical
90	359	Roedd y fflam fwyaf yn dawel.	anomalous	literal
90	360	Roedd y llygaid mwyaf yn dawel.	anomalous	Metaphorical
91	361	Roedd y ddelw dywyll yn llonydd.	sensible	Literal
91	362	Roedd y noson dywyll yn llonydd.	sensible	Metaphorical
91	363	Roedd y ddelw dywyll yn llon .	anomalous	Literal
91	364	Roedd y noson dywyll yn llon.	anomalous	Metaphorical
92	365	Roedd y stabl a archwiliodd yn dywyll.	sensible	literal
92	366	Roedd y siwrnal a archwiliodd yn dywyll.	sensible	Metaphorical
92	367	Roedd y stabl a archwiliodd yn berwi.	anomalous	literal
92	368	Roedd y siwrnal a archwilioddyn berwi.	anomalous	Metaphorical
93	369	Roedd ei the boreol yn oer.	sensible	literal
93	370	Roedd ei mynegiant boreol yn oer.	sensible	Metaphorical
93	371	Roedd ei the boreol yn rhuo.	anomalous	literal
93	372	Roedd ei mynegiant boreol yn rhuo.	anomalous	Metaphorical
94	373	Mae stryd yr awdur yn dawel.	sensible	literal
94	374	Mae tudalennau’r awdur yn dawel.	sensible	Metaphorical

94	375	Mae stryd yr awdur wedi chwyddo.	anomalous	literal
94	376	Mae tudalennau’r awdurwedi chwyddo.	anomalous	Metaphorical
95	377	Symudodd y canwrdisgo i'r curiad.	sensible	literal
95	378	Symudodd y goleuadau disgo i'r curiad.	sensible	Metaphorical
95	379	Symudodd y canwr disgo i'r braw.	anomalous	literal
95	380	Symudodd y goleuadau disgo i'r braw.	anomalous	Metaphorical
96	381	Achosodd y ddamwain ddrwg ysgytiad.	sensible	Literal
96	382	Achosodd y newyddion drwg ysgytiad.	sensible	Metaphorical
96	383	Achosodd y ddamwain ddrwg syched.	anomalous	Literal
96	384	Achosodd y newyddion drwg syched.	anomalous	Metaphorical
97	385	Mae'r ceffyl ifanc ar garlam.	sensible	literal
97	386	Mae'r ddynes ifanc ar garlam.	sensible	Metaphorical
97	387	Mae'r ceffyl ifanc ar sibrwd.	anomalous	literal
97	388	Mae'r ddynes ifanc ar sibrwd.	anomalous	Metaphorical
98	389	Gorffennodd y person lliwgar gyda bloedd.	sensible	literal
98	390	Gorffennodd y pamffled lliwgar gyda bloedd.	sensible	Metaphorical
98	391	Gorffennodd y person lliwgar gyda curiad.	anomalous	literal
98	392	Gorffennodd y pamffled lliwgar gyda curiad.	anomalous	Metaphorical
99	393	Roedd ras y dyn yn farathon.	sensible	literal
99	394	Roedd diwrnod y dyn yn farathon.	sensible	Metaphorical
99	395	Roedd ras y dyn yn lais.	anomalous	literal
99	396	Roedd diwrnod y dyn yn lais.	anomalous	Metaphorical
100	397	Disgynnodd y ferch yn ei breuddwyd.	sensible	literal
100	398	Cyflawnodd y ferch ei breuddwyd.	sensible	Metaphorical
100	399	Disgynnodd y ferch yn ei chwd.	anomalous	literal
100	400	Cyflawnodd y ferch ei chwd.	anomalous	Metaphorical
101	401	Achosodd y gwleidydd clyfar ergyd.	sensible	Literal
101	402	Achosodd y cynllun clyfar ergyd.	sensible	Metaphorical
101	403	Achosodd y gwleidydd clyfar farathon.	anomalous	Literal
101	404	Achosodd y cynllun clyfar farathon.	anomalous	Metaphorical
102	405	Mae ei nadroedd yn aflonydd.	sensible	literal
102	406	Mae ei nerfau yn aflonydd.	sensible	Metaphorical
102	407	Mae ei nadroedd yn felys.	anomalous	literal
102	408	Mae ei nerfau yn felys.	anomalous	Metaphorical
103	409	Rhoddodd y plentyn tawel sibrydiad.	sensible	literal
103	410	Rhoddodd y gwynt tawel sibrydiad.	sensible	Metaphorical
103	411	Rhoddodd y plentyn tawel garlam.	anomalous	literal
103	412	Rhoddodd y gwynt tawel garlam.	anomalous	Metaphorical
104	413	Gadawodd y gwrthdrawiad dychrynllyd graith.	sensible	literal
104	414	Gadawodd y gwahaniad dychrynllyd graith.	sensible	Metaphorical
104	415	Gadawodd y gwrthdrawiad dychrynllyd gan.	anomalous	literal
104	416	Gadawodd y gwahaniad dychrynllyd gan.	anomalous	Metaphorical
105	417	O'r doctor unigdaeth waedd.	sensible	literal

105	418	O'r galon unig daeth waedd.	sensible	Metaphorical
105	419	O'r doctor unig daeth fflach.	anomalous	literal
105	420	O'r galon unigdaeth fflach.	anomalous	Metaphorical
106	421	Roedd yr arth fach yn rhuo.	sensible	Literal
106	422	Roedd y car bach yn rhuo.	sensible	Metaphorical
106	423	Roedd yr arth fachyn blino.	anomalous	Literal
106	424	Roedd y car bach yn blino.	anomalous	Metaphorical
107	425	Roddodd y llygoden ar y chwith sgrech.	sensible	literal
107	426	Roddodd yr olwyn ar y chwith sgrech.	sensible	Metaphorical
107	427	Roddodd y llygoden ar y chwith fwythau.	anomalous	literal
107	428	Roddodd yr olwyn ar y chwith fwythau.	anomalous	Metaphorical
108	429	Achosodd yr hogyn tew bwniad.	sensible	literal
108	430	Achosodd y llythyr tew bwniad.	sensible	Metaphorical
108	431	Achosodd yr hogyn tew daith.	anomalous	literal
108	432	Achosodd y llythyr tew daith.	anomalous	Metaphorical
109	433	O'i fwnci unigdaeth udiad.	sensible	literal
109	434	O'i graidd unigdaeth udiad.	sensible	Metaphorical
109	435	O'i fwnci unig daeth dril.	anomalous	literal
109	436	O'i graidd unig daeth dril.	anomalous	Metaphorical
110	437	Roedd ei falwoden actif yn effro.	sensible	literal
110	438	Roedd ei phen actif yn effro.	sensible	Metaphorical
110	439	Roedd ei falwoden actif yn oer.	anomalous	literal
110	440	Roedd ei phen actif yn oer.	anomalous	Metaphorical
111	441	Roedd dwylo'r claf yn chwifio.	sensible	Literal
111	442	Roedd y dail ar y goeden yn chwifio.	sensible	Metaphorical
111	443	Roedd dwylo'r claf yn chwant.	anomalous	Literal
111	444	Roedd y dail ar y goeden yn chwant.	anomalous	Metaphorical
112	445	Roedd y dyn yn socian mewn lot o chwys.	sensible	literal
112	446	Roedd y dyn yn socian mewn bwcedi o chwys.	sensible	Metaphorical
112	447	Roedd y dyn yn socian mewn lot o gwsg.	anomalous	literal
112	448	Roedd y dyn yn socian mewn bwcedi o gwsg.	anomalous	Metaphorical
113	449	Roedd y mellt swnllyd drosodd gyda fflach.	sensible	literal
113	450	Roedd y ras swnllyd drosodd mewn fflach.	sensible	Metaphorical
113	451	Roedd y mellt swnllyd drosodd gyda llwnc.	anomalous	literal
113	452	Roedd y ras swnllyd drosoddmewn llwnc.	anomalous	Metaphorical
114	453	Taflodd eu golau cryf gysgod.	sensible	literal
114	454	Taflodd eu hamheuaeth gryf gysgod.	sensible	Metaphorical
114	455	Taflodd eu golau cryf chwys.	anomalous	literal
114	456	Taflodd eu hamheuaeth gryf chwys.	anomalous	Metaphorical
115	457	Rhoddodd y ffilm hir fraw.	sensible	literal
115	458	Roedd yr araith hiryn fraw.	sensible	Metaphorical
115	459	Rhoddodd y ffilm hir sws.	anomalous	literal
115	460	Roedd yr araith hir yn sws.	anomalous	Metaphorical

116	461	Gwnaeth y bachgen i'r triongl ganu.	sensible	Literal
116	462	Gwnaeth y triongl i'w phen ganu.	sensible	Metaphorical
116	463	Gwnaeth y bachgen i'r triongl hercian.	anomalous	Literal
116	464	Gwnaeth y triongl i'w phen hercian.	anomalous	Metaphorical
117	465	Roedd sylwad y ferch ysgol yn sbeit.	sensible	literal
117	466	Roedd ysgol y ferchyn llawn sbeit.	sensible	Metaphorical
117	467	Roedd sylwad y ferch yn gwymp.	anomalous	literal
117	468	Roedd ysgol y ferch yn llawn gwymp.	anomalous	Metaphorical
118	469	Gan y gwr dyner daeth mwythau.	sensible	literal
118	470	Gan yr awel dyner daeth mwythau.	sensible	Metaphorical
118	471	Gan y gwr dyner daeth faglad.	anomalous	literal
118	472	Gan yr awel dyner daeth faglad.	anomalous	Metaphorical
119	473	Roedd gan y ci bywiog gosiad.	sensible	literal
119	474	Roedd yr hogyn bywiog yn gosiad.	sensible	Metaphorical
119	475	Roedd gan y ci bywiog gân.	anomalous	literal
119	476	Roedd yr hogyn bywiog yn gân.	anomalous	Metaphorical
120	477	Achosodd y gwastraff masnachol dagiad.	sensible	literal
120	478	Achosodd yr araith fasnachol dagiad.	sensible	Metaphorical
120	479	Achosodd y gwastraff masnachol chwifiad.	anomalous	literal
120	480	Achosodd yr araith fasnachol chwifiad.	anomalous	Metaphorical
121	481	Achosodd y rwbel anodd lithriad.	sensible	Literal
121	482	Achosodd y drafodaeth anodd lithriad.	sensible	Metaphorical
121	483	Achosodd y rwbel anodd freuddwyd.	anomalous	Literal
121	484	Achosodd y drafodaeth anodd freuddwyd.	anomalous	Metaphorical
122	485	Roedd trechu'r fyddin ddinistriol yn frwydr.	sensible	literal
122	486	Roedd trechu'r cancr dinistriol yn frwydr.	sensible	Metaphorical
122	487	Roedd trechu'r fyddin ddinistriol yn sblash.	anomalous	literal
122	488	Roedd trechu'r cancr dinistriol yn sblash.	anomalous	Metaphorical
123	489	Ar yr wyneb, gwnaeth y bel mawr sblash.	sensible	literal
123	490	Ar y clawr, gwnaeth y canwr mawr sblash.	sensible	Metaphorical
123	491	Ar yr wyneb, gwnaeth y bel mawr wasgu.	anomalous	literal
123	492	Ar y clawr, gwnaeth y canwr mawr wasgu.	anomalous	Metaphorical
124	493	Achosodd y naid gymhleth syrthiad.	sensible	literal
124	494	Achosodd yr arholiad cymhleth syrthiad.	sensible	Metaphorical
124	495	Achosodd y naid gymhleth gysgod.	anomalous	literal
124	496	Achosodd yr arholiad cymhleth gysgod.	anomalous	Metaphorical
125	497	Gwnaeth lleoliad lletchwith ei stôl iddi faglu.	sensible	literal
125	498	Gwnaeth lleoliad lletchwith ei geiriau iddi faglu.	sensible	Metaphorical
125	499	Gwnaeth lleoliad lletchwith ei stôl iddi chwipio.	anomalous	literal
125	500	Gwnaeth lleoliad lletchwith ei geiriau iddi chwipio.	anomalous	Metaphorical
126	501	Gwnaeth y ddamwain annisgwyl i'w gar lithro.	sensible	Literal
126	502	Gwnaeth y ddamwain annisgwyl i falans ei fanc lithro.	sensible	Metaphorical
126	503	Gwnaeth y ddamwain annisgwyl i'w gar ddrewi.	anomalous	Literal

126	504	Gwnaeth y ddamwain annisgwyl i falans ei fanc ddrewi.	anomalous	Metaphorical
127	505	Roedd y llwybr hir yn daith.	sensible	literal
127	506	Roedd y traethawd hir yn daith.	sensible	Metaphorical
127	507	Roedd y llwybr hir yn sgrech.	anomalous	literal
127	508	Roedd y traethawd hir yn sgrech.	anomalous	Metaphorical
128	509	Gwisgodd mewn brys ac roedd ei drowsus yn gwasgu.	sensible	literal
128	510	Gwisgodd mewn brys ac roedd amser yn gwasgu.	sensible	Metaphorical
128	511	Gwisgodd mewn brys ac roedd ei drowsus yn udo.	anomalous	literal
128	512	Gwisgodd mewn brys ac roedd amser yn udo.	anomalous	Metaphorical
129	513	Cynhyrchodd y drwm gloyw alaw.	sensible	literal
129	514	Cynhyrchodd yr afon loyw alaw.	sensible	Metaphorical
129	515	Cynhyrchodd y drwm gloyw grachen.	anomalous	literal
129	516	Cynhyrchodd yr afon loyw grachen.	anomalous	Metaphorical
130	517	O'r fam fyrlymus daeth chwerthiniad.	sensible	literal
130	518	O'r afon fyrlymus daeth chwerthiniad.	sensible	Metaphorical
130	519	O'r fam fyrlymus daeth clais.	anomalous	literal
130	520	O'r afon fyrlymus daeth clais.	anomalous	Metaphorical
131	521	O lygoden yr hen ddyn daeth gwich.	sensible	Literal
131	522	O glun yr hen ddyn daeth gwich.	sensible	Metaphorical
131	523	O lygoden yr hen ddyn daeth brwydr.	anomalous	Literal
131	524	O glun yr hen ddyn daeth brwydr.	anomalous	Metaphorical
132	525	Derbyniodd ei ymgais brys glod.	sensible	literal
132	526	Mynnodd ei ymgais brys glod.	sensible	Metaphorical
132	527	Derbyniodd ei ymgais brys sbeit.	anomalous	literal
132	528	Mynnodd ei ymgaisbrys sbeit.	anomalous	Metaphorical
133	529	O'r ystafell bell daeth llais.	sensible	literal
133	530	O'r llyn pell daeth llais.	sensible	Metaphorical
133	531	O'r ystafell bell daeth chwinciad.	anomalous	literal
133	532	O'r llyn pell daeth chwinciad.	anomalous	Metaphorical
134	533	Yn y llyn gwagoedd adlewyrchiad.	sensible	literal
134	534	Yn y darlun gwag oedd adlewyrchiad.	sensible	Metaphorical
134	535	Yn y llyn gwag oedd ffrae.	anomalous	literal
134	536	Yn y darlun gwag oedd ffrae.	anomalous	Metaphorical
135	537	Gan y ferch fer derbyniodd wthiad.	sensible	literal
135	538	Gan y llythyr byr derbyniodd wthiad.	sensible	Metaphorical
135	539	Gan y ferch fer derbyniodd gosiad.	anomalous	literal
135	540	Gan y llythyr byr derbyniodd gosiad.	anomalous	Metaphorical
136	541	Roedd ei gi cyflym yn ras.	sensible	Literal
136	542	Roedd ei feddwl cyflym yn ras.	sensible	Metaphorical
136	543	Roedd ei gi cyflym yn floedd.	anomalous	Literal
136	544	Roedd ei feddwl cyflymyn floedd.	anomalous	Metaphorical
137	545	Achosodd y sgriwiau llac gwymp.	sensible	literal
137	546	Achosodd ei sgriwiau llac ei gwymp.	sensible	Metaphorical

137	547	Achosodd y sgriwiau llac ochenaid.	anomalous	literal
137	548	Achosodd ei sgriwiau llac ei ochenaid.	anomalous	Metaphorical
138	549	O'r sinema brydferth daeth golau.	sensible	literal
138	550	O'r baban prydferth daeth golau.	sensible	Metaphorical
138	551	O'r sinema brydferth daeth cracio.	anomalous	literal
138	552	O'r baban prydferth daeth cracio.	anomalous	Metaphorical
139	553	Roedd ei offeryn uchel yn ddril.	sensible	literal
139	554	Roedd ei wraig uchel yn ddril.	sensible	Metaphorical
139	555	Roedd ei offeryn uchel yn lithriad.	anomalous	literal
139	556	Roedd ei wraig uchel yn lithriad.	anomalous	Metaphorical
140	557	Dechreuodd y wal fawr gracio.	sensible	literal
140	558	Dechreuodd y dyn mawr gracio.	sensible	Metaphorical
140	559	Dechreuodd y wal fawr waeddi.	anomalous	literal
140	560	Dechreuodd y dynmawr waeddi.	anomalous	Metaphorical
141	561	Roedd sinc y Brifysgol yn llawn chwd.	sensible	Literal
141	562	Roedd traethawd y brifysgol yn llawn chwd.	sensible	Metaphorical
141	563	Roedd sinc y Brifysgol yn llawn tagiad.	anomalous	Literal
141	564	Roedd traethawd y brifysgol yn llawn tagiad.	anomalous	Metaphorical
142	565	Roedd ei gymysgfa derfynol yn anodd i'w lyncu.	sensible	literal
142	566	Roedd ei oglau terfynol yn anodd i'w lyncu.	sensible	Metaphorical
142	567	Roedd ei gymysgfa derfynol yn anodd i'w waedu.	anomalous	literal
142	568	Roedd ei oglau terfynol yn anodd i'w waedu.	anomalous	Metaphorical
143	569	Roedd newid ei bwlb domestigyn ymestyniad.	sensible	literal
143	570	Roedd newid ei ffordd o fyw domestig yn ymestyniad.	sensible	Metaphorical
143	571	Roedd newid ei bwlb domestig yn gryniad.	anomalous	literal
143	572	Roedd newid ei ffordd o fyw domestig yn gryniad.	anomalous	Metaphorical
144	573	Wedi'r gwrthdrawiad roedd ei phen wedi chwyddo.	sensible	literal
144	574	Wedi'r sylw roedd ei phenwedi chwyddo.	sensible	Metaphorical
144	575	Wedi'r gwrthdrawiad roedd ei phen wedi deffro.	anomalous	literal
144	576	Wedi'r sylw roedd ei phen wedi deffro.	anomalous	Metaphorical
145	577	Roedd ei chyri cryf yn berwi.	sensible	literal
145	578	Roedd ei thempar cryf yn berwi.	sensible	Metaphorical
145	579	Roedd ei chyri cryf yn ddisglair.	anomalous	literal
145	580	Roedd ei thempar cryf yn ddisglair.	anomalous	Metaphorical
146	581	Roedd eu cariad at gig yn yn chwant.	sensible	Literal
146	582	Roedd eu cariad at ei gilydd yn chwant.	sensible	Metaphorical
146	583	Roedd eu cariad at gig yn ymestyniad.	anomalous	Literal
146	584	Roedd eu cariad at ei gilydd ynyn ymestyniad.	anomalous	Metaphorical
147	585	Wedi opera hir fe aeth i gysgu.	sensible	literal
147	586	Wedi bywyd hir fe aeth i gysgu.	sensible	Metaphorical
147	587	Wedi opera hir fe aeth i syrthio.	anomalous	literal
147	588	Wedi bywyd hir fe aeth i syrthio.	anomalous	Metaphorical
148	589	O'i phwrs newydd daeth drewdod.	sensible	literal

148	590	O'i stori newydd daeth drewdod.	sensible	Metaphorical
148	591	O'i phwrs newydd daeth briw.	anomalous	literal
148	592	O'i stori newydd daeth briw.	anomalous	Metaphorical
149	593	Roedd yr hen ddyn tan wedi blino.	sensible	literal
149	594	Roedd yr hen goeden wedi blino.	sensible	Metaphorical
149	595	Roedd yr hen ddyn tan yn llyfn.	anomalous	literal
149	596	Roedd yr hen goedenyn llyfn.	anomalous	Metaphorical
150	597	Y gosb a gafwyd hi am siarad oedd chwip.	sensible	literal
150	598	Roedd y ffrae a gafwyd hi am siarad yn chwip.	sensible	Metaphorical
150	599	Y gosb a gafwyd hi am siarad oedd clod.	anomalous	literal
150	600	Roedd y ffrae a gafwyd hi am siarad yn glod.	anomalous	Metaphorical
151	601	Rhedodd yr haid araf gyda herc.	sensible	Literal
151	602	Rhedodd yr ymennydd araf gyda herc.	sensible	Metaphorical
151	603	Rhedodd yr haid arafgyda chwerthiniad.	anomalous	Literal
151	604	Rhedodd yr ymennydd araf gyda chwerthiniad.	anomalous	Metaphorical
152	605	Roedd ei harmoni anghyffredinyn gân.	sensible	literal
152	606	Roedd ei swyn anghyffredin yn gân.	sensible	Metaphorical
152	607	Roedd ei harmoni anghyffredin yn ergyd.	anomalous	literal
152	608	Roedd ei swyn anghyffredin yn ergyd.	anomalous	Metaphorical
153	609	Roedd anadl ei gwr yn ochenaid.	sensible	literal
153	610	Roedd ei chariad i’w gwr yn ochenaid.	sensible	Metaphorical
153	611	Roedd anadl ei gwr yn ysgytiad.	anomalous	literal
153	612	Roedd ei chariad i’w gwr yn ysgytiad.	anomalous	Metaphorical
154	613	Gwnaeth lais y canwr iddi grynu.	sensible	literal
154	614	Gwnaeth lais y canwr i'r stadiwn grynu.	sensible	Metaphorical
154	615	Gwnaeth lais y canwr iddi lithro.	anomalous	literal
154	616	Gwnaeth lais y canwr i'r stadiwn lithro.	anomalous	Metaphorical
155	617	Achosodd y foment emosiynol chwinciad.	sensible	literal
155	618	Gorffennodd y foment emosiynol mewn chwinciad.	sensible	Metaphorical
155	619	Achosodd y foment emosiynol wthiad.	anomalous	literal
155	620	Gorffennodd y foment emosiynol mewn gwthiad.	anomalous	Metaphorical
156	621	Roedd ei hangen am siocled yn newyn.	sensible	Literal
156	622	Roedd ei hangen am esgidiau yn newyn.	sensible	Metaphorical
156	623	Roedd ei hangen am siocled yn graith.	anomalous	Literal
156	624	Roedd ei hangen am esgidiau yn graith.	anomalous	Metaphorical
157	625	Cafodd y bwtler a'i feistr ffrae.	sensible	literal
157	626	Cafodd y bwtler a'i ben ffrae.	sensible	Metaphorical
157	627	Cafodd y bwtler a'i feistr bwniad.	anomalous	literal
157	628	Cafodd y bwtler a'i ben bwniad.	anomalous	Metaphorical
158	629	Iddo ef, rhoddodd oen ygwanwyn sws.	sensible	literal
158	630	Iddo ef, rhoddodd awel ygwanwyn sws.	sensible	Metaphorical
158	631	Iddo ef, rhoddodd oen ygwanwyn ras.	anomalous	literal
158	632	Iddo ef, rhoddodd awel ygwanwyn ras.	anomalous	Metaphorical

159	633	Gwnaeth yr hoelen finiog iddo waedu.	sensible	literal
159	634	Gwnaeth y geg finiog iddo waedu.	sensible	Metaphorical
159	635	Gwnaeth y geg finiogo'n arw.	anomalous	literal
159	636	Gwnaeth y geg finiog o'n arw.	anomalous	Metaphorical
160	637	Achosodd gerddediad bychan syched.	sensible	literal
160	638	Achosodd lyfr bychan syched.	sensible	Metaphorical
160	639	Achosodd gerddediad bychan wich.	anomalous	literal
160	640	Achosodd lyfr bychan wich.	anomalous	Metaphorical

Appendix F

Experimental stimuli used in chapter 4

Atodiad F

Ysgogiadau arbrofol a ddefnyddir ym mhennod 4

Item	*Sentence*	*Sentence*	*Condition*
1	1	On this winter evening, the wind is thin.	Welsh
1	2	On this winter evening, the wind is a scratch.	Acceptable
1	3	On this winter evening, the wind is a beetle.	Anomalous
1	4	On this winter evening, the wind is freezing.	Best
2	5	After calling the doctor, she went to the appointment on her head.	Welsh
2	6	After calling the doctor, she went to the appointment on her belly.	Acceptable
2	7	After calling the doctor, she went to the appointment on her cloth.	Anomalous
2	8	After calling the doctor, she went to the appointment on her bike.	Best
3	9	In his youth, John was a bit of a bird.	Welsh
3	10	In his youth, John was a bit of a fart.	Acceptable
3	11	In his youth, John was a bit of an armpit.	Anomalous
3	12	In his youth, John was a bit of a rebel.	Best
4	13	Beth thought her employer was a bit of a slice.	Welsh
4	14	Beth thought her employer was a bit of a poo.	Acceptable
4	15	Beth thought her employer was a bit of a cage.	Anomalous
4	16	Beth thought her employer was a bit of a weirdo.	Best
5	17	Dan spoke like a pepper mill.	Welsh
5	18	Dan spoke like a peppery mouth.	Acceptable
5	19	Dan spoke like a peppery creature.	Anomalous
5	20	Dan spoke like a peppery comedian.	Best
6	21	She thought the woman was an old hat.	Welsh
6	22	She thought the woman was an old face.	Acceptable
6	23	She thought the woman was an old blue.	Anomalous
6	24	She thought the woman was an old hag.	Best
7	25	After he forgot the appointment, she called him a funnel.	Welsh
7	26	After he forgot the appointment, she called him a mule.	Acceptable
7	27	After he forgot the appointment, she called him the best side.	Anomalous
7	28	After he forgot the appointment, she called him a fool.	Best
8	29	Lisa was told off for being a cloth.	Welsh
8	30	Lisa was told off for being second.	Acceptable
8	31	Lisa was told off for being a roof.	Anomalous
8	32	Lisa was told off for being a brat.	Best
9	33	The man on reception was a bit of an old nose.	Welsh
9	34	The man on reception was a bit of an old square.	Acceptable
9	35	The man on reception was a bit of an old eye.	Anomalous
9	36	The man on reception was a bit of an old romantic.	Best
10	37	Her experienced yoga teacher was an old mouth.	Welsh
10	38	Her experienced yoga teacher was an old bird.	Acceptable
10	39	Her experienced yoga teacher was an old field.	Anomalous
10	40	Her experienced yoga teacher was an old hippie.	Best
11	41	After her father ate everything, the woman called him an old belly.	Welsh

11	42	After her father ate everything, the woman called him an old barrel.	Acceptable
11	43	After her father ate everything, the woman called him an old ear.	Anomalous
11	44	After her father ate everything, the woman called him an old pig.	Best
12	45	The car thieves managed to pass the blue.	Welsh
12	46	The car thieves managed to pass the gate.	Acceptable
12	47	The car thieves managed to pass the fist.	Anomalous
12	48	The car thieves managed to pass the police.	Best
13	49	She skipped the networking buffet, but was told off for having a face.	Welsh
13	50	She skipped the networking buffet, but was told off for having a sandwich.	Acceptable
13	51	She skipped the networking buffet, but was told off for having a funnel.	Anomalous
13	52	She skipped the networking buffet, but was told off for having a excuse.	Best
14	53	Her friends were shocked when they saw Megan hooking.	Welsh
14	54	Her friends were shocked when they saw Megan's feet.	Acceptable
14	55	Her friends were shocked when they saw Megan's blue.	Anomalous
14	56	Her friends were shocked when they saw Megan's behaviour.	Best
15	57	Once she sat on the horse, he realised Mia was a hook.	Welsh
15	58	Once she sat on the horse, he realised Mia was holding.	Acceptable
15	59	Once she sat on the horse, he realised Mia was a place.	Anomalous
15	60	Once she sat on the horse, he realised Mia was a catch.	Best
16	61	He walked oddly as his shoes were boats.	Welsh
16	62	He walked oddly as his shoes were scratching.	Acceptable
16	63	He walked oddly as his shoes were money.	Anomalous
16	64	He walked oddly as his shoes were uncomfortable.	Best
17	65	He was told off by his father for being a sandwich.	Welsh
17	66	He was told off by his father for being too thin.	Acceptable
17	67	He was told off by his father for being a gate.	Anomalous
17	68	He was told off by his father for being a nuisance.	Best
18	69	The public thought the impersonator was a case.	Welsh
18	70	The public thought the impersonator was an ear.	Acceptable
18	71	The public thought the impersonator was a face.	Anomalous
18	72	The public thought the impersonator was a hoot.	Best
19	73	To pay for his new boat, the fisherman is scratching.	Welsh
19	74	To pay for his new boat, the fisherman is hooking.	Acceptable
19	75	To pay for his new boat, the fisherman is a slice.	Anomalous
19	76	To pay for his new boat, the fisherman is borrowing.	Best
20	77	When she read his texts, she realised he was a bit of a beetle.	Welsh
20	78	When she read his texts, she realised he was a bit of a cuckoo.	Acceptable
20	79	When she read his texts, she realised he was a bit of hands.	Anomalous
20	80	When she read his texts, she realised he was a bit of an idiot.	Best
21	81	The girl was in bed, waiting for the phone call on spikes.	Welsh
21	82	The girl was in bed, waiting for the phone call on her belly.	Acceptable
21	83	The girl was in bed, waiting for the phone call on her fart.	Anomalous
21	84	The girl was in bed, waiting for the phone call on television.	Best

22	85	After a nap in the park, she woke up like a cuckoo.	Welsh
22	86	After a nap in the park, she woke up like a pigeon.	Acceptable
22	87	After a nap in the park, she woke up like a mill.	Anomalous
22	88	After a nap in the park, she woke up like a zombie.	Best
23	89	His mum was upset when she found out the sugar had got feet.	Welsh
23	90	His mum was upset when she found out the sugar had got a beetle.	Acceptable
23	91	His mum was upset when she found out the sugar had got hooking.	Anomalous
23	92	His mum was upset when she found out the sugar had got hard.	Best
24	93	The furious fashion designer was breaking poo.	Welsh
24	94	The furious fashion designer was breaking a hat.	Acceptable
24	95	The furious fashion designer was breaking a mouth.	Anomalous
24	96	The furious fashion designer was breaking records.	Best
25	97	The funny mechanic was talking through his hat.	Welsh
25	98	The funny mechanic was talking through his funnel.	Acceptable
25	99	The funny mechanic was talking through his mill.	Anomalous
25	100	The funny mechanic was talking through his joke.	Best
26	101	After her birthday party, Ann was like a calf.	Welsh
26	102	After her birthday party, Ann showed her best side.	Acceptable
26	103	After her birthday party, Ann was like a belly.	Anomalous
26	104	After her birthday party, Ann was like a zombie.	Best
27	105	In this petting zoo, the main attraction is like a fart.	Welsh
27	106	In this petting zoo, the main attraction is a calf.	Acceptable
27	107	In this petting zoo, the main attraction is like spikes.	Anomalous
27	108	In this petting zoo, the main attraction is a rabbit.	Best
28	109	Morgan hated the smell of the six place.	Welsh
28	110	Morgan hated the smell of his armpit.	Acceptable
28	111	Morgan hated the smell of the hook.	Anomalous
28	112	Morgan hated the smell of his fridge.	Best
29	113	After the deal, the yacht salesman was disappointed on the best side.	Welsh
29	114	After the deal, the yacht salesman was disappointed on the boats.	Acceptable
29	115	After the deal, the yacht salesman was disappointed on the nose.	Anomalous
29	116	After the deal, the yacht salesman was disappointed on the outcome.	Best
30	117	He was criticised by his friend for being a front horse.	Welsh
30	118	He was criticised by his friend for being in front of his eye.	Acceptable
30	119	He was criticised by his friend for being a front hat.	Anomalous
30	120	He was criticised by his friend for being a front runner.	Best
31	121	The builder realised the rotten beam was the bad in the cheese.	Welsh
31	122	The builder realised the rotten beam was the bad in the roof.	Acceptable
31	123	The builder realised the rotten beam was the bad in the hat.	Anomalous
31	124	The builder realised the rotten beam was the bad in the building.	Best
32	125	The romantic father looked for the candle of his eye.	Welsh
32	126	The romantic father looked for the candle in his case.	Acceptable
32	127	The romantic father looked for the candle in his poo.	Anomalous

32	128	The romantic father looked for the candle of his lantern.	Best
33	129	He was uncomfortable because his bum was square.	Welsh
33	130	He was uncomfortable because his bum was blue.	Acceptable
33	131	He was uncomfortable because his bum was a goblin.	Anomalous
33	132	He was uncomfortable because his bum was sore.	Best
34	133	She came out of the store smiling like a gate.	Welsh
34	134	She came out of the store smiling like a goblin.	Acceptable
34	135	She came out of the store smiling like a sandwich.	Anomalous
34	136	She came out of the store smiling like a cat .	Best
35	137	Everyone heard him in the kitchen breaking sky.	Welsh
35	138	Everyone heard him in the kitchen breaking a teapot.	Acceptable
35	139	Everyone heard him in the kitchen breaking a belly.	Anomalous
35	140	Everyone heard him in the kitchen breaking a glass.	Best
36	141	He went to bed after swallowing a mule.	Welsh
36	142	He went to bed after swallowing a slice.	Acceptable
36	143	He went to bed after swallowing a scratch.	Anomalous
36	144	He went to bed after swallowing a pill.	Best
37	145	He walked to the shop with the wind in his fist.	Welsh
37	146	He walked to the shop with the wind in his hat.	Acceptable
37	147	He walked to the shop with the wind in his spikes.	Anomalous
37	148	He walked to the shop with the wind in his hair.	Best
38	149	In the competition, the chef tried his best blue.	Welsh
38	150	In the competition, the chef tried his best cheese.	Acceptable
38	151	In the competition, the chef tried his best head.	Anomalous
38	152	In the competition, the chef tried his best recipe.	Best
39	153	After three pints his mouth was like a camel's armpit.	Welsh
39	154	After three pints his mouth was like a cloth.	Acceptable
39	155	After three pints his mouth was like a bird.	Anomalous
39	156	After three pints his mouth was like a desert.	Best
40	157	After the crisis, the companies were in the same field.	Welsh
40	158	After the crisis, the companies were in the same place.	Acceptable
40	159	After the crisis, the companies were in the same teapot.	Anomalous
40	160	After the crisis, the companies were in the same situation.	Best
41	161	She had strange taste in men, because he was a bit of a creature.	Welsh
41	162	She had strange taste in men, because he was a bit of a fist.	Acceptable
41	163	She had strange taste in men, because he was a bit of boats.	Anomalous
41	164	She had strange taste in men, because he was a bit of a flirt.	Best
42	165	She could depend on her director to be an ear.	Welsh
42	166	She could depend on her director to be a head.	Acceptable
42	167	She could depend on her director to be a calf.	Anomalous
42	168	She could depend on her director to be a leader.	Best
43	169	Mari lost her temper because the girl was a tail.	Welsh
43	170	Mari lost her temper because the girl was all hands.	Acceptable

43	171	Mari lost her temper because the girl was a cheese.	Anomalous
43	172	Mari lost her temper because the girl was a bully.	Best
44	173	On deck the pirate had a face like a cow.	Welsh
44	174	On deck the pirate had a face like a hook.	Acceptable
44	175	On deck the pirate had a face like a barrel.	Anomalous
44	176	On deck the pirate had a face like an angel.	Best
45	177	After they finished painting, the grandmother said her grandson was a goblin.	Welsh
45	178	After they finished painting, the grandmother said her grandson was blue.	Acceptable
45	179	After they finished painting, the grandmother said her grandson was a cow.	Anomalous
45	180	After they finished painting, the grandmother said her grandson was a brat.	Best
46	181	He got the saddle because he was first to the mill.	Welsh
46	182	He got the saddle because he was first to the horse.	Acceptable
46	183	He got the saddle because he was first to the square.	Anomalous
46	184	He got the saddle because he was first to the stable.	Best
47	185	She expected them to lose but she got second.	Welsh
47	186	She expected them to lose but they got the money.	Acceptable
47	187	She expected them to lose but she got a case.	Anomalous
47	188	She expected them to lose but she got disappointed.	Best
48	189	The farmer and his wife were on thorn spikes.	Welsh
48	190	The farmer and his wife were in a thorn field.	Acceptable
48	191	The farmer and his wife were on thorn head.	Anomalous
48	192	The farmer and his wife were on a thorn hill.	Best
49	193	Sarah hated the customer because she was a pigeon.	Welsh
49	194	Sarah hated the customer because she was a cow.	Acceptable
49	195	Sarah hated the customer because she was a sky.	Anomalous
49	196	Sarah hated the customer because she was a nightmare.	Best
50	197	His carelessness caused his supervisor to go to the top of the cage.	Welsh
50	198	His carelessness caused his supervisor to go to the top of the mill.	Acceptable
50	199	His carelessness caused his supervisor to go to the top of the mule.	Anomalous
50	200	His carelessness caused his supervisor to go to the top of the company.	Best
51	201	She acted like her boyfriend was a rock of money.	Welsh
51	202	She acted like her boyfriend was a rock of spikes.	Acceptable
51	203	She acted like her boyfriend was a rock of horse.	Anomalous
51	204	She acted like her boyfriend was a rock of gold.	Best
52	205	Harry told his friends that his fat teacher was a teapot.	Welsh
52	206	Harry told his friends that his fat teacher was head.	Acceptable
52	207	Harry told his friends that his fat teacher was thin.	Anomalous
52	208	Harry told his friends that his fat teacher was an imbecile.	Best
53	209	The man with a fluffy beard behaved like a sheep's head.	Welsh
53	210	The man's fluffy beard looked like a sheep's tail.	Acceptable
53	211	The man with a fluffy beard behaved like a sheep's feet.	Anomalous
53	212	The man's fluffy beard looked like a sheep's fleece.	Best
54	213	He was so adventurous, the gliding instructor told him to go scratch.	Welsh

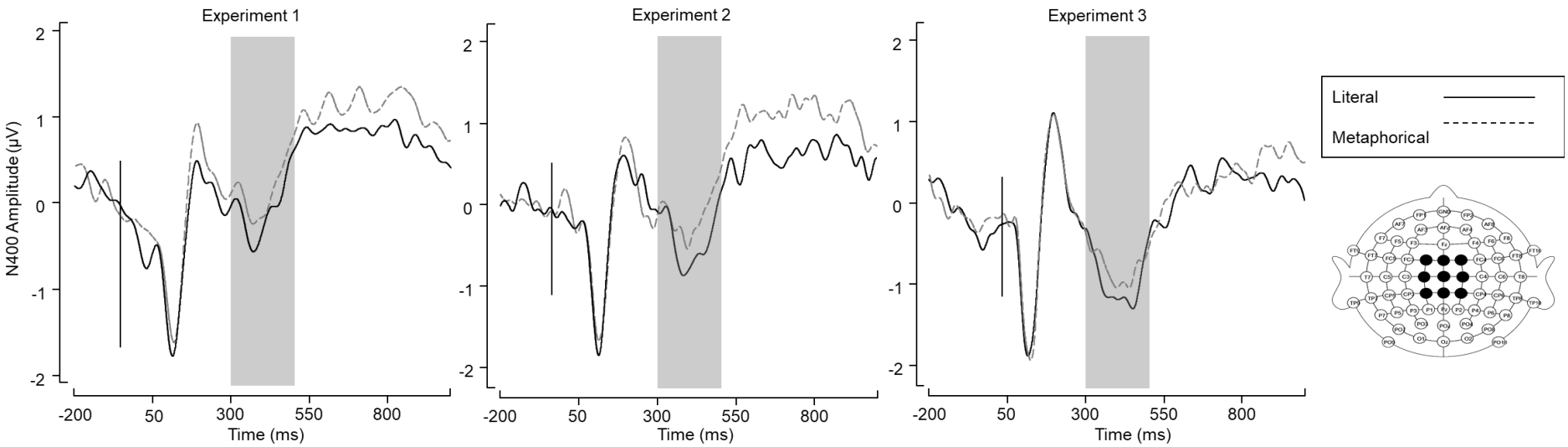
54	214	He was so adventurous, the gliding instructor told him to go for the sky.	Acceptable
54	215	He was so adventurous, the gliding instructor told him to go the tail.	Anomalous
54	216	He was so adventurous, the gliding instructor told him to go for it.	Best
55	217	After the disastrous barn dance, he put the violin in the roof.	Welsh
55	218	After the disastrous barn dance, he put the violin in the mill.	Acceptable
55	219	After the disastrous barn dance, he put the violin in the scratching.	Anomalous
55	220	After the disastrous barn dance, he put the violin in the case.	Best
56	221	On the cold mountain, the wind is holding.	Welsh
56	222	On the cold mountain, the wind is likespikes.	Acceptable
56	223	On the cold mountain, the wind is acuckoo.	Anomalous
56	224	On the cold mountain, the wind is strong.	Best
57	225	Toward the end of their relationship, her boyfriend was like a barrel.	Welsh
57	226	Toward the end of their relationship, her boyfriend was like a cage.	Acceptable
57	227	Toward the end of their relationship, her boyfriend was like a holding.	Anomalous
57	228	Toward the end of their relationship, her boyfriend was like a friend.	Best
58	229	He was sent to jail for having hairy hands.	Welsh
58	230	He was sent to jail for having a hairy creature.	Acceptable
58	231	He was sent to jail for having a hairy second.	Anomalous
58	232	He was sent to jail for having a hairy chest.	Best
59	233	The hotel kitchen was as dark as a cow's belly.	Welsh
59	234	The hotel kitchen was as dark as a cow's nose.	Acceptable
59	235	The hotel kitchen was as dark as a cow's pigeon.	Anomalous
59	236	The hotel kitchen was as dark as a cow's spots.	Best

Appendix G

Illustration of metaphor detection in Welsh across experiments 1a, 1b and 2

Atodiad G

Darlun o ganfod trosiad yn Gymraeg ar draws arbrofion 1a, 1b a 2


Experiment 1
Experiment 2
Experiment 3
N400 Amplitude (μV)
2
1
0
-1
-2
-200
50
300
550
800
Time (ms)
Literal
Metaphorical