DOCTOR OF PHILOSOPHY

Cross-linguistic treatment generalisation in Welsh-English bilingual aphasia

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Award date:
2013

Awarding institution:
Bangor University

CROSS-LINGUISTIC TREATMENT GENERALISATION IN WELSH-ENGLISH BILINGUAL APHASIA

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A thesis submitted to the School of Psychology, Bangor University, in partial fulfilment of the requirements for the Degree of Doctor of Philosophy.

2013

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ABSTRACT

Background: Rehabilitation of language disorders in bilinguals is a relatively new field of research, with few studies concerned with the treatment of acquired aphasia in bilingual people having been reported, particularly with respect to the treatment of dysgraphia. Capitalising on successful approaches to diagnosis and treatment of aphasia in both monolinguals and bilinguals, this thesis investigates the effectiveness of model-based therapy following damage to language processing in Welsh-English bilingual individuals. It contributes to discovering the most effective approaches to rehabilitation in bilingual aphasia and informs theories of bilingual language processing.

Objectives: 1) To discover whether cross-linguistic treatment generalisation may occur in Welsh-English bilingual aphasia; 2) To explore generalisation as a function of deficit type, language of treatment, and stimuli used; 3) To inform theories of bilingual word processing using patterns of treatment generalisation.

Methods: Bilingual individuals with aphasia took part in studies of model-based language rehabilitation. A phonemic cueing treatment targeting severe anomia, a delayed-copy spelling protocol targeting lexical and graphemic buffer deficits, and a sublexical spelling therapy are described. It was hypothesised that all participants would show treatment-specific gains, and predictions regarding within and between-language generalisation varied according to the language and type of therapy, and the nature of the deficit.

Results: As predicted, within-language improvement in untreated items was observed in all participants. Between-language effects varied according to deficit: cross-language generalisation was observed in treatment of phonological output (cognates only), graphemic buffer, and sublexical deficits.

Conclusions: This is the first research exploring Welsh-English bilingual aphasia therapy, and also includes the first studies of bilingual dysgraphia therapy. It supports previous research in both monolinguals and bilinguals, regarding benefits of therapy to different deficits, but also provides new evidence that cross-language treatment generalisation can occur in bilingual dysgraphia. It also contributes toward developing theories of bilingual language processing, particularly in terms of spelling.

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LIST OF ABBREVIATIONS

ACT – Anagram and Copy Treatment

ANOVA – Analysis of Variance

BIA – Bilingual Interactive Activation

BL – Baseline

CART – Copy and Recall Treatment

CSE – Cognate Superiority Effect

DRM – Dual Route Model

FU – Follow-up

GB – Graphemic Buffer

MRI – Magnetic Resonance Imaging

OOL – Orthographic Output Lexicon

PDP – Parallel-Distribution Processing

PIE – Phonologically Implausible Error

PPE – Phonologically Plausible Error

PT – Post-test

SFA – Semantic Feature Analysis

DECLARATION

This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

Signed………………………………………………

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This dissertation is the result of my own independent work/investigation, except where otherwise stated. A list of references is appended.

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For my mum

ACKNOWLEDGEMENTS

I would like to take this opportunity to thank my PhD supervisor, Marie-Josephe Tainturier, for her guidance, advice and encouragement. Her knowledge and expertise have been invaluable.

I would like to thank my other supervisory committee members, Ginny Gathercole and Guillaume Thierry, for their contributions in review meetings. Thank you also to Daniel Roberts and Nicola Savill for their valuable help.

I would also like to express my appreciation to CWS, HBL and RON for making the research possible. They were a delight to work with. Diolch yn fawr.

The School of Psychology in Bangor University provided me with a 1+3 studentship, for which I would like to express my gratitude.

Last, but by no means least, I would like to thank Sheila and Sam Roberts for being such wonderful and supportive parents; also to my dear friends for their continued encouragement throughout.

THESIS OVERVIEW

This thesis explores therapy in Welsh-English bilingual aphasia. The investigation consists of three experimental studies, the overall aim of which was to discover the effectiveness of therapy targeting different acquired language impairments and, importantly, whether effects of treating one language might generalise to the untreated language.

The first chapter describes models of monolingual and bilingual word processing. It also introduces a working model of bilingual spelling that was to be used in designing two of the experimental chapters. Chapter 2 reviews the literature on spoken naming deficits and their treatment in monolinguals and bilinguals, and then discusses written language (reading and spelling) deficits and their treatment in monolinguals and bilinguals. The rationale, aims and predictions of the experimental chapters are then introduced.

The first experimental chapter (Chapter 3) is an exploration of spoken naming treatment in bilingual anomia. This study used a progressive cueing hierarchy protocol and sought to discover whether cross-linguistic treatment transfer might occur in Welsh-English bilingual anomia therapy. It contrasts generalisation of cognate versus non-cognate stimuli, as well as looking at the effects of repeated naming attempts in the absence of feedback. Results are discussed in relation to cognitive neuropsychological models of single word processing, and to previous findings in bilingual spoken naming therapy data.

Chapter 4 describes a model-based treatment study of bilingual dysgraphia, contrasting the effect of treatment on two spelling deficits (orthographic output lexicon, and graphemic buffer). A delayed-copy treatment protocol, based on that of Rapp and Kane (2002), aimed to discover whether treatment effects would vary as a function of the level of the deficit, and also as a function of the language treated.

The final study (Chapter 5) investigates sublexical therapy in bilingual mixed dysgraphia, aimed at aiding re-learning impaired phoneme-grapheme mappings. It is the first study that directly contrasts the effects of treating mappings that are shared between languages with those that are divergent, in bilingual acquired dysgraphia.

Chapter 6 is a general discussion of the findings of the treatment studies. The overall findings of the research are described in relation to predictions made based on previous literature and models of language processing. Implications for spelling and spoken naming in developing models of bilingual single word processing are outlined, as are implications for clinical practice. Limitations and future perspectives of the research are discussed, followed by concluding remarks.

INTRODUCTION

Spoken and written language production generally occurs effortlessly in fluent speakers of any language but when neurological damage occurs, this processing can become effortful and errorful. Extensive research exists exploring the mechanisms involved in monolingual word processing and the most effective treatment methods of acquired language impairments in monolinguals. This is not the case for bilingualism.

Bilingualism refers to the ability to speak two (or more) languages. Bilingual aphasia refers to acquired language disorders such as dyslexia, dysgraphia and anomia in speakers of more than one language. Research into different aspects of bilingualism is fast growing and vital given over half of the world's population of speaks more than one language (Ansaldo, Marcotte, Scherer & Raboyeau, 2008; Azarpazhooh, Jahangiri & Ghaleh, 2010). But there remain many unanswered questions and unresolved arguments in bilingual language processing and treatment research in bilinguals. Therapists are seeing growing number of bilingual people (Marrero, Golden & Espe-Pfeifer, 2002), but as yet there has been no resolutions as to the most effective approach to treating bilingual aphasia, or to what extent treatment effects can generalise both within and between languages.

This research contributes to a better understanding of bilingual word processing, particularly with respect to spelling and spoken naming. It tests hypotheses regarding the functional architecture of bilingual word processing by analysing patterns of generalisation in bilingual spelling and spoken naming therapy. It also aims to contribute to discovering the most effective treatment methods and patterns of generalisation in bilingual aphasia.

The first chapter of the introduction will present models of single word monolingual and bilingual spoken word production, followed by models of monolingual written production, and a working model of bilingual written production. The second chapter explores language disorders and their treatment in both monolingual and bilingual people, before introducing the experimental chapters.

CHAPTER 1: MODELS OF SPOKEN AND WRITTEN WORD PRODUCTION

CHAPTER 1: MODELS OF SPOKEN AND WRITTEN WORD PRODUCTION

Theories of bilingual word processing extract and adapt fundamental features from the theories of language processing in monolinguals. This mostly applies to spoken word production, and there is, as yet, no model that describes spelling in bilinguals. Thus, it is first necessary to briefly summarise models of monolingual word processing, before proceeding to describe their bilingual counterparts. Among many classifications of models, an important distinction is that of localist versus distributed models: "In localist models, a word or a concept is represented by a single, unitary processing node in the network, whereas in distributed models, information about a word or concept is distributed across several or many units of processing" (Li & Farkas, 2002, pp.60; see also Elman, 2009).

Monolingual and bilingual models of spoken word production are described first. Monolingual models of reading and spelling are then described, and then models of written word processing (reading), before introducing a working model of bilingual spelling. The predictions of the working model are derived from monolingual spelling models, but also from theories of bilingual speech processing.

1.1: MODELS OF SPOKEN WORD PRODUCTION

1.1.1. MONOLINGUAL MODELS OF SPOKEN WORD PRODUCTION

Models of spoken word production generally explain word production in terms of spreading activation through a localist non-distributed network, and agree on two stages of lexical access: the lexical item corresponding to an intended meaning (semantics) is activated in the first stage; and in the second stage, the phonological properties are retrieved and the word is articulated.

The Syntactic Mediation and Independent Networks Hypotheses are presented in Figure 1.1. The Syntactic Mediation Hypothesis suggests that access to word-forms is mediated by prior access to lexical-syntactic representations (e.g. Dell, 1990; Levelt, Roelofs & Meyer, 1999; Roelofs, 1997), whereas Independent Networks Hypothesis (Caramazza, 1997), argues that grammatical information about words is represented separately and word-form representations can receive activation directly from semantics, without syntactic mediation. Despite the difference in their predictions about accessing syntactic information, both agree that there is a semantic level, a word-form level, and a phonological level to spoken word production.

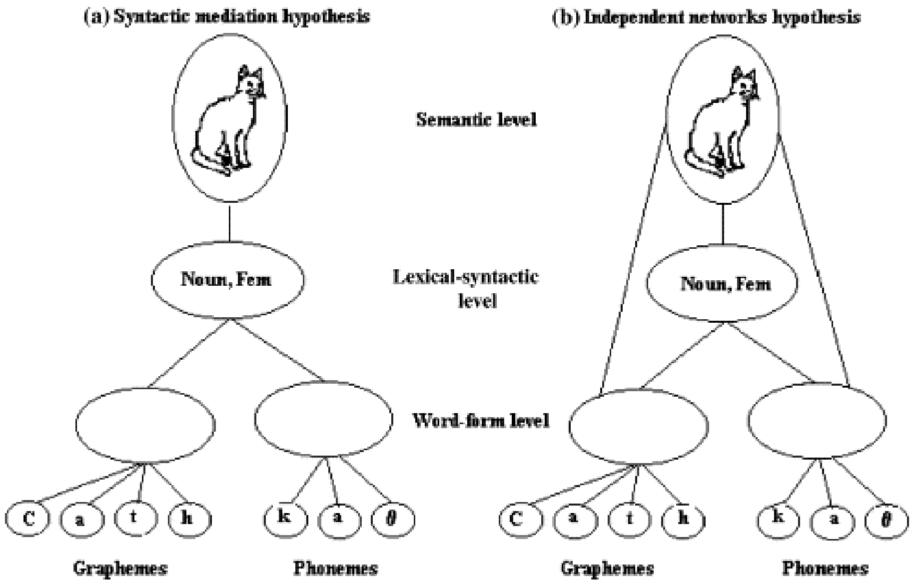

Figure 1.1. Illustration of the Syntactic Mediation Hypothesis and the Independent Networks hypothesis (From Leek, Wyn & Tainturier, 2003).

Dell et al.'s (1997) two-step interactive activation model is a computational model of the lexical network (Figure 1.2) adapted from the Interactive Activation Model of visual word recognition by McClelland and Rumelhart (1981), to explain the processes involved in speech production. Like the Syntactic Mediation and Independent Networks hypotheses, it includes a semantic level, a word-form level and phonology: activation of semantic feature nodes spreads to word-form or lemma nodes, before activating phoneme nodes. Unlike the previously mentioned models, the Interactive Activation model proposed by Dell et al. (1997) is an interactive model, where bi-directional connections link words to their semantic features and phonemes (hence 'interactive'). Each word corresponds to a single unit in the word layer, thus although it is a connectionist model, it also includes localist representations (i.e. word-form representations).

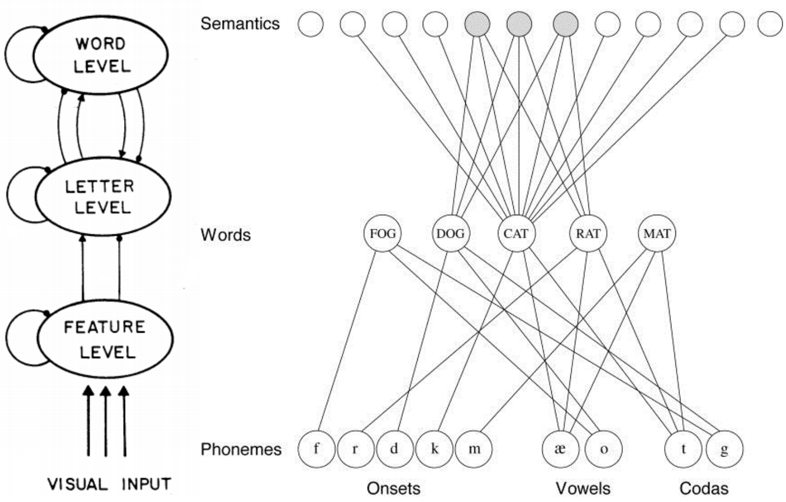

Figure 1.2. Interactive activation model.
Left: McClelland & Rumelhart (1981); Right: Dell et al. (1997).

The assumptions of these models have been used as a basis for developing theories of bilingual speech production, incorporating multiple languages to the existing fundamental predictions about spoken word processing.

1.1.2. BILINGUAL MODELS OF SPOKEN WORD PRODUCTION

Further questions and complications in developing a suitable model to explain word processing arise when multiple languages are involved, as compared to the processing of a single language. A number of models have been proposed to account for bilingual spoken word processing. Early models focused on how words and concepts are connected between L1 and L2 of a bilingual speaker. Figures 1.3 and 1.4 depict two early models of bilingual lexical processing in acquisition of L2 presented by Potter, So, Von Eckardt and Feldman (1984). These models attempt to explain how new L2 knowledge is incorporated into their existing L1 language system. They assume that each language has independent representations at the lexical level, but shared conceptual/semantic representations. The word association model (Figure 1.3) assumes that newly acquired words in L2 are represented in the lexicon by association to their L1 translation counterparts, and therefore semantic representations of words in L2 would be accessed via L1. Alternatively, the concept mediation model (Figure 1.4) proposes that new words in L2 are directly linked to their meanings (that is, not via L1). Potter et al. (1984) provided support for the concept mediation model. Reaction times for L2 picture naming and translation tasks of words from L1 to L2 did not differ, suggesting direct access to meaning (if meaning were accessed via L1, one would expect slower responses in L2 than L1 -> L2 translations). However, these results were not replicated in subsequent studies, where support was found for processing akin to that seen in the word association model for L2 late learners, whereas highly proficient bilinguals displayed processing more like that shown in the concept mediation model (Chen & Leung, 1989; Kroll & Curley, 1988, as cited in Schwartz & Kroll, 2006).

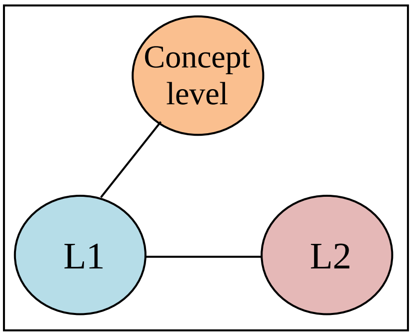

Figure 1.3: The word association model (Potter, So, Von Eckardt &Feldman, 1984)

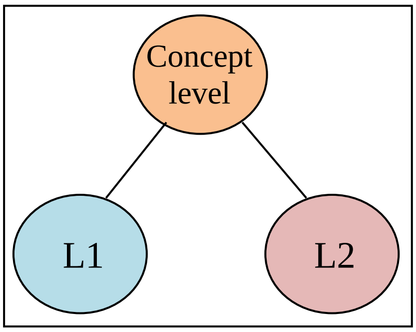

Figure 1.4: The conceptual mediation model (Potter, So, Von Eckardt &Feldman, 1984)

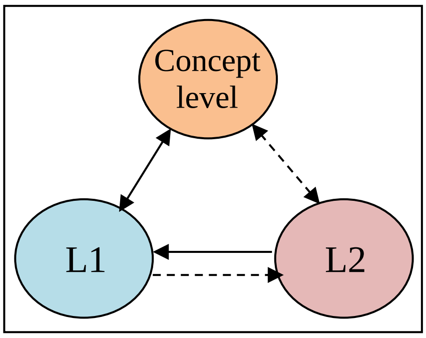

Figure 1.5: The Revised Hierarchical Model (Kroll & Stewart, 1994)

The revised hierarchical model presented in Figure 1.5 (Kroll & Stewart, 1994), proposes that as a rule L1 has stronger connections between words and concepts than does L2, but as L2 proficiency increases, so do the links between L2 words and the concept level. Kroll and colleagues propose a translation assymmetry for language learners, where L1 to L2 translation is slower than L2 to L1. Their rationale is that L1 to L2 translation is more likely to involve concept mediation and activation of the L1 through their strong connections to the concept level. Alternatively, translation from L2 to L1 can be done via direct connections at the lexical level, providing a direct route to translation. These predictions are supported by translation studies showing faster L2->L1 (than L1->L2) translation (e.g. Kroll, Michael, Tokovicz & Dufour, 2002). The assumptions of the Revised Hierarchical model are also supported by Kiran, Grasemann, Sandberg and Miikkulainen (2013), who created a computational model to simulate a Spanish-English bilingual language system (Figure 1.6).

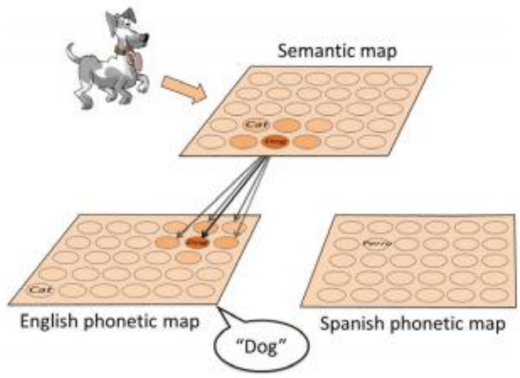

Figure 1.6. A schematic representation of the architecture of the bilingual DISLEX model (from Kiran et al., 2013)

The bilingual DISLEX model was lesioned, and in most cases, successfully predicted language recovery subsequent to therapy.

The models discussed thus far are localist models consisting of distinct word-form lexical representations in separate but interconnected lexicons for each language with shared semantic representations. Language task performance in both unimpaired and aphasic people has provided further evidence to suggest that representations for each language may be interconnected. For example, there is evidence to suggest an advantage for word-form representations that are related in meaning and form, known as cognates.

Costa, Caramazza and Sebastian-Galles (2000) described the cognate superiority effect (CSE) in naming, whereby cognates were named faster than non-cognates in picture naming, in Catalan-Spanish bilinguals. CSE, depicted in Figure 1.7, has also been shown in a picture naming study with German-English bilingual children where it was also observed in translation (Schelletter, 2002), and using lexical decision tasks in Dutch-English bilinguals, demonstrating the effect in word recognition (Dijkstra, Grainger and Van Heuven, 1999). The CSE is also observed in people with aphasia, for example in picture naming and lexical decision tasks (Lalor and Kirsner, 2001). It has been described with reference to the Interactive Activation Model (Dell at al., 1997), in terms of bi-directional activation between adjacent layers in the system.

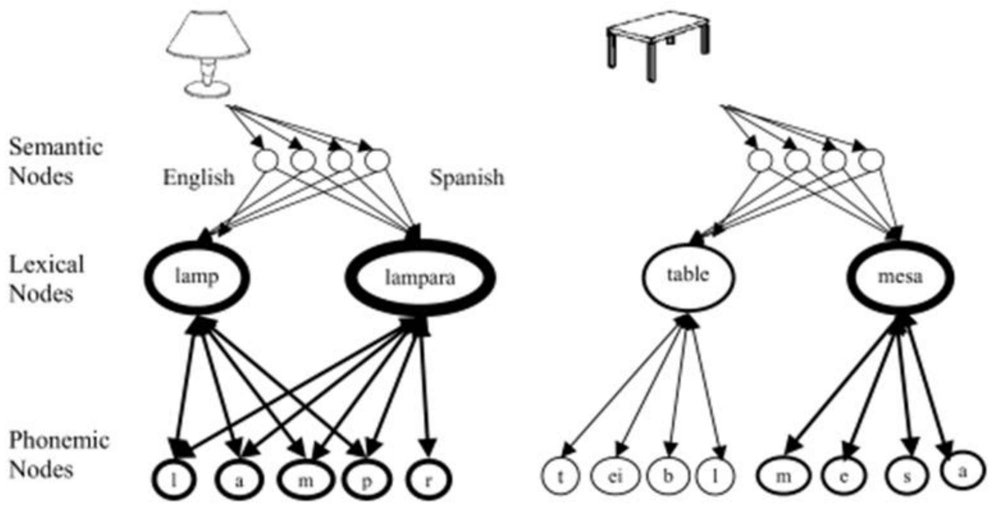

Figure 1.7. A theoretical account of the cognate facilitation effect (from Costa et al., 2005).

According to interactive models of speech production, selection of the target lexical nodes is influenced by activation from the semantic system, but also by the feedback activation received from the phonological level. Thus, cognates will receive more activation given their semantic and phonological overlap. Non-cognates would not receive additional activation from the phonological level, because of their lack of phonological overlap.

There is still much debate regarding the structure of the bilingual lexicon(s), and there is as yet no single model that successfully explains bilingual language processing; but what is certain is that there is some degree of language co-activation and interaction between languages.

In terms of neural networks, there is evidence to suggest that L1 and L2 lexicons are represented in overlapping brain areas in proficient bilinguals (e.g. Abutalebi & Green, 2007; Chee, Hon, Lee, & Soon, 2001; Chee, Tan & Thiel, 1999; Hernandez, Martinez & Kohnert, 2000; Illes, Francis, Desmond, Gabrieli & Glover, 1999; Klein, Milner, Zatorre, Zhao, & Nikelski, 1999; Perani et al., 2003; Sebastian, Laird, & Kiran, 2011). "How does the bilingual brain distinguish and control which language is in use? Previous functional imaging experiments have not been able to answer this question because proficient bilinguals activate the same brain regions irrespective of the language being tested" (Crinion et al., 2006). This does not necessarily mean that bilinguals have a single lexicon: it is possible that there are two lexicons that are fundamentally distinct, but represented in overlapping brain areas (e.g. Tainturier, Keidel, Owen-Booth & Thierry, 2012).

1.2: MODELS OF WRITTEN WORD PROCESSING

A number of models attempt to explain the processes involved in reading and writing, with the most highly-cited models being the dual-route (Beeson & Rapcsak, 2002; Coltheart, Rastle, Perry, Langdon & Ziegler, 2001) and connectionist models (Seidenberg & McClelland, 1989; Plaut, McClelland, Seidenberg & Patterson, 1996). Both models are widely used in the literature, with no resolution as yet as to which is the better model. Dual-route models (DRM) assume that word recognition or production is the result of coordinated activity within numerous cognitive components, whereas connectionist models propose three levels of interconnected units. The main difference between the two is that the DRM incorporates localist representations, whereas the connectionist 'triangle' model assumes distributed representations.

1.2.1. MONOLINGUAL MODELS OF WRITTEN WORD PROCESSING

1.2.2. Dual Route Model

Figure 1.8 represents the Dual Route Model (DRM) of reading, spelling and spoken naming (e.g. Beeson & Rapcsak, 2002; Coltheart, Rastle, Perry, Langdon & Ziegler, 2001). According to this hypothesis, there are two 'routes' converting print to sound (and vice-versa): the lexical and sublexical routes. Once a written or spoken word has been experienced, a memory trace for that word is stored in the lexicon (Rapp, 2002). As a result, the lexical route (depicted in grey boxes in Figure 1.8) permits processing of words that have previously been encountered and stored in long term memory (the lexicon). Input and output lexicons are involved in word recognition and production respectively. Lexical processing is thought to be divided into two functionally independent components: the semantic system, which holds representations of word meanings; and the lexicon, which provides information about word forms. The lexical route deals with processing familiar words via meaning in a number of stages, with the similar central features to those described in models of naming (Caramazza, 1997; Dell, 1990; Levelt, Roelofs & Meyer, 1999; Roelofs, 1997).

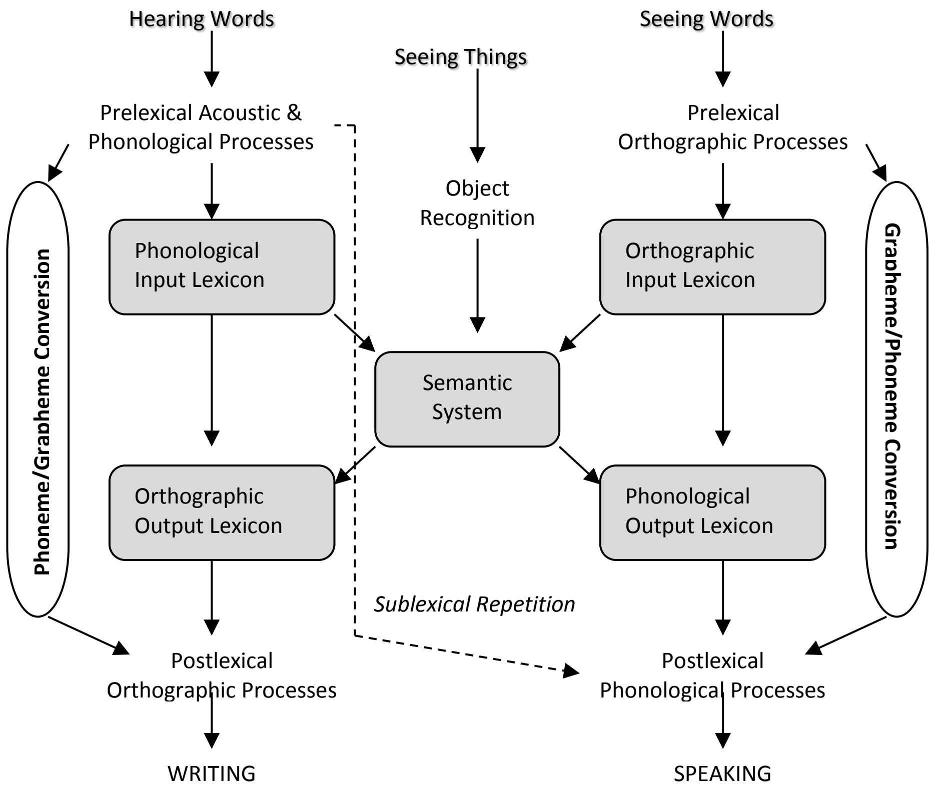

Figure 1.8. The dual-route model illustrating the processes involved in spelling, reading and spoken naming.

Reading via the lexical route begins with prelexical orthographic processes, before activating the orthographic input lexicon, and the semantic system (apart from when processing via the 'non-semantic' route). From here, the phonological output lexicon and the post-lexical phonological processes are accessed in order to produce the spoken word form. Prelexical orthographic processes identify letters in written words, encode their position, and perceptually group ones that belong together as part of the word. The orthographic input lexicon in reading is equivalent to the phonological input lexicon in perceiving speech. It is a 'mental word-store' (Ellis, 1993) that identifies familiar words. Meaning is derived from interaction with the semantic system. It is assumed that this system is involved in understanding and processing both spoken and written words and is therefore essential for word comprehension (Ellis, 1993; Rapp, 2002). The phonological output lexicon stores phonological knowledge and the postlexical phonological processes provide information about how to pronounce the word.

During spelling to dictation, the lexical route functions by first accessing prelexical acoustic and phonological processes, which extract speech sounds (phonemes). The phonological input lexicon recognises familiar spoken words and activation spreads to the semantic system once a word has been recognised. In order for a word to be comprehended, activation of the semantic system is necessary. The orthographic output lexicon (OOL) stores knowledge of memories for word forms (spellings), and makes them available in an abstract 'grapheme' form. Post-lexical phonological processes include the graphemic buffer, which is a working memory store that keeps the sequence of letters active during spelling. There is also evidence that the same graphemic buffer may also be involved in reading. Tainturier and Rapp (2003) propose that reading may require a temporary store of graphemic information, which is supported by their report of MC, who presented with the symptoms of graphemic buffer dysgraphia and also, a comparable pattern of dyslexia.

As mappings between print and sound (and vice versa) are inconsistent for many words in opaque orthographies, it seems that there should be no alternative to the lexical route for processing irregularly spelt words, because knowledge of their pronunciation and spelling is required to read and write them correctly, without error. Individuals can also read and spell unfamiliar words that are not stored in the lexicon by applying regular rules of phonology for their language, something that would not be possible via the lexical route. This type of reading and spelling is accounted for by an alternative process - the sublexical route.

The sublexical route (oval boxes either side of the model shown in Figure 1.8), sometimes referred to as the phonological or grapheme-to-phoneme conversion system, bypasses the lexical route and converts print into sound for reading (and vice-versa for writing). This route permits processing of unfamiliar words by using prelexical orthographic processes to identify each letter and its position, and then by representing their individual speech sounds with postlexical phonological processes. It is assumed that prelexical orthographic processes consist of knowledge of the most common letter-sound correspondences (presumably acquired during written language acquisition), which permits the individual to read unfamiliar words in a serial left to right fashion. It would, for instance, allow the reader to produce a nonword like FOLN by identifying its component letters (F1, O2, L3, N4) and converting each one into the speech sound (phoneme) it normally represents in regular English orthography. However, if unfamiliar words are irregular, the reader is likely to make a ‘regularisation’ error, such as pronouncing ISLAND as ‘izland’, because they would be using the most common (regular) letter-sound correspondence for those letters.

In spelling, the sublexical route functions by activating prelexical acoustic and phonological processes, where the word is broken down into its component phonemes. Those phonemes are converted into appropriate graphemes (based on regular spelling rules of the language), and in turn activates post-lexical orthographic processes, including the graphemic buffer. As is the case with reading, the sublexical route will only successfully process unfamiliar words or nonwords correctly if the spelling is regular. If the word is irregular, the sublexical route will still process it according to the regular rules of the orthography, producing regularisation errors (e.g. misspelling YACHT as YOT).

Although it was designed primarily to describe the processes involved in reading and spelling, the dual route framework can also account for spoken naming: activation passes from the semantic memory store to the phonological output lexicon, where the spoken form of the word is accessed. The phonological buffer maintains activation of the word form while speech is being produced.

1.2.3. Connectionist Models

Initially developed to explain processes involved in reading, the connectionist (or 'triangle') model (Seidenberg & McClelland, 1989; Plaut, McClelland, Seidenberg & Patterson, 1996) provides an alternative account of single-word processing, consisting of three levels made up of interconnected units that support both spoken and written language production: semantics, phonology and orthography (illustrated in Figure 1.9). The triangle model assumes distributed representation of lexical information: unlike the dual-route model, it does not include lexicons. Rather, it states that word processing occurs via interactions between central semantic, orthographic and phonological representations (in smaller units than words) that support reading, spelling, spoken language production and comprehension. Under the assumptions of this model, spoken naming would occur via links between semantics and phonology, reading occurs via direct links between orthography and phonology (vice-versa for spelling), with additional mediation by semantics. Reading and spelling efficiency is determined by hidden units between these three levels that are

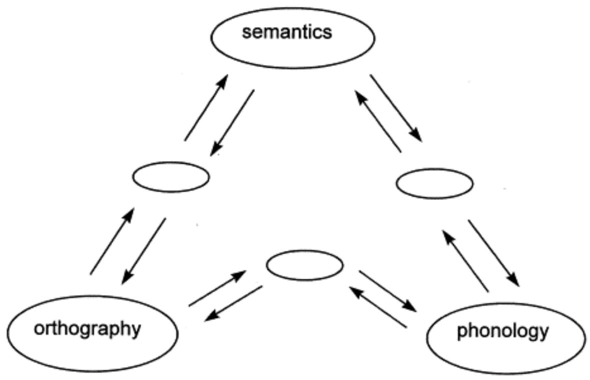

Figure 1.9. Single-word processing according to connectionist networks.

weighted by word frequency and by phonological/orthographic structure. Although semantic activation is said to occur automatically, it is assumed that this level plays an especially important role for words of lower frequency with irregular phoneme-grapheme/grapheme-phoneme correspondences. According to this model, written and spoken language impairments have a common origin and are different manifestations of the same underlying central or modality-independent impairment. Therefore, in terms of written word processing, if one had a deficit at the semantic level, a semantic impairment would be expected in both reading and spelling (surface dyslexia/dysgraphia); If one had disruption at the phonological level, this would lead to both phonological dyslexia and dysgraphia, because they are the "result of damage to central semantic and phonological representations that also support spoken language production and comprehension" (p.261; Henry, Beeson, Alexander & Rapcsak, 2011).

Both models provide accounts of the processes involved in 'normal' language, and can also be used to identify those that may be damaged in acquired language disorders (aphasia). Both models also have strengths in accounting for patterns of aphasia. The triangle model assumes all modalities should be affected if one layer of processing is impaired, and also that common neuroanatomical regions should be responsible for each layer. These assumptions are supported by the frequent co-occurrence of surface dyslexia and dysgraphia, and phonological dyslexia and dysgraphia. However, while dyslexias and dysgraphias usually do accompany one another (e.g. Behrmann & Bub, 1992; Weekes & Coltheart, 1996), it must be noted that dissociations in reading and spelling impairments can occur (e.g. Byng & Coltheart 1986; Caramazza, 1988; Caramazza & Hillis, 1990; Coltheart & Byng, 1989; Tainturier & Rapp, 2001; Tainturier, Schiemenz & Leek, 2006; Tainturier, Valdois, David, Leek, and Pellat, 2002). The connectionist triangle model struggles to account for these instances where all modalities are not affected in the same way.

1.3. BILINGUAL MODELS OF WRITTEN WORD PROCESSING

The Bilingual Interactive Activation (BIA; and subsequently BIA+) model of the bilingual lexicon by Dijkstra and Van Heuven (1998; 2002) is a computational model of visual word recognition and comprehension proposing that the bilingual lexicon is integrated across languages (Figure 1.10). It is extension of the previously mentioned Interactive Activation model (McClelland & Rumelhart, 1989), including the addition of language nodes. It postulates that word-form representations, as well as mappings (phoneme-grapheme/grapheme-phoneme), are learned, represented and processed via a common system, and this is said to be regardless of the type of script used by each language. It suggests that all words are processed by the same patterns of activation, regardless of the language. Thus, the word level holds knowledge of both L1 and L2 representations, but the additional level of language nodes are said to hold representations for language membership. This language independent hypothesis is extended to structurally overlapping strings: when words are read in one language, orthographically overlapping words from both the target and non-target language will receive some activation in parallel. This is supported by studies showing cross-language neighborhood effects (e.g. Van Heuven, Dijkstra, & Grainger, 1998), the

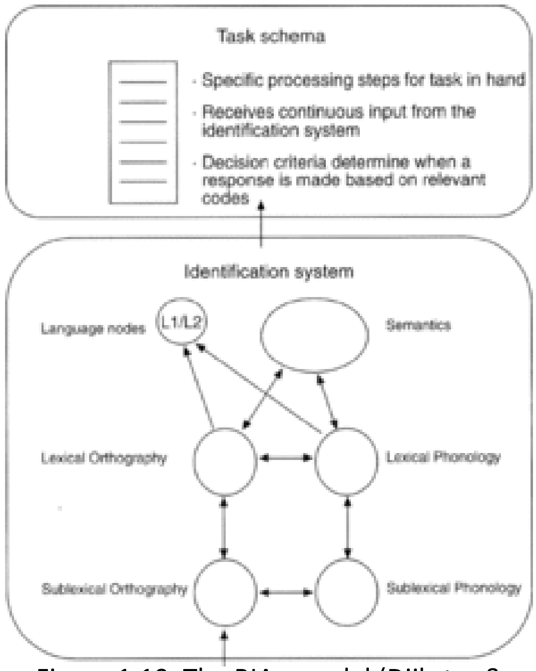

Figure 1.10. The BIA+ model (Dijkstra & van Heuven, 2002).

cognate facilitation effect (described above) and also interlingual homograph (words that are structurally similar but have different meanings) effects (e.g. De Groot, Delmaar & Lupker, 2000).

Because the BIA model assumes language independent lexical access, this would suggest that in acquired dyslexia and dysgraphia, patterns of impairment should be equivalent for both languages (for balanced bilinguals), which is indeed the most common pattern of impairment (e.g. Hernández, Costa, Sebastián-Gallés, Juncadella, & Reñé, 2007; Tainturier, Roberts & Leek, 2011).

Cases of differential impairment patterns between the two languages of bilingual people with acquired language disorders pose a challenge to this assumption.
For example, two studies by Ibrahim (2008; 2009) provided a double dissociation in impairment patterns between two speakers of the same languages (Arabic-Hebrew). One had more difficulties with L1, while for the other, L2 was more problematic. Ibrahim (2008; 2009) concluded that the two languages might be represented in different areas of the brain, and argued in favour of the revised hierarchical model's two-lexcion account of bilingual lexical access (Kroll & Stewart, 1994). However, it is unlikely that this would be the only explanation for non-parallel deficits. For example, an alternative explanation could have been one of language control difficulties: pathological language switching and mixing are not uncommon in bilingual people with aphasia and could account for non-parallel deficits (e.g. Abutalebi, Miozzo & Cappa, 2000; Fabbro et al, 2000).

The BIA(+) was developed as a model of visual word recognition and comprehension rather than production, and does not as yet consider spoken word production. More importantly, there are no models of bilingual spelling. Thus, models of bilingual processing are still in the relatively early stages of development, and for highly proficient bilinguals it is not fully established to what extent processing of the two languages are interconnected.

1.4. A WORKING MODEL OF BILINGUAL SPELLING

Figure 1.11 represents a working model of bilingual word processing that incorporates spelling (Tainturier, Roberts & Roberts, 2011). Predictions are partly based on research in other areas of word processing in bilinguals, and existing models of bilingual word recognition and spoken word processing. This model advocates a shared conceptual/semantic level for both languages, concerned only with meaning, and not with word form. This is consistent with the models of bilingual processing described previously (e.g. Potter, So, Von Eckardt &Feldman, 1984; Kroll & Stewart, 1994; Potter, So, Von Eckardt &Feldman, 1984).

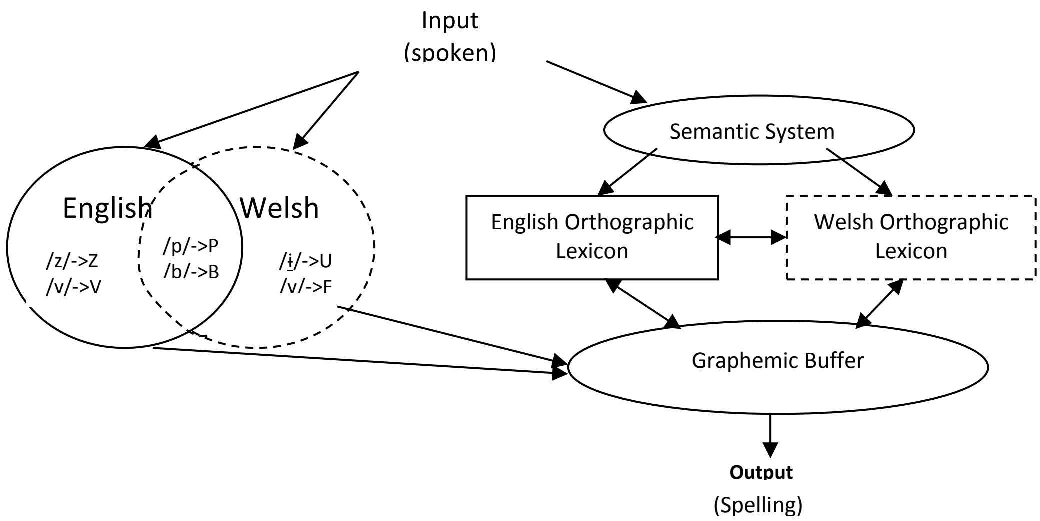

Figure 1.11. A working model of bilingual spelling to dictation using English and Welsh as examples (Tainturier, Roberts & Roberts, 2011).

With reference to models of bilingual spoken word production, particularly the revised hierarchical model (Kroll & Stewart, 1994), it is proposed for the bilingual spelling system word-form representations (orthographic) may be stored in distinct lexicons, but are jointly activated by semantics or phonology when a stimulus is heard. Furthermore, it is hypothesised that corresponding units are interconnected between languages, and that activation is stronger between these units in words that have structural overlap (i.e. cognates), due to feedback from the grapheme level (buffer). This is supported by evidence from spoken naming research in bilingual aphasia showing an advantage for naming cognates over non-cognates (e.g. Costa, Caramazza & Sebastian-Galles, 2000; Kohnert, 2004).

In terms of post-lexical processes (i.e. short term memory-based graphemic and phonological buffers), based on findings from monolingual research that the graphemic buffer processes all word types and that treatment at this level results in global generalisation, it is proposed that the buffer may be language non-specific, as well as lexicality non-specific. This prediction that a single buffer may process all words, regardless of language or lexicality, has not been tested, as there have been no previous predictions for the role of the buffer in bilinguals, no reports of buffer deficits in bilingual aphasia, and no research exploring the effects of treatment to this deficit in bilinguals.

Sublexical processing may be partially shared and partially distinct for two languages, because some phoneme-grapheme correspondences are shared across languages (e.g. /m/->M, /p/->P), some mappings differ (e.g. /v/->V/F, /f/->F/FF [English/Welsh], and some are language-specific (e.g. /z/->Z [English only], /r̥/->RH [Welsh only]). This is also a speculative hypothesis, because no research has yet explored sublexical processing of phoneme-grapheme mappings in bilingual spelling.

This model, based on the dual-route framework, but incorporating multiple languages, is used as a basis for the present studies. It was developed because there are as yet no models incorporating written production in bilingual word processing. Although the dual-route framework would assume that the co-occurrence of dyslexias and dysgraphias as coincidental due to reading and spelling being processed via separate routes, it can account for instances where deficits are not generalised across modalities. It also provides a clearer method of diagnosis of graphemic buffer dysgraphia. The deficits of the people with aphasia who took part in these studies include graphemic buffer dysgraphia, a crossed-aphasic with mixed dysgraphia in the absence of surface dyslexia, and severe anomia. While not dismissing the arguments for the triangle model (Seidenberg & McClelland, 1989; Plaut, McClelland, Seidenberg & Patterson, 1996) it nevertheless seemed logical to test the DRM, for the reasons outlined above, and also, because in acquired dysgraphia research, and all bilingualism research, it appears to be the only model that has been used thus far.

CHAPTER 2: LANGUAGE DISORDERS AND TREATMENT

CHAPTER 2: LANGUAGE DISORDERS AND TREATMENT

The aim of language treatment is ultimately to improve communication. But studies of language therapy can also allow a better understanding of deficits, and can also contribute to understanding of normal word processing. This chapter focuses on language disorders and their rehabilitation. Treatment studies targeting spoken naming impairments in monolinguals and bilinguals will be discussed first, leading to one of the unanswered questions regarding rehabilitation of spoken naming deficits in bilingual aphasia. In the second section, written word (reading and spelling) processing deficits and their rehabilitation will be explored in monolingual aphasia research, and the limited work on bilingual written language rehabilitation will be described. It focuses primarily on treatment of acquired language disorders, but also describes some relevant work from the study of developmental dyslexia and dysgraphia; particularly in cases where literature from acquired aphasia is non-existent. More emphasis will be put on research that is key to the studies presented in this thesis; spoken naming and spelling.

Assessment of an individual's language processing impairment is critical in planning effective therapy on the basis of understanding that person's spared and impaired processes. Models of language processing, including those described in Chapter 1, provide hypotheses regarding the processes involved in 'normal' word production. They can also serve as a basis for diagnosing impairments in these processes subsequent to neurological damage, and in designing treatment protocols. Reports of deficits can be used to test the predictions of such models, and also to guide treatment. Model-based treatment outcomes, such as patterns of generalisation, can be used to support, or add to, predictions of cognitive neuropsychology models. In fact, Nickels, Kohnen and Biedermann (2010) propose that the aim of cognitive neuropsychology be better defined as "To use data from the investigation *and treatment* of individuals with cognitive disorders to develop, evaluate, and extend theories of normal cognition" (pp. 540). But despite this, the majority of treatment research is not based on cognitive neuropsychological models.

There is a large, and rapidly growing, body of literature exploring spoken and written language disorders in monolinguals, but far less in bilinguals. Some have had more success than others. But how does one know whether treatment has been effective? Methods include comparing pre- and post-therapy performance; comparing treatment items to untreated items to control for the possibility of spontaneous recovery; assessing long-term gains (follow-up testing); comparing different therapies with the same person; and comparing a single therapy in people with contrasting deficits.

2.1. SPOKEN NAMING

Word finding difficulties, or anomia, are one of the most prominent features of aphasia (Raymer, 2005; Wisenburn & Mahoney, 2009). Clinically, the main symptom of anomia is problems with verbal interaction, and assessment of this can be difficult (i.e. conversational data are not easily measured), thus anomia is usually assessed using picture naming tasks. Often people with anomia are unable to provide the name for a stimulus (not due to articulation difficulties), despite knowing what it is. Circumlocutions are compensatory errors in which someone describes a word for which they are unable to access the phonological representation (e.g. the thing you use to put butter on bread [knife]). Anomic people also can sometimes access information regarding the orthographic structure of a word (e.g. initial phoneme, length or number of syllables).

Damage at the semantic level can result in comprehension problems as well as semantic errors (e.g. table -> CHAIR), whereas post-semantic damage (phonological output lexicon) leads to problems in retrieving the word-form, with errors such as phonologically related word errors (e.g. table -> CABLE), circumlocutions, semantic errors, and ‘don’t know’ responses.

2.2. TREATMENT OF MONOLINUGAL ANOMIA

Research of treatment of word-finding impairments in monolingual aphasia is extensive (Wisenburn & Mahoney, 2009). Methods of therapy and their general improvement patterns are described in this section. This is necessary before introducing the research of word-finding impairments in bilingual anomia (which goes into more detail because of its relevance to the research presented in this thesis).

2.2.1. Cueing Methods

In spoken naming therapy targeting lexical deficits, phonological and orthographic treatment methods (respectively) normally involve phonological cues, where each phoneme of a word is given in progression until the person is able to name it, or orthographic cues are given using graphemes.

Phonological cueing has been successful using methods such as progressive cueing hierarchies (e.g. Best, Herbert, Hickin, Osborne & Howard, 2002; Biedermann, Blanken & Nickels, 2002; Hickin, Best, Herbert, Howard & Osborne, 2002), word and sentence cueing techniques (Conroy, Sage & Lambon Ralph, 2009a), decreasing and increasing naming cues (Conroy, Sage & Lambon Ralph, 2009b), and combined with semantic cueing (e.g. Raymer et al., 2007).

Raymer et al. (2007) administered a combined semantic-phonological treatment protocol to eight people with aphasia, with the aim of discovering whether success of therapy for nouns would differ from treating verbs. Five of the participants displayed therapeutic effects, but were restricted to trained items only. Although both types of words differ in terms of psycholinguistic and neural characteristics, there was no difference in success rates for training nouns versus verbs: both displayed similar patterns of improvement. These results suggest that therapy was effective at the level of the output lexicon rather than semantics, because improved semantic processing would be expected to generalise to semantically related words.

Treatments utilising orthographic cues are not as common as phonological treatment studies, but have had encouraging findings, most comparing their success with that of phonological cueing or combining both methods (Best, Herbert, Hickin, Osborne & Howard, 2002; Hickin, Best, Herbert, Howard & Osborne, 2002; Lorenz & Nickels, 2007). Similar levels of improvement have been observed for both phonological and orthographic cue types (Hickin et al., 2002; Best, et al., 2002). It was also argued by Best et al. (2002) that different mechanisms within the dual-route framework support these types of cueing; phonological cues via the lexical (but non-semantic) route, and orthographic cues via the sublexical route.

Progressive phonological and orthographic cueing methods (coined 'errorful' therapy, where the participant is given therapy on errorful responses) have been compared and contrasted with 'errorless' therapy, in which the name is given (by the experimenter/therapist) along with a picture and the written form of the word (Fillingham, Sage & Lambon Ralph, 2006; Fillingham, Sage & Lambon Ralph, 2005). Fillingham et al. (2006) found that nine (out of 11) people with deficits at the level of phonology, semantics, or semantics and phonology, improved significantly in naming performance and eight of these displayed equally significant therapeutic gains after both errorful and errorless therapy. These results were replicated by Fillingham et al. (2005) in a modified follow-up study, with the addition of a condition where feedback was removed from the errorful technique (i.e. repeated attempts), and was still successful. Although there was no greater benefit in using one treatment method over the other, those who took part expressed a preference for errorless learning. Furthermore, McKissock and Ward (2007) support the previous findings of Fillingham et al. (2005; 2006), with regard to errorless and errorful (with feedback) techniques, but a condition involving repeated exposure to items (errorful without feedback), did not prove to be successful.

Errorless treatment methods have not always been found to be as effective as errorful approaches. For example, Abel, Schultz, Radermacher, Willmes, and Huber (2005) found increasing cues to be more effective than decreasing cues in therapy, leading them to conclude that errors produced during therapy do not jeopardise their chances of improvement. Despite these results, errorless techniques seem to be as effective as errorful in general.

One method that has elicited generalisation to untreated words is to use homophones (phonologically identical words, but semantically different [e.g. FLOUR-FLOWER]) in treatment. Biedermann, Blanken and Nickels (2002) report successful remediation of a person with aphasia subsequent to a phonological cueing hierarchy, with generalisation to untreated words, but only if they were homophones of the treated items. This supports the predictions of the interactive activation model positing both top-down and bottom-up activation between lexical representations and phonology.

2.2.2. Semantic Treatment

Semantic therapy using analysis of semantic features (Semantic Feature Analysis) is an approach that aims to improve lexical retrieval by cueing production of distinguishing features and semantically associated items of target stimuli. It involves improving semantic representations and thus facilitating spoken/written picture naming by strengthening semantic features related to treated pictures. According to the assumptions of localist models, if treatment is effective at the level of semantics, it will aid in clarifying distinctions between features that define certain concepts, therefore benefits can be observed in semantically related words, regardless of the output (Caramazza & Hillis, 1990). Connectionist models would make similar assumptions also.

Boyle and Coelho (1995) report using semantic feature analysis (SFA): pictures were presented for oral naming, along with semantic features associated with each picture, which were written in boxes around the item. Trained items improved significantly and generalisation was observed to untrained, semantically related items. The success of this approach has since been reported across aphasia types, with improvement observed in people who have different aetiology, nature, and severity of lexical deficits (Boyle, 2004; Boyle, 2010; Coelho, McHugh & Boyle, 2000; Conley & Coelho, 2003; Falconer & Antonucci, 2012). The SFA protocol has also been modified successfully, utilising fewer features (three rather than six; Hashimoto & Frome, 2011; Hashimoto, 2012). Generalisation to related words and across modalities subsequent to semantic feature training supports the cognitive neuropsychological theories postulating a semantic level/store that mediates spoken and written output.

The findings of semantic feature training have been replicated using different approaches. For example, Kiran and Thompson (2003) manipulated semantic complexity and observed generalisation within semantic categories when semantic therapy was provided for atypical (e.g. ostrich) rather than typical items (e.g. crow) within a semantic category ('bird' in this example), in three out of four people with fluent aphasia. This research was based on connectionist models, with the findings supporting the idea that "exposure to items sharing some features of the prototype as well as disparate features results in activation of both typical and atypical entries, whereas exposure to items with features similar to a semantic prototype results in a high probability of activating only a limited set of items with comparable features" (pp. 10, Kiran & Thompson, 2003).

Nadeau and Kendall (2006) report an intensive semantic features analysis approach to treatment in ten people with aphasia: they do not disclose a diagnosis of the level of the deficits presented by the 10 participants, only that they had word-finding difficulties. Three people improved in performance on repeated probes in object and action naming, but this was not put down to semantic training, because the generalisation observed was to unrelated words. Rather, it was suggested that it might have been the result of motivation to use a technique that could be used in daily life for increasing semantic representations. Comprehension scores provided do not suggest severe impairments in semantics. Semantics appear to be mildly impaired, and only in 3 of the participants; with the lowest scores being on the Boston Naming Test. It may be the case that opting for a semantic treatment approach in 10 people who appear to have deficits beyond the semantic level, may have resulted in limited treatment effects: if the deficit is at the phonological output lexical stages of word production, training semantics is unlikely to aid in re-learning word-form representations. Although participants were provided with the name if they were unable to produce it after 3 attempts, they were not asked to repeat the word (or carry out any other phonologically-based tasks). If the word-form itself is difficult to retrieve due to a post-semantic deficit, therapy may wish to focus on re-learning specific words, rather than focusing on their meaning.

Drew and Thompson (1999) reported a semantic treatment protocol based on an interactive model of lexical processing (McClelland & Rumelhart, 1989). Four people with aphasia who had severe word finding problems in picture naming, attributed at least partly to semantic impairment based on testing of the lexical system, took part. The semantic treatment involved sorting, judgment and definition-to-picture-matching tasks, yielding improvements in two of the four participants. Phonological and orthographic (i.e. word-form) information was added to the treatment, resulting in immediate gains in the two people who had not previously shown improvement (explained as an interactive rather than additive effect by Drew & Thompson, 1999), and further improvement in the two who had benefited from semantic treatment alone. These response patterns were evident despite all four participants having similar background testing profiles, which emphasises the fact that response to therapy is individual. The benefits of using a combined (over separate phonological and semantic approaches) method have been demonstrated by others also (e.g. LeDorze, Boulay, Gaudreau & Bassard, 1994), and are not restricted to semantic-phonological methods: combined methods have also been successful in phonological cueing methods, as described previously (Best, Herbert, Hickin, Osborne & Howard, 2002; Hickin, Best, Herbert, Howard & Osborne, 2002; Lorenz & Nickels, 2007).

Taken together, studies of monolingual anomia therapy have been successful in eliciting gains, to both treated items and in some instances, untreated items. Cueing methods have generally been successful in electing gains in treated items, with some also reporting generalisation to phonologically related items, supporting the assumptions of the interactive activation model (Dell et al., 1997) positing feedback activation between the phoneme and word-form levels. Semantic features therapy has been successful in eliciting gains across deficits types, but for generalisation to semantically related words, it may be better suited to those with deficits at the semantic level (rather than post-semantic).

2.3. BILINGUAL LANGUAGE THERAPY

Research over the past three decades has shown that the two languages of a bilingual speaker are interconnected both neurologically and functionally (Paradis, 1997), which should have implications for therapy. Most existing studies of bilingual language therapy have focused on spoken naming (for a full review of those that exist to date, see Faroqi-Shah, Frymark, Mullen & Wang, 2010). A number of questions have arisen regarding the circumstances in which treatment is successful and when cross-linguistic generalisation may occur: Which language should be treated? What type of treatment works best? What type of stimuli should be used? Few studies investigating cross-linguistic treatment generalisation exist, and those reported provide mixed results.

Success can be related to pre-morbid proficiency and age of acquisition. Bilingual speakers are typically defined as either early/native/simultaneous bilinguals, or late/successive bilinguals (Paradis, 2004). Early bilinguals learn both languages simultaneously from a young age (acquired before adolescence according to Ardila, 1998; as cited in Lorenzen & Murray, 2008), compared to late bilinguals who learn both languages at different times (i.e. L2 is learned at a later stage than L1).

There are contrasting arguments as to why varying patterns of impairment arise in bilingual aphasia. One early idea was that the native language would recover first or to a greater extent, based on the idea that oldest memories would be most resistant to brain damage (Ribot, 1881; as cited in Paradis, 2004). Others have suggested that the most proficient language, or the language used most prior to neurological damage, would recover first or to a greater extent (Pitres, 1895; Minkowski, 1928; 1949; 1965; Bay, 1964; as cited in Paradis 2004).

These issues of bilingualism type (early versus late acquisition) and premorbid proficiency also have implications for therapy. Two of the earlier studies investigating cross-language generalisation in bilingual aphasia reported cross-language benefits when treating L2 in 40 bilinguals (Fredman, 1975); and in treating L2 in two bilinguals with Brocas aphasia and Wernicke's aphasia deficits (Watamori & Sasanuma, 1976; 1978); although improvement was based on self-rated questionnaires in the former, and testing in the acute stage of neurological illness in the latter (with no statistical analyses on results). Still, the earlier studies led to further research and hypotheses regarding language therapy in bilingual populations.

The greatest success since these early studies has been in treatment of L2 or a pre-morbidly weaker language, with success being defined as cross-linguistic effects of treatment gains (e.g. Edmonds & Kiran, 2006; Gil & Goral, 2004; Goral, Levy & Kastl, 2010; Goral, Rosas, Conner, Maul & Obler, 2012; Fabbro & Frau, 2001; Filiputti, Tavano, Vorano, De Luca & Fabbro, 2002; Kiran & Edmonds, 2004; Kiran & Iakupova, 2011; Kiran & Roberts, 2010; Laganaro & Venet, 2001; Miertsch, Meisel & Isel, 2009). Evidence of a lack of generalisation in studies of bilingual language treatment when the language of therapy was L1 also provides further support for the advantage of selecting a person's L2 or pre-morbidly weaker language (e.g. Ansaldo, Saidi & Ruiz, 2010; Galvez & Hinckley, 2003; Meinzer, Obleser, Flaisch, Eulitz & Rockstroh, 2007). However, this is by no means the rule, as there have been instances where treatment of L1 has elicited gains in L2 (e.g. Croft, Marshall, Pring & Hardwick, 2011; Junque, Vendrell & Vendrell-Brucet, 1989); and instances where L2 treatment has not led to generalisation (e.g. Amberber, 2012).

It is apparent that pre-morbid proficiency and type of bilingualism are of importance for treatment planning. For those who were pre-morbidly dominant in one language, it seems that providing therapy in the non-dominant language is most effective.

2.4. TREATMENT OF BILINGUAL ANOMIA

The majority of treatment studies of bilingual spoken word finding difficulties have utilised the semantic approach (Ansaldo, Saidi & Ruiz, 2010; Croft, Marshall, Pring & Hardwick, 2011; Kiran & Edmonds, 2004; Edmonds & Kiran, 2006; Kiran & Roberts, 2010; Kiran & Iakupova, 2011; Miertsch, Meisel & Isel, 2009; Meinzer, Obleser, Flaisch, Eulitz & Rockstroh, 2007). Some have used semantic methods combined with phonological methods (Galvez & Hinckely, 2003; Kohnert, 2004; Kurland & Falcon, 2011), others have used mixed protocols (Filiputti, Tavano, Vorano, De Luca & Fabbro 2002; Galvez & Hinkley, 2003; Gil & Goral, 2004; Goral, Rosas, Conner, Maul & Obler, 2012; Marangolo, Rizzi, Peran, Piras & Sabatini, 2009); one study has directly contrasted semantic with a purely phonological approach (Croft et al., 2011), and some used conversational therapy (Amberber, 2012; Meinzer, Obleser, Flaisch, Eulitz & Rockstroh, 2007).

A semantic features analysis treatment study by Edmonds and Kiran (2006) provides evidence of generalisation in both languages of a balanced bilingual after therapy in Spanish, and generalisation from L2 treatment to L1 (not vice versa) in two unbalanced bilinguals (English-Spanish) with aphasia. Participant 1, a balanced bilingual, started treatment in Spanish, and improvement was seen in both sets of English stimuli, as well as in semantically related Spanish words. For Participants 2 and 3, English dominant bilinguals, treatment was administered in English for a first set of words. Generalisation was observed in untreated semantically related English words, but no cross-linguistic generalisation was seen. Treatment was switched to Spanish (L2) for the second set of words, and in this case, although there was no generalisation to semantically related words, improvement in the cross-language translation equivalents and semantically related items in the untrained language were evident. No significant improvements were noted on naming performance of unrelated control words for either person, showing that improvement in treated items was not due to spontaneous recovery. Kiran and Roberts (2010) replicated these findings in one (French-English) out of four (either French-English or Spanish-English) people with aphasia, as did Kiran and Iakupova (2011) with a Russian-English bilingual.

These results extend the findings from monolingual treatment studies targeting semantics, providing evidence that generalisation *can* be observed in untreated but semantically related words in the untrained language. But, this is not always the observed effect. Three of the participants in Kiran and Roberts (2010) failed to show cross-linguistic generalisation. The authors provide multiple explanations for this, and it becomes apparent that many factors can contribute to success (or lack of), including high baseline accuracy, mild aphasia, poor response on treated items (in a more severe case), language history, and/or spontaneous recovery.

Other methods have been less successful than the semantic approach. Amberber (2012) selected L2 for conversational therapy with a French-English bilingual with aphasia, and observed only gains in the language of therapy (L2). Amberber provides explanations for the lack of generalisation, but upon scrutiny of this study, the cause is likely to be that some baseline scores in French (L1) were so high that there was no room to measure improvement. Miertsch, Meisel and Isel (2009) report a similar lack of L2->L1 generalisation (but L2->L3 generalisation was seen in this case), again with high baseline scores in L1 (German in that case).

Amberber (2012) also recommends BAT as an assessment tool for measuring therapeutic gains. However, given the disproportionate baseline scores, it is advised that baselines, as well as treatment, should be tailored to each individual's needs. Creating baseline sets with adequately low performance in all languages would allow better measurement of possible cross-language effects.

Treatment studies utilising conversational approaches to therapy have not been as successful as semantic approaches in eliciting cross-language effects of therapy. Meinzer, Obleser, Flaisch, Eulitz and Rockstroh (2007) and Amberber (2012) both used conversational techniques and did not observe cross-language gains. In the case of Amberber (2012), as mentioned, it is likely to be attributed to high baseline performance in the untreated language. Meinzer et al. (2007) conducted an fMRI study in order to investigate the neural correlates of language performance in German-French bilingual aphasia. CQ took part in an intense therapy programme involving motivational language 'games' in which communication was only allowed via spoken language, and where cues were provided for word-finding difficulties. Performance was measured on a picture naming task, with adequately low scores in the untreated language to allow room for improvement. Training significantly improved naming of pictures in German, but the number of correct responses in French was low both before and after the intervention. The fMRI data revealed changes in brain activation in the trained language (German) only. While being a rewarding, motivational method for the person with aphasia, treatment via conversation may not allow treatment of specific words as explicitly as other methods. This study was not model-based, did not use more than one baseline, and did not explicitly treat target words. For the purposes of observing cross-language gains between translation pairs, and for testing models of word production, conversational therapy may not be the most appropriate approach.

Other approaches have also been unsuccessful in eliciting cross-linguistic gains. Ansaldo, Saidi and Ruiz (2010), designed a protocol involving semantic feature analysis and ‘switch-back through translation therapy’ which encouraged the participant not to inhibit the untreated language (English) during therapy in Spanish, but rather to translate errors. No cross-linguistic generalisation was observed. While this method, like the conversational therapy approaches of Amberber (2012) and Meinzer et al. (2007), encourages communication, with responses provided in either language being viewed as positive communication; it may not be the most appropriate approach to testing the models of bilingual processing outlined in Chapter 1, given that therapy essentially involves both languages.

Mixed approaches to treatment have been effective in bilingual aphasia. Filiputti, Tavano, Vorano, De Luca and Fabbro (2002) also observed lasting cross-linguistic transfer of treatment effects after treatment of L2, in a quadrilingual person with aphasia, but only to L3 and L4. Performance in L1 decreased. Treatment was provided in his L2, Italian, and aimed to target language control, phonemic discrimination and improving phonological and morphological features of Italian. The language of treatment, L2 Italian, his L3 Friulian and L4 English displayed partial parallel improvement subsequent to treatment, but there was a decline in his L1, Slovenian. He had not used Slovenian for 35 years before neurological damage, suggesting that this is a case of pre-morbid language use rather than type of bilingualism. In this case, the lack of exposure to Slovenian over 35 years is likely to have resulted in natural pre-morbid decay for lexical representations in this language, rendering it unlikely to respond to therapy.

Similarly, Goral, Rosas, Conner, Maul and Obler (2012) also provide evidence for the success of a mixed method in a quadrilingual (Spanish-German-French-English) person with aphasia. Treatment involved semantic features analysis, sentence generation, and rapid naming tasks. When treatment was provided in L1 (Spanish), limited within-language and no cross-language gains were observed, whereas treatment of a weaker language, English, yielded some gains in German and French (but not Spanish). Furthermore, Marangolo, Rizzi, Peran, Piras and Sabatini (2009) observed parallel recovery in both languages of Flemish-Italian woman after intensive (5 times per week for 6 months) phonological (repetition) and orthographic (reading of names of pictures) therapy in L2.

Gil and Goral (2004) provided a Russian-Hebrew bilingual man with an intensive treatment programme targeting all language modalities. After a month of treatment in Hebrew, assessment revealed parallel improvement in both languages. After a further 2 months of treatment in Hebrew, an evaluation of language skills revealed significantly more improvement in Russian (the untreated language). This is an interesting pattern of recovery because it is rarely reported (perhaps never before) that benefits are greater for the untreated language in bilingual aphasia. However, there appears to have been no control condition, or statistical analyses, and all testing was complete within 6 months of a left cerebrovascular accident (CVA), therefore this improvement is likely to have been due to spontaneous recovery.

Not all mixed therapy studies have reported cross-linguistic generalisation. Galvez and Hinkley (2003) observed no cross-linguistic effects subsequent to a semantic and phonological cueing therapy in a Spanish-English individual. Thus, many studies using a mixed approach demonstrate positive effects on both treated and untreated languages in bilingual aphasia. They cannot, however, provide any answers for the influence of the type of therapy on recovery patterns.

Conversely, others have directly contrasted different approaches to treatment. Croft, Marshall, Pring and Hardwick (2011) recently compared the effects of semantic and phonological treatment methods in four Bengali-English bilinguals. They found that three out of five Bengali-English participants showed cross-language effects of treatment, but only when the language of therapy was L1. The generalisation effect on one of these participants is likely to have been spontaneous recovery. The other two participants showed cross-linguistic gains only after semantic therapy (not phonological). However, there are methodological flaws in the design of this study. The L1->L2 response to therapy was in two participants who had close to normal performance in background testing, participants chose to be treated in L1 first, and L1 was treated by co-workers rather than therapists (L2 was treated by therapists). Also, there is no mention of the status of the items used in therapy in this study (only that they were chosen by participants), but all of the background naming items were cognates – but not Bengali-English cognates; rather, they were Sylheti-Bengali cognates. This potentially adds another confound to the results: Bengali may have had an advantage over English in therapy, due to the cognate facilitation effect from another language pair. The cognate facilitation effect (described in Chapter 1) is an advantage in bilinguals for processing cognates - “cross-linguistic word pairs that are similar in meaning and form” (e.g. ‘rose’ and ‘rosa’, Kohnert, 2004). Thus, if connections or co-activation between the lexical representations of cognates are stronger than non-cognate words, they might be more resistant to neurological damage, and thus show an advantage in a therapeutic setting. According to Costa et al. (2000), activation of cognate pairs are more likely to be facilitated than non-cognates, due to feedback activation from phonology, as well as activation from semantics. In the case of Croft et al. (2011), if Bengali treatment items were cognates, but English items were not, this questions the validity of the items used. These methodological discrepancies make it difficult for Croft et al. (2011) to claim success of treating one language over another.

In other work, the cognate facilitation effect has been successfully exploited between target languages. Kohnert (2004) provides evidence for cross-linguistic generalisation using cognates. A bilingual Spanish-English person with severe naming difficulties received a combined semantic-phonological-orthographic treatment intervention involving two sets of 20 Spanish-English translated word pairs (half cognates, half non-cognates). Results indicated lasting cross-linguistic generalisation from Spanish to English, but only for cognate stimuli. Despite the encouraging findings, the methodological validity of Kohnert (2004) is questionable. It is unclear whether any baseline measurements were made before the Spanish phase of treatment, and the combined treatment time over both phases was 4 hours (two 1-hour sessions in each language). The study also lacks a control condition; therefore it is not possible to rule out spontaneous recovery, or effects of multiple attempts, as an explanation for the improvements. Also, and most importantly, the items used for baseline/post-testing were not the same as those used in treatment: cognates improved in the untreated language, but they were not the ones that had been treated. Despite these confounds, cognate stimuli did improve more than non-cognates. Future work should directly compare treatment of cognates and non-cognates on their translation equivalents.

There is also contradicting evidence for the status of cognates in therapy. Kurland and Falcon (2011) investigated therapy involving cognates in Spanish-English aphasia. An intensive naming therapy was provided in three phases: Spanish therapy, English therapy, and mixed therapy yielded mostly within-language improvement. Gains were observed in untrained tasks of auditory comprehension when the language of treatment was Spanish, in both Spanish and English (providing further evidence of L2->L1 treatment gains). However, results of picture naming tasks in all three phases revealed improved trained and untrained (but semantically related) words, but predominantly in Spanish and for non-cognates. These results contradict those of Kohnert (2004), and Kurland et al. (2011) suggest that rather than facilitating production, in this case cognates appeared to be interfering. Upon comparison of the deficits of the participants involved in both studies, it becomes apparent that they had differing deficits. In the case reported by Kohnert (2004), the participant had relatively high comprehension (i.e. semantics) scores as compared to naming, in both languages; whereas the person described by Kurland et al. (2011) appears to have both impaired comprehension and naming skills. It is suggested that treatment using cognate stimuli may be best applied to deficits beyond the semantic level. This highlights the importance of model-driven therapy research. In the case of Kurland et al. (2011), a semantic-based therapy may have been more appropriate.

The exploration of cognate use in language therapy is still at an early stage, with conflicting findings. Further research is required to investigate the possibility of successfully exploiting the use of cognates to promote cross-language transfer (in support of the findings of Kohnert, 2004). As only two studies exist to date that specifically target cognate stimuli in bilingual language therapy, much more research will be needed to even begin to resolve this issue.

The use of cognates in spoken naming therapy is investigated in the first experimental chapter (Chapter 3). It is the first study exploring cognates as a function of a phonological (rather than semantic) treatment protocol.

2.5. READING AND SPELLING: DYSLEXIA AND DYSGRAPHIA

Central dyslexia and dysgraphia can be divided into surface, phonological and deep sub-types, with the addition of graphemic buffer dysgraphia in spelling.

Surface dyslexia and dysgraphia are characterised by impairments in reading and spelling irregular words. In surface dyslexia, people have a tendency to make regularisation errors when reading irregular words (e.g. Marshall & Newcombe, 1973; Parkin, 1993), whereas people with surface dysgraphia spell words in accordance with sound-form rules of the language, resulting in phonologically plausible misspellings of irregular words (e.g. Beauvois & Dérouesné, 1981; Shallice, 1981). They are often associated with left temporo-parietal occipital lesions (e.g. Beauvois & Dérouesné, 1981; Goodman & Caramazza, 1986; Rapp & Caramazza, 1997; Tainturier & Rapp, 2001; Tainturier, Valdois, David, Leek, & Pellat, 2002).

According to the DRM, surface dyslexia and dysgraphia arise subsequent to damage of the lexical route, leading to reliance upon sublexical processing. Regular words can be processed successfully using phoneme-grapheme/grapheme-phoneme conversion, but leads to regularisations errors in attempting irregular words. According to the assumptions of the DRM, components can be damaged independently of one another, meaning that surface dyslexia may occur without surface dysgraphia (e.g. Tainturier, Valdois, David, Leek, & Pellat, 2002), or vice-versa (Tainturier, Schiemenz & Leek, 2006).

The connectionist model explains surface dyslexia and dysgraphia as arising from damage to semantic representations, or a reduction of their influence on orthography (for spelling) and phonology (for reading). That is, semantic impairments lead to a shift in efficiency of processing, with increased reliance on phonological processing leading to an advantage for processing nonwords over irregular words. There has been support in the literature using the connectionist framework for general semantic impairment co-occurring with semantic impairments in both reading and spelling (e.g. Graham, Patterson, & Hodges, 2000; Patterson & Marcel, 1992). Because all language tasks are underpinned by the three systems, under the assumptions of this model, it is expected that both reading and spelling will be affected in the same way to a certain degree. That is, if a person displays the symptoms of surface dyslexia, they should also have surface dysgraphia.

Phonological dyslexia and dysgraphia are, in effect, the antithesis of the surface types. Associated with damage to the peri-sylvian language area (in particular Wernicke's area, the supramarginal gyrus, and Broca's area [e.g. Shallice, 1981; Roeltgen & Heilman, 1984; Alexander, Friedman, Loverso & Fischer, 1992; Henry, Beeson, Stark & Rapcsak, 2007; Fiez, Tranel, Seager-Frerichs & Damasio, 2006]), they are characterised by difficulties with unfamiliar words, with relatively preserved familiar word processing, and lexicalisation errors ('petweem' -> BETWEEN) are often made in attempts to read or spell nonwords (Bub & Chertkow, 1988; Bub & Kertesz, 1982; Nolan & Caramazza, 1982; Shallice, 1981).

Phonological dyslexia and dysgraphia are interpreted by the DRM as impairment to the sublexical processing route (grapheme-phoneme or phoneme-grapheme conversion). Due to the relative lack of damage to the lexical route, familiar words (regular and irregular) are processed without difficulty, whereas unfamiliar/nonword processing is impaired. Also, particularly in phonological dyslexia, reliance upon lexical processing leads to lexicalisation of nonwords (e.g. prath -> PATH).

According to connectionist models, phonological dyslexia and dysgraphia arise from disruption at the phonological level, of representations involved in speech production/perception (e.g. Crisp & Lambon Ralph, 2006; Patterson & Lambon-Ralph, 1999). Because phonological representations are important for processing nonwords, impairments at this level should lead to a shift in efficiency in processing nonwords as opposed to semantic processing, and a shift toward better irregular word processing in both reading and spelling.

Deep dyslexia and dysgraphia are more global impairments and are often the result of large lesions to the peri-sylvian region of the left hemisphere, including Broca’s area (e.g. Rapcsak, Beeson & Rubens, 1991; Miceli, Benvegnu, Capasso & Caramazza, 1997. For a review, see Black & Behrmann, 1994). People with deep dyslexia/dysgraphia have relative difficulties with all word types. In particular, abstract words are more difficult to process than concrete words, and most difficulty is in processing function words. Another consistent impairment is in reading or spelling nonwords; but the key feature of deep dyslexia and dysgraphia are semantic paralexias/errors (e.g. NIGHT -> SLEEP; CHAIR -> TABLE; Marshall & Newcombe, 1973; Bub & Kertesz, 1982).

According to DRM damage to both lexical and sublexical routes gives rise to deep dyslexia and dysgraphia. Damage to the sublexical route leads to problems in nonword production, and an additional deficit to the lexical route results in difficulties with real words and semantic paralexias (e.g. Michel & Andreewsky, 1983; Morton & Patterson, 1980; Nolan & Caramazza, 1982).

The connectionist approach explains deep dyslexia and dysgraphia as a consequence of severe phonological and orthography-to-semantics pathway impairments (Plaut & Shallice, 1993). It proposes that both deep dyslexia and dysgraphia should accompany each other due to this underlying phonological impairment responsible for all output (e.g. Jefferies, Sage & Lambon Ralph, 2007). Under the assumptions of this model, it has also been proposed that phonological and deep dyslexia and dysgraphia can be placed on a continuum of phonological deficit severity (e.g. Patterson & Lambon Ralph, 1999; Wilshire & Fisher, 2004).

Graphemic buffer dysgraphia is characterised by a length effect in spelling all word-types, and errors including letter substitutions, deletions, additions and transpositions (e.g. Aliminosa, McCloskey, Goodman-Schulman, & Sokol, 1993; Caramazza & Miceli, 1990; Caramazza, Miceli, Villa, & Romani, 1987; De Partz, 1995; Hillis & Caramazza, 1989; Miceli, Benvegnu, Capasso, & Caramazza, 1995; Posteraro, Zinelli, & Mazzucchi, 1988; Tainturier & Rapp, 2003; 2004). It is an impairment in the serial output of the correct sequence of letters of the word form. Graphemic buffer dysgraphia is predominantly described with reference to the DRM, and is said to arise from damage to the graphemic buffer, a short term memory store that maintains representations after lexical or sublexical processing (Tainturier & Rapp, 2001), but has also been described using connectionist computational modeling, with a similar explanation: "the breakdown of a system to generate serial order in the output stages of spelling production" (pp. 304; Glasspool & Houghton, 2005). Lesion locations of people with symptoms consistent with graphemic buffer dysgraphia have varied widely, but have been mostly parietal; including the left frontal parietal region (e.g. Caramazza, Miceli, Villa & Romani, 1987; Hillis & Caramazza, 1989; Posteraro, Zinelli & Mazzucchi, 1988), left parietal lobe (e.g. Miceli, Silveri, & Caramazza, 1985; Sage & Ellis, 2004; Tainturier & Rapp, 2003), but also the temporal (e.g. Cotelli, Abutalebi, Zorizi & Cappa, 2003) and occipital (e.g. Hanley & Kay, 1998) cortex.

2.6. TREATMENT OF MONOLINGUAL READING AND SPELLING

In reading and spelling, lexical damage leads to problems with irregular words (surface dyslexia/dysgraphia) due to dependence on the sublexical system. Treatment targeting deficits at the level of the output lexicons have employed a variety of techniques, depending on the modality that is affected (spoken naming/reading/spelling). They include, but are not limited to, cueing hierarchies (phonological and orthographic), repeated copying of words, repeated attempts at naming/reading/spelling, as well as combinations of these. Therapies targeting the output lexicons primarily display item-specific gains: a review by Nickels (2002a) revealed that therapy effects were predominantly limited to the words used in therapy. Generalisation to untreated words was less common, and it was suggested that, where present, it could have resulted from repeated administration of probes throughout treatment studies. That is, word-form representations in output lexicons can be re-learned and stored in long-term memory, and the correct word-form representation for those that are repeatedly attempted can be re-activated or accessed. Very few treatment studies directly targeting the graphemic buffer have been reported, with most utilising treatment protocols aimed at lexical deficits. Because it is a post-lexical processing working memory store, treatment that is successful at ‘strengthening’ the capacity of graphemic buffer is expected to result in generalisation of effects to all words.

Studies reporting reading and spelling treatment aimed at improving processing at the sublexical and/or lexical level have provided mixed results. Success, defined as generalisation to untreated words as well as item specific gains subsequent to therapy, has been reported in many studies using reading treatment. If treatment is successful in strengthening sublexical processing, it will result in improved grapheme-phoneme (reading) or phoneme-grapheme (spelling) conversion, and therefore should lead to generalisation to untreated words containing treated mappings.

2.7. TREATMENT OF MONOLINGUAL DYSLEXIA

Treatment targeting lexical and sublexical processing in monolingual reading therapy is discussed in this section. Reading/dyslexia is not a central feature of the research presented in this thesis and, as such, only the main treatment methods and general patterns of generalisation are reported.

2.7.1. Treatment of Lexical Reading

A reading treatment protocol using mnemonics was first described by Byng and Coltheart (1986; Coltheart & Byng, 1989). They used the dual route model to design treatment for a deficit in the lexical route, more specifically at the level of orthographic input lexicon (word recognition).The reading therapy using mnemonics on flashcards improved reading of irregular words, and led to some partial improvement in other words, suggesting more widespread improvement. These findings have since been replicated by Weekes and Coltheart (1996), who also found that untreated words which did show improvement were ones that fluctuated in accuracy over two baseline testing sessions.

The mnemonic method has been contrasted with reading treatment using flashcards without mnemonics. Brunsdon, Hannan, Coltheart and Nickels (2002) report a multiple-baseline therapy programme aimed at targeting the lexical system in severe mixed developmental dyslexia (visual word recognition and sublexical deficit). The treatment employed a multiple-baseline design with sets matched for baseline accuracy and frequency. Treatment involved reading words on flashcards, and half were given together with mnemonic cues. Results showed that flash card treatment was successful, regardless of whether mnemonic cues were provided, in eliciting improvement in trained items. In addition, generalisation was observed to untreated words that were read with fluctuating accuracy prior to treatment, similar to Weekes and Coltheart (1996), adding to the argument that untreated words with some level of pre-treatment orthographic representation can improve. Brunsdon, Hannan, Coltheart and Nickels (2002) proceeded to administer the flash card method alone in another study (without mnemonic cues), with improvement of treated items and partial generalisation to untreated items, thus replicating the findings of the first part of the study (but disposing of mnemonics). The therapy had worked at the lexical level, and sublexical processing (i.e. nonword reading) remained impossible after treatment. Interestingly, spelling accuracy of the treated items improved significantly subsequent to treatment. Taken together, the findings of both studies by these authors suggest that reading with feedback can lead to item-specific gains of treatment, extending to written output, without the need for additional strategies (i.e. mnemonics). The cross-modal improvement from reading to spelling observed by Brunston et al. (2002) contradicts the findings of Weekes and Coltheart (1996) of modality-specific gains in a lexical deficit. The methodologies of both studies were highly similar in terms of baseline testing, matching sets, and treatment; both participants also had deficits in visual word recognition. The main difference was that one was a study of acquired dyslexia, while the other was of developmental dyslexia; thus generalisation may occur more readily in the early stages of written language development.

Rowse and Wilshire (2007) compared the effects of two different approaches to treatment in a child, NS, with surface dyslexia: a phonological treatment programme targeting sublexical processing, where grapheme-phoneme correspondences were trained; and a ‘whole-word’ protocol targeting lexical processing, using visually degraded words and mnemonics. NS responded best to the whole-word approach, showing improvement on the trained stimuli, as well as a mild generalisation to untreated words. Rowse et al. (2007) propose that the generalisation to untreated words may be attributed to increased confidence and motivation for reading, especially for irregular words, rather than a direct result of treatment targeting lexical processing. This may also explain the findings of Brunston et al. (2002), described earlier.

2.7.2. Treatment of Sublexical Reading

A very successful reading treatment was reported by Kiran, Thompson and Hashimoto (2001). Two English monolingual adults (RN and RD) were diagnosed with damage to the phonological output lexicon and grapheme-phoneme conversion (sublexical system). An oral reading treatment was administered, which involved training regular words: 1) oral reading, 2) repetition, 3) oral spelling, 4) selection, among distracters, of the letters of the word, 5) identification of the letters of the word presented randomly, and 6) reading the letters of the word. Oral reading of the treated items improved considerably, and also generalised to untreated items. The effects of the oral reading treatment also generalised to written naming of trained words, and writing to dictation of treated and untreated words also improved for both people. No improvement was observed for irregular words, which was expected since they cannot be processed via grapheme-phoneme conversion. The generalisation of treatment effects to writing to dictation of treated and untreated (regular) items demonstrates generalisation of grapheme-phoneme mappings learned during therapy. The findings can be explained by the dual-route framework, with which the therapy was designed, but can also be explained by the triangle model, in terms of strengthening links between orthography and phonology. The results of this study are promising, providing evidence of generalisation to untreated words as well as generalisation across modalities subsequent to a sublexical reading treatment protocol.

Therapy with an 8 year old child with acquired mixed dyslexia (due to traumatic brain injury) has been described by Brunsdon, Hannan, Nickels and Coltheart (2002). Nonword reading therapy was used, to ensure sublexical processing, with the aim of strengthening grapheme-phoneme correspondences, grapheme parsing and phoneme blending (assessed pre and post treatment). Training of grapheme-phoneme correspondences was done by training single letter sounding and two-letter grapheme sounding. Then treatment focused on two-and three-grapheme nonword reading, where the child sounded out the phoneme corresponding to the graphemes before combining them to read the whole word. The child improved significantly in all areas of sublexical reading skills that were assessed pre and post treatment, with generalisation of the rules in untrained nonword items, and also in regular word reading. These findings are supported by a similar study by Rowse and Wilshire (2007), where grapheme-phoneme treatment led to improved nonword reading (over irregular words).

2.8. TREATMENT OF MONOLINGUAL SPELLING

2.8.1. Lexical Spelling Treatment

Spelling therapies targeting the orthographic output lexicon (OOL) normally include repeated presentation of the correct spellings of words, and/or delayed copy of words. This is based on the hypothesis that neural damage has resulted in impaired word-form representations in the long-term memory, and that repeated exposure to words will strengthen those representations. Thus this type of treatment should result in item specific improvement, but no generalisation of effects to untreated words (it would be a way of ‘re-learning’ the spelling of each word).

Aliminosa, McCloskey, Goodman-Schulman and Sokol (1993) provide evidence that delayed copy protocols are most effective for targeting deficits at of the orthographic output lexicon. Treatment was provided to a person with OOL, phoneme-grapheme conversion and possibly also graphemic buffer deficits. The treated items improved, but there was no generalisation. This suggests that access to lexical representations was improved, but the functioning of the graphemic buffer and sublexical processing remained unchanged. Beeson (1999) designed a spelling treatment that targets spelling at the level of the OOL, based on the methods of Aliminosa et al. (1993), which has since been used successfully in other studies (Beeson, Hirsch & Rewega, 2002; Orjada & Beeson, 2005).

The treatment targeted orthographic representations so that single word writing could be used for communication in ST, a multilingual person (Polish-Yiddish-German-English) with severe Wernicke's aphasia, and no ability to make phoneme-grapheme conversions. The aim of the treatment protocol was to increase ST's vocabulary for single word spelling, to maximise his use of single word spelling for day-to-day communication, and ultimately to make him responsible for his own rehabilitation.

The first part of the treatment was called Anagram and Copy Treatment (ACT), which is a cueing hierarchy protocol. ST was given words to spell to dictation. If he was unable to spell them he was given the component letters as an anagram and asked to sort them into the correct order to spell that word. Once the letters were correctly sorted he was asked to copy the word using pen and paper. If the letters were organised incorrectly, the clinician would re-arrange them, and ST would copy. Once mastery was achieved with the anagrams, the clinician made the task more difficult by adding two more letters to the array (one vowel, one consonant), and the same anagram and copy procedure ensued. Once these letters were successfully arranged, ST was asked to write the word from memory. A daily homework programme called Copy and Recall Treatment (CART) was also created. CART involved repeatedly copying the target words, which were presented as labelled pictures, and then testing recall with a written naming task. ST's performance improved for spelling treated words, but no generalisation was observed to untreated items. CART alone has also been shown to be as effective as the combine CART & ACT method (Beeson, 1999; Beeson, Hirsch & Rewega, 2002).The item-specific gains of ACT and CART support of the aforementioned studies in acquired reading and spoken naming treatment studies that have targeted lexical output.

The CART method has since been used in conjunction with oral reading treatment (ORT). Orjada and Beeson (2005) showed that ORT and CART methods resulted in positive changes for a person with Broca's aphasia, in reading new text, reading comprehension and spoken language production, providing evidence that combining treatment methods, in this case administering both reading and spelling treatment, can be effective in improving production in all output modalities.

In accordance with the success of the CART as a homework-based therapy, Beeson, Rewega, Vail and Rapcsak (2000) implemented a homework-based treatment to improve spelling. Unlike ST in the Beeson (1999) study, who is reported to have had no residual sublexical processing, SV and SW showed evidence of partially preserved sublexical processing (due to their phonologically plausible errors in spelling), and lexical processing (evidence of partial word-form knowledge). A 'problem-solving' treatment protocol was created, involving self-correction, and use of an electronic speller to aid in resolving spelling errors. The treatment created for SV involved completing written assignments (writing short vignettes) at home. When SV was unable to retrieve the spelling of a word, she would try to assemble the spelling using letter-sound correspondences, and use an electronic spellchecker if unsure of accuracy. SW took part in a 10-week home programme for writing, where he kept a daily journal and was encouraged to spend time attempting to resolve his spelling difficulties by using an electronic spellchecker. Both SV and SW improved significantly in spelling accuracy, and displayed evidence of interactive use of impaired lexical and sublexical systems in resolving spelling errors. Furthermore, when errors were made after treatment, a higher proportion of them were phonologically plausible misspellings, suggesting that they both had increased use of sublexical processing. These improvements were seen over very different time periods. SW's improvement was seen over a 10-week period, whereas SV improved over the course of 10 months. In summarising the effects of treatment, Beeson et al. (2000) came to two different conclusions about which mechanisms may have improved spelling for SW and SV. During post-testing, SW made many self-corrections, which supports the problem-solving approach. On the other hand, SV did not make many errors in spelling at post-testing, and the authors suggest that graphemic representations had been strengthened. Thus, taking the evidence from this study together with that of Beeson (1999), it seems that it is important to take the available cognitive mechanisms into account when designing therapy. If access to both lexical and sublexical processing is available, both should be exploited in order to gain maximum benefits from treatment.

Schmalzl and Nickels (2006) targeted the orthographic output lexicon for therapy in FME, a lady diagnosed with deficits in semantic, orthographic-lexical and sublexical components of the dual-route model. The treatment aimed to aid re-learning of words by strengthening and facilitating retrieval of lexical representations. Based on the method used by Brunsdon, Hannan, Coltheart and Nickels (2002) in developmental dyslexia, the protocol involved copying words, delayed copy (upon removal of a flashcard), and a condition incorporating use of flashcards with mnemonics, in both therapy sessions and as a homework-based task. Unlike Brunsdon et al. (2002) they found an advantage for use of mnemonics over the treatment without mnemonics, with only the former eliciting significant improvement. This is explained by the treatment aiding activation of damaged semantic representations and thus facilitating access to word-form representations in the output lexicon. It is suggested that Brunston et al. (2002) failed to observe the mnemonic effect in therapy because the child in their study had unimpaired semantics. The findings of this study in contrasting two approaches to therapy highlights the importance of carefully designing treatment with reference to cognitive neuropsychological models, and monitoring their success. Here, it is evident that repeated copy alone was not sufficient in facilitating re-learning of word-form representations, and that additional treatment at the semantic level was beneficial.

Guided by the dual-route framework, Rapp and Kane (2002) created a treatment programme aimed at strengthening lexical representations, and compared its effects on deficits affecting two different spelling components. This study is described in more detail than others because part of the research conducted in this thesis derives directly from the study of Rapp and Kane (2002). RSB, who had symptoms consistent with a graphemic buffer deficit, and MMD, who had impairment in the orthographic output lexicon (OOL), both took part in a delayed-copy spelling protocol. It included three sets of 30 items: a treatment set, a repeated set and a control set, and the treatment procedure for each word in the treatment set was as follows: 1) The person was asked to repeat the word after hearing it, and then make an attempt at spelling it. 2) They were then shown a note card with the word typed on it, and the clinician pointed to each letter while reading them out loud. The person was allowed to study the card for as long as he wished. 3) After the note card was removed, if the first spelling attempt had been unsuccessful, the person was asked to try again. This step was repeated until the word was written correctly. The treatment continued until there was stable performance at 95% correct or above on treated items. For the repeated set, words were repeated, and then spelled without feedback. The control sets were only administered at pre-treatment baseline and during follow-up sessions. Responses were analysed in two ways. First, each word was scored as being correct or incorrect. In addition, each letter was given a score: 1 for being correct, 0 if absent, and 0.5 if present but in the wrong position. This measure was employed as it is a more sensitive way of scoring than that of whole word accuracy.

The treatment resulted in significant improvement of the treated items in RSB and MMD, but patterns of generalisation differed. For MMD, there was improvement in treated items, but also in repeatedly attempted stimuli. Treatment and repeated attempts at spelling items is said to have strengthened their representations in the lexicon. Rapp and Kane (2002) suggest that repeated attempts at activating the word-form representation can be effective in strengthening that representation, but that providing feedback and visual presentation of the stimuli can elicit additional gains. Under the predictions of the dual-route framework (and also the triangle model), the graphemic buffer is involved in spelling all words, thus if treatment is effective at this level, gains should not be restricted to treated items only, which is what Rapp and Kane (2002) observed in RSB. RSB improved on all sets, despite the treatment being aimed at strengthening lexical access. Rapp and Kane (2002) suggest this pattern of improvement is likely to have arisen due to “both a strengthening of individual word representations and some general benefit (either direct or indirect) to the buffering process” (pp. 452).

The findings of Rapp and Kane (2002) have since been replicated by Rapp (2005), who found the same generalisation patterns from delayed copy and repeated testing in OOL and graphemic buffer deficits. The reports of Rapp and Kane (2002) and Rapp (2005) of gains from repeated testing in lexical output deficits are supported by Nickels (2002b), who found that repeated attempts at naming pictures alone (without treatment or feedback) led to improved naming of those items in a person with severe picture and object naming difficulties. However, investigations of repeated attempts at naming/spelling/reading and have not always been successful (e.g. McKissock & Ward, 2007). Neither does repeated testing lead to the same improvement levels as their treated counterparts (as reported in the findings of MMD). Thus for maximum gains, it is still necessary to provide feedback. Benefits of repeated attempts may be linked to deficit severity: those with more severe deficits at the level of the output lexicon may be more resistant to the effects of repeated attempts.

There is as yet no established treatment method specifically targeting the graphemic buffer. However, as described above, delayed copy can be successful. An effective method of treating the graphemic buffer was reported by Panton and Marshall (2008). ‘Ray’ received therapy in spelling practice and writing strategies. The former involved spelling to dictation, spelling via letter-by-letter dictation, copying, and filling in missing parts when part of a word was covered; he was also given homework involving copying, anagrams and filling in missing letters in targets. The latter involved practice in writing down key points in messages, as Ray had expressed a keen interest in improving his note taking skills. The spelling practice technique elicited significant improvement in trained words, as well as untrained words matched for frequency and length (though the effect was not maintained). His note taking skills improved significantly also.

Raymer, Cudworth and Haley (2003) have also provided evidence that treatment that is effective at the level of the buffer can generalise to untreated words. Case NM presented with impairments consistent with damage to both the graphemic buffer and the OOL components of the spelling process. Therapy was an adaptation of the copy and recall treatment of Beeson (1999). First, NM copied the word. Then the first two letters were covered and he was required to recall and write those letters before copying the rest of the word. If this was correct, the next two letters of the word were also covered and he was asked to do the same again. This continued until NM could write the word when it had been fully covered. This was with the aim of increasing the capacity of NM's graphemic buffer and OOL. He was also given daily homework. Indeed, it seems that the capacity of the graphemic buffer did increase as a function of therapy in NM, as the same positive effect was seen in the treated words as in a second set of words. Raymer et al. (2003) argued that NM's improvement on a new set of words reflected an interaction of training effects that influenced both the graphemic buffer and OOL components, and suggests that "If the graphemic buffer can be strengthened through training, effects are likely to generalise to all spelling tasks and stimuli for which the buffer plays a role."

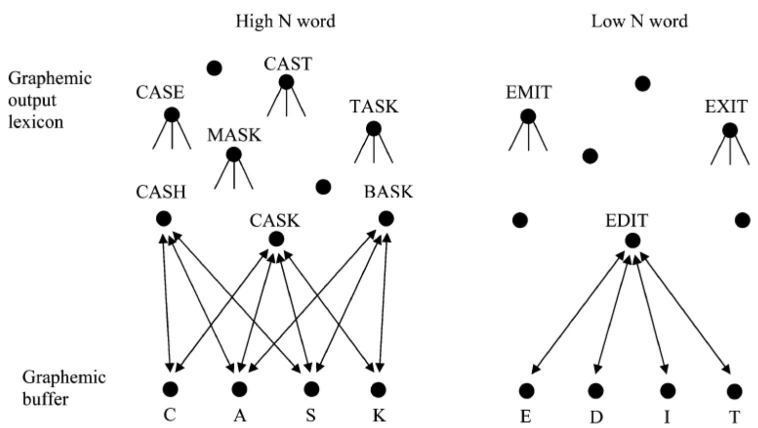

Figure 2.1. Neighbourhood activation for words between graphemic output lexicon and graphemic buffer (from Sage & Ellis, 2006).

Orthographic neighbours, words that differ from each other by one letter, have been successfully incorporated in treatment of graphemic buffer deficits (Sage & Ellis, 2006; Harris, Olson & Humphreys, 2012). Figure 2.1 depicts neighbourhood activation within the graphemic buffer. Sage and Ellis (2006) report the case of BH, who had the symptoms of graphemic buffer dysgraphia. Words with multiple orthographic neighbours were used to treat BH's spelling impairment. This was decided because a previous study (Sage & Ellis, 2004) revealed that performance improved when spelling words that had been primed with words which have many orthographic neighbours (e.g. BAT – cat, hat, mat, rat, bag, but, bar) as opposed to those that do not (e.g. EGG), in both nonwords and real word stimuli. The therapy programme was based on errorless learning techniques of pairwise comparisons (comparing two versions of a word, one misspelled, and selecting the correct spelling), inserting missing letters, and word searches. This errorless learning technique ensured that feedback between the graphemic buffer and the lexicon was as accurate as possible. Directly and indirectly (treating the orthographic neighbours) treated words displayed improvement, whereas the unrelated control set did not. Thus, improvement and generalisation were observed for the treated and neighbour (indirectly treated) sets of words. These results of generalisation to orthographic neighbours of treated items (but not unrelated control items) have been replicated by Harris, Olson and Humphreys (2012) using the 'errorful' method of ACT (anagram and copy treatment), showing treatment generalisation effects only in neighbours with shared middle letters. In relation to the depiction of the buffer represented in Figure 2.1, words that have multiple neighbours will receive bi-directional activation between the graphemic buffer and the graphemic output lexicon from structurally overlapping representations. Sage and Ellis (2006) suggest that the best way to improve representations of a word's letter units is to boost activations of the word itself through priming or long-term practice. Despite the encouraging findings of exploiting words with multiple orthographic neighbours, it is unlikely that this treatment was effective at the level of the graphemic buffer. As stated by Raymer et al. (2003), therapeutic gains due to treatment acting on the buffer should generalise to all words. The results could be attributable to improvements at the lexical level, given that only treated words and those with overlapping structure benefited from therapy.

2.8.2. Sublexical spelling treatment

Treatment protocols targeting sublexical spelling deficits have also been successful. Kiran (2005) extended the previous work of Kiran, Thompson and Hashimoto (2001), to discover whether training phoneme-grapheme conversion (as opposed to grapheme-phoneme conversion in the previous study) would improve oral spelling and writing to dictation of treatment words, and whether treatment effects would generalise to untreated words and untrained tasks. The treatment was administered to three English monolinguals with aphasia, all with impaired phoneme-grapheme conversion. Treatment was given twice per week for two hours, and began once stable baselines were established. For each word, participants were asked to: 1) write to dictation, 2) copy, 3) read orally, 4) select and write the letters of the word from distracters, in the correct sequence, 5) write the letters of the word which were presented orally, and 6) write to dictation again.

Patients 1 and 3 showed similar improvements in writing to dictation and generalisation of effects in writing to dictation of untreated words, written naming of treated and untreated regular words, oral spelling of treated words, but no effect on oral naming. Patient 2 showed no improvement of training. These are promising findings from the two participants who showed extensive gains subsequent to therapy. Their responses to a treatment protocol utilising various simple tasks were seen not only in treated items across modalities, but also in untreated items across modalities. Although patient 2 presented with a similar deficit to patient 1, he had additional deficits in phonological processing, which may explain why he did not respond to treatment when the others did. Kiran (2005) suggests that as well as being effective at the level of sublexical processing, the treatment may also have benefited the OOL, because treated items displayed most improvement (which is true of most studies targeting various different types of dyslexia/ dysgraphia/anomia). In fact, in this case, Kiran (2005) used a protocol involving repeated copying which is characteristic of lexical treatments. It is not clear how this protocol would be a method of specifically targeting phoneme-grapheme conversion. If the study wished to focus specifically on sublexical spelling, it may have been advantageous to measure changes in particular phoneme-grapheme correspondences with which participants were having difficulties. There were 10 trained and 10 untrained items with the treated items improving to a greater extent. But if the untreated items included some impaired phoneme-grapheme mappings that had not been trained within the treated items, it is unlikely that these would improve, and as such, whole word accuracy would not improve to the same extent. Pinpointing and measuring differences in impaired mappings, or scoring words via letter accuracy, may be advisable in sublexical deficits.

Further support for the success of treatment of sublexical deficits was provided by Luzzatti, Colombo, Frustaci and Vitolo (2000), who rehabilitated spelling along the sub-word-level route in two Italian people with dysgraphia, with a protocol involving simple acoustic-phonological-orthographic segmentation of words, repetition and lexical decision. Both participants displayed significant gains subsequent to therapy: post treatment, both were close to normal levels in spelling, and both could apply their restored skills to written naming and spontaneous writing. The success of this treatment could be a reflection of the transparency of the Italian orthography. It may be the case that languages with transparent (or shallow) orthographies, in which most words can be successfully spelled/read sublexically, will respond well to sublexical treatment due to the increased possibility of applying phoneme-grapheme correspondences to other words within the language.

Success in specifically training phoneme-grapheme correspondances has been reported by Kohnen, Nickels, Brunsdon and Coltheart (2008). A treatment approach to training rules that had not yet been learned by a child with developmental mixed dysgraphia is described. Treatment initially involved contrasting words in minimal pairs and direct copy of letters from the pairs, and progressed to repetition of both words from a pair before spelling the words on separate pieces of paper. The treatment was a success, not only for spelling, but for reading also. Subsequent to training two rules that had not yet been acquired by KM, /^/ -> U and the final E rules, trained <U> words and untrained <U> nonwords improved. There was delayed improvement for untrained <U> words which was also evident for untrained <O_E> words). Dramatic improvements were made for spelling words and NWs with the final <E> vowels, even those not specifically trained. Also, a significant improvement was observed in spelling to dictation of words containing other untrained rules that had not yet been acquired (but not for exception words, which would be expected, as spelling of these relies on lexical representation). It was suggested that training two rules led to improved sublexical processing, which in turn aided the acquisition of other new rules. Kohnen, Nickels and Coltheart (2010) further studied this approach to treatment in another child with dyslexia subsequent to brain injury. Using the same methodology as Kohnen et al. (2008), the final silent <E> (e.g. COPE/MATE) rule was trained. Spelling did not improve; but reading of words including the trained rule improved significantly. This suggests that even if the modality that was targeted for treatment, in this case spelling, reveals no significant change, improvement may be evident in other modalities (reading for the child in this case). This highlights the importance of examining across modalities at baseline, as some improvements may otherwise go undetected.

The converging evidence from both developmental and acquired treatment of sublexical processing suggests generalisation to untreated (regular) words and across modalities may occur, and treatment of specifically targeted phoneme-grapheme mappings may generalise across modalities.

2.9. READING AND SPELLING TREATMENT IN BILINGUALS

2.9.1. Reading therapy in bilinguals

There is one report of reading treatment in bilingual acquired dyslexia. Laganaro and Venet (2001) designed a computer-based reading treatment protocol for a bilingual Spanish-English person with mixed alexia (letter-by-letter and phonological dyslexia). Treatment targeted phonological blending skills (i.e. skills that are common to both languages), and tasks to inhibit letter-by-letter reading (lexical decision, word categorisation and word associations). The treatment was effective in promoting cross-linguistic generalisation in nonword reading when the language of treatment was L2 (English). Measurement of reading was made on whole nonwords. However, a more stringent method of analyzing phonological dyslexia would be to explicitly measure improvement in grapheme-phoneme mappings (as Kohnen, Nickels, Brunsdon & Coltheart, 2008; Kohnen, Nickels & Coltheart (2010). This highlights the need for more studies specifically measuring gains of treating impaired mappings.

2.9.2. Spelling therapy in bilinguals

As yet, there have been no reports of spelling therapy in bilingual aphasia. This research includes the first explorations of spelling therapy in bilingual acquired dysgraphia.

2.9.3. Model-based bilingual therapy

Despite the encouraging findings from some of the studies exploring cross-linguistic generalisation, their external validity is limited: "In bilingual aphasia, intervention has generally lacked a theory-driven rationale" (Ansaldo, Saidi & Ruiz, 2010; pp. 311). Also, few have targeted the level of deficit in bilingual language therapy, and none have contrasted effects of treatment at the level of the deficit. As in the case of monolingual treatment studies, model-based treatment, targeting the level or component of the deficit in treatment, can maximise gains. Gaining an understanding of each individual's language deficit should guide therapy choice, according to Marrero, Golden, and Espe-Pfeifer (2002).

The work of Edmonds and Kiran (2006), Kiran and Roberts (2010), Laganaro and Venet (2001) were based on the dual-route model, and were successful in eliciting cross-linguistic generalisation in targeted deficits. Bilingual language therapy research has not ignored models of bilingual word processing; rather it has generally not used models to diagnose deficits or to develop treatment in accordance with such deficits. Most studies have mentioned theories of word processing, with the majority assuming the existence of either one or two lexicons (e.g. Croft et al., 2011; Edmonds & Kiran, 2006; Kiran & Roberts, 2010; Miertsch, Meisel & Isel, 2009; Laganaro & Venet, 2001). Bilingual treatment studies using non-localist theories (PDP theories) have yet to be reported.

Also, no research in bilingual language therapy has investigated spelling. One study reporting a case of bilingual phonological dysgraphia (Kambanaros & Weekes, 2013), and another of bilingual deep dysgraphia (Raman & Weekes, 2005) exists, which were both explained using a dual route framework (and not given treatment). There are no reports of surface dysgraphia or graphemic buffer dysgraphia in bilingual aphasia research to date.

This section highlights the need for a) more theoretically-motivated treatment protocols in bilingual aphasia, and b) the first exploration of treating bilingual spelling deficits.

2.10. INTRODUCTION TO EXPERIMENTAL CHAPTERS

A review of the literature on aphasia therapy reveals that this area of research is at an early stage of development in bilinguals with acquired language disorders, as compared to studies of aphasia and its therapy in monolinguals. Findings from research of aphasia in monolinguals, including models of language processing, diagnosis of deficit types, and therapy studies, have been used as guidance in designing studies with bilingual people with aphasia. It becomes apparent that there is no resolution as yet to some of the questions raised in bilingual aphasia therapy research, and some issues that have yet to be addressed. In particular, the issue of cognates as being facilitatory or inhibitory in spoken naming therapy is unresolved, and spelling therapy in bilingual dysgraphia has yet to be reported.

It is estimated that over 150,000 people in England and Wales have a stroke each year according to the NHS, with the number continuing to rise, and according the 2001 UK census in the North Wales counties of Anglesey and Gwynedd 69% of the population of Gwynedd and 59% of Anglesey were Welsh-English bilingual. This suggests that of those that suffer a stroke affecting language processing in this area, around half will have difficulties in two languages. As well as being important for finding the most effective ways of treating both languages of bilingual people in North Wales, studying the bilingual people who live in this area also provides a basis for investigating some of the unanswered questions in bilingual aphasia research.

The studies that follow contribute to further understanding of bilingual aphasia therapy, and are the first studies of bilingual aphasia therapy in Welsh-English bilinguals. The main contribution of this research is that it includes the first known studies exploring exclusive spelling treatment of acquired dysgraphia in bilinguals. Specifically, descriptions of deficits to the orthographic output lexicon, and to the graphemic buffer have yet to be reported in bilingual aphasia research, let alone reports of treating these deficits in bilinguals. Bilingual phonological dysgraphia (damage to the sublexical phoneme-grapheme conversion route) has previously been described (Kambanaros & Weekes, 2013), but this research includes the first spelling treatment study targeting impaired phoneme-grapheme conversion in a bilingual person with acquired phonological dysgraphia. It also includes the first direct examination of the effect of deficit type in bilingualism research. The research also contributes to previous conflicting findings about the use of cognates in spoken naming therapy. Three studies aimed to discover whether specific treatment programmes would be effective for bilinguals who have the characteristics of impairment in different components of language processing, and whether any generalisation effects would be seen in their untrained language.

2.10.1. Research Questions

The studies, investigating either bilingual anomia therapy or spelling therapy in bilingual aphasia, had three primary objectives: 1) to discover whether cross-linguistic treatment generalisation may occur in (Welsh-English) bilingual aphasia; 2) to explore generalisation patterns as a function of deficit type, language of treatment, and word type;

and 3) to inform theories of bilingual word processing using patterns of treatment generalisation.

2.10.2. Predictions

Based on predictions of bilingual word processing, and findings from both bilingual and monolingual aphasia therapy research, hypotheses were made regarding patterns of generalisation. Different predictions of treatment generalisation were made. Lexical output deficits were expected to elicit item-specific gains of treatment, with generalisation of effects when cognates are included, in accordance with previous findings from spoken naming therapy.

Treatment of a graphemic buffer deficit was expected to show generalisation across word-types within the language of treatment. Because no cases have previously been reported of bilingual graphemic buffer dysgraphia, predictions were made based on monolingual studies. Because the graphemic buffer is a working memory store that processes the spelling of all words, it was predicted that it may be language non-specific (see model). Treatment of a shared buffer for both languages was expected to elicit cross-language gains.

Spelling therapy targeting impaired phoneme-grapheme mappings was expected to elicit cross-language effects in mappings that are shared between languages, but within language gains only for mappings that are divergent between languages.

With regards to the language of therapy, based on previous findings, it was hypothesised that treatment of L2 would elicit greater cross-language gains than vice versa.

2.10.3. Selection of participants

Three people with aphasia took part in the present research (one took part in two studies and the others took part in one each). Ethical procedure followed Bangor University protocol: participants gave informed consent, were informed of the full purpose of the study and were told that they could withdraw from the study at any time. They were all pre-morbidly highly proficient Welsh-English early bilinguals, early being defined as having acquired both languages before adolescence (Ardila, 1998; as cited in Lorenzen & Murray, 2008). They were all born in North Wales and had lived there all of their lives. All spoke Welsh at home during childhood, but would have at least heard English from an early age too (television, radio etc) with English being introduced formally at school at the age of 5 or 6. Reading and writing was taught in both languages from this age also. During adult life they all used Welsh and English daily, with Welsh being used primarily in the home, and English at work. English was the primary language of reading, writing and media use. This use of English and Welsh is true of the majority of people in Anglesey and Gwynedd, especially for the generation of the participants of these studies. All participants were in the chronic phase of their illness (5, 11, and 23 years post-onset when testing began). In sum, all participants had highly similar language backgrounds. They were selected on the basis of 1) Having relatively circumscribed deficits; 2) Having deficits at different levels (to contrast); 3) Having comparable deficits in both languages; 4) Having no peripheral, comprehension or memory deficits severe enough to rule out treatment.

All three studies were multiple-baseline single-case investigations. Baseline testing was carried out to establish the pre-treatment stability and post-treatment gains of each treatment protocol. In two of the studies, three baseline sessions for each language (3 English, 3 Welsh) were carried out in a pre-treatment phase, and also at post-testing (beginning in the week following treatment ceasing) and follow-up (around 6 weeks post therapy, apart from the anomia study which had a 16-week follow-up) stages. The other study had 2 sessions for each language in each phase. The language of each baseline session alternated from one to the next, and each session was administered in one language only to avoid language confusion. Changes in accuracy between pre and post-test sessions in all studies was primarily calculated using McNemar's tests (for an example of how changes were calculated, see Appendix A). McNemar's test is a nonparametric test for paired nominal data such as accuracy scores, and is used to compute statistical significance of treatment-induced changes in behavioural scores in aphasia research.

The studies investigating lexical and post-lexical processing contained five sets of stimuli for each participant: 1) treated; 2) repeatedly attempted but untreated [without feedback]; 3) within language untreated control; 4) translations of treated set [untreated language]; 5) untreated control in untreated language. The study focusing on sublexical processing differed because accuracy was measured in terms of correct mappings produced in nonwords (to ensure non-lexical processing). Predictions about the possibility of both within and between-language generalisation were made, based on what has been learned from treatment of such deficits in bilinguals and, in cases where no evidence from bilinguals exists, predictions were made based on findings from monolingual treatment studies, along with predictions from models of bilingual processing.

Treatment protocols differed between studies but, during the testing period, participants were visited in their homes twice per week (when possible; 3 times for the study targeting sublexial spelling), and therapy sessions lasted around one hour. Criteria for treatment discontinuation were when participants reached 90% accuracy in treatment sessions, or when performance plateaued with no fluctuation in performance across four consecutive sessions.

CHAPTER 3: CROSS-LINGUISTIC TREATMENT GENERALISATION OF SPOKEN NAMING IN WELSH-ENGLISH BILINGUAL ANOMIA

CHAPTER 3: CROSS-LINGUISTIC TREATMENT GENERALISATION OF SPOKEN NAMING IN WELSH-ENGLISH BILINGUAL ANOMIA

3.1. ABSTRACT

This study aimed to gain further understanding of the conditions under which cross-linguistic treatment generalisation may occur in bilingual anomia. Earlier studies suggest that cross-linguistic treatment can occur, particularly with semantic treatments and maximally for therapy using cognates (Kiran & Edmonds, 2004; Kohnert, 2004). This issue was explored using a phonological cueing treatment in a Welsh-English bilingual woman with a deficit to the phonological lexicon. Improvement was made on treated words and (to a lesser extent) words that were repeatedly presented but not treated. In addition, as predicted, cross-language transfer occurred, but was restricted to cognate translations of treated words. This is consistent with psycholinguistic models positing stronger co-activation between cognates in the bilingual lexicon (e.g. Costa, Caramazza & Sebastian-Galles, 2000). It is suggested that this co-activation allows for an indirect activation of untreated Welsh cognates when the corresponding English word is being treated, boosting the strength of impaired lexical representations. This is the first study to demonstrate a generalisation to cognates using a phonological cueing treatment in a person with a deficit limited to the phonological output lexicon.

3.2. INTRODUCTION

The small number of studies investigating cross-language generalisation of treatment in aphasia have yielded mixed results, with the majority focusing on spoken naming (for a full review, see Faroqi-Shah, Frymark, Mullen & Wang, 2010). Patterns of cross-language treatment generalisation observed in treatment studies not only provide therapists with guidelines on how to elicit maximal gains in bilingual therapy, but also contribute to further understanding of the processes involved in bilingual word processing.

One debate that remains to be resolved is that of the status of the bilingual lexicon. Some earlier theories posit two separate lexicons (Kroll & Stewart, 1994; Potter, So, Von Eckardt & Feldman, 1984), supported by cases of differential impairment between the two languages of a bilingual with aphasia (e.g. Béland & Mimouni, 2001; Ibrahim, 2008; 2009); whereas other models specify the existence of a single lexicon that is integrated across languages (Dijkstra & Van Heuven, 1998; 2002). This is supported by the high occurrence of parallel recovery/deficits in bilingual aphasia (Paradis, 2004).

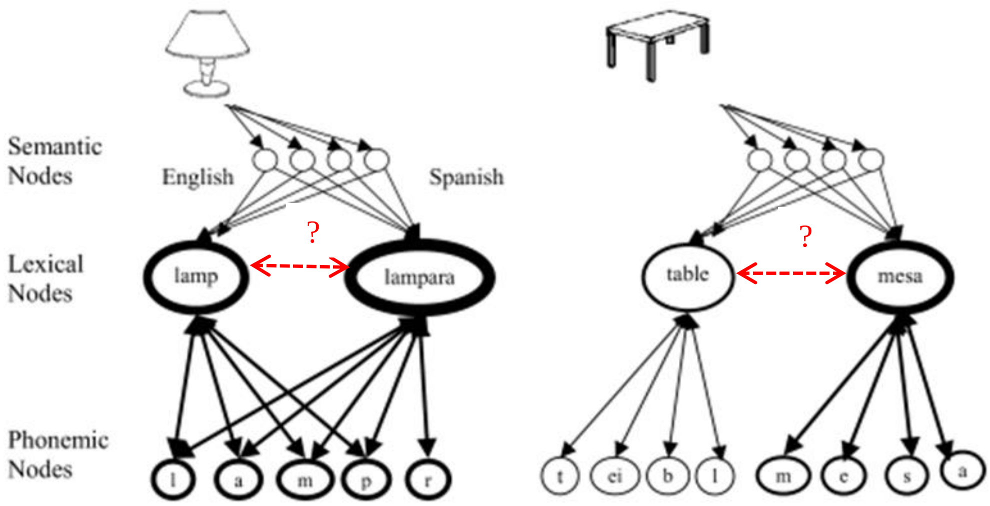

Figure 3.1. A theoretical account of the cognate facilitation effect (from Costa et al., 2005). Red arrows represent possible activation between lexicons (akin to Kroll & Stewart, 1994).

The cognate superiority effect (Costa, Caramazza & Sebastian-Galles, 2000), presented in Figure 3.1, has been used to inform models of lexical processing. It refers to an advantage for processing cognates over non-cognates, and has been described in numerous studies (e.g. Costa, Caramazza & Sebastian-Galles, 2000; Costa, Santesteban & Caño, 2005; Dijkstra, Grainger & Van Heuven, 1999; Lalor & Kirsner, 2001; Roberts & Deslauriers, 1999; Schelletter, 2002). It is derived from Dell et al.’s (1997) Interactive Activation model, with its main features being co-activation of both lexicons from a shared semantic system, and bi-directional feedback between the lexical level and phonology. Under these assumptions it is proposed that there is an advantage for processing words that are similar in meaning and form in bilinguals, due to both co-activation from the semantic level, but also bi-directional feedback from the phonological level. Like the models of bilingual lexical access described in Chapter 1 (Kroll & Stewart, 1994; Potter, So, Von Eckardt & Feldman, 1984) it assumes a shared concept/semantic level, that activates both languages in parallel, but unlike these models it does not include direct connections at the lexical level between translation equivalents (red arrows in Figure 3.1). It is unclear why not. It may be because it would be very difficult to test direct links between lexicons, given the predictions of parallel activation from semantics, and bi-directional activation between the lexical level and phonology: improvement of translation equivalents could be explained by either approach.

The most common approach to bilingual anomia therapy, semantic treatment, normally involves identifying semantic features/categories of target words in order to assist with naming (Ansaldo, Saidi & Ruiz, 2010; Croft, Marshall, Pring & Hardwick, 2011; Goral, Rosas, Conner & Obler, 2012; Kiran & Edmonds, 2004; Edmonds & Kiran, 2006; Kiran & Roberts, 2010; Kiran & Iakupova, 2011; Miertsch, Meisel & Isel, 2009; Meinzer, Obleser, Flaisch, Eulitz & Rockstroh, 2007). Other methods have utilised phonological methods generally involving phonological cueing (progressive cueing of phonemes until accurate naming is achieved), repetition, and rhyme judgement (Croft et al., 2011), and mixed semantic and phonological methods (Galvez & Hinckely, 2003; Kohnert, 2004; Kurland & Falcon, 2011). Both have been shown to be effective in producing significant and lasting improvement in treated words, but the impact of each method on cross-linguistic generalisation has varied between studies.

As the models described in Chapter 1 agree, it is suggested that both languages have a shared conceptual (or semantic) system. Under this assumption, treatment targeting impaired semantics should elicit some cross-language gains. This is because strengthening semantic representations should facilitate co-activation of lexical representations in both languages in pre-morbidly proficient bilinguals, via their shared semantic features (e.g. Dell et al., 1997; Kroll & Stewart, 1984; Potter, So, Von Eckardt & Feldman, 1984 [concept mediation]). Edmonds and Kiran (2006) reported cross-linguistic generalisation in three people with aphasia subsequent to a semantic feature analysis (SFA) protocol. The authors concluded that in this case, cross-language generalisation was determined by pre-morbid proficiency, because generalisation was only observed after treatment of the participants' pre-morbidly weaker language. In a follow-up study, Kiran and Roberts (2010) presented four bilingual participants with a semantic feature based treatment protocol, and cross-language generalisation was observed in one participant, to some semantically related words. Furthermore, Kiran and Iakupova (2011) presented a semantic therapy study with Russian-English bilinguals, and found treatment of L2 (English) to evoke improvement in trained and untrained (but semantically related) items in both languages. Although the methodology and design of all three studies was similar, Kiran and Roberts (2010) failed to observe cross-linguistic treatment effects in three of their participants. There seem to be many possible explanations for the varied responses across the three participants, including high baseline accuracy, mild aphasia, poor response to treatment on treated items (in a more severe case); but also factors such as language-use history, spontaneous recovery, and executive function are also possibilities. This highlights the fact that treatment of aphasia is highly individual, and treatment should be designed according to each individual's specific deficit, and spared processing abilities.

Others have been less successful in their attempts to induce cross-language generalisation after semantic naming therapy (e.g. Ansaldo, Saidi & Ruiz, 2010; Galvez & Hinckley, 2003). Thus, it becomes apparent that although semantically-based treatment protocols have been successful in producing cross-language gains, this is by no means the rule. In fact, of the studies mentioned above, fewer than half of the participants showed signs of generalisation to the untreated language. This highlights the fact that each person is different, presenting with an individual deficit, and an individual response to therapy.

One factor that has emerged from studies exploring bilingual language therapy is that treatment of the person's L2 is more likely to result in cross-language gains (Edmonds & Kiran, 2006; Fredman, 1975; Goral, Rosas, Conner & Maul, 2012; Kiran & Roberts, 2010; Miertsch, Meisel & Isel, 2009) than targeting L1 (Ansaldo, Saidi & Ruiz, 2010; Galvez & Hinckley, 2003; Meinzer, Obleser, Flaisch, Eulitz & Rockstroh, 2007). This is consistent with the predictions of models, such as the revised Hierarchical model, positing a stronger L2->L1 (than L1->L2) flow of activation. But again, this is not the rule, and some studies have observed cross-linguistic generalisation subsequent to L1 therapy (e.g.Croft, Marshall, Pring & Hardwick, 2011; Junque, Vendrell & Vendrell-Brucet, 1989; Kohnert, 2004), and others have shown no generalisation subsequent to treatment of L2 (e.g. Amberber, 2012). This is by no means the only factor that contributes to successful cross-language generalisation: type of treatment, level of deficit, severity of deficit and motivation can also affect outcomes.

Croft, Marshall, Pring and Hardwick (2011) contrasted semantic and phonological methods, and compared generalisation effects after treating both L1 and L2 for each approach. Unlike the common L2->L1 pattern of generalisation, they found that three out of five Bengali-English participants showed cross-language effects of treatment, but only when the language of therapy was L1. The generalisation effect on one of these participants is likely to have been spontaneous recovery. The other two participants showed cross-linguistic gains after semantic therapy. These were the two participants who had highest baseline scores in naming and semantics. However, this L1->L2 response to therapy is likely to have arisen because participants chose to be treated in L1 first, and L1 was treated by co-workers rather than therapists (L2 was treated by therapists). These methodological discrepancies make it difficult for Croft et al. (2011) to claim success of treating one language over another. It is also important to consider the stimuli being used in therapy. As theories positing bi-directional activation between the lexical level and phonology, or theories positing direct links between lexicons, would suggest; exploiting the use of phonologically as well as semantically related words may have also elicited cross-language gains. In fact, there is no mention of the status of the items used in therapy in this study, but all of the background naming items were cognates – but not Bengali-English cognates; rather, they were Sylheti-Bengali cognates. This potentially adds another confound to the results: Bengali may have had an advantage over English in therapy, due to the cognate facilitation effect from another language pair.

Combined semantic, phonological and orthographic therapy has also made successful use of the cognate facilitation effect. Kohnert (2004) provides evidence for an advantage of using cognates in therapy with a bilingual Spanish-English person, DJ, with equally impaired naming in both languages. DJ received a very brief treatment protocol: 4 treatment sessions in a cognate based intervention; two in Spanish (L1) during one week, and after a week-long break, the language of treatment was changed to English (L2). The protocol involved word-picture matching, semantic associations, cloze tasks, spelling to dictation, and confrontation naming using phonological cues. Lasting cross-linguistic treatment generalisation was observed from Spanish to English, but only for cognates rather than non-cognate translations, suggesting that exploiting lexical and phonological-semantic links between languages can maximise treatment effects. However, the cognate treatment investigation of Kohnert (2004) was very brief (two 1-hour sessions in each language), the cognates used to evaluate performance were not those used for treatment, and it is not clear whether baseline testing took place before the beginning of Spanish therapy.

Kurland and Falcon (2011) recently explored treatment using cognates with GLP, who, like DJ, was a Spanish-English bilingual aphasic. GLP took part in intensive naming treatment, first in Spanish; then after a period of no treatment, English, and after that, treatment in both Spanish and English combined. Treatment involved naming, reading names, semantically cued cloze tasks, word-picture matching, and repetition. The treatment did not elicit cross-language improvement for cognates: in fact, non-cognates improved to a greater extent than cognates, and mostly in Spanish. It was suggested that, rather than facilitating access via spreading activation, treatment of cognates caused interference, hindering reacquisition in this case. Kurland and Falcon (2011) did, however, observe improved performance on measures of auditory comprehension, both within and between-languages.

Therefore the two treatment investigations exploring the use of cognates in bilingual language therapy, have provided contrasting results. The pre-treatment assessment scores of DJ suggest a predominant deficit in naming, whereas the scores of GLP suggests a more global deficit, with impaired comprehension and repetition scores; as well as more impaired naming than DJ. It may be the case that GLP did not respond to treatment of cognates in the same way as DJ because of additional deficits. This highlights the importance of designing treatment according to the specific deficit of the person with aphasia.

In sum, there are contradictory findings regarding the use of cognates in therapy. This leaves an unresolved question regarding the status of cognates, both in therapy, and within models of lexical access. The present study explores treatment of cognates in a woman with a naming deficit restricted to the phonological output lexicon. It also provides the first report of a purely phonological treatment approach in bilingual anomia therapy (i.e. no semantic training). Because semantics remain relatively unimpaired, it was expected that treatment would elicit a similar response as that of DJ in the study of Kohnert (2004).

3.2.1. Rationale, aims and hypotheses

This study has been designed in order to further understand the mechanisms underlying bilingual word production, and to investigate cross-language generalisation of cognates in bilingual anomia.

The specific research questions were: Can treating one language lead to improvement in the untreated language? If so, will it be restricted to cognate stimuli? Can patterns of treatment generalisation in bilingual lexical naming deficits support theories of normal bilingual word processing positing an advantage for cognates?

These questions were addressed using a progressive phonological cueing treatment protocol. A Welsh-English bilingual woman with severe anomia as a result of impairment in the phonological output lexicon took part. Based on past research and theories of bilingual word processing, predictions were made regarding both within and between language treatment generalisation. Five sets of stimuli were created: A treated set, including half cognates; a repeatedly attempted set (with no feedback); a within-language control set; a set of translations of the treated items (including half cognates), and an untreated language control set.

Treatment was expected to aid re-learning lexical phonological representations of treated words. Indeed, treatment studies of lexical output deficits in both monolinguals and bilinguals have elicited item-specific gains of treatment (e.g. Hickin, Best, Howard & Osborne, 2002; Best, Herbert, Osborne & Howard, 2002; Fisher, Wilshire & Ponsford, 2008; Edmonds & Kiran, 2006); therefore this was also expected in the present study.

A repeatedly tested but not treated set of word was included to discover whether repeated testing alone has an effect on naming performance, and what additional benefits are provided by treatment. Based on findings from repeated testing during treatment of spelling deficits at the level of the output lexicon, in monolinguals (e.g. Rapp & Kane, 2002), it was hypothesised that re-activation of damaged lexical representations may be possible from repeated attempts at retrieval.

No improvement was expected in the untreated and unrelated control sets, in either language. Because the deficit is at the lexical level, without treatment or repeated exposure to these stimuli, the damaged representation of unrelated control words is not expected to be retrieved.

Based on Kohnert (2004), and models of bilingual lexical access, improvement was predicted in the Welsh translations set. Costa et al. (2000) suggest a facilitation of cognates due to feedback activation from phonology, in addition to semantic activation. Therefore, treatment targeting cognate stimuli was expected to elicit gains in the cross-language equivalent. The treatment was not expected to elicit gains in non-cognate translations due to the lack of additional activation from phonology from their cross-language treated counterparts.

3.3. METHOD

3.3.1. Case study: HBL

HBL was 60 years old and 23 years post onset at the time of testing. She is a Welsh-English bilingual who suffered a large left hemisphere stroke in 1986 (see Figure 3.2). MRI scan reveals a very large left-sided infarct, which has affected most linguistic abilities including severe anomia, problems with sentence production, dyslexia and dysgraphia. She has no problems with comprehension for single words, or vision problems, but some problems with working memory. Prior to neurological damage she was right handed, but due to right-sided hemiplegia she now has use of only her left hand.

Figure 3.2: MRI 2000, Very large left hemisphere infarct involving virtually the entire left middle cerebral artery territory and atrophy of left cerebral peduncle and midbrain.

HBL was educated to secondary level, and has spoken both Welsh and English from an early age. She was formerly a hospital cleaner but retired at age 42 (due to the stroke). Speech and language therapy was provided for 6 months post onset, but not since. HBL attends a weekly stroke club where she has the opportunity to practise speaking with others in Welsh (supported conversation).

HBL has always lived in North Wales, and had a predominantly Welsh upbringing, which became more balanced with use of both languages as an adult. She began to speak Welsh first (around 12 months) as this was the language spoken in the home. English was introduced formally around age 5, in school, but she would have been exposed to English before this age (e.g. television and radio). During adult life in general she spoke English and Welsh equally (50% each, self-reported). Before the stroke she reports having native-like fluency in both English and Welsh. Welsh was the language used at home, and English was the language of media exposure, all written communication, and when conversing with monolingual friends/colleagues. Since the stroke she prefers to communicate through the medium of Welsh, as she feels that her use of English has suffered most. Present use of English is predominantly from media exposure (magazines, radio and television). For the full language background questionnaire of HBL, refer to Appendix B).

3.3.2. General Language Assessment

HBL presents with severe phonological/deep dyslexia in both English and Welsh (full details presented in Tainturier, Roberts & Leek, 2011): she was unable to read any nonwords, and real word reading is severely impaired (English: 12/40; Welsh: 4/40). She was completely unable to spell. Working memory is also impaired: HBL was able to produce 4 items in a forward digit span task, and 2 backward.

Visual lexical decision tasks were used to asses word recognition (input lexicon). Real word recognition was high relative to that of 'legal' nonwords (e.g. GLOP) in both languages (English words versus nonword identification [71/80 vs. 20/40] - χ^2 (1) = 21.8, p<.001; Welsh words versus nonwords [36/40 vs. 20/40 - χ^2 (1) = 15.2, p<.001). When 'illegal' nonwords were used alongside real words (PALPA 24; Kay, Lesser & Coltheart, 1992), decisions were 100% correct. HBL's ability to recognise real words, and her ability to distinguish between real words and illegal nonwords, is relatively preserved, whereas legal nonword identification is at chance, suggesting problems in lexical phonology.

Comprehension (semantics) at single word level remains unimpaired in English. Scores in spoken and written word to picture matching (PALPA 47-48) were within normal range (both 38/40 [control range 35-40 for both]) and non-verbal semantic processing was also unimpaired (50/52 3-picture version of pyramids and palm trees test [control range 49-52). Welsh written word picture matching was impaired (26/38; translated from PALPA written word-picture matching [2 items removed due to not being suitable for translation; results also described in Tainturier et al., 2011]). Receptive vocabulary is outside control range in Welsh (203/240 [control range 213-239]; Prawf Geirfa Cymraeg; Gathercole, Thomas & Hughes, 2008). It must be noted that the Welsh Vocabulary test is much more stringent than the PALPA word-picture matching tasks. The Prawf Geirfa includes nouns, verbs and adjectives, of increasing difficulty as the task proceeds, whereas the PALPA tasks include nouns only.

3.3.3. Spoken naming deficit diagnosis

HBL has severe anomia in both English and Welsh, and tends to utilise the words most readily available, regardless of the language. For example, during spoken conversation, she tends to use Welsh syntax but inserts many English words. For example, she may say, “Y boy mynd i school” [The boy go(es) to school]. This is her most effective way of communicating.

The first goal was to quantify naming the disorder of HBL in English versus Welsh, and to evaluate any effect of word frequency and length. Stimuli were selected from Druks and Masterson (2000) for English naming. A set of 98 items from Lists A and B of the object naming battery was selected for English naming, and a list of 40 items was created for naming in Welsh (some extracted from Druks & Masterson, 2000; others from tests created in Bangor University). The English list included 9 cognates (2 of which were named correctly), and the Welsh list included no cognate items. They were divided into categories according to frequency and length (see below Table 3.1): High frequency (English M=196.5; Welsh M=181.7), low frequency (English M= 10.4; Welsh M=14.6), Long (English M=5.7; Welsh M=5.3) and short (English M=3.3; Welsh 3.5) sets were matched. Correct responses for high versus low frequency and long versus short words were analysed.

Table 3.1: Picture naming (objects) assessment of HBL

	English Object Naming			*Welsh Object Naming*		
	Repetition (%)	Correct (N)	Correct (%)	Repetition (%)	Correct (N)	Correct (%)
High Frequency	100	22/38	58	100	4/20	20
Low Frequency	97	15/60	25	100	2/20	10
Long Words	95	11/38	30	100	3/20	15
Short Words	100	26/61	43	100	3/20	15
HF Long	100	3/10	30	100	2/10	20
HF Short	100	19/28	68	100	2/10	20
LF Long	93	8/27	30	100	1/10	10
LF Short	100	7/33	21	100	1/10	10

High Frequency ≥80 K-F [English]; CEG [Welsh]
Low Frequency ≤20 K-F [English]; CEG [Welsh]
Long ≥5 phonemes; Short ≤4 phonemes

In separate sessions (one English, one Welsh), HBL was asked to name the stimuli presented on PowerPoint slides (see Appendix C for the list of stimuli); she was also asked to complete a repetition task using the same stimuli. Repetition scores were high (93-100% accuracy for English; 100% Welsh) suggesting good auditory processing, articulation capability and post-lexical phonology, for the same items that she was asked to name.

The task revealed spoken naming deficits in both languages, particularly in Welsh, as compared to English (15% Welsh, 38% English correct: Fisher's exact, *p*=.009).

There was no effect of word length in English (χ^2 (1) = 1.63, *p=n.s)* or Welsh (both short and long words were 3/20) picture naming, suggesting unimpaired postlexical processing (buffers). However, there was a frequency effect in English, with better performance on high frequency words (HF 58%, LF 25% [χ^2 (1) = 10.71, p<.001]), and a trend toward a frequency effect in Welsh, but the number of correct responses was too low to reach statistical significance (HF 20%, LF 10% correct [Fisher's exact, p<.661]). This frequency effect seen in English (and a trend toward it in Welsh), taken together with relatively unimpaired comprehension and repetition, suggest that HBL has impaired lexical access at the output stage.

The errors made are consistent with this interpretation. Figure 3.3 illustrates the distribution of error types made by HBL in the English and Welsh object naming tasks presented above. The most common errors in English are 'no response' (n=26). The other types of errors in English naming suggest that partial access to semantics and lexical representations are available for some words: Semantic errors (n=15), the initial phoneme of the target (n=4), circumlocutions (n=4), morphological errors (n=6; 5 plural, 1 phonological arrow->barrow), and translation errors (n=6) are produced when the correct spoken word-form cannot be retrieved.

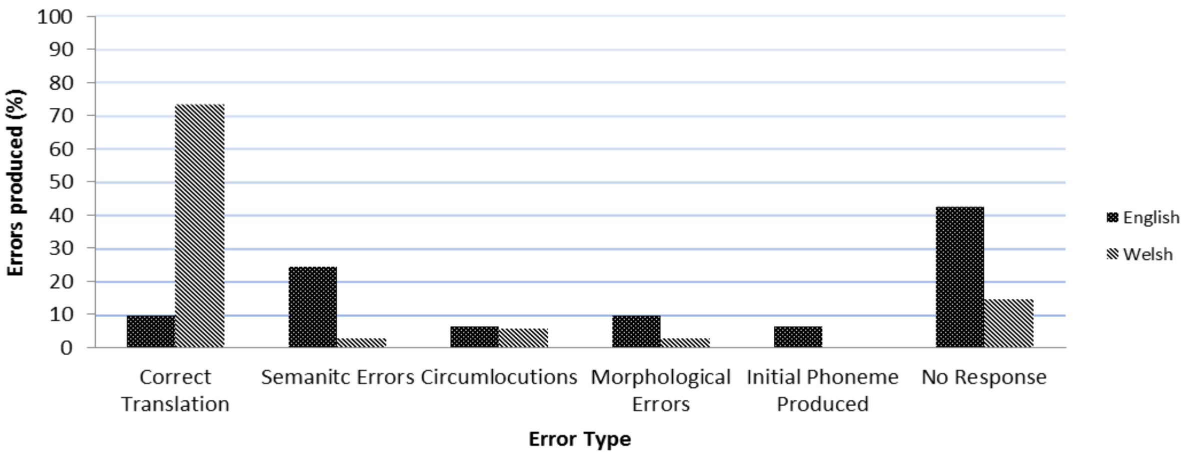

Figure 3.3. The distribution of error types by HBL in English (N=98) and Welsh (N=40) object naming.

In Welsh object naming, the majority of errors are correct translations (n=25). Other errors included ‘no response’ (n=5), circumlocutions (n=2) and one semantic and one morphological error. The high number of translation errors as compared to other error types and accurate responses suggest that semantic information is accessed; but activation is fed forward to less impaired, English, lexical representations.

The converging evidence suggests that HBL has a lexical deficit, primarily at the level of the phonological output lexicon. This is borne out as follows: 1) single word comprehension (access to semantics) is good; 2) the input lexicon seems to be well-preserved, as she has little difficulty recognising real words; 2) real word repetition ability is good; 3) spoken naming is very impaired; 4) a frequency effect is evident in spoken naming; 5) there is no effect of length, and 6) there are no phonetic/phonological errors. Thus in sum, semantics are preserved, as is post-lexical phonology, leaving a damaged phonological output lexicon.

3.3.4. Treatment investigation

A cueing hierarchy treatment protocol was provided, targeting the impaired phonological output lexicon, and exploiting HBL’s positive response to phonological cues (which had been previously piloted). The study aimed to employ a cross-over design, but HBL was unable to continue with testing after the English treatment phase.

3.3.5. Stimuli

Stimuli for the present study were acquired by combining the results of existing spoken picture naming data of HBL in both English and Welsh, and selecting previously erroneous items, as well as some previously correct (for morale). They were then distributed into five sets (see Table 3.2); a treated set, repeatedly attempted (but untreated) set, English control set, Welsh translations of English treated set, and a Welsh control set. Each set included n=26 [n=25 for English control] high frequency, highly imageable, nouns, and sets were matched across sets for frequency (English - Kucera and Francis (1967); Welsh - CEG Cronfa Electroneg o Gymraeg [Ellis, O'Dochartaigh, Hicks, Morgan, & Laporte, 2001]). One-way ANOVA confirmed that there was no significant difference in frequency (F (1, 4) = .100, p=.982), nor imageability ratings (F (1, 4) = 1.458, p=.220) between sets. There was, however, a significant difference in word length (in phonemes) between the 5 sets (F (1, 4) = 3.087, p=.018). Ten highly proficient Welsh-English neurologically unimpaired bilinguals were asked to name pictures of the nouns selected for this study, with 90-100% naming agreement on all items, apart from the item ‘mushroom’ in the English repeated (untreated) set (70% naming agreement with the other 3 being ‘toadstool’).

Table 3.2. Items per set, control naming scores, average length (in phonemes), frequencies, and imageability for each set (M=Mean, S.D= Standard Deviation, K-F=Kucera-Francis, CEG=CEG Cronfa Electroneg o Gymraeg).

	N	Control (n=10) naming agreement (M, Range)	Word length (phonemes; Mean [Range])	Frequency (Log10 K-F & CEG; Mean [S.D])	Imageability rating (MRC; Mean [S.D])
English Treated words (All)	26	26	4.19 [3-7]	1.54 [0.49]	595.76 [25.85]
Cognates:	13	13	4.31 [3-7]	1.47 [0.47]	584.25 [24.78]
Non-cognates:	13	13	4.08 [3-6]	1.60 [0.52]	606.38 [22.77]
English Repeated controls (untreated)	26	25.5 (25-26)	3.73 [2-7]	1.50 [0.53]	611.13 [24.36]
English Untreated controls	25	24.6 (24-25)	4.00 [2-8]	1.50 [0.59]	606.26 [29.21]
Welsh translations of English treated (All)	26	25.7 (25-26)	4.69 [3-6]	1.42 [0.55]	595.76 [25.85]
Cognates:	13	12.9 (12-13)	4.62 [3-6]	1.33 [0.59]	584.25 [24.78]
Non-cognates:	13	12.8 (12-13)	4.77 [3-6]	1.51 [0.51]	606.38 [22.77]
Welsh unrelated control words	26	24.9 (23-26)	4.65 [3-7]	1.58 [0.49]	605.05 [32.93]

The English treated and Welsh translation sets included half cognates, defined as having at least 70% of phonemes in common between both languages (e.g. ‘cat’ and ‘cath’). The cognates also all shared the same initial phoneme (apart from bottle -> potel, but most Welsh speakers would say ‘botel’ because it is normally used with a preceding article, inducing mutation), with the difference in phonological overlap appearing at the middle or the end of words (9 and 4 respectively). No cognates used had 100% overlap in phoneme (for the experimenter to be sure of which language was being produced). Stimuli were presented, one picture per slide, in a Microsoft PowerPoint slideshow.

For each item there were two pictures: one that was used in evaluation sessions (baselines, post-tests and follow-ups), and the other for use in treatment. This was to ensure HBL was able to name the target after the treatment protocol, regardless of the visual input.

3.3.6. Design and procedure

A single-case study design was employed. All five sets of stimuli were administered in spoken picture naming tasks three times at each evaluations stage; baseline, post-testing, and 16 weeks follow-up. Both baseline testing and post-testing took 6 sessions over a period of 3 weeks: two sessions per week, one English and one Welsh. In these evaluation sessions, the order of presentation was randomised (i.e. English treated, repeated and control items were randomised for naming, and Welsh translation and control sets were also randomised). English and Welsh testing were restricted to different sessions in order to reduce the possibility of any additional language mixing. The treated and repeated attempt sets were then used in bi-weekly sessions. The criterion for discontinuation was no further improvement over 4 consecutive sessions in the treated set, which occurred after 15 treatment sessions (at an accuracy of 23/26).

3.3.7. Treatment protocol

HBL was visited at her home twice per week (when possible) for treatment. Treated and repeated sets were administered in a blocked design with the order of presentation alternating between sessions: the first session began with the treated words followed by the repeated attempt set, and the next session would begin with the repeated attempt set followed by the treated, and so on. For the repeated attempt set of words, HBL was asked to try to name the pictures in every session, without feedback or therapy.

The treatment involved progressive phonological cueing, and was administered as follows for each item: 1) HBL was asked to name the picture presented to her; 2) if she was unable to name the picture, she was given the first phoneme and asked to try to recall the name; 3) if she was still unsuccessful, the next phoneme was combined with the first; 4) each phoneme of the word was provided progressively until she was successful at naming; 5) regardless of the initial response or number of cues given, HBL was asked to repeat the word orally after naming.

3.3.8. Scoring and analysis

Performance was measured by initial response accuracy. A correct response was given a score of 1; an incorrect response was given 0. Scores for each word were pooled over 3 repeated sessions and compared between baselines and post-testing, and again between baselines and follow-ups, for each set. Improvement was measured using McNemar's analyses (those reported are 2-tailed, unless otherwise stated), which calculate the instances of positive change and negative change, and disregard instances where there is no change between conditions. This was constrained by the number of items that HBL was able to attempt in one session. Given the low number of testable values for cognates and non-cognates (13 of each in the English treated and Welsh translations sets), the clear presence of a trend, and the fact that post-test and follow-up scores were very similar, the post-test and follow-up score changes were combined for these items in order to increase statistical power.

Analyses were also made of the change in distribution of each error type between baseline and post-testing, and between baseline and follow-up (correct translation, no response, semantic, circumlocutions, morphological, and initial phoneme produced). The change in distribution of each error type with each set was measured using Chi-square analysis (only significant chi-square results are reported due to the large number of comparisons involved).

3.4. RESULTS

Figure 3.4 depicts naming accuracy at each evaluation stage, for each set. The English treatment and Welsh translation sets have been separated into cognates and non-cognates in order to depict the differences in improvement between the two. Table 3.3 clarifies the extent of change (in percentage, most being positive, but some negative) in correct responses between baseline and post-testing, and between baseline and 16 week follow-up. The findings for each language are presented in turn.

3.4.1. English results

As predicted, HBL improved significantly on the treated words. The English treated cognates improved by 38.46% (from 33.33% correct at baseline, to 71.79% correct at post-test; McNemar's test $p<.001$), and effects were still evident at the 16-week follow-up (61.54% correct, McNemar's test $p=.031$). The English treated non-cognates improved by 35.9% (from an average of 35.9% correct at baseline, to 71.79% at post-test [McNemar's test, $p<.001$] and 61.54% at follow-up [McNemar's test, $p=.021$]). Thus, English treated cognates and non-cognates showed highly comparable patterns of improvement, and these effects were still significantly evident at 16 weeks follow-up (with some decline between post-test and follow-up, but not significantly so [McNemar's tests - cognates *p*=.13; non-cognates- *p*=.45]).

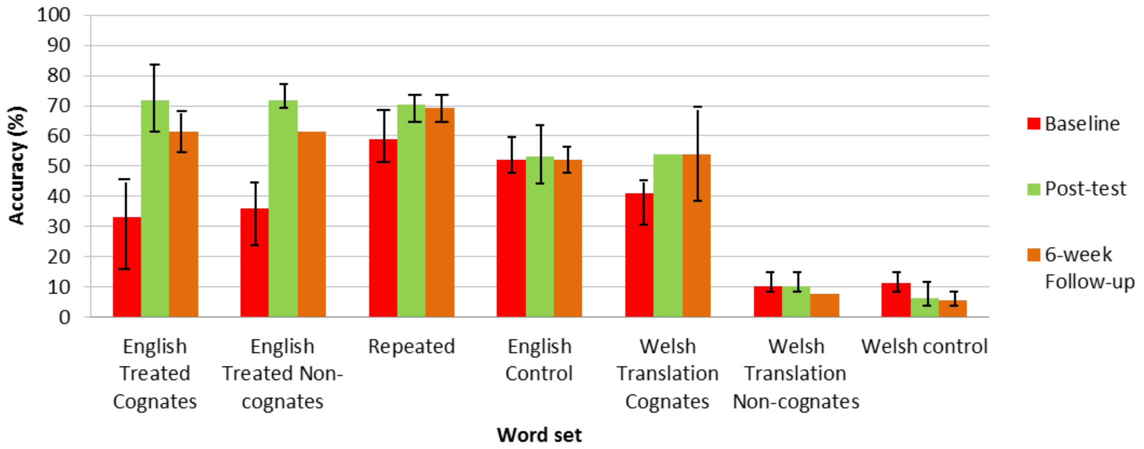

Figure 3.4. Accurate responses (averaged over 3 baseline, 3 post-test and 2 follow-up administrations) in each set made by HBL (Per administration: English Treated Cognates, n=13; English Treated Non-cognates, n=13; English Repeated Set, n=26; English Control set, n=25; Welsh Translation cognates, n=13; Welsh Translation Non-cognates, n=13). Error bars represent the range in accuracy.

In addition, the set of English words which were repeatedly attempted but not treated improved significantly (McNemar's test, *p*=.01), although to a lesser extent than the treated items (from 58.97% correct at baseline to 70.51% at post-test, and 69.23% at follow-up). These words were at a higher performance level at baseline, although (as the significant result shows) there was room for improvement.

Control words that were neither treated nor presented during the treatment phase yielded no improvement (McNemar's test, *p*=n.s).

Table 3.3. Difference in % word accuracy between post-test and baseline and follow-up and baseline (significant McNemar's tests in bold). Note there were only 2 Follow-up sessions (hence difference in N)

	Baseline (x3)	Post-test (x3)	Follow-up (x2)	Baseline-Post-test improvement (%)	Follow-up (%)
English treated cognates	13/39	28/39	16/26	**38.5**	**28.2**
English treated non-cognates	14/39	28/39	16/26	**35.9**	**25.6**
English repeated	46/78	55/78	36/52	**11.5**	**10.3**
English control	39/75	40/75	26/50	1.3	6.0
Welsh translation cognates	16/39	21/39	14/26	**12.8**	**12.8**
Welsh translation non-cognates	4/39	4/39	2/26	0.0	-2.6
Welsh control	9/78	5/78	3/52	-5.1	-5.8

3.4.2. Welsh results (cross-linguistic generalisation)

As predicted, significant improvement was seen for the Welsh translation cognates (McNemar's test, *p*=.023, 1-tailed). Naming of Welsh cognates improved from 41.03% at baseline to 53.85% correct at post-test, with the effect being maintained to the same extent at 16-week follow-up. Further analysis was made in terms of the position of overlap between cognate pairs, with no significant effect of overlap position.

There was no change in Welsh words that were non-cognate translations of English treated words. Performance on the Welsh control set decreased slightly but not significantly between baseline and post-test (McNemar's test, *p*=.22), with a further decrease at follow-up (McNemar's test, *p*=.22).

Naming accuracy for all sets was stable between post-test and the 16 week follow-up for all sets of words (no significant difference between post-test and 16-week follow-up, all McNemar's tests, *p*=n.s), suggesting lasting effects of treatment on the phonological output lexicon.

3.4.3. Error analyses

Circumlocution errors increased significantly between baseline and post-testing in the English control set (χ^2 (1) = 4.549, p = .033). This was the one significant shift in error distribution among the English sets of stimuli between pre- and post-treatment, and the shift was still evident at follow-up (baseline vs. follow-up: χ^2 (1) = 4.775, p = .029).

More changes were observed among Welsh sets. There was an increase in the number of translation errors in the non-cognate translations (χ^2 (1) = 7.00, p=.008), but this effect was not maintained at follow-up. Thus, after therapy, more targets in the Welsh non-cognates set were provided in English. A decrease in circumlocution errors (χ^2 (1) = 5.80, p=.02) was observed in the Welsh translation set, but this effect was not evident at follow-up. There was a significant increase in semantic errors in the Welsh unrelated control set between baseline and post-testing (χ^2 (1) = 5.40, p=.02), with the effect maintained at follow-up (χ^2 (1) = 6.146, p=.019).

The results of the present study will be used as evidence to support the hypothesis that cross-linguistic treatment generalisation may occur in bilingual anomia, particularly for cognates, and to support the assumptions of bilingual models of lexical processing positing stronger co-activation between words that share meaning and form, either via direct links between lexicons (e.g. Kroll & Stewart, 1994), or via feedback activation from phonology (Costa et al., 2000).

3.5. DISCUSSION

This study aimed to discover the effect of a treatment protocol targeting bilingual anomia, and what effect cognates have on cross-language generalisation. It also aimed to contribute to theories of bilingual lexical processing. The specific research questions were:

can treating one language lead to improvement in the untreated language? If so, will it be restricted to cognate stimuli? And, can patterns of treatment generalisation in bilingual lexical naming deficits support theories of normal bilingual word processing that posit an advantage for cognates?

3.5.1. Within-language improvement

As predicted, significant improvement was observed subsequent to therapy for treated items (generalising to different pictures). It is suggested that the treatment aided re-acquisition or re-activation of lexical representations of the treated words. This is consistent with previous findings of improvement in treated items subsequent to phonological treatment protocols in both monolinguals and bilinguals (e.g. Croft, Marshall, Pring & Hardwick, 2011; Hickin, Best, Howard & Osborne, 2002; Best, Herbert, Osborne & Howard, 2002; Fisher, Wilshire & Ponsford, 2008; Edmonds & Kiran, 2006).

Items that were repeatedly attempted by HBL in each session, but which were not specifically treated, also improved significantly. This is consistent with previous findings that repeated attempts can result in improved production (e.g. Rapp & Kane, 2002; Rapp, 2005), suggesting that repeated attempts can aid activation of damaged representations. The fluctuation in accuracy that is seen at baseline measurements (error bars in Figure 3.4) supports previous findings that items that fluctuate at baseline testing are more likely to respond well to repeated testing (e.g. Weekes & Coltheart, 1996; Brunsdon, Hannan, Coltheart & Nickels, 2002), than those that have stable performance (McKissock & Ward, 2007).

No improvement was observed in items in either English or Welsh that were untrained and unrelated to the treated items (i.e. English and Welsh control sets). This is consistent with the hypothesis that strengthening damaged lexical representations results in improvement in items that are explicitly exposed to therapy or repeated testing, and will not result in improvements in untreated, unrelated words.

Analysis of errors made by HBL revealed a decrease in the proportion of semantic errors across English sets. This may be due to improved access to lexical representations within the treated and repeated attempt set. Closer inspection of the English sets exposes an increase in circumlocution errors between baseline and post-testing in the English control set. As this was the only English set that was not involved in the protocol, and thus was not affected by therapy, it is suggested that HBL could have been more motivated to attempt to gain access to the representations of these words, given her increased success on other items.

3.5.2. Cross-language improvement

Because HBL was diagnosed with an output-lexical deficit, it was hypothesised that she would be more likely to show cross-language generalisation to Welsh cognates than non-cognates, given their structural similarity, and the phonological nature of the treatment. This was based on models positing stronger co-activation between words that share meaning and form in two languages due additional feedback activation (over non-cognates) from phonology (e.g. Costa, Caramazza & Sebastian-Galles, 2000). This was the observed effect: improvement was made in the Welsh translations set, but only for cognate stimuli. Thus it is proposed that the treatment aided cognates by feedback from phonology in addition to their semantic links. This supports the findings of Kohnert (2004), who observed cross-linguistic generalisation from Spanish to English, in cognate stimuli only.

Because there was no difference in accuracy of non-cognate translations, this can be taken as evidence that the treatment was working at the output lexicon level: there would have been an improvement in non-cognate translations also if treatment had affected semantics rather than lexical representations, given their similarity in meaning but not form. There was an increase in translation errors in the Welsh non-cognate translation items. This could be because her English naming in general is better than Welsh, but it could also be a by-product of therapy: she may have been accustomed to naming in English. Also, she was aware that some of the words in the Welsh translations set sound similar to the English words; this could have caused confusion when attempting to name the non-cognate translations.

The high number of translation errors in Welsh naming, and the higher accuracy in English naming suggest that HBL has non-parallel recovery, for spoken naming. This has implications for models of bilingual lexical access. HBL appears to be processing single words primarily in English. This non-parallel recovery is consistent with models that posit two lexicons for bilingual speakers (e.g. Kroll & Stewart, 1994; Potter, So, Von Eckardt &Feldman, 1984), but also poses a challenge to their assumptions: although HBL was pre-morbidly highly proficient in both English and Welsh, she self-reports that her L1 and pre-morbidly stronger language (in spoken production) was Welsh. Under the assumptions of these models, L1 (Welsh) should have been more resilient to damage than L2 (English). Her recovery pattern is also inconsistent with the argument that the native language should recover to a greater extent (Ribot, 1881; as cited in Paradis, 2004), as well as the suggestion that the language used most pre-morbidly should recover to a greater extent (Pitres, 1895; Minkowski, 1928; 1949; 1965; Bay, 1964; as cited in Paradis 2004).

3.5.3. Clinical implications

The clinical implication to the findings presented is that model-based treatment using cognate stimuli can be effective in promoting cross-linguistic generalisation in people with bilingual anomia. The therapeutic gains, benefits from repeated testing, and increases in translation errors and circumlocutions are all positive outcomes in terms of HBL's communication ability. All results were maintained at 16-week follow-up (i.e. there was no significant difference in performance on any set between post-test and follow-up, in any set), suggesting that treatment gains in phonological output deficits can be maintained. From the perspective of speech and language therapists, there is anecdotal evidence that her communication improved. Ultimately, this is the most important aspect of therapy.

3.5.4. Limitations

Some limitations are noted in the matching of items and baseline performances. The repeatedly attempted (but untreated) set had higher baseline performance than the treated set. This was due to a difficulty in matching in terms of performance across baselines: the aim was to include some items in each set that HBL had previously been successful in naming, for morale reasons. But this appears to have led to higher baseline scores for the repeated set, where she would have successfully named these items as well as some previously erroneous ones. Nevertheless, all sets still provided ample room for improvements.

The mean length of words in the repeated set was shorter than the other sets: despite this, it is not considered the reason for baseline accuracy being higher in the repeated set, given the lack of length effect in background naming tasks. In creating five sets, matched for frequency, and with the aim of having accuracy above floor at baseline, while also having items that were not translations of words in any other set (apart from those that were measuring translations); discrepancies in matching arose. Nevertheless, there was still room for improvement, which was observed.

3.5.5. Future perspectives

This study intended to have a crossover design to test previous findings about which language should be selected for treatment. Unfortunately HBL was unable to continue with testing after the first phase. Treating her weaker language (in terms of spoken naming performance), Welsh, may also have led to cross-linguistic generalisation.

In order to maximise potential therapeutic gains and maintenance of these gains, it is suggested that a combination of cues may aid lexical retrieval. Orthographic cues may be used because they have been found to be as successful as phonological cues (Lorenz & Nickels, 2007; Hickin, Best, Herbert, Howard & Osborne, 2002; Best, Herbert, Osborne & Howard, 2002) in naming therapy. HBL's written word comprehension is unimpaired in English (moderately in Welsh) thus orthographic cues could potentially aid lexical retrieval if combined with phonological cueing.

Another future avenue for testing the status of the bilingual lexicon would be to exploit the use of interlingual homophones: words that sound the same in both languages but have different meanings (e.g. KEY – CI [dog]). There has been evidence to suggest that lexical access in language non-selective (De Groot, Delmaar & Lupker, 2000), thus it would be interesting to investigate this using treatment involving interlingual homophones, and whether cross-language generalisation may occur in words that share form but not meaning. Under the predictions of the Costa et al., (2000) hypothesis, activation of interlingual homophones may be facilitated in both languages due to feedback from phonology, but without additional sematic activation, perhaps they would not improve as much as cognates.

3.5.6. Conclusion

In conclusion, a phonological treatment approach was successful in eliciting cross-language transfer of cognate stimuli in a woman with a deficit to the phonological output lexicon. Treated items and repeatedly attempted items improved in the treated language. Cross-linguistic generalisation did occur, but only for cognate stimuli. This supports the theory of Costa et al., (2000) suggesting that cognates may be facilitated more readily than non-cognates due to feedback from phonology.

CHAPTER 4. DIFFERENTIAL CROSS-LINGUISTIC GENERALISATION PATTERNS AS A FUNCTION OF LEVEL OF DEFICIT IN BILINGUAL ACQUIRED DYSGRAPHIA

IN PREPERATION: COGNITIVE NEUROPSYCHOLOGY

CHAPTER 4. DIFFERENTIAL CROSS-LINGUISTIC GENERALISATION PATTERNS AS A FUNCTION OF LEVEL OF DEFICIT IN BILINGUAL ACQUIRED DYSGRAPHIA

4.1. ABSTRACT

This study compares treatment effects in two bilingual participants with contrasting written language deficits and tests model-based predictions about differential within and between language generalisation patterns. Two Welsh-English bilingual participants with acquired dysgraphia, one with a deficit to the orthographic lexicon and the other to the graphemic buffer were administered a spelling treatment protocol based on earlier work with monolingual dysgraphic participants with similar deficits (Rapp & Kane, 2002; Rapp, 2005). In terms of within-language effects, the results of this delayed copy spelling protocol replicate earlier work by showing robust improvements on treated sets in both participants but with widespread generalisation to untreated sets for the graphemic buffer case only. There was no evidence of cross-linguistic generalisation in the orthographic lexical deficit case, whereas some generalisation was observed in the graphemic buffer case. This is the first study to examine cross-linguistic generalisation patterns in acquired dysgraphia. It highlights the importance of systematically investigating generalisation patterns as a function of the level of deficit in bilingual aphasia research.

4.2. INTRODUCTION

Even though at least half of the world's population speaks more than one language on a daily basis (Ansaldo, Marcotte, Scherer & Raboyeau, 2008; Azarpazhooh, Jahangiri & Ghaleh, 2010), very little is known about language rehabilitation in multilingual brain-damaged individuals. Of particular interest is the issue of cross-linguistic generalisation of treatment, i.e., the effects that treating one language may have on the untreated language(s). This issue is of both clinical and theoretical interest. Clinically speaking, and given limited resources for rehabilitation, gaining a better understanding of how to maximise gains in all languages would be highly desirable. Theoretically speaking, patterns of treatment generalisation within and across languages may serve to test and constrain language processing models (Nickels, Kohnen & Biedermann, 2010).

In this study, we will be comparing treatment effects in two participants with contrasting written language deficits (i.e., deficit at the level of the orthographic lexicon vs. the graphemic buffer), and test model-based predictions about differential generalisation patterns. This is the first study to examine cross-linguistic generalisation patterns in acquired dysgraphia. In addition, it is also the first study to systematically investigate generalisation patterns as a function of level of deficit in bilingual aphasia research. In the remainder of this introduction, we will first briefly review prior work on cross-linguistic treatment generalisation. We will then move on to the diagnosis and treatment of acquired spelling disorders and propose a working model of bilingual spelling which will guide our predictions.

4.2.1. Studies of cross-linguistic generalisation of treatment

Studies of bilingual language therapy have aimed to discover under what conditions treating one language may benefit the untreated language, with most of the work focusing on spoken word production deficits (for reviews see Lorenzen & Murray, 2008; Faroqi-Shah et al., 2010), and to a lesser extent on reading (Laganaro & Venet, 2001). Differential patterns of improvement have been observed across therapy studies. It is not yet entirely clear what determines cross-linguistic transfer although several potentially influential factors have been proposed. For example, some have argued that maximum cross-linguistic generalisation is observed when treating the non-native language (e.g., Edmonds & Kiran, 2006; Fredman, 1975; Gil & Goral, 2004; Goral, Levy & Kastl, 2010), although this has been contested (Croft, Marshall, Pring & Hardwick, 2011; Filiputti et al., 2002). It is unclear whether the relevant factor is which language was learned first, which language was most proficient pre-morbidly or which language is most affected post-morbidly. For example, generalisation following treatment of either language was observed in patients with comparable proficiency in both languages (Edmonds & Kiran, 2006; Junque et al., 1989). In addition, results contradicting the claim that treating L2 leads to more language transfer have been reported when either L1 was not the most used language before brain damage (e.g., Filiputti et al., 2002), or when damage did not lead to comparable deficits in the two languages (e.g., Amberber, 2012; Meinzer, Obleser, Flaisch, Eulitz & Rockstroh, 2007). In sum, which language was first acquired, which was most proficient and which was most affected by brain damage can all contribute to treatment outcomes in bilingual aphasia.

Other important factors to consider when studying cross-language generalisation in bilingual aphasia treatment are the type of treatment administered as well as the characteristics of the stimuli used to assess generalisation. Notably, semantic treatment is more likely to promote generalisation (Croft et al., 2011), and generalisation following semantic treatment can be limited to items semantically related to the treated stimuli (e.g., Kiran & Edmonds, 2004; Kohnert, 2004). Phonological overlap also increases the likelihood of generalisation in naming deficits (Kohnert, 2004).

In summary, research on cross-linguistic treatment generalisation has provided valuable information and insight into parameters likely to influence treatment outcomes. On the other hand, this area of research is still in its infancy and there is still much to be understood. One difficulty is that the results are highly variable across participants for reasons that are not fully understood. Studies are difficult to compare because they vary widely in methodology. Another difficulty is there is as yet insufficient understanding of the precise mechanisms of action of different treatment methods. Finally, it is highly likely that a given treatment method would interact with the specific characteristics of the treated disorder (e.g., level of deficit, severity). Unfortunately, most studies either present cases with highly complex disorders and/or do not attempt to define the deficit in relation to bilingual word processing theories. However, there is evidence from dysgraphia treatment studies in monolinguals that, everything else being equal, generalisation patterns vary as a function of the level of deficit, and one of our main goals will be to examine this claim in the treatment of bilingual dysgraphia. Ideally, treatment for a given individual should be guided by a thorough analysis of their symptoms and of the likely origin of their disorder by reference to theories of language processing.

4.2.2. The spelling processes and acquired dysgraphia in monolinguals

Figure 4.1 presents a model of the main processing components involved in spelling. Models of this type have been most commonly used in analysing spelling disorders and in designing targeted treatment protocols for acquired dysgraphia (e.g. Ellis, 1993; Beeson, Rewega, Vail & Rapcsak, 2000; Weekes, 2012; Kambanaros & Weekes, 2013). According to this model, spelling to dictation can be accomplished using either a lexical process or a sublexical process (Tainturier & Rapp, 2001).

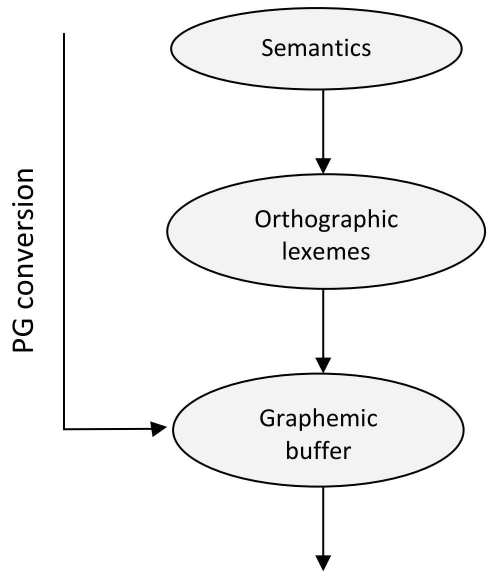

Figure 4.1. Monolingual spelling

The lexical process involves retrieving long term memory representations of written words in the “orthographic lexicon” and is involved in spelling familiar words. In contrast, the sublexical process is used for spelling unfamiliar words or pseudo-words. It bypasses the lexicon and consists in mapping phonemes to graphemes as a function of their probability of use in the language. Following either of these operations, abstract letter strings are thought to be stored in short-term memory store, known as the graphemic buffer, which maintains their activation level while the stimulus is being outwardly produced. Alternative, “connectionist/parallel distribution” processing accounts have also emerged in recent years do not directly incorporate an orthographic lexicon but represent spelling knowledge in terms of connection patterns between sublexical orthographic and phonological units and semantics (e.g. Patterson & Lambon Ralph, 1999). These models also posit two procedures for spelling, although they are characterised as being phonological vs. semantic, rather than lexical vs. sublexical. Such models can also account for the types of dysgraphia described below. However, we will focus on dual-route models as they are, at this stage, the types of models that can most easily be adapted to studying bilingual dysgraphia as most if not all bilingualism research has relied on models with localist rather than distributed lexical representations.

The deficits that are central to the current study are those affecting the orthographic lexicon or the graphemic buffer. Selective deficits to the orthographic lexicon as often referred to as “Surface dysgraphia”. Such deficits are characterised by impaired spelling of irregular words, particularly of lower frequency of use, with relatively preserved regular and non-word spelling (e.g. Beauvois & Derouesné, 1981; Behrmann, 1987; Behrmann & Bub, 1992; DePartz, Seron, & van der Linden, 1992; Parkin, 1993). Individuals with such deficits show an over-reliance on sublexical phoneme-grapheme conversion leading to the production of phonologically plausible errors, such as ‘eighteen’ spelled ATEEN.

Due to the central location of the graphemic buffer at the output of lexical and sublexical processes, graphemic buffer deficits affect all stimuli types (e.g. Miceli, Silveri, & Caramazza, 1985; Caramazza, Miceli, Villa & Romani, 1987; Posteraro, Zinelli & Mazzucchi, 1988; Hillis & Caramazza, 1989; Caramazza & Miceli, 1990; Piccirilli, Petrillo & Poli, 1992; Tainturier & Rapp, 2003; Rapp & Tainturier, 2004) . Consistent with a reduction in working memory resources, graphemic buffer deficits are characterised by an exaggerated effect of word length and the errors made reflect of loss of information about the identity and order of letters in the string. These errors are typically not phonologically plausible and include letter substitutions (problem -> BROBLEM), deletions (absence -> ABENCE), additions (dog ->DOOG) and movement errors (success -> SCUCESS). An effect of lexical frequency is not considered to be one of the key symptoms, but it can play a role, as suggested by Sage and Ellis (2004) and others.

4.2.3. Acquired dysgraphia treatment studies

Successful treatments targeting the OOL usually include repeated presentation of the correct spelling of words, and/or delayed copy of words (e.g. Beeson, 1999; Rapp & Kane, 2002; Rapp, 2005; Raymer, Cudworth, & Haley, 2003). This is based on the assumption that repeated exposure and attempts at spelling will aid re-learning word-form representations in the lexicon. Treatment of OOL deficits/surface dysgraphia primarily results in improvement in trained items without generalisation to untreated words (e.g. Beeson 1999; Beeson, Hirsch & Rewega, 2002; Orjada & Beeson, 2005; Beeson, Rewega, Vail & Rapcsak, 2000; Rapp & Kane, 2002; Rapp, 2005; Ball, Riesthal, Breeding & Mendoza, 2011). This is consistent with the view that treatment aids people with OOL damage to re-learn individual orthographic representations. However, items treated for spelling can also improve in untreated modalities such as spoken naming (Beeson & Egnor, 2006).

Few treatment studies have targeted the graphemic buffer (Hillis & Caramazza, 1989; Pound, 1996; Rapp & Kane, 2002; Rapp, 2005; Sage & Ellis, 2006) and no specific rationale for treatment has yet been established. Interestingly, treatment effects in GB disorders can generalise to untreated words (Rapp & Kane, 2002; Rapp, 2005; Raymer, Cudworth & Haley, 2003), with a possible advantage for orthographic neighbours (Sage & Ellis, 2006). This generalisation is to be expected if the treatment somehow improves the functioning of the buffer itself, leading to a better retention of letter strings and lesser loss of information about letter identity and order for all words, treated or not.

Rapp and Kane (2002) contrasted the effects of treatment of OOL and GB deficits, with the aim of determining the effects of the same protocol on different components of the spelling process. The delayed-copy protocol included three sets - a treatment set, a repeated (untreated) set, and a control set. The procedure for each word in the treatment set was as follows: 1) Spelling to dictation; 2) A note card with the word typed on it was presented and clinician pointed to each letter while reading them aloud; 3) After the note card was removed, if the first spelling attempt was unsuccessful the participant was asked to try again. This step was repeated until correct spelling was achieved. For the repeated set of words, words were repeated orally before being spelled to dictation, in every session (but no feedback was given). Words in the control set were repeated and spelled to dictation only at pre-treatment baseline, and during post-test and follow-up sessions. Treated items improved in both participants. Although maximum improvement was seen in treated sets, some generalisation effects where observed which differed between deficits. As predicted, spelling performance in the GB deficit improved across all sets, and these gains were still evident at 20-weeks post-therapy. The person with an OOL deficit showed improvement in the repeatledly attempted (but untreated) set, though the effect was much smaller than for treated words; and spelling of the control words remained unchanged from baseline. The improvement in the set of words that was repeatedly spelled to dictation though not treated indicates that repeated administration alone can aid successful spelling although not as much as actual treatment. Rapp (2005) replicated these results with three new participants with OOL or GB impairments. Improvement in the OOL deficits to treated items was interpreted as reflecting re-learning and strengthening of orthographic representations, as to a lesser extent, the repeated attempts condition. With regards to generalisation to all sets in GB cases, Rapp and Kane (2002) suggest the most likely explanation was that there was "a strengthening of individual word representations and some general benefit (either direct or indirect) to the buffering process" (pp. 452).

4.2.4. A framework for the study of bilingual dysgraphia diagnosis and treatment

Some of the dysgraphic disorders reported in monolingual speakers have also been described in bilingual patients (e.g. phonological dysgraphia, Kambanaros & Weekes, 2013; deep dysgraphia, Raman & Weekes, 2005) and interpreted in similar ways. However, no cases of OOL and GB bilingual spelling deficits have yet been reported. In order to diagnose and generate predictions about patterns of generalisation in such cases, we are proposing a working model of bilingual spelling which merges properties of monolingual spelling processes with the most agreed upon theoretical proposals from studies of bilingual spoken language production (e.g. Kroll & Stewart, 1994; Costa & Caramazza, 1999; Costa, Caramazza, & Sebastian-Galles, 2000, Van Heuen, Dijkstra & Grainger, 1998).

In short (see legend of Figure 4.2 for more details), this model proposes the existence of distinct yet highly interconnected orthographic lexicons for each language, feeding into a shared graphemic buffer.

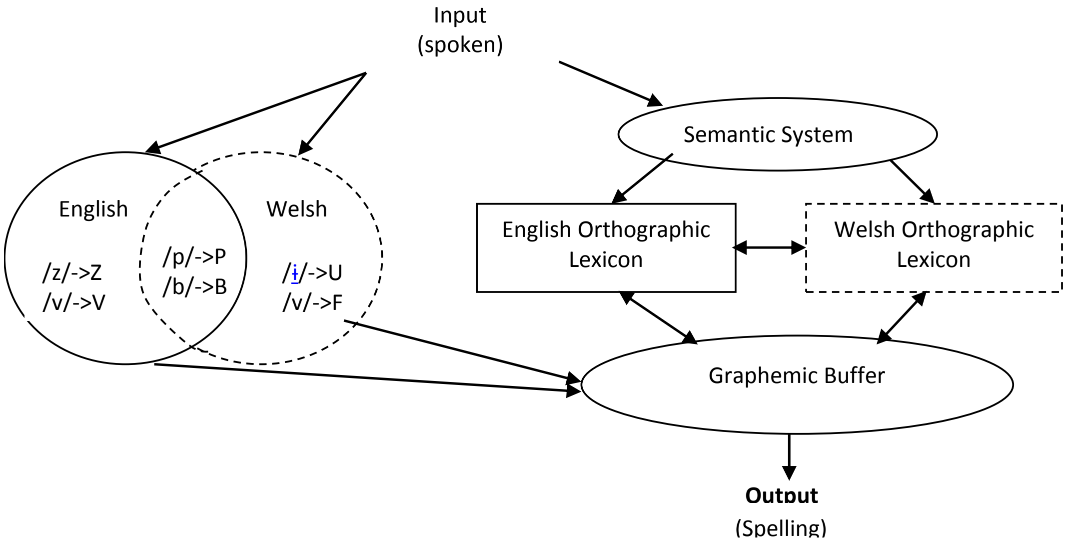

Figure 4.2. A working model of bilingual spelling (Tainturier, Roberts & Roberts, 2011)

Legend. Semantic knowledge is not language-specific. Meanings are usually expressed using different words in different languages, hence the distinction between an English and a Welsh orthographic lexicon. The arrows from the semantic system represent the non-selective activation of words from the two languages (e.g., the meaning "pet that meows" activates "cat" and "cath"). The arrow between the two lexicons represents connections between translation words. Lexical units activate strings of graphemes in the graphemic buffer. This level is assumed to be shared between the two languages. There is feedback activation from the buffer to the lexical level. The amount of feedback activation received by lexical units in both languages is proportional to their orthographic overlap with the string held in the buffer. This can explain why cognates (cat-cath) may show more co-activation than non-cognates (dog-ci; this is adapted from Costa et al's proposal depicted in Appendix 2). Spoken stimuli also activate phoneme-grapheme (PG) mappings in both languages. The overlapping area of the circles represent PG mappings that are identical in the two languages. Non-overlapping areas depict mappings that are language-specific, either because a given phoneme exists in one language only, or because a phoneme has competing mappings in the two languages (e.g., /v/->V or F). Although not directly represented in the figure, it is understood that units from the target language (as determined by context and speaker's intentions) are more strongly activated than units from the non-target language. The same general hypotheses should apply to other combinations of alphabetic languages.

4.2.5. Aims and hypotheses

The present study aimed to discover under what circumstances a spelling treatment programme may lead to within and between language generalisation in bilinguals with deficits to the orthographic output lexicon (OOL) or graphemic buffer (GB) deficits. In essence, it extends the work of Rapp and Kane (2002) and Rapp (2005), to assess the effectiveness of a previously successful therapy in bilingual populations, and to examine theory-driven predictions about patterns of cross-linguistic generalisation.

The protocol used by Rapp and Kane (2002) and Rapp (2005) was utilised, having been previously successful in promoting generalisation in monolingual persons with the same types of dysgraphia (OOL and GB). We expected to replicate their findings with regards to within-language generalisation patterns. In other words, we predicted improvement on treated sets for both participants with possible partial generalisation to untreated repeated items but generalisation to unpractised and untreated items for the GB deficit only. In terms of cross-linguistic generalisation, we made the following hypotheses: 1) For the OOL deficit, that generalisation may be obtained for translations of the treated words due to co-activation from the semantic system and possibly via direct lexical connections. 2) For the GB deficit, we expected treatment to generalise to all sets, both within and between languages, under the assumption of a shared GB.

4.3. METHOD

4.3.1. CASE STUDIES

The following two participants were selected for the current study because they were Welsh-English bilinguals who displayed contrasting difficulties in spelling in the absence of comprehension problems, following neurological damage. Ethical procedure followed Bangor University protocol: participants gave informed consent, were informed of the full purpose of the study and were told that they could withdraw from the study at any time.

4.3.2. CWS

CWS is a retired builder from North Wales, educated to secondary level (age 16). He suffered a stroke (right frontal infarct, as revealed by CT and MRI scanning) in 1997 (see Figure 4.3). At the time of testing he was 60 years old, and 11 years post onset. Initially he was unable to speak, but this improved over two to three years (for a more complete description of his reading deficit, see Tainturier, Roberts & Leek, 2011). He received speech and language therapy for 6 months post-stroke. He has left sided hemiplegia, predominant in the upper limb, and is pre- and post-morbidly right handed.

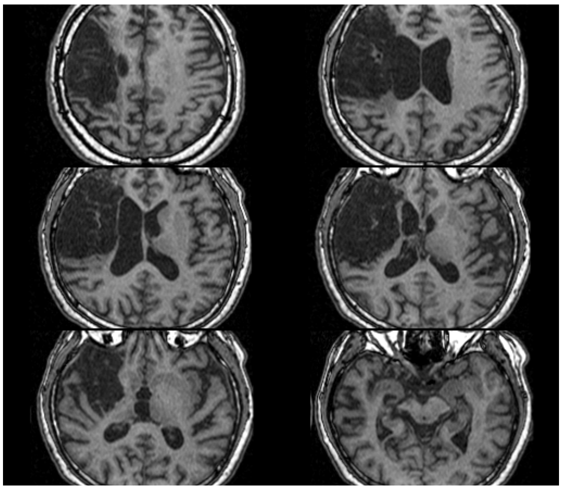

Figure 4.3. CWS MRI Scan: RH ischemic lesion of the motor and pre-motor cortex, the homolog of Broca's area, the frontal eye-field and dorso-lateral prefrontal cortex.

CWS is a Welsh-English bilingual, who used mainly Welsh as a means of communication pre-morbidly (self-reported), and still does at present, with the exception of media usage (i.e. listening to the radio or watching the television), which is mainly English. Welsh was his first language, and he reports learning English in school from around 6 years, although he would have been exposed to some English earlier. As a child he reportedly used mostly Welsh at home and with friends. During adult life, before the stroke, he used both Welsh and English on a regular basis at home, at work, and in the community. He speaks Welsh most of the time with his current partner, but used English mostly with a previous partner. He also reports speaking both English and Welsh regularly post-morbidly. Table 4.1 provides a breakdown of estimated language use in different stages of life (for a full breakdown of the self-reported language use and abilities of CWS see Appendix D). Although in terms of spoken language, L1 appears to be Welsh, in terms of reading and spelling there is more of an influence of English. He reports reading in English most often, and being equally happy writing in either language. Thus, CWS was fully proficient in both English and Welsh pre-morbidly.

Table 4.1. Self-reported language use of CWS and RON

		Childhood	Adult life	Post-Morbidly
CWS	English	0%	60%	60%
	Welsh	100%	40%	40%
RON	English	0%	50%	80%
	Welsh	100%	50%	20%

4.3.3. CWS: Language background

CWS is articulate in spoken communication, although production is slow and effortful, with signs of agrammatism. He presents with crossed-aphasia in both languages, and reduced fluency with symptoms consistent with those of mixed dysgraphia and phonological dyslexia. This diagnosis was made based on his language assessment (Table 4.2) and analysis of spelling to dictation data (Table 4.3).

His ability to recognise written words as being real is normal, demonstrated by English and Welsh lexical decision task scores, indicating intact input lexicons. All tests of verbal and non-verbal comprehension were within normal range, in both languages. The results of these tests suggest that his recognition and semantic processing abilities were preserved.

Repetition of single words is intact in English and Welsh, and for English-like nonwords. Welsh nonword repetition may be mildly impaired, though no normative data are available. Scores are based on initial response data, but CWS was always able to make correct repetition on subsequent attempts if he failed first time. This performance on tasks of word repetition suggests that any problems in oral reading or naming should not be due to an inability to articulate the words.

Spoken picture naming of items from the Object and Action Naming Battery (Druks & Masterson, 2000) of objects and actions was within control range. Items for the Welsh object and action naming lists were taken from the English battery (50 Welsh objects, 30 actions, with 90% or above name agreement among controls). Action naming in Welsh was within control range, but object naming was not.

Table 4.2: Language assessment of CWS (impaired scores in bold)

Task	Score	%	Control N	Control Mean	Control Range	Control SD
Comprehension						
PALPA 47: oral word-picture matching	40/40	100%	31	39.29	35-40	1.07
PALPA 48: written word-picture matching	40/40	100%	32	39.47	35-41	1.01
Pyramids and Palm Trees Test	50/52	96%	13	51.22	49-52	
Welsh word-picture matching (screener adapted from PALPA)	8/8	100%	N/A	N/A	N/A	N/A
Welsh receptive Vocabulary test	217/240	90%	13	231.7	213-239	7.90
Spoken Naming						
English Object Naming battery (list B)	73/81	91%	40		73-81	
English Action Naming battery (list B)	43/50	86%	40		43-50	
Welsh Object Naming	**39/50****	78%	20	49.8	47-50	0.70
Welsh Action Naming	28/30	93%	20	29.35	27-30	0.88
Single word Repetition						
English word repetition	80/80	100%	N/A	N/A	N/A	N/A
English Non-word repetition	40/40	100%	N/A	N/A	N/A	N/A
Welsh word repetition	40/40	100%	N/A	N/A	N/A	N/A
Welsh Non-word repetition	**37/40***	93%	N/A	N/A	N/A	N/A
Visual Word Recognition						
English visual lexical decision (from English Real & Non-word list): Real and non-words	118/120	98%	N/A	N/A	N/A	N/A
Welsh visual lexical decision (from Welsh Real & Non-word list): Real words	77/80	96%	N/A	N/A	N/A	N/A
PALPA 3: minimal pairs - Written word selection (Implicit reading: same/different discrimination)	70/72	97%	23	70.96		1.69
Reading						
PALPA 19: upper case to lower case letter matching	25/26	96%	26	25.96	25-26	0.20
PALPA 32: grammatical class reading (matched for conreteness)	76/80	95%	32	79.74		1.16
English Reading: Regular words	39/40	98%	20	39.7	38-40	0.66
English Reading: Irregular words	40/40	100%	20	39.55	38-40	0.69
English Reading: Non-words	**17/40****	43%	20	37.95	33-40	2.04
Welsh Reading: Regular words	**37/40****	93%	20	40	40-40	0.00
Welsh Reading : Non-words	**14/40****	35%	20	38.2	32-40	2.24

** depicts scores that are at least 2.5 standard deviations below control mean

* represents scores that are thought to be impaired to some degree, where normative data are not available

Regular and irregular word reading was normal in English (this combined with English object and action naming, suggests intact phonological output lexicon). Reading was slightly, but significantly, below age matched control range in Welsh words. His nonword reading, however, is impaired (43% correct in English [17/40; control range 33-40]; 35% correct in Welsh [14/40; control range 32/40]).

In summary, CWS appears to have relatively preserved word recognition and semantic processing, as shown by his lexical decision and word-picture matching scores. He also presents with a mild anomia in Welsh. The symptoms of impaired nonword reading and comparatively high performance in real word reading are consistent with a diagnosis of phonological dyslexia. Further details on the reading performance of CWS are given in Tainturier, Roberts and Leek (2011).

4.3.4. CWS: Spelling deficit diagnosis

For the purpose of diagnosing the specific deficit and in order to ascertain the extent and severity of his dysgraphia, CWS completed numerous spelling tasks (Table 4.3). In addition, Table 4.4 provides a breakdown of the distribution of different error types made in spelling. All spelling is severely impaired, with some specific patterns emerging. Irregular word spelling has suffered most, followed by regular words and nonwords.

Tasks assessing peripheral processing revealed no difficulties. Repetition of both real and nonwords in English and Welsh were non-problematic, suggesting intact pre- and post-lexical acoustic and phonological processing. Also, scores in visual lexical decision are within normal range. Direct copy of words is unimpaired, showing he has the motor skills and letter form knowledge required in spelling, and that any difficulties in spelling can therefore not be attributed to either of these. These scores suggest that the impairment may be located more centrally.

An effect of regularity exists in English and Welsh. Although Welsh has a shallow orthography, some words have ambiguity in spelling, which is evidenced by phonologically plausible errors occurring in Welsh spelling. The method used by CWS in spelling is that words are spelt grapheme by grapheme as he sounds out each phoneme as he proceeds with spelling. Sounds are produced correctly and in the correct sequence, but the correct corresponding grapheme is not always produced. In both English and Welsh, CWS tends to substitute graphemes for phonologically plausible mappings, resulting in many phonologically plausible errors (often with influence from Welsh, e.g.'thirty' – THYRTY), suggesting that reliance is being placed upon utilising knowledge of phoneme-grapheme mappings (i.e. sublexical processing). However, he also makes substitutions that are closely related to target mappings (e.g. p-b, c-g, t-d, n-m), resulting in phonologically implausible errors; which is consistent with an impairment in sublexical processing. An in-depth diagnosis of the sublexical spelling deficit of CWS is presented in Chapter 5 (which focuses on treatment of his sublexical deficit).

In tasks of English regular versus irregular/exception word spelling, significantly more regular words were correctly spelled to dictation by CWS (χ^2 (1) = 10.9, p=.001). A subset of words was also extracted from Welsh lists based up on them having ambiguous mappings in Welsh. In contrast with regular word spelling, production of these 'irregular' words is more impaired (χ^2 (1) = 2.94, p<.05 [1-tailed]). In addition, nonword spelling accuracy does not differ significantly from regular word spelling, in both English (χ^2 (1) = .104, p=.46) and Welsh ([χ^2 (1) = .313, p=.39] real and nonword spelling tasks (initially created for reading in Tainturier, Roberts & Leek, 2011). This regularity effect combined with the incidence of PPEs suggests damaged orthographic output lexicon, with reliance upon the sublexical system for spelling. However, phonologically implausible spelling errors are also made, suggesting that the sublexical system may also be damaged.

It is thought that this pattern of spelling is related to reliance upon a damaged sublexical system (rather than, for example, the graphemic buffer), due to the phonological nature of his errors (mostly substitutions for mappings that are one phonetic feature apart from the target mapping). Also, although the regular and nonword spelling do not differ significantly from each other for CWS, performance is significantly lower in spelling of all word types than that of control subjects, suggesting a mixed deficit.

Table 4.3. Performance of CWS on various spelling tasks, in English and Welsh. Impaired scores in bold.

	Number of stimuli	Number correct	% correct	Control N	Control Mean	Control Range	Control SD
ENGLISH SPELLING							
English spelling to dictation (two administrations)							
Regular words	80	33	**41**	20	38.8 (97%)	32-40	2.09
Irregular words	80	14	**18**	20	36.5 (91%)	22-40	4.96
Non-words	80	31	**39**	20	29.6 (74%)	21-37	4.82
PALPA regularity and spelling							
Regular words	20	12	**60**	N/A	N/A	N/A	N/A
Exception words	20	1	**5**	N/A	N/A	N/A	N/A
Frequency (words collapsed across JHU lists)							
High frequency words	147	31	**21**	N/A	N/A	N/A	N/A
Low frequency words	146	18	**12**	N/A	N/A	N/A	N/A
PALPA imageability							
High imageability words	20	4	**20**	10	18.93	16-20	1.42
Low imageability words	20	4	**20**	10	17.47	8-20	3.34
JHU word length list							
Four letter words	14	3	**21**	5	100%	N/A	N/A
Five letter words	13	5	**38**	5	97%	N/A	N/A
Six letter words	15	1	**7**	5	92%	N/A	N/A
Seven letter words	14	2	**14**	5	93%	N/A	N/A
Eight letter words	14	0	**0**	5	93%	N/A	N/A
PALPA length list							
Three letter words	6	4	**67**	N/A	N/A	N/A	N/A
Four letter words	6	1	**17**	N/A	N/A	N/A	N/A
Five letter words	6	1	**17**	N/A	N/A	N/A	N/A
Six letter words	6	0	**0**	N/A	N/A	N/A	N/A
JHU part-of-speech							
Nouns	28	1	**4**	N/A	N/A	N/A	N/A
Verbs	28	1	**4**	N/A	N/A	N/A	N/A
Adjectives	28	2	**7**	N/A	N/A	N/A	N/A
Function words	19	1	**5**	N/A	N/A	N/A	N/A
Total words	103	5	**5**	N/A	N/A	N/A	N/A
Nonwords	34	4	**12**	N/A	N/A	N/A	N/A
PALPA grammatical class spelling (matched for concreteness)							
Nouns	5	2	**40**	28	4.79		0.42
Verbs	5	1	**20**	28	4.82		0.39
Adjectives	5	2	**40**	28	4.82		0.48
Function words	5	2	**40**	28	4.68		0.55
JHU concreteness							
Concrete words	21	4	**19**	5	98%	N/A	N/A
Abstract words	21	0	**0**	5	91%	N/A	N/A
JHU probability list (four to six letters)							
High-probability words	30	14	**47**	5	99.50%	N/A	N/A
Low probability words	80	18	**23**	5	98%	N/A	N/A
Direct copy (PALPA 44)	40	39	98	N/A	N/A	N/A	N/A
Delayed copy transcoding							
Regular words	20	16	**80**	N/A	N/A	N/A	N/A
Exception words	20	9	**45**	N/A	N/A	N/A	N/A
WELSH SPELLING							
Regularity							
Regular words	40	9	**23**	20	39.3 (98%)	37-40	1.01
Irregular words	20	1	**5**	N/A	N/A	N/A	N/A
Non-words	40	7	**18**	20	30.1 (77%)	23-37	3.49
Frequency							
High frequency (CEG count above 150)	29	8	**28**	N/A	N/A	N/A	N/A
Low frequency (CEG count below 150)	11	1	**9**	N/A	N/A	N/A	N/A
Length							
Four letter words	8	3	**38**	N/A	N/A	N/A	N/A
Five letter words	9	3	**33**	N/A	N/A	N/A	N/A
Six letter words	11	1	**9**	N/A	N/A	N/A	N/A
Seven+ letter words	10	1	**10**	N/A	N/A	N/A	N/A

Further evidence to support a diagnosis of damaged lexical processing is that, in addition to the regularity effect, CWS displays a frequency effect. Significantly more high frequency words were correctly spelled to dictation (JHU lists collapsed and analysed by frequency [χ^2 (1) = 4.04, p=.032], and real words extracted from the Welsh real and nonword spelling task, separated into high vs. low frequency [χ^2 (1) = 6.14, p=.014], see Table 4.3). This effect of frequency suggests that lexical damage exists because more salient representations for words (i.e. more frequently experienced, thereby having a stronger representation) are more resistant to neurological damage.

A length effect also exists in English, with shorter words being spelled more accurately than longer words (4-5 letter words vs. 6+ letters, JHU length analysis χ^2 (1) = 6.43, p=.015). There was a trend toward a length effect in Welsh, though it did not reach statistical significance [χ^2 (1) = 3.75, p=.062]. However, although delayed copy transcoding is impaired, with a significant effect of regularity (χ^2 (1) = 5.23, p=.02), a length effect is not evident (PALPA 44 delayed copy of regularity list, short [4-5 letters] vs long [6+]; χ^2 (1) = 0.176, p=.674), suggesting that the impairment is not at the level of the buffer, and that impaired memory of certain mappings makes errors more likely in longer words (increasing the probability of a damaged mapping being present in the word).

Table 4.4. A breakdown of errors made by CWS in English and Welsh

	Examples	Words Number	Words %	Nonwords Number	Nonwords %
English					
Error percentages in spelling real words (N = 599) and nonwords (N = 45)					
Phonologically plausible errors	into -> INTU	236	39.40	N/A	N/A
Real word error	work -> WORD	42	7.01	1	2.22
Phonologically implausible nonwords (50% or more letters correct)	hotel -> HOTOL	199	33.22	36	80.00
Phonologically implausible nonwords (less than 50% letters correct)	feather -> FAFARA	47	7.85	7	15.56
Cross language errors	nine -> NAIN	75	12.52	1	2.22
Detailed distribution of scoreable errors (n = 1133 for words and 117 for non-words)					
Omissions	lamb -> LAM	421	37.16	30	25.64
Substitutions	love -> LAVE	542	47.84	69	58.97
Additions	october -> OCTOBARY	67	5.91	10	8.55
Exchanges/shitfs	Tuesday -> TEUSBAY	103	9.09	8	6.84
Welsh					
Error percentages in spelling real words (N = 150) and nonwords (N = 67)					
Phonologically plausible errors	troed -> TROUD	25	16.67	N/A	N/A
Real word error	saith -> SAETH	10	6.67	0	0.00
Phonologically implausible nonwords (50% or more letters correct)	hawdd -> HAWF	75	50.00	46	68.66
Phonologically implausible nonwords (less than 50% letters correct)	mynydd -> MUNUFF	25	16.67	14	20.90
Cross language errors	mawrth -> MAURCH	15	10.00	7	10.45
Detailed distribution of scoreable errors (n = 287 for words and 147 for non-words)					
Omissions	hydref -> HDREF	63	21.95	29	19.73
Substitutions	chwaer -> CHWAUR	208	72.47	109	74.15
Additions	llwy -> LLWID	8	2.79	5	3.40
Exchanges/shitfs	oer -> ARE	8	2.79	4	2.72

In summary, the regularity effect, combined with the phonological nature of his errors and a frequency effect, suggest a lexical spelling deficit. In addition, it is suggested there is a further impairment to sublexical processing, because phonologically implausible errors are also made. This is consistent with a diagnosis of mixed dysgraphia. It is thought that graphemic buffer processing is comparatively spared, given the lack of length effect in delayed/direct copy transcoding.

4.3.5. RON

RON is also a retired builder from North Wales, educated to secondary level. He was 58 years old at the time of testing, and 5 years post onset. Figure 4.4 depicts the MRI scan of RON. He had a brain haemorrhage and 5 aneurisms in 2003, after which he had mild right sided weakness, reading and writing problems, and problems with sentence production.

RON is a right-handed Welsh-English bilingual, who has lived in North Wales throughout his life and was proficient in both English and Welsh pre-morbidly. As in the case of CWS, RON's first language was Welsh, having been brought up in a Welsh family and community, with English being introduced formally at 6 years. Table 4.1 depicts his self-rated spoken use of each language. RON reported speaking Welsh with family and friends as a child. As an adult, he spoke both to an equal extent: mostly Welsh at work, and mostly English at home (he has an English wife). In terms of other modalities, he reports reading and writing most in English. Post-morbidly RON prefers to communicate in English, as he feels that he has lost confidence in speaking Welsh (for a full summary of self-reported language abilities of RON, see Appendix E).

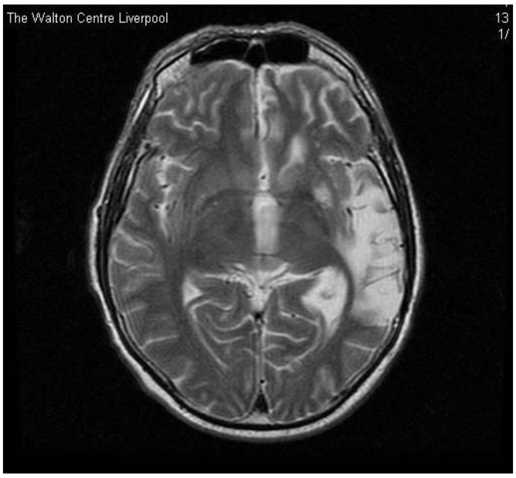

Figure 4.4. RON MRI scan: LH lesion involving the inferior and anterior temporal lobe, the superior temporal gyrus, the medial temporal lobe, the ventral putamen, the caudate nucleus, the posterior insula, and the left frontal lobe.

4.3.6. RON: Language background

RON presents with mild/moderate aphasia in both languages, with symptoms consistent with damage primarily to the sublexical system in reading (phonological dyslexia), and to the graphemic buffer in spelling. Diagnosis was made based on language background assessment (Table 4.5) and analysis of spelling to dictation (Table 4.6).

Verbal and non-verbal comprehension task scores are normal, suggesting access to semantics is intact. Visual word recognition abilities were tested using visual lexical decision tasks, also revealing performance within control range. Performance on a task involving minimal pairs (PALPA 3) suggests there may be a mild impairment in recognising whether or not two written words are phonologically distinct.

Table 4.5: Language background assessment of RON (impaired scores in bold)

Task	Score	%	Control N	Control Mean	Control Range	Control SD
Comprehension						
PALPA 47: oral word-picture matching	40/40	100%	31	39.29	35-40	1.07
PALPA 48: written word-picture matching	40/40	100%	32	39.47	35-41	1.01
Pyramids and Palm Trees Test	52/52	100%	13	51.22	49-52	
Welsh word-picture matching (screener adapted from PALPA)	8/8	100%	N/A	N/A	N/A	N/A
Welsh Vocabulary test	232/240	97%	13	231.7	213-239	7.90
Spoken Naming						
English Object Naming battery (list B)	81/81	100%	40		73-81	
English Action Naming battery (list B)	50/50	100%	40		43-50	
Welsh Object Naming	50/50	100%	20	49.8	47-50	0.70
Welsh Action Naming	27/30	90%	20	29.35	27-30	0.88
Single word Repetition						
English Real word repetition (Regular & Irregular; from English Real & Non-word list)	80/80	100%	N/A	N/A	N/A	N/A
English Non-word repetition (from English Real & Non-word list)	**37/40***	93%	N/A	N/A	N/A	N/A
Welsh Regular word repetition (from Welsh Real & Non-word list)	40/40	100%	N/A	N/A	N/A	N/A
Welsh Non-word repetition (from Welsh Real & Non-word list)	**37/40***	93%	N/A	N/A	N/A	N/A
Word Recognition						
English visual lexical decision (from English Real & Non-word list): Real and non-words	118/120	98%	N/A	N/A	N/A	N/A
Welsh visual lexical decision (from Welsh Real & Non-word list): Real words	77/80	96%	N/A	N/A	N/A	N/A
PALPA 3: minimal pairs - Written word selection (Implicit reading: same/different discrimination)	**65/72****	90%	23	70.96		1.69
Reading						
PALPA 19: upper case to lower case letter matching	26/26	100%	26	25.96	25-26	0.20
PALPA 32: grammatical class reading (matched for conreteness)	77/80	96%	32	79.74		1.16
PALPA 34: lexical morphology and reading	90/90	100%	N/A	N/A	N/A	N/A
English Reading: Regular words	40/40	100%	20	39.7	38-40	0.66
English Reading: Irregular words	40/40	100%	20	39.55	38-40	0.69
English Reading: Non-words	**31/40****	78%	20	37.95	33-40	2.04
Welsh Reading: Regular words	40/40	100%	20	40	40-40	0.00
Welsh Reading : Non-words	33/40	83%	20	38.2	32-40	2.24

** depicts scores that are at least 2 standard deviations below control mean

* represents scores that are thought to be impaired to some degree, where normative data are not available

Repetition data reveal no impairment in word repetition in either language, but there may be a very mild impairment in non-word repetition in both English and Welsh (no normative data available). This suggests (mostly) intact pre- and post-lexical acoustic processing.

He has little difficulty with spoken word production with scores on English and Welsh versions of the Object and Action naming battery. Both English and Welsh scores are within normal range, suggesting that the phonological output lexicon is unaffected by neurological damage in both languages.

Regular word reading in both languages is unimpaired, as is irregular word reading in English. Nonword reading is mildly impaired in English but within normal range for Welsh.

In summary, performance of RON on all tasks is high, with some mild impairment in non-word repetition, and minimal pairs. RON presents with very mild phonological dyslexia, in English alone, suggesting a mild impairment in English phonological processing, at the level of the sublexical grapheme-phoneme conversion route.

4.3.7. RON: Spelling Deficit diagnosis

The spelling deficit of RON is not severe, but certain patterns did emerge upon analysis of various tasks. Tables 4.6 and 4.7 display performance on various spelling tasks and the error types (respectively) made by RON, and the distribution of these errors in English and Welsh. The data in Table 4.7 have been extracted from a large corpus of RON's spelling to dictation data, which was collapsed together and analysed in terms of spelling errors.

The most marked effect that emerges from the various spelling tasks is a length effect. The JHU length list shows a significant difference between spelling short (4-5 letter words) and long (7-8 letters) words (χ^2 (1) = 18.77, p<.001). This is also the case in Welsh spelling. A list of Welsh words created in preparation for the study was spelled to dictation by RON. Shorter words (4-6 letters) were produced significantly more accurately than longer words (7-8 letters; χ^2 (1) = 15.99, p<.001). A length effect is primarily indicative of a graphemic buffer deficit. He displays a frequency effect in both English (χ^2 (1) = 15.76, p<.001) and Welsh (χ^2 (1) = 12.27, p<.001), which can also follow from graphemic buffer deficits, as in the case described by Sage and Ellis (2004).

The error patterns of RON in spelling to dictation (Table 4.6) are also consistent with damage to the graphemic buffer. His spelling to dictation data displays many errors related to a damaged buffer and problems in maintaining the word form representation in spelling (despite initial retrieval from the lexicon), such letter omissions, substitutions, shifts and reversals (e.g. "cigarette"-> GIGAREET). And, unlike the case of CWS, the errors are not predominantly phonologically based.

Further evidence that contributes to a diagnosis of a deficit at the level of the graphemic buffer comes from the delayed copy transcoding scores of RON. Reliance is put upon the graphemic buffer in delayed copy tasks, as it is responsible for keeping the representation active in working memory. A length effect (2-5 vs. 6+ letters) is present in English irregular word (χ^2 (1) = 3.69, p=.055), as well as in both English and Welsh nonword delayed copy (English, χ^2 (1) = 16.8, p<.001; Welsh, χ^2 (1) = 3.96, p=.047). Regular word delayed copy transcoding is unimpaired relative to other word types (no norms are available). This lexicality effect suggests that the GB deficit is not pure.

There is also a lexicality effect in both English and Welsh spelling to dictation. In the English and Welsh real and nonword spelling (taken from real and nonword reading task in Tainturier, Roberts & Leek, 2011; see Appendices F and G for lists), performance for real words was higher than that of nonwords (English regular & irregular vs. nonword spelling, χ^2 (1) = 25.31, p<.001; Welsh real vs. nonword spelling, χ^2 (1) = 35.84, p<.001). This is also seen in tasks of grammatical class spelling, where nonwords were correctly spelled significantly less than nouns, verb, adjectives and functors (χ^2 (1) =5.81, p=.015).

Table 4.6. Performance of RON on various tests of spelling. Impaired performance in bold.

	Number of stimuli	Number correct	% correct	Control N	Control Mean	Control Range	Control SD
ENGLISH SPELLING							
English Regular, Irregular and Non-word spelling to dictation **(two administrations)**							
Regular words	80	68	85	20	38.8 (97%)	32-40	2.09
Irregular words	80	46	**58**	20	36.5 (91%)	22-40	4.96
Non-words	80	30	**38**	20	29.6 (74%)	37-40	4.82
PALPA regularity and spelling							
Regular words	20	19	95	N/A	N/A	N/A	N/A
Exception words	20	15	**75**	N/A	N/A	N/A	N/A
Frequency (words collapsed across JHU lists)							
High frequency words	181	151	**83**	N/A	N/A	N/A	N/A
Low frequency words	181	118	**65**	N/A	N/A	N/A	N/A
JHU word length list (two administrations)							
Four letter words	28	26	**93**	5	100%	N/A	N/A
Five letter words	26	23	**88**	5	97%	N/A	N/A
Six letter words	30	20	**67**	5	92%	N/A	N/A
Seven letter words	28	19	**68**	5	93%	N/A	N/A
Eight letter words	28	11	**39**	5	93%	N/A	N/A
PALPA length list							
Three letter words	6	6	100	N/A	N/A	N/A	N/A
Four letter words	6	6	100	N/A	N/A	N/A	N/A
Five letter words	6	4	**67**	N/A	N/A	N/A	N/A
Six letter words	6	5	**83**	N/A	N/A	N/A	N/A
English longer words (list created for RON in preperation for therapy project)							
Six letter words	29	16	**55**	N/A	N/A	N/A	N/A
Seven letter words	20	10	**50**	N/A	N/A	N/A	N/A
Eight letter words	17	2	**12**	N/A	N/A	N/A	N/A
Nine letter words	10	2	**20**	N/A	N/A	N/A	N/A
Ten letter words	8	0	**0**	N/A	N/A	N/A	N/A
JHU part-of-speech							
Nouns	28	20	**71**	N/A	N/A	N/A	N/A
Verbs	28	17	**61**	N/A	N/A	N/A	N/A
Adjectives	28	19	**68**	N/A	N/A	N/A	N/A
Function words	19	16	**84**	N/A	N/A	N/A	N/A
Total words	103	72	**70**	N/A	N/A	N/A	N/A
Nonwords	34	16	**47**	N/A	N/A	N/A	N/A
PALPA grammatical class spelling (matched for concreteness)							
Nouns	5	4	80	28	4.79		0.42
Verbs	5	5	100	28	4.82		0.39
Adjectives	5	4	80	28	4.82		0.48
Function words	5	4	80	28	4.68		0.55
JHU concreteness							
Concrete words	24	19	**79**	5	98%	N/A	N/A
Abstract words	24	16	**67**	5	91%	N/A	N/A
JHU probability list (four to six letters)							
High-probability words	30	29	97	5	99.50%	N/A	N/A
Low probability words	80	62	**78**	5	98%	N/A	N/A
Delayed copy transcoding							
Regular words	40	36	**90**	N/A	N/A	N/A	N/A
Irregular words	40	29	**73**	N/A	N/A	N/A	N/A
Non-words	40	31	**78**	N/A	N/A	N/A	N/A
WELSH SPELLING							
Regularity							
Regular Words	80	67	**84**	20	39.3 (98%)	37-40	1.01
Irregular words (E Thomas)	21	15	**71**	N/A	N/A	N/A	N/A
Non-words	80	30	**38**	20	30.1 (77%)	23-37	3.49
Frequency (words collapsed across lists)							
High frequency words (CEG cronfa >80)	141	79	**56**	N/A	N/A	N/A	N/A
Low frequency words (CEG cronfa <80)	117	40	**34**	N/A	N/A	N/A	N/A
Welsh Length list (By J Roberts, Bangor Univeristy)							
Four letter words	9	6	**67**	N/A	N/A	N/A	N/A
Five letter words	8	4	**50**	N/A	N/A	N/A	N/A
Six letter words	14	11	**79**	N/A	N/A	N/A	N/A
Seven letter words	10	2	**20**	N/A	N/A	N/A	N/A
Eight+ letter words	17	2	**12**	N/A	N/A	N/A	N/A
Delayed copy transcoding							
Real words	40	37	**93**	N/A	N/A	N/A	N/A
Non-words	40	26	**65**	N/A	N/A	N/A	N/A

In addition to the symptoms contributing toward a diagnosis of graphemic buffer impairment, RON also shows other patterns of spelling problems. He makes a large number of PPEs, which are more consistent with reliance upon sublexical processing as a consequence of lexical impairment. This, taken together with his frequency and lexicality effect, may mean that RON has an additional lexical deficit.

Table 4.7. A breakdown of errors made by RON in English and Welsh

		Words		Nonwords	
	Examples	**Number**	**%**	**Number**	**%**
English					
Error percentages in spelling real words (N = 287) and nonwords (N = 50) for RON					
Phonologically plausible errors	holiday -> HOLLIDAY	92	31.83	N/A	N/A
Real word error	college -> COLLAGE	13	4.50	6	12.00
Phonologically implausible nonwords (50% or more letters correct)	attract -> ATRAC	163	56.40	29	58.00
Phonologically implausible nonwords (less than 50% letters correct)	excess -> EXS	5	1.73	6	12.00
Cross language errors	solve -> SOLF	14	4.84	9	18.00
Detailed distribution of scoreable errors					
(n = 514 for words and 122 for non-words)					
Omissions	absence -> ABSENC	177	34.44	29	23.77
Substitutions	problem -> BROBLEM	127	24.71	57	46.72
Additions	lobster -> LOBESTER	89	17.32	10	8.20
Exchanges/shitfs	success -> SUCCSES	121	23.54	26	21.31
Welsh					
Error percentages in spelling real words (N = 178) and nonwords (N = 66) for RON					
Phonologically plausible errors	afiechyd -> AFIECHID	35	19.66	N/A	N/A
Real word error	yfory -> FORY	5	2.81	1	1.52
Phonologically implausible nonwords (50% or more letters correct)	dynes -> DYNGHES	111	62.36	59	89.39
Phonologically implausible nonwords (less than 50% letters correct)	awydd -> AWTHN	5	2.81	1	1.52
Cross language errors	nerf -> NERV	22	12.36	5	7.58
Detailed distribution of scoreable errors					
(n = 367 for words and 135 for non-words)					
Omissions	fforch -> FORCH	81	22.07	28	20.74
Substitutions	ystyried -> YSTYRIAD	137	37.33	53	39.26
Additions	styfnig -> STYFFNIG	82	22.34	34	25.19
Exchanges/shitfs	llwyddo -> LLYWDDO	67	18.26	20	14.81

4.4. TREATMENT INVESTIGATION

The treatment extended the methodology of the protocol used by Rapp and Kane (2002), to measure treatment generalisation from English to Welsh (Phase 1), and, 6 months later, from Welsh to English (Phase 2), as well as within-language generalisation. This protocol was selected because it had previously demonstrated its efficacy with both lexical and graphemic buffer impairments at aiding people with dysgraphia to re-learn damaged lexical representations (Rapp & Kane, 2002).

4.4.1. Stimuli

Five sets of words were created in each phase, to explore possible generalisation patterns. Three sets of words in the language of treatment, and two in the untreated language: Treated, Repeated attempt set (but untreated), Control; Translations of treated words, and Untreated language control. In each phase, there were three stages: baseline assessment prior to treatment, treatment, and post treatment follow-up. At baseline and follow-up, all sets of words were spelled to dictation, and during the treatment stage only the treated and repeatedly attempted word sets were used. See appendices H and I for CWS Phase 1 and 2 stumilus sets, and Appendices J and K for RON Phase 1 and 2 sets.

Words were selected from a large corpus of spelling to dictation data of each participant. The selection criteria for words to be used in the protocol were that they mostly words that participants had previously made errors on. The aim was to have sufficiently low performance to allow observation of possible improvement, but also not so low that it would de-motivate participants. The sets were closely matched for frequency, and length (see Table 4.8). Frequency counts from the CEG cronfa ddata (Ellis, O'Dochartaigh, Hicks, Morgan, & Laporte, 2001) were used for Welsh, and the CELEX lemmatised frequency database for English (Baayen, Piepenbrock, & Gulikers, 1995). Baseline performance was matched within each set, with no significant difference between baseline 1 and 2 of sets in both Phases for CWS and RON, for whole word accuracy (all McNemar's tests = n.s) and letter accuracy (all Wilcoxon tests = *n.s.*, with the exception of the Welsh control set in phase 2 for CWS [z = -2.36, p=.02], although this variability cannot be accounted for by practice effects, as the difference was a decrease in accuracy).

Due to the difference in deficit and severity between the participants, the sets for CWS contained shorter words with a higher frequency, whereas the words selected for RON tended to be longer and generally of lower frequency than those of CWS. Note that the number of stimuli used for each set is different between participants (n=24 for CWS and n=36 for RON). This was because, given the length of each session (1 hour) and the severity of each of their deficits: for CWS, two sets of 24 took up an hour, whereas more could be done with RON. Also, having more in each set for RON was necessary given that his deficit was milder and spelling was close to accuracy (letters correct) for the majority of words at baseline.

Table 4.8. Average word length and frequency (log) for CWS and RON in each treatment phase

		English Therapy			Welsh Therapy		
		Baseline (%)	Length	Log Frequency	Baseline (%)	Length	Log Frequency
CWS							
	Treated set	14.6	5.50	2.26	12.5	4.92	2.21
	Repeated (untreated) set	14.3	5.48	2.44	18.8	5.00	2.32
	Treated language control set	22.7	5.41	2.23	16.7	4.96	2.43
	Untreated language translation set	8.3	5.17	2.31	29.2	4.83	2.13
	Untreated language unrelated control set	6.3	5.29	2.44	14.6	5.54	2.20
RON							
	Treated set	25.0	7.22	2.12	29.2	7.58	2.27
	Repeated (untreated) set	20.8	7.00	2.01	40.0	7.22	2.05
	Treated language control set	26.4	7.08	1.88	23.6	7.06	2.21
	Untreated language translation set	34.7	7.11	2.21	34.7	7.83	2.12
	Untreated language unrelated control set	37.5	7.22	2.05	26.4	7.72	1.71

4.4.2. Treatment plan

Baseline, post-testing and follow-up

For words in all sets, participants heard the word and were asked to repeat it then attempt to spell it. Repetition had to be correct before participants attempted spelling. At baseline and post-testing, performance of participants was measured twice on the five sets of words matched for length and lexical frequency and in each session, testing in only one language was administered. Baseline and post-testing took place over two weeks, with two sessions per week (one English and one Welsh). Thus for example, for baseline 1 of Phase 1, English words (treated, repeated attempt and control) would be spelled in session 1, and Welsh words in session 2 (translation set and unrelated controls). This was reversed for baseline 2. Post-testing was carried out in the week following treatment ceasing, and follow-up testing 6 weeks later. The languages in each set were swapped 6 months later for the Welsh treatment (Phase 2). CWS completed 6-week follow-up testing subsequent to Phase 2, but RON was unable to continue with testing after the end of Phase 2, thus no follow-up data was gathered from him at this stage.

Treatment procedure

Participants had twice-weekly hour-long sessions with the first author at their homes. The criterion for discontinuation was to reach and maintain an accuracy level of above 90% over 4 sessions for RON, or when no improvement was made over 4 consecutive sessions for CWS (as he could not reach the 90% criterion). The words from the treated and repeated (untreated) sets were used in each session, and which set was used first was alternated.

Words from the repeated set were spelled to dictation in each session. The participant was asked to repeat the word spoken by the experimenter, and then attempt to spell it. No treatment or feedback was provided for these words.

After spelling to dictation of words in the treated set, participants were shown a note card with the correct spelling typed on it and the experimenter pointed to each letter of the word while reading them aloud (whether they the correct response had been provided or not). They were given the opportunity to study it for as long as they wished. If the response they had given was correct, the experimenter then moved on to the next item. If they had provided an incorrect response, after studying the correct spelling on the card, and having each letter read aloud to them, the card would be removed and the participant would try again. This would be repeated until the correct response was provided.

4.5. RESULTS

4.5.1. Scoring and statistics

Throughout the study, accuracy of spelling for all words was scored in two ways: by number of correctly spelled words and by letter scoring. For the latter, target letters were scored as follows: 1 if present, 0 if not present, .5 if switched and 0 if shifted. This method allows a more stringent analysis of whether spelling improves, not on a whole word level, but by whether attempts become closer to target. In addition to this, error types produced by participants were all scored; the number of phonologically implausible errors (PIEs) and phonologically plausible errors (PPEs) were measured at baseline and post-testing to determine whether there was any shift in error patterns. Within words, PPEs are errors that can be deemed plausible, such as ‘Table’ - <TABL_>/<TAIBLE>/<TABEL> and are related to reliance upon sublexical processing subsequent to lexical damage. PIE’s are errors that cannot be deemed plausible, such as ‘priority’ -> <PRIOTIRY>, due to letter omissions, additions and switches and are more associated with GB deficits.

In keeping with the methods used by Rapp and Kane (2002), and Rapp (2005), Chi-squares were used for observing shifts in whole-word accuracy levels initially, but McNemar’s analyses were also used to ascertain the significance of improvement, and these are the analyses deemed most appropriate (although the Chi-square analyses revealed the same patterns). This method of analysis works by observation of the number of positive versus negative changes between baseline and post-testing for each individual word (in each set), discarding instances where there is no change. For the purpose of the current study, data were collapsed over two administrations and words were double marked (i.e. two scores for each word at baseline (BL1, BL2) and two at post-test (PT1, PT2). As there was only one follow up session (at 6-weeks post-treatment), the accuracy in this session in both phases was duplicated and analysed versus the two baselines. McNemar's were carried out by calculating the instances of positive and negative changes between words in each set for baseline 1 versus post-test 1, and baseline 2 versus post-test 2. Thus each attempt at spelling each word was analysed. McNemar's analyses reported are two-tailed, unless otherwise stated.

Wilcoxon analyses were used to examine any difference in production of letters correctly produced in each set, between baseline and post-testing. It ranks the number of letters correctly produced in each word, at both stages of the protocol, and analyses the magnitude of change, per word set (analysed as were the whole words – BL1 vs. PT1, BL2 vs. PT2). This method of analysis allowed closer inspection of changes in accuracy within words, rather than on a whole word basis. It depicts whether spelling became closer to target.

4.5.2. Within language results

Table 4.9 represents within language improvement between baseline and post-testing in each phase of treatment for CWS and RON. Figure 4.5 depicts the progression of improvement across evaluation sessions from baselines to post-test and follow-up for CWS in the English and Welsh treatment phases, respectively. Figure 4.6 represents the same for

RON (bar the follow-up in phase 2). The highest score possible in each set was 24 for CWS (with some sets having slightly fewer items due to removal of duplicates), and 36 for RON.

Table 4.9 Within language improvement in Phases 1 and 2 for CWS and RON

	Whole words				Letters			
Set	*N (2 administrations)*	*Baseline*	*Post Test*	*% improvement*	*N (2 administrations)*	*Baseline*	*Post Test*	*% improvement*
CWS								
Phase 1: Treatment of English words (n=24 per set unless otherise stated, in parentheses)								
English treated	48	7	22	**+31%**°°	264	178	225	**17.99** °°
English repeated (untreated) [n=21]	42	6	8	+5%	230	166	160.5	-2.17
English control [n=22]	44	10	7	-7%	238	173	170.5	-1.05
Phase 2: Treatment of Welsh words (n=24 per set)								
Welsh treated	48	6	25	**+40%**°°	236	161	196.5	**15.25** °°
Welsh repeated (untreated)	48	9	14	+10%	240	160	174	**6.04** °°
Welsh control	48	8	7	-2%	238	161	171.5	4.24
RON								
Phase 1: Treatment of English words (n=36 per set)								
English treated	72	18	68	**+69%**°°	520	369	516	**28.27** °°
English repeated (untreated)	72	15	60	**+63%**°°	504	370	491	**24.01** °°
English control	72	19	35	**+22%**°°	510	396	445	**9.61** °°
Phase 2: Treatment of Welsh words (n=36 per set)								
Welsh treated	72	21	59	**+53%**°°	546	424	529.5	**19.41** °°
Welsh repeated (untreated)	72	29	42	**+18%**°°	520	456	476	**3.85** °°
Welsh control	72	17	32	**+21%**°°	508	418	447.5	**3.54** °°

°° Depicts 2-tailed significance of McNemar analyses (whole words) and Wilcoxon analyses (graphemes) at post-testing AND 6-week follow up.

In Phase 1, CWS improved significantly between baseline and post-test for treated items, with a 31% improvement between baseline and post-test (McNemar's test $p<.0001$). There was no significant improvement observed in the Repeated but untreated (McNemar's test, $p=.73$) or within language control (McNemar's test, $p=.75$) sets in this phase of treatment for CWS. These effect were still present at 6-week follow-up (McNemar's tests – Treated, $p<.001$; Repeated, $p>.99$; Control, $p=.774$).

For Phase 1 (English treatment) the within-language letter accuracy analysis of CWS was comparable to the whole word results: the letters accurately produced in English treated set improved (Z= -4.125, $p<.001$), but no significant improvement was observed in the English repeated set (Z= -.695, $p=.49$) or the English unrelated control set ($Z=-.530$, $p=.60$).

The pattern was comparable in Phase 2. Significant improvement was seen in the treated words (a 40% improvement, McNemar's test *p*<.001). Also, there was a trend toward improvement in the repeated set, but it did not reach significance (McNemar's test, *p*=.09 [one-tailed]). No improvement was observed in the within language control (McNemar's test, p=.99) set. Again, this pattern of improvement, significant increase in treated items only, was maintained at 6-week follow-up (McNmear's tests – Treated, p=.004; Repeated, p>.99; Control, p=.688).

Letter accuracy analysis of the Welsh treatment (Phase 2) revealed similar results to the whole word accuracy analyses for CWS with the Welsh treated set (*Z*=-4.639, *p*<.001) improving significantly. In addition, the Welsh repeated improved also, supporting the trend observed in the whole word analysis (*Z*=-2.434, *p*=.014). The Welsh control showed no sign of increased accuracy (*Z*=-1.414, *p*=.16) at the grapheme level.

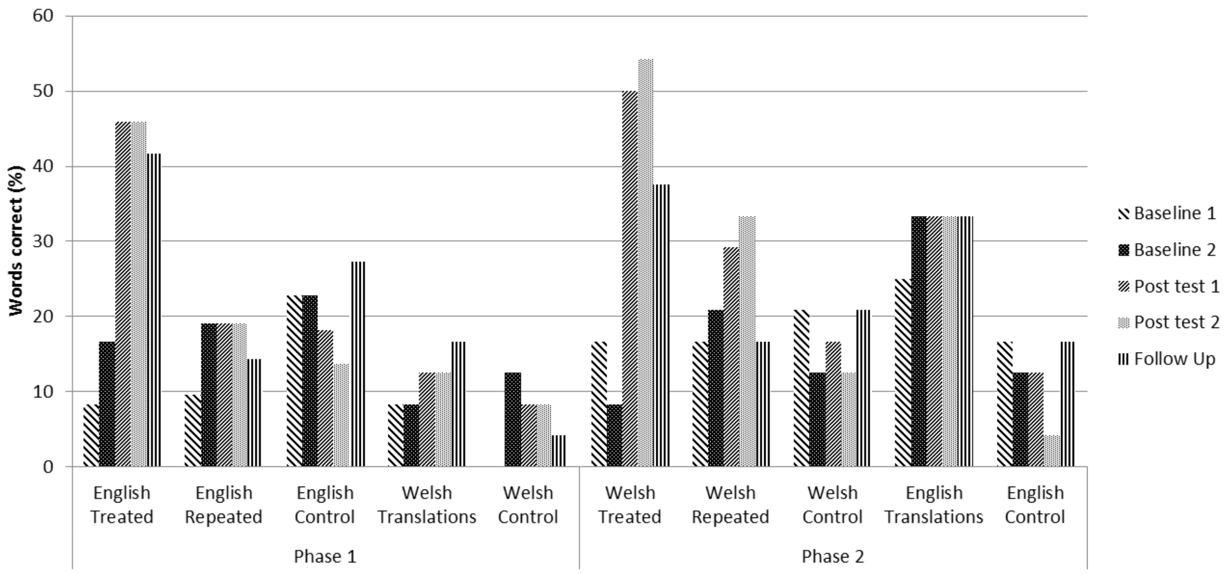

Figure 4.5. CWS whole-word spelling accuracy in Phase 1 and 2 evaluation sessions.

Figure 4.6 depicts the progress of RON in the English and Welsh treatment phases. Patterns of improvement were similar in both phases (see Table 4.9 also). In the English phase significant improvement was observed in the English treated (a 69% improvement, McNemar's test, *p*<.001), English repeated (a 63% improvement, McNemar's test, *p*<.001), and English untreated control (a 22% improvement, McNemar's test, *p*=.002) sets between baseline and post-testing, with maintenance of gains at 6-weeks follow-up (McNemar's - Treated, *p*<.001; Repeated, *p*<.001; Control, *p*=.035)

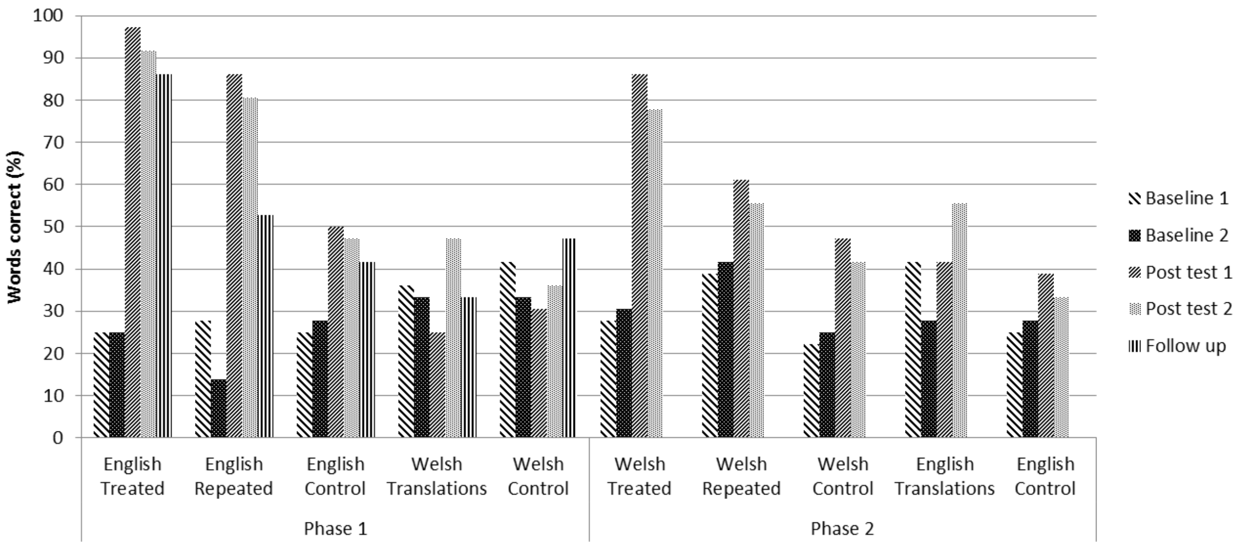

Figure 4.6. RON whole-word spelling accuracy in Phase 1 and 2 evaluation sessions.

Analysis of RON's letter production accuracy of each set in Phase 1 (English treatment) revealed a similar pattern to that of whole word accuracy. The English treated (*Z*=-6.304, *p*<.001), English repeated (*Z*=-6.285, *p*<.001), and English control (*Z*=-3.963, *p*<.001) sets improved significantly.

Phase 2 yielded similar patterns of improvement. Again, the within-language treated, repeated and control sets all improved significantly. The Welsh treated set improved by 53% (McNemar's test, *p*<.001). Both other Welsh sets improved too – the repeated set by 18% (McNemar's test, *p*=.01), and the within language control set by 21% (McNemar's test, *p*<.001) between baseline and post-testing. Unfortunately no data are available for follow-up, as RON was unable to continue after post-testing.

The within-language results of letter accuracy examination in the Welsh treatment phase for RON were also similar to the whole word analyses. The Welsh treated (Z=-6.065, p<.001), Welsh Repeated (Z=-2.326, p=.02), and Welsh control, Z=-2.980, p=.003) all improved significantly at the letter level.

4.5.3. Between language results

Table 4.10 shows between language improvement at Phase 1 and Phase 2 for both participants. In Phase 1, CWS showed no significant improvement in either of the Welsh sets at the whole word level (McNemar's analyses – Welsh Translation set, p=.63; Welsh control set, p=.99), or at the letter level (Welsh Translation set, Z=-1.406, p=.16; Welsh control set, Z=-1.639, p=.10). At 6-week follow-up, there was still no change in cross-language sets (McNemar's – Welsh Translation, p=.219; Welsh Control, p<.99).

In Phase 2, there was no improvement for CWS in whole word accuracy in translations of the treated Welsh items (McNemar's test, p=.99). There was however, a trend toward a decrease in accuracy of spelling to dictation of the whole words in the English control set, although this did not reach significance (McNemar's test, p=.063 [two-tailed]). At follow-up, accuracy levels were not significantly different from baseline level (McNemar's test – English Translations, p=.754; English Control, p>.99). There were also no signs of increased accuracy at the letter level for CWS in the cross-language sets in Phase 2, with Wilcoxon signed ranks test not significant for English translations (Z=-.664, p=51), and English controls (Z=-.148, p=89).

For RON, no significant change was observed between baselines and post testing in Phase 1 in the untreated language Translations set (McNemar's test p=.52) and Control set

(McNemar's test *p*=.59), maintained at 6-week follow-up testing (McNemar's – Welsh Translations, *p*=.832; Welsh Control, *p*=.405). In addition, no significant increase in letter accuracy was observed in either Welsh set (Welsh translations [*Z*=-1.519, *p*=.13]; Welsh control [*Z*=-.573, *p*=.57]).

In Phase 2 however, significant improvement was observed in the English translations of the Welsh treated set: there was a 14% (McNemar's test, *p*=.032, 1-tailed) increase in words correctly spelled to dictation between baseline and post-test (35->49% correct). There was also a trend towards improvement in cross-language controls (10% increase in correct responses, McNemar's test *p*=.105 [one-tailed]). No 6-week follow-up data are available, as RON was unable to continue after Phase 2 post-testing). Letter accuracy performance showed a similar pattern, with improvement in English translations reaching significance (*Z*=-2.906, *p*=.004), but not the English control set (*Z*=-.346, *p*=.73).

Table 4.10. Between language improvement in Phases 1 and 2 for CWS and RON

	Whole words				**Letters**			
Set	*N (2 administrations)*	*Baseline*	*Post Test*	*% improvement*	*N (2 administrations)*	*Baseline*	*Post Test*	*% improvement*
CWS								
Phase 1: Treatment of English words (n=24 per set)								
Welsh translations of English treated	48	4	6	+4%	248	153	164	4.44
Welsh unrelated control	48	3	4	+2%	254	150	164	5.51
Phase 2: Treatment of Welsh words (n=24 per set)								
English translations of Welsh treated	48	14	14	+0%	232	176	170	-2.37
English unrelated control	48	7	2	-10%	266	175	176	0.38
RON								
Phase 1: Treatment of English words (n=36 per set)								
Welsh translations of English treated	72	25	29	+6%	512	407.0	435.5	5.57
Welsh unrelated control	72	27	30	+4%	520	433.0	441.0	1.54
Phase 2: Treatment of Welsh words (n=36 per set)								
English translations of Welsh treated	72	25	35	**+14%***	564	469.0	500.5	**5.59** **
English unrelated control	72	19	26	+10%	556	462.0	468.5	1.17

** Depicts 2-tailed significance of McNemar analyses (whole words) and Wilcoxon analyses (graphemes) at post-testing AND 6-week follow up.
* Depicts 1-tailed significance of McNemar analyses (whole words) and Wilcoxon analyses (graphemes) at post testing.

4.5.4. Error type analyses

Analyses were made of the distribution of phonologically plausible errors (PPEs) and phonologically implausible errors (PIEs) in mappings for both CWS and RON between baseline and post-testing. PPEs are more closely associated with deficits in the OOL, due to reliance upon sublexical phoneme/grapheme conversion, whereas PIEs are more buffer type errors that arise from omissions, additions, substitutions and shifts. The purpose of analysing the number of each error made pre- and post-testing was to examine whether lexical-type and buffer-type errors may be affected by treatment.

The shifts in proportion of PPEs versus PIEs between baseline and post-testing in Phase 1 and 2 of the protocol are presented in Figures 4.7 and 4.8 for CWS, and Figures 4.9 and 4.10 for RON, with the PIEs separated into subcategories: Substitutions, No response/fragment, omissions, additions, shift/exchange. Substitutions were further divided into phonologically close (1 phonetic feature apart from target), far (more than 1 phonetic feature apart) and vowel. The figures show similar patterns at Phase 1 and Phase 2 for each participant, but differing patterns between CWS and RON. In both phases at baseline and post testing, CWS shows a high number of PPEs, consistent with lexical damage and reliance upon sublexical processing. When he does make PIE errors, they are most often substitutions, and most often phonetically close or vowel errors. PIEs such as NR/frag (no response/fragment), omissions, additions and shifts, which are more closely associated with GB deficits, remain low at both times and phases of testing.

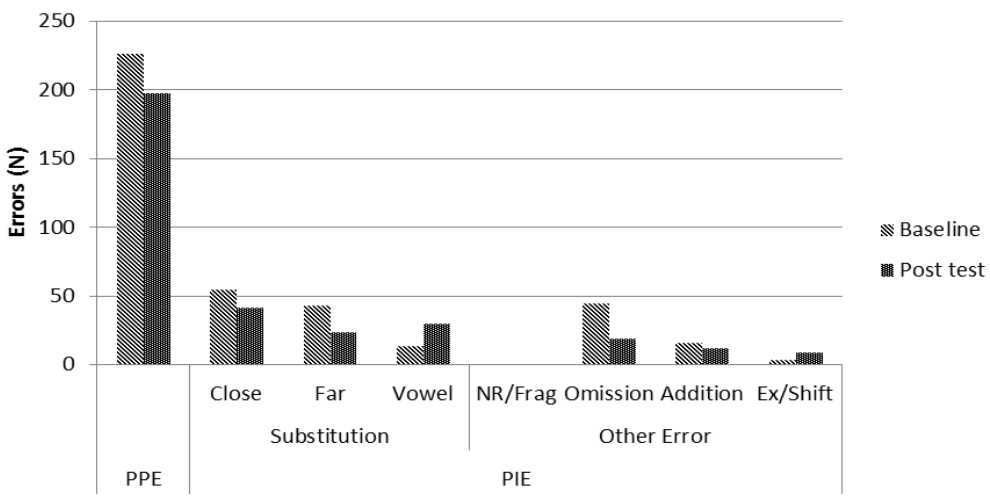

Figure 4.7. Distribution of phonologically plausible (PPE) and implausible errors (PIE) by CWS at baseline and Post-test in Phase 1.

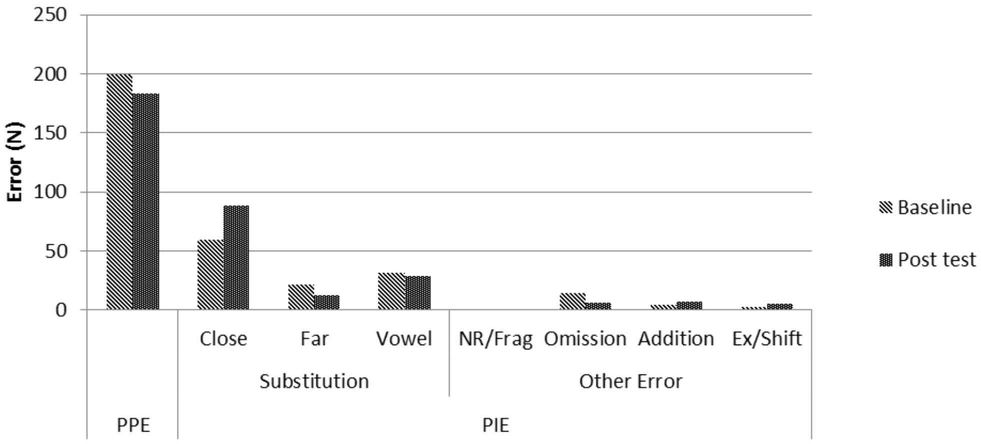

Figure 4.8. Distribution of phonologically plausible (PPE) and implausible errors (PIE) by CWS at baseline and Post-test in Phase 2.

Inspection of of RON's error proportions also reveals many PPEs at baseline and post-testing (Figures 4.9 and 4.10). However, unlike CWS, he makes few substitution errors but many omissions, additions, and exchanges/shifts. These drop between baseline and post testing. Chi-square analyses were made of the number of each error type in English and Welsh sets, in each phase of treatment. The PPEs and PIEs made in the treated sets in both phases are provided separately, and other sets are combined by language, for observation of possible effect on untreated sets in the treated and untreated language.

There was no significant difference in the number of PPEs in relation to PIEs between baseline and post-test in the treated set in either phase for CWS (Phase 1, χ^2 (1) = 0.194, *p*=.659; Phase 2, χ^2 (1) = 0.654, *p*=.798). That is, both error types were reduced to a similar extent subsequent to therapy. RON showed a different pattern of errors. In Phase 1, there was no shift in the proportions of PPEs and PIEs made between baseline and post-testing (χ^2 (1) = 1.00, *p*=.317). In phase 2, however, there was a significant decrease in the number of PIEs produced between baseline and post-test (PIEs reduced from n=115 to n=10, PPEs from n=13 to n=5; χ^2 (1) = 9.28, *p*=.002). This high number of PIEs at baseline in Phase 2 supports the argument for Welsh being L2: orthographic representations are less resistant to neurological damage in the weaker language, resulting in more errors. The significant drop in PIE errors depicts the success of the treatment protocol.

A significant difference in the number of PPEs and PIEs between baselines and post-tests in sets of English words in phase 1 was observed for CWS. The distribution shifted toward a large decrease of PIEs (χ^2 (1) = 4.14, *p*=.04) in the language of treatment, while the total number of PIEs remains the same (N=88). No significant change in the distribution of PINs and PPEs was observed in Welsh spelling in Phase 1 for CWS (χ^2 (1) = 0.316, *p*=.859). This suggests that treatment may be resulting in his attempts at spelling becoming closer to target for the treated language, in the English treatment phase. In phase 2 there was no significant change in the proportion of PPEs versus PIEs in the treated language (Welsh - χ^2 (1) = 1.97, *p*=.161), or untreated language (English - χ^2 (1) = 1.87, *p*=.171) for CWS.

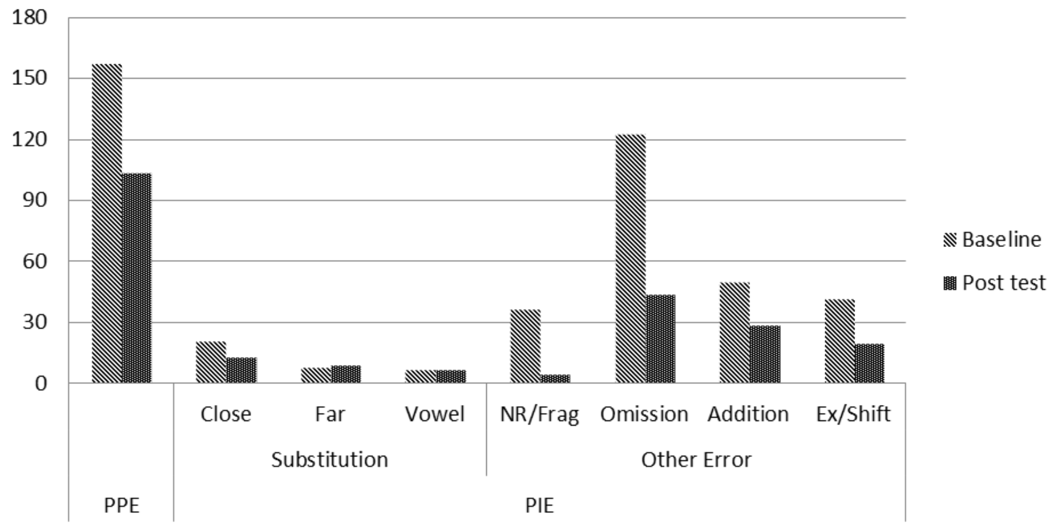

Figure 4.9. Distribution of phonologically plausible (PPE) and implausible errors (PIE) by RON at baseline and Post-test in Phase 1.

The distributions of PPEs and PIEs made by RON are represented in Figures 4.9 and 4.10. In the English phase of treatment, no significant shift in PPEs versus PIEs was observed in the performance of RON, in the treated language (English - χ^2 (1) = 1.81, *p*=.179). There was, however, a shift in Welsh words, with PPEs increasing between baseline and post-test, and PIEs decreasing (χ^2 (1) = 4.01, *p*=.045).

Phase 2 resulted in no significant change in number of PPEs versus PINs in Welsh words (χ^2 (1) = 0.857, *p=.355*), whereas in English words, there was a shift in error types, PPEs increasing and PIEs decreasing, with the shift almost reaching significance (χ^2 (1) = 3.66, *p*=.056 [2-tailed]). Further analyses show that the shift lay within the translations set (χ^2 (1) = 3.08, *p*=.04 [1-tailed]; English control set - χ^2 (1) = 0.682, *p*=.41). The decrease in PIEs relative to PPEs in English words in the translation set in Phase 2 supports the whole word and letter-level accuracy findings of words becoming closer to accuracy in the translations set.

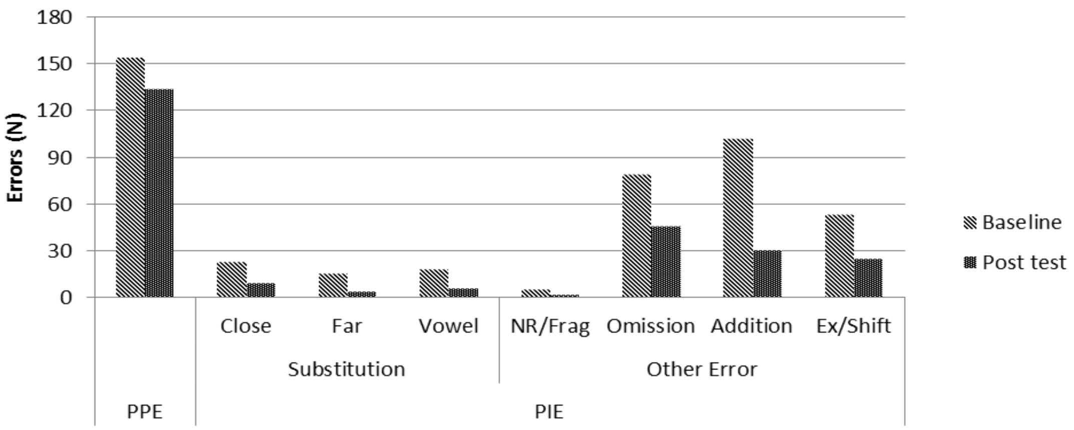

Figure 4.10. Distribution of phonologically plausible (PPE) and implausible errors (PIE) by RON at baseline and Post-test in Phase 2.

4.6. DISCUSSION

The aim of this study was to examine the circumstances under which both within and between-language treatment generalisation may occur in Welsh-English bilingual dysgraphia. The specific questions that arose in preparation of a spelling treatment study with two bilinguals were as follows: if generalisation were to occur, would it depend on the language of treatment, and/or on the type of deficit? To address these questions, two people with acquired dysgraphia took part in a spelling treatment protocol. They were first given treatment in English (Phase 1), with effects on both English and Welsh observed, and 6 months later given therapy in Welsh (Phase 2) with effects on both languages measured. The same protocol (but with different stimuli) was given to both participants, with the aim of discovering whether different effects would be seen due to their contrasting spelling deficits.

Our results converge with a number of studies that suggest that both within and between-language generalisation of treatment effects can occur in bilingual aphasia, and add new information regarding the treatment of bilingual spelling disorders. For the purpose of discussing therapeutic gains and treatment transfer in this study, although in terms of spoken language, both participants would consider themselves to be L1 Welsh, with regard to their written output, we consider L1 to be English. This is because, especially for the generation of the two participants, Welsh is the main language spoken at home, with friends, and in the community, whereas English is the main language used in written communication and for reading.

4.6.1. Within-language effects

The within-language results of both phases replicate the findings in monolingual dysgraphia of Rapp and Kane (2002) and Rapp (2005): significant improvement in two participants with acquired dysgraphia subsequent to a delayed copy spelling protocol, with treatment transfer varying according to the deficit. Consistent with the within-language hypotheses based on the findings of previous monolingual studies (e.g. Beeson 1999; Beeson, Hirsch & Rewega, 2002; Orjada & Beeson, 2005; Beeson, Rewega, Vail & Rapcsak, 2000; Rapp & Kane, 2002; Rapp, 2005; Ball, Riesthal, Breeding & Mendoza, 2011), the treatment was successful in improving performance on treated sets of words (in both phases of treatment), in both participants. This provides further evidence that simple spelling therapy protocols involving copying of words can "strengthen their representations in long term memory" (Rapp & Kane, 2002, p.452), for those words treated, in the language of treatment.

Given that the deficit of CWS was comparable to that of MMD in the study of Rapp and Kane (2002) in that they both had a diagnosis of orthographic lexicon deficit, and that a similar protocol was used, the within-language results of CWS were compared to MMD for treated items. Consistent with the findings for MMD, subsequent to treatment CWS displayed a significant improvement in treated words, and in letter accuracy, suggesting that the treatment aided CWS in re-learning the orthographic lexical representations for treated words in the lexicon. Some improvement extended to words that were repeatedly spelled to dictation, though to a much lesser extent than for MMD. Although CWS and MMD have similar symptoms of dysgraphia, the OOL impairment in CWS is more severe than it was in MMD, and thus strengthening representations by mere multiple attempts may prove more difficult. In addition, a transparent language such as Welsh may be more receptive to repeated exposure/attempts at spelling, hence the clearer effects of repeated attempts in Phase 2. In addition, as well as re-learning lexical representations of words, this therapy (in Welsh) may also have been aiding some damaged phoneme-grapheme mappings. Another explanation for the lack of improvement in repeatedly attempted items in English therapy is that the lesion of CWS does not correspond to the region that is reported mostly in the literature. Not only is his lesion is in the right hemisphere, but it is also more frontal than most reported cases.

Studies aimed directly at treating GB deficits in monolinguals have reported improvements in all spelling sets (e.g. Rapp & Kane, 2002; Rapp, 2005), and the within-language results of RON are consistent with these findings in terms of improvement in both whole word and letter-level accuracy. As expected, RON improved significantly on the treated set of words in both phases of the study. Whole word spelling and letter-level accuracy in the other within-language sets (i.e. repeated and control) in both the English and Welsh treatment phases also improved. This generalisation to untreated words in the treated language was expected for impairment in the graphemic buffer, based on the findings of Rapp and Kane (2002). They suggest that although it is not clear why the graphemic buffer deficits improve subsequent to delayed copy treatment and repeated exposure to stimuli, "it is certainly possible that the capacity of the buffer to maintain the activation of representations was improved by the treatment" (p.452). However, it is not clear whether this treatment was specifically acting on the graphemic buffer. It could be that the therapy strengthened representations in the orthographic output lexicon, making them more resistant to impairment at the level of the graphemic buffer. Although re-learning orthographic representations may have played a role, given that the treated set improved most, it is unlikely to be the only impact of treatment. It is suggested that treatment did indeed lead to improvement at the level of the buffer, due to the generalisation observed across all sets. Few previous treatment studies have targeted the graphemic buffer alone, thus it is not yet known what type of treatment works best for this type of deficit.

4.6.2. Between-language effects

CWS showed no evidence of cross-linguistic generalisation (at the whole word or letter level), regardless of which language was treated, or whether or not the words were related to the treated ones (i.e. translations did not improve). We had predicted that in lexical deficits there may be generalisation to translations of treated items (but not untreated between-language controls), depending on the organisation of the lexicon in bilingual written language production. Because this is the first study of its kind, it was not known whether or not lexically-related items in the untreated language would benefit from therapy.

The lack of cross-linguistic generalisation of CWS suggests that the links/activation between lexically related words were damaged, and that parallel activation would not implicitly aid in re-learning damaged mappings for translations of treated words. Another explanation is that there was no or insufficient co-activation of lexical representations of the untreated language during treatment. This may in part be due to the severity of CWS's deficit, considering that many studies have provided strong evidence for co-activation (e.g. Colommé, 2001; Costa, Caramazza, & Sebastian-Galles, 2000; Costa & Caramazza, 1999, Costa, 2005; Costa & Santesteban, 2004; Kroll, Bobb, & Wodniecka, 2006; Marian, Spivey, & Hirsch, 2003). For CWS, lexical representations may have to be re-learned, whereas in less severe OOL cases, treatment may make representations more accessible both within and between languages.

It was hypothesised that if there were to be cross-language improvement subsequent to treatment in the GB case, this should extend to both cross-language sets, on the assumption of GB's status as a general working memory store. In fact, between-language improvement was only observed in Phase 2, and only in cross-language translations of the treated set. This is consistent with previous findings of L2->L1 cross-language generalisation in other modalities (Fredman, 1975; Gil & Goral, 2004; Edmonds & Kiran, 2006; Goral, Levy, & Kastl, 2007; Kohnert, 2004).

This benefit to translations of treated items in Phase 2 suggests that the therapy may have been primarily targeting the lexical level, with additional benefits to the buffer (as seen within-language). As this is what delayed-copy treatment protocols are set out to do, these results support the claim by Rapp and Kane (2002) that the treatment most likely aided representations at the lexical level, in addition to some “general benefit (either direct or indirect) to the buffering process” (pp. 452), but also extend it cross-linguistically. On the basis of this suggestion, it could be argued that the amalgamation of effects of treatment on the lexicon and the buffer led to significant improvement, but only for lexically related items in the untreated language, in Phase 2.

The significant improvement of RON in the English translations set for the Welsh treatment, though limited (a 14% increase in correct responses from baseline to follow-up), could be explained by there being a single graphemic buffer processing lexical outputs for both languages. Even if separate working memory stores existed for each language, the improvement of RON in the English translations set in the Welsh treatment phase suggests there are connections between buffers. Another possible explanation is that there may have been an additive effect of treatments, because the Welsh treatment phase was the second. Thus the experience of RON of having received the same type of treatment protocol previously (but in another language), could have influenced the second phase of treatment, resulting in more improvement to the graphemic buffer. Another possibility is that the fact that he had been practising spelling (when he does not normally use written communication) may have had an impact by the time the second phase began. There could also be an effect of language transparency, as Welsh has a relatively transparent orthography compared to that of English, or that the most proficient language is most likely to improve. But it could also be the case that the treatment used in the present study was not specifically targeting the graphemic buffer.

Considering all the alternative possibilities for this effect, it is suggested the most likely explanation for this cross-language improvement for RON in phase 2 would be a combination of language proficiency with an additive effect of treatment and practice by the second phase, resulting in greater improvements in working memory by the end of the second phase. As discussed, RONs written L1 is considered to be English, with L2 being Welsh. The findings of cross language generalisation from L2->L1 is consistent with past studies suggesting stronger connections exist between L2->L1 as opposed to L1->L2. Also, prior to commencing this study, RON rarely used writing as a means of communication, thus repeated practice across two phases of therapy is likely to have produced amplified effects.

4.6.3. Future perspectives

Because these are the first cases of Welsh-English bilingual dysgraphia, the first cases of bilingual OOL and GB deficits, and the first bilingual dysgraphia treatment studies that have been described, many unanswered questions still remain. These initial findings suggest differing patterns of recovery and therapeutic gains between people with the characteristics of damaged OOL and GB. However, the present study is that of two single-cases, and therefore to increase power and disentangle effects between deficits and outcomes of therapy, there is a need for further case studies.

Future work with bilingual acquired dysgraphia should investigate the effectiveness of including orthographically, phonologically, and/or semantically related words. It is suggested that more can be learned about the possibility of both within and between language generalisation with the use of orthographic neighbours and cognate stimuli. It has been shown that orthographic neighbours in the non-active language of bilinguals can affect recognition of words in a target language (French & Ohnesorge, 1997), and may be an avenue to explore in future bilingual dysgraphia research. Also, given that cognates are similar in terms of structure as well as meaning, and that their status of being closely connected within the lexicon, cognate stimuli might facilitate stimulation of their translation equivalent in spelling, similar to the study of Kohnert (2004).

4.6.4. Conclusion

This study strengthens prior evidence regarding orthographic lexical and graphemic buffer deficits, and extends it within a bilingual context. Treatment generalisation differs depending on the nature of the deficit, and treatment transfer to the untreated language may occur, as a function of the nature of the deficit and the language treated. In terms of clinical implications, therapists may wish use the findings of the present study in guiding treatment of bilingual dysgraphia. This is the first study of bilingual dysgraphia therapy, leaving some unanswered questions. Further studies need to investigate the effectiveness of different treatment techniques of bilingual dysgraphia, and also manipulation of closely related lexical items in relation to therapy (cognates, orthographic neighbours, semantically related within- and between-language items). In conclusion, this study demonstrates effectiveness of therapy, both within and between languages, in Welsh-English bilingual acquired dysgraphia.

CHAPTER 5: TRAINING SUBLEXICAL SPELLING IN BILINGUAL ACQUIRED DYSGRAPHIA.

CHAPTER 5: TRAINING SUBLEXICAL SPELLING IN BILINGUAL ACQUIRED DYSGRAPHIA.

5.1. ABSTRACT

This is the first study to explore treatment of sublexical spelling deficits in bilingual dysgraphia. Earlier sublexical treatment studies have been successful in improving trained items, but also in promoting generalisation to untrained words, but these investigations have been restricted to monolingual aphasia (e.g. Kiran, Thompson & Hashimoto, 2001) and developmental dyslexia/dysgraphia (e.g. Rowse & Wilshire, 2007). This is the first report of acquired dysgraphia treatment targeting impaired phoneme-grapheme mappings, with one of the key contributions being that it directly compares the effects of treating shared and divergent orthographic representations. As predicted, results show successful remediation of mappings that are shared between languages, with those that are divergent being more resistant to therapy. This supports the view that sublexical processing of mappings that are shared across languages is processed via a common system, whereas divergent mappings are processed via distinct mechanisms.

5.2. INTRODUCTION

Language therapy in bilingual aphasia is a relatively new research area, with mixed results being reported in terms of generalisation to the untreated languages. Few studies investigating cross-linguistic treatment generalisation exist, and those reported primarily concern spoken naming and provide mixed results, some being more successful in reporting the existence of cross-linguistic transfer of treatment effects (Watamori & Sasanuma, 1978; Kiran & Edmonds, 2004; Konhert, 2004; Goral, Levy, Obler, & Cohen, 2006; Goral, Levy, & Kastl, 2007) than others (Galvez & Hinckley, 2003; Meinzer, Obleser, Flaisch, Eulitz & Rockstroh, 2007). This study focuses on the treatment of spelling disorders following brain damage. More specifically it explores treatment of sublexical spelling disorders in bilinguals, contrasting the effects of treating phoneme-grapheme mappings that are shared between languages, with those that are divergent.

It has been established that training phoneme-grapheme and grapheme-phoneme rules can generalise to untreated words and across modalities, but the question of whether effects can generalise across languages in bilinguals remains unanswered. This study explores impaired bilingual sublexical processing, with the aim of discovering patterns of generalisation both within and between-languages, and to use these patterns in contributing to developing theories of bilingual spelling.

Existing (monolingual) models generally agree that two processes are involved in spelling: one for processing familiar words, and another for unfamiliar words. This paper focuses on the mechanism involved in spelling unfamiliar words. There is a shared consensus that unfamiliar words are processed by combining knowledge of phoneme-grapheme mappings that occur between phonology and orthography. Connectionist models propose processing of unfamiliar words via connections between phonology and orthography, which underpin both spelling and reading. Dual-route models argue that unfamiliar words are processed via a sublexical phoneme-grapheme conversion system, specific to spelling (with a separate sublexical system for reading). The sublexical route functions by activating prelexical acoustic and phonological processes, where the word is broken down into its component phonemes. Those phonemes are converted into graphemes, and in turn post-lexical orthographic processes are activated, including the graphemic buffer, which maintains activation of the sequence during execution of writing each letter (e.g. Goodman & Caramazza, 1986).

Spelling via the sublexical system involves using knowledge of typical phoneme-grapheme mappings and applying them to create plausible spellings. In bilingual spelling, some mappings are shared between languages, others differ, and there are some that are language-specific. For example, in English and Welsh the phoneme /g/ maps on to the grapheme <G> in both languages, whereas the phoneme /f/ maps on to <F> in English but <FF> in Welsh, and /z/->Z exists in English but not Welsh, whereas /r̥/->RH is specific to Welsh. This is true for other language pairs also. For example, in English and French /b/ maps on to the grapheme <B> in both languages, whereas /ʃ/ maps on to <SH> in English but <CH> in French. Some language pairs are even more similar to one another, for example, Spanish and Italian share many mappings, but there are still some divergences.

Phonological dysgraphia is the term used to describe impairments in spelling unfamiliar words, or nonwords, with comparatively spared production of familiar words (Bub & Chertkow, 1988; Bub & Kertesz, 1982; Nolan & Caramazza, 1982; Shallice, 1981). According to dual route models (DRM), this arises from damage to sublexical phoneme/grapheme conversion processes, whereas connectionist models explain it as a deficit in connections between phonology and orthography. These are described in detail in Chapter 1. The assumptions of the DRM postulate separate sublexical routes for reading and spelling, whereas connectionist models assume generalised problems in phonology that should occur across reading and spelling. There is still much debate as to which explains sublexical processing best. Reports of simultaneous phonological dyslexia and dysgraphia support connectionist models (e.g. Beeson, Rising, Kim & Rapcsak, 2010; Crisp & Lambon Ralph, 2006) and can also be explained by the DRM, whereas cases of phonological dyslexia/dysgraphia in the absence of general phonological impairments (e.g. Caccappolo, Vliet, Miozzo, & Stern, 2004) support the separate systems proposed by the DRM.

A number of model-based language treatment studies have been described in which phoneme-grapheme and/or grapheme-phoneme correspondences have been re-trained. For example, Luzzatti, Colombo, Frustaci and Vitolo (2000), rehabilitated spelling along the sub-word-level route in two Italian individuals with dysgraphia. A protocol involving simple acoustic-phonological-orthographic segmentation of words, repetition and lexical decision elicited significant gains. Post treatment, both participants were close to normal levels in spelling, and both could apply their restored skills to written naming and spontaneous writing of untreated items. The success of this treatment to untreated tasks of writing can be explained by both the DRM and connectionist models. Under the assumptions of the DRM, the treated phoneme-grapheme rules were re-learned and could be utilised in all spelling, whereas the connectionist models would explain the generalisation as coming from strengthened connections between nodes in the phonology-orthography pathway. Further support for generalisation subsequent to sublexical treatment is reported by Beeson, Rising, Kim and Rapcsak (2010). They trained phoneme-grapheme correspondences using sound-to-letter production and using key words beginning with impaired mappings. Additionally they provided an interactive treatment protocol, using an electronic spell-check. Both participants improved significantly in untrained reading and spelling tasks, again, illustrating the possible generalisation effects of therapy targeting sublexical processing, but also adding the possibility of cross-modal generalisation.

Others have also reported encouraging findings from training phoneme-grapheme and grapheme-phoneme conversion, with generalisation to untrained items (e.g. Brunsdon, Hannan, Nickels & Coltheart, 2002) and across modalities (e.g. Kiran, 2005; Kiran, Thompson & Hashimoto, 2001; Kohnen, Nickels, Brunsdon & Coltheart, 2008; Kohnen, Nickels & Coltheart, 2010; Rowse & Wilshire, 2007). Kohnen and colleagues (Kohnen et al., 2008;

Kohnen et al., 2010) describe a protocol guided by the DRM that proved to be very successful in two children with mixed dysgraphia. They trained impaired phoneme-grapheme correspondences using minimal pairs, and report success of training, in spelling, but also in reading. Also, in a study targeting acquired reading and oral naming impairments Kiran et al. (2001) used repetition, oral reading, oral spelling, and using scrabble pieces for selecting letters of target words. This was very successful, with generalisation to spelling and reading of both treated and untreated items, and (oral and written) naming of treated items.

There is some evidence from bilingual dyslexia research supporting and extending the generalisation effects that have been previously reported in monolinguals. Laganaro and Venet (2001) designed a reading treatment protocol to be used with a bilingual Spanish-English mixed alexic person who had letter-by-letter and phonological dyslexia. A computer-based programme was used, targeting phonological blending skills (i.e. skills that are common to both languages). The treatment was effective in promoting cross-linguistic generalisation in nonword reading when the language of treatment was L2 (English). These are encouraging findings from treatment targeting sublexical (reading) processing in bilingual aphasia, providing an insight that generalisation of treatment effects can be seen both within and across languages. However, cross-language gains were marginal, and there was no explicit measurement of improvement in grapheme-phoneme mappings. This highlights the need for more studies specifically measuring gains of treating impaired mappings.

In addition, one case of phonological dysgraphia has been reported in bilingual aphasia. Kambanaros and Weekes (2012) described the case of a Greek-English person with acquired phonological dysgraphia, characterised by similar impairments in nonword spelling in both languages. It is explained by Kambanaros and Weekes (2012) in accordance with the dual-route framework as damage to phoneme-grapheme conversion mechanisms, but they do not consider what these findings mean for developing theories of bilingual spelling. They merely state that the participant was unable to spell via phoneme-grapheme conversion mechanisms in either language.

There is a need for further exploration of bilingual sublexical spelling, with suggestions to be proposed with regards to the framework of sublexical processing in multiple languages. In general terms, the core question is whether or not there are two entirely separate systems for each language. There is some evidence that this is not the case in studies showing that children can easily transfer skills acquired in one language to another language (e.g. Bialystok, Luk, & Kwan, 2005; Joy, 2011).

No research has yet investigated treatment of sublexical spelling deficits in bilinguals with acquired dysgraphia, nor whether there may be different outcomes from treating shared versus divergent mappings.

5.2.1. Rationale, aims and hypotheses

This study has been designed in order to further understand the mechanisms underlying the bilingual sublexical spelling system, and to investigate cross-language generalisation in bilingual dysgraphia. A key contribution to bilingual aphasia research is that this study directly compares shared and divergent mappings in bilingual sublexical processing, which has not been explored previously in acquired dysgraphia or dyslexia.

The specific research questions were: Can treating phoneme-grapheme mappings in one language lead to improvement in the untreated language? If so, does it depend on aspects of sublexical spelling that are targeted (shared versus divergent mappings)? Can patterns of treatment generalisation in bilingual phonological dysgraphia inform theories of normal bilingual spelling?

These research questions were addressed using a protocol aimed at treating damaged phoneme-grapheme mappings in a case of acquired bilingual dysgraphia. Impaired phoneme-grapheme mappings (either shared in both languages or divergent) were targeted in spelling therapy, using a methodology that combined aspects of treatment used by Kohnen, Nickels, Brunsdon and Coltheart (2008), Kohnen, Nickels and Coltheart (2010) and Kiran, Thompson and Hashimoto (2001). English was treated first, and generalisation to Welsh was assessed. Twelve months later, Welsh was treated and generalisation to English was measured. The purpose of administering therapy in each of the languages of the participant was to observe for possible differences in gains and patterns of generalisation.

Predictions differed as a function of the type of mapping that was treated. It was hypothesised that generalisation of treatment effects both within and between languages would be observed subsequent to treatment of mappings that are shared between languages. This is based on the assumption that shared mappings may be processed by a shared mechanism between the two languages, and would thus respond well to treatment. Activation of representations for shared mappings should be strengthened in both languages.

Training divergent mappings was expected to have a different outcome. Treatment was expected to be effective for the treated language alone, with spelling accuracy for the divergent mapping in the untreated language remaining unaffected, or even decreasing due to possible competition. Performance on divergent mappings was relatively high as baseline in terms of spelling accuracy in the untreated language, to allow for observation of any possible adverse effects (i.e. decline) of the untreated language in performance that may occur as a consequence of treatment.

Treatment of a language-specific mapping (introduced in Phase 2), was expected to result in improved spelling of that mapping, with no effects on the untreated language or other untreated mappings. It was tested as if it were a ‘monolingual’ mapping per se, and it was hypothesised that it may not improve to the same extent as mappings that are shared between languages. This was under the assumption that treating ‘shared’ mappings may lead to higher activation by mutual facilitation, whereas the Welsh-specific mapping would improve, but would not be enhanced further by the other language. No improvement was expected for any control mappings: without treatment it was unlikely that these impaired phoneme-grapheme conversion rules would be re-learned.

5.3. METHOD

5.3.1. Case Report

The background information of CWS is described in detail in Chapter 4. This is the second treatment study he took part in, targeting sublexical spelling. At the time of therapy he was 61 years old and 12 years post onset of aphasia. As mentioned previously, CWS presents with aphasia in both languages, with symptoms consistent with those of mixed dysgraphia and (almost pure) phonological dyslexia. The present study is concerned with the sublexical spelling deficit of CWS.

Table 5.1 presents the spelling to dictation performance of CWS in English and Welsh. A diagnosis of a deficit at the level of the OOL (see Chapter 4) was made because irregular/exception word spelling is most impaired (relative to regular words and nonwords), particularly for lower frequency words, while comprehension (semantics) remains unimpaired. He makes many phonologically plausible errors in spelling (in English 218/349, and in Welsh 207/378 errors were PPEs).

However, CWS's spelling deficit is not confined to the orthographic lexicon, as he is also impaired in regular words and nonword spelling, and makes many non-plausible errors (in English 131/349, and in Welsh 171/378 errors were non-plausible [represented in Table 5.2]). Nonword spelling accuracy does not differ significantly from regular word spelling, in either English (χ^2 (1) = .104, p=.46) or Welsh ([χ^2 (1) = .313, p=.39] (list initially created for reading, see Tainturier, Roberts & Leek, 2011), with both being around 40% accuracy.

Table 5.1: Performance of CWS on repetition, phonemic decomposition and spelling tasks, in English and Welsh. Impaired scores in bold.

	Number of stimuli	Number correct	% Correct	Control N	Control Mean	Control Range	Control SD
ENGLISH REPETITION & PHONEMIC DECOMPOSITION							
English word repetition	80	80	100	N/A	N/A	N/A	N/A
English Non-word repetition	40	40	100	N/A	N/A	N/A	N/A
English word phonemic decomposition	51	50	98	N/A	N/A	N/A	N/A
English non-word phonemic decomposition	51	49	96	N/A	N/A	N/A	N/A
ENGLISH SPELLING							
English spelling to dictation (two administrations)							
Regular words	80	33	**41**	20	38.8 (97%)	32-40	2.09
Irregular words	80	14	**18**	20	36.5 (91%)	22-40	4.96
Non-words	80	31	**39**	20	29.6 (74%)	21-37	4.82
Frequency (words collapsed across JHU lists)							
High frequency words	147	31	**21**	N/A	N/A	N/A	N/A
Low frequency words	146	18	**12**	N/A	N/A	N/A	N/A
Length nonwords							
3-5 letter words	54	23	**43**	N/A	N/A	N/A	N/A
Six+ letter words	48	10	**21**	N/A	N/A	N/A	N/A
JHU concreteness							
Concrete words	21	4	**19**	5	98%	N/A	N/A
Abstract words	21	0	**0**	5	91%	N/A	N/A
Direct copy transcoding (lower-upper case)	34	34	100	N/A	N/A	N/A	N/A
WELSH REPETITION & PHONEMIC DECOMPOSITION							
Welsh word repetition	40	40	100	N/A	N/A	N/A	N/A
Welsh Non-word repetition	40	37	93	N/A	N/A	N/A	N/A
Welsh word phonemic decomposition	47	46	98	N/A	N/A	N/A	N/A
Welsh non-word phonemic decomposition	47	47	100	N/A	N/A	N/A	N/A
WELSH SPELLING							
Regularity							
Regular words	40	9	**23**	20	39.3 (98%)	37-40	1.01
Non-words	40	7	**18**	20	30.1 (77%)	23-37	3.49
Irregular words (subset from different spelling tasks)	20	1	**5**	N/A	N/A	N/A	N/A
Frequency							
High frequency (CEG count above 150)	29	8	**28**	N/A	N/A	N/A	N/A
Low frequency (CEG count below 150)	11	1	**9**	N/A	N/A	N/A	N/A
Length Nonwords (subset from different spelling tasks)							
3-5 letter words	46	15	**33**	N/A	N/A	N/A	N/A
Six+ letter words	41	8	**20**	N/A	N/A	N/A	N/A

In order to diagnose the level of deficit, it was necessary to address the processes involved in nonword spelling. Spelling to dictation of nonwords should occur as follows: upon hearing the word, it is broken down into its component phonemes by pre-lexical acoustic and phonological processes; those phonemes are then converted into appropriate graphemes, and the post-lexical processes include the graphemic buffer that maintains activation of the sequence of graphemes; followed by the selection and execution of letter shapes.

Preserved real word and nonword repetition ability suggests that pre-lexical processing was unimpaired (English word & Non-word repetition 100%; Welsh words 100%, nonwords 93%). A phonemic decomposition task also was created to test pre-lexical processing, but more specifically to test the ability to decompose phonological sequences: CWS was given words aurally and was asked to recite each sound of the word. For example, if he were given the word ‘tub’ (aurally), he would recite ‘tuh’, ‘uh’, ‘buh’. The task contained 40 items: 10 words and 10 nonwords in each language (Welsh word and nonword length, M=4.7 phonemes [range 3-6]; English, M=5.2 [range 4-6]). All items were extracted from the English and Welsh real and nonword lists, which were also used in spelling to dictation task (matched for structure, length and frequency). The task was scored by individual phonemes correctly extracted from the sequence (N=47 for Welsh and N=51 for English words and nonwords). The importance of this task was to ensure that CWS is able to break down words into phonemes orally (i.e. that there are no problems before he attempts spelling), and to exploit the fact that he spells in this way by developing a therapy that utilises the skill. Of the total of 196 mappings that made up the 40 words and nonwords in the task, he was 98% accurate, suggesting his ability to segment words is good. Chi-square analysis revealed no difference in phonetic decomposition of words and nonwords in Welsh (χ^2 (1) = 1.01, p=.32) or English (χ^2 (1) = .343, p=.56).

It is also apparent that CWS does not have difficulties in letter-shape conversion, with the motor abilities involved in executing the written forms of words and letters, as revealed by his excellent direct copy transcoding score (100%).

This process of elimination leaves phoneme-grapheme conversion and/or the graphemic buffer as possible candidates for the location of the deficit. It is proposed that he has an impairment at the level of phoneme-grapheme conversion. CWS uses phonetic decomposition spontaneously while spelling, pronouncing phonemes with a North-Walian accent (whether he is spelling in Welsh or English) but often producing an incorrect grapheme. He seems to be influenced by the names of letters, and also the fact that the phonemes can sound similar because of the way he sounds out each phoneme in the Caernarfon accent. The errors made by CWS in spelling are consistent with a phoneme-grapheme conversion deficit.

Table 5.2 provides a breakdown of errors in spelling for CWS. Errors have been scored by mapping, as CWS often makes multiple errors within each word. In both English and Welsh, CWS tends to make substitutions for phonetically plausible graphemes resulting in many phonologically plausible errors (often with influence from Welsh, e.g. ’thirty’ – THYRTY, ‘cup’ - <CYP>). Aside from the abundance of PPE errors, the majority of errors he makes are substitutions, most of them being closely related to the target mapping (e.g. p-b, c-g, t-d, n-m). Substitutions classed as ‘close/vowel’ are those that are one phonetic feature apart from the target (e.g. ‘ship’ > SHID). These phonetically ‘close’ substitutions are consistent with difficulties in sublexical processing, but are not a hallmark of graphemic buffer dysgraphia (e.g. Caramazza, Miceli, Villa & Romani, 1987). Non-phonetically-based errors such as ‘far’ substitutions (more than one phonetic feature apart from the target; e.g. ‘cross’ > CROX), and ‘other error’ types occur less frequently by comparison.

Table 5.2. Distribution of phonologically implausible errors (English N= 131, Welsh N=171).

		English		Welsh	
Error		Example	N	Example	N
Substitution	Close/vowel	twenty>TWANDY	54	pump>PUND	103
	Far	cross > CROX	25	awst>AWSG	38
Other Error	Omission	thousand>THAWSD	37	gwyrdd > GWUR_	21
	Addition	october > OCTOBARY	12	llwy > LLWID	7
	Movement	sixty > SICTX	3	diwrnod > DWURNOD	2

In addition to the phonological nature of his errors, CWS makes errors on particular phoneme-grapheme correspondences, while others remain relatively unimpaired. Figure 5.1 depicts spelling accuracy of some mappings within words and nonwords that had been targeted for potential use in therapy (from tests of spelling to dictation collapsed together). It illustrates the relative accuracy and inaccuracy of some phoneme-grapheme correspondences. For example, the mappings /æ/-> A and /m/ -> M were around 90% accuracy in English and Welsh spelling of both real and nonwords. Conversely, mappings such as /ɛ/ -> E and / θ/-> TH were below 20% accuracy.

He also seems to have preserved access to a single graphemic representation for phonemes that correspond to divergent mappings in both languages in some cases, such as /ʃ/->SH/SI and /f/->F/FF depicted in Figure 5.1. In these examples, for CWS the phoneme /ʃ/ maps on to SH, and /f/ onto F, irrespective of the language in which he is spelling.This is consistent with a diagnosis of phoneme-grapheme conversion deficit because access to representations of certain correspondences appears to have been lost (or have a low probability of retrieval).

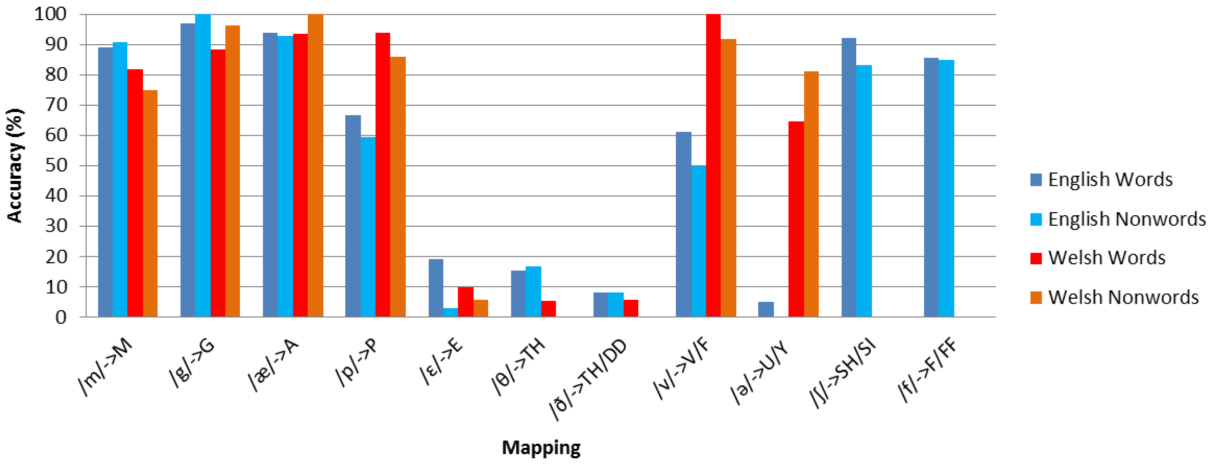

Figure 5.1. Variability in accuracy on a sample of mappings.

In nonword spelling, CWS displays a length effect in English (3-5 letter [43% correct] vs. 6+ letter [21% correct] nonwords; χ^2 (1) = 5.50, *p*=.009 [1-tailed]), but not in Welsh (3-5 letter vs. 6+ letter nonwords; χ^2 (1) = 1.91, *p*=.167 [English and Welsh nonword spelling data from nonword spelling tasks, collapsed for analysis]). This is thought to have arisen by chance due to the presence of impaired phoneme-grapheme correspondences. This was inspected further to distinguish between length effects as symptoms of sublexical, as compared to graphemic buffer, impairments. In a sublexical deficit there should be no difference within the word as to where errors may occur, whereas errors in graphemic buffer deficits should occur in longer words. This was tested by analysing the accuracy of the first three graphemes of words in long versus short nonwords. Thus, in sublexial deficits there should be no difference in the number of errors in the first three graphemes between long or short words, whereas graphemic buffer deficits should elicit more errors in the first three graphemes of long words as compared to short words. There was no effect of the length of the target: no significant difference was revealed in accuracy of the first three graphemes in long versus short words (96/114 short vs. 102/126 long, χ^2 (1) = .440, *p*=.507), suggesting the length effect in whole-nonword accuracy is due to an increasing probability of a damaged mapping being present in the word. To explore this further still, accuracy of grapheme position 3 was contrasted between short and long words, with no significant difference (short 29/38, long 30/42, χ^2 (1) = .878, *p*=.767). This is consistent with sublexical deficits, but inconsistent with graphemic buffer impairments, where length effects are most pronounced in the medial positions of words (Wing & Baddeley, 1980).

5.3.2. Treatment Investigation

A treatment protocol was designed to target sublexical spelling. There were two phases to the investigation: Phase 1 focused on treating English phoneme-grapheme mappings, with measurement of both within and between-language gains; and 1 year later Phase 2 provided treatment to Welsh phoneme-grapheme mappings.

5.4. PHASE 1: ENGLISH TREATMENT

5.4.1. Stimuli

Data from previous tests of spelling to dictation completed by CWS were collapsed and analysed in order to select phonemes to target for treatment. Phoneme-grapheme correspondences were scored for accuracy, and the criterion for selection was that the accuracy level was below 20% in the language that therapy was to be administered in, to allow room for significant improvement.

In Phase 1 (English therapy), two phonemes were selected (one to be treated, one control) that were low in performance in both English and Welsh, and that have shared mappings in both languages (/ɛ/-> E and /θ/->TH). Another two phonemes were chosen (one for treatment, one control), that map on to divergent graphemes in English and Welsh (/ə/->U/Y and /ʊ/->OO/W). The divergent mappings were impaired in English spelling, but less so in Welsh, allowing potential for observation of gains in the treated language and possible decline in the untreated language. Note that, particularly in English, phonemes can map on to different graphemes. For example, the phoneme */ε/* can map on to different graphemes (e.g. BED/HEAD). The mappings chosen for therapy were the highest probability ones in monosyllabic CVC or CCVC or CVCC words (Zeigler, Stone & Jacobs, 1997). In this example, */ε/->*E was the highest probability mapping.

Nonwords that included target phonemes were created for baseline testing. Monosyllabic nonwords were used as not do 'drown' the target in longer stimuli, but also because mappings can change in the context of words with more than one syllable. Stimuli were simple CVC, CCVC and CVCC words and nonwords. The nonwords were created to be as 'English-like' (e.g. SETCH) and 'Welsh-like' (e.g. RHEP) as possible, to encourage use of sublexical processing for each language. Particularly in this instance (Phase 1) it was important to carefully manipulate context in order to ensure that phonemes mapped on to target graphemes.

A new set of items containing the target mappings were used for the treatment phase: a total of 40 treated items (20 for each phoneme, n=14 words; n=6 nonwords). Treatment words were matched for frequency across sets, and did not include any of the phonemes from the non-treated sets. See Appendix L for the full nonword lists used in baselines, and Appendix M for items used in treatment sessions.

5.4.2. Design and Procedure

Target mappings were each tested three times at baseline in 8 sets of nonwords (30 'English' and 30 'Welsh' for each of the 4 mappings), in order to establish stable performance prior to treatment. For each language, there were two sets containing mappings targeted for treatment, and two sets containing control mappings (matched for accuracy with those targeted for treatment). All sets were collapsed into a single list for each language, randomised, and spelled to dictation in separate sessions per language. The order of presentation was counterbalanced to control for fatigue effects of spelling a long list (thus, the second administration of the English and Welsh lists began from the end of the list, working back). These nonwords were also spelled to dictation in six post-test sessions (3 English; 3 Welsh), and six follow-up sessions (6 weeks after post-tests).

In all spelling to dictation (evaluation sessions and treatment sessions), CWS was asked to repeat each word/nonword before spelling: if repetition was inaccurate, he was asked to repeat it again (until accuracy was achieved).

Treatment sessions took place three times per week at the home of CWS. Using the protocol described below, each phoneme was treated separately, and the mapping treated first alternated between sessions. For example, the first session began by treating the mapping /ɛ/->E, followed by /ə/->U, and vice versa in the next session. Progress was monitored using weekly probes (Step 1 of the protocol, spelling to dictation), and treatment was ceased after 22 treatment sessions, when accuracy of both target mappings had reached 90% or above on the treatment sets.

5.4.3. Treatment protocol

Words and nonwords were kept separate in each session in order to avoid confusion. Words were treated first, nonwords second, based on the protocols of Kiran, Thompson and Hashimoto (2001); and Kohnen, Nickels, Brunsdon and Coltheart, (2008). Nonwords were included to encourage generalisation of mappings. The treatment implemented was a progressive intervention, containing three steps:

Step 1: Spelling to dictation. In the first weekly session (before treatment began), words and nonwords from the treatment lists were spelled to dictation, to monitor progress. Words and nonwords were randomised, and items from both sets were mixed.

Step 2: Minimal pairs. CWS was asked to spell to dictation two items in a minimal pair (one phoneme differing between two words, e.g. BET-BAT, GUT-GOT). If correct, the next pair was administered; if incorrect, feedback was given. Feedback entailed the experimenter highlighting errors and providing the correction for target mappings. Once CWS had studied the correction, it was covered, and the spelling procedure for the minimal pairs was repeated until correct spelling was given. This is based on the technique used by Kohnen, Nickels, Brunsdon and Coltheart (2008).

Step 3: Anagram sorting and delayed copy. The anagram task was carried out using a small white board and letter tiles. These included all possible letters from that treatment set presented in a random order on the board (plus the letters that CWS tends to substitute in spelling). Some multi-letter grapheme tiles were also used (e.g. ‘CH’; ‘SH’). CWS was given the target word (aurally), and was then asked to select the correct letters and put them into the correct sequence (based on the reading treatment protocol of Kiran, Thompson & Hashimoto, 2001). Once the word had been correctly spelled this way, CWS was asked to copy it into a notebook, in order to reinforce the spelling. If he was incorrect, the correct spelling was shown, the letters were scrambled, and he was asked to try again.

5.4.4. Scoring and Analyses

Accuracy at baseline, post-test and follow-up was scored by the number of times target mappings were produced. Accurately produced mappings were given a score of 1, and incorrect responses were given a score of 0. McNemar analyses were performed on each set, contrasting accuracy (positive versus negative changes) for each target phoneme-grapheme mapping collapsed over 3 baselines versus 3 post-tests (90 observations in total for each set). All McNemar tests reported are two-tailed, unless otherwise stated. Generalisation was measured in terms of correct use of target mappings in untreated sets within and between languages, pre- versus post-treatment. Analysis was also made of the changes in accuracy between pre- and post-treatment between treatment sets, using Chi-square tests.

5.4.5. Results

Figure 5.2 presents the spelling to dictation mean accuracy and range of each target mapping at baseline, post-test (3 sessions of each, averaged), and 6-week follow-up in Phase 1.

At baseline, spelling performance of all mappings in English was similar (between 0% and 5% correct). In Welsh, performance was similar between the treated and untreated 'shared' phonemes (0%-5% corect), and between the treated and untreated 'divergent' phonemes (average of 68-85% correct), at baseline. Treatment results for each target mapping will be described in turn.

Figure 5.3 presents the substitution errors made in spelling. Green bars depict the percentage of each erroneous phoneme-grapheme mapping. Each letter within the green bars depicts the percentage that this specific grapheme was used in place of the target mapping. For example, at baseline testing /ɛ/->E was substituted for /ɛ/->A in 93% of responses (with 4% correct and another 3% to other assorted substitutions). The substitution graphs are provided to give a clear view of the consistency of errors.

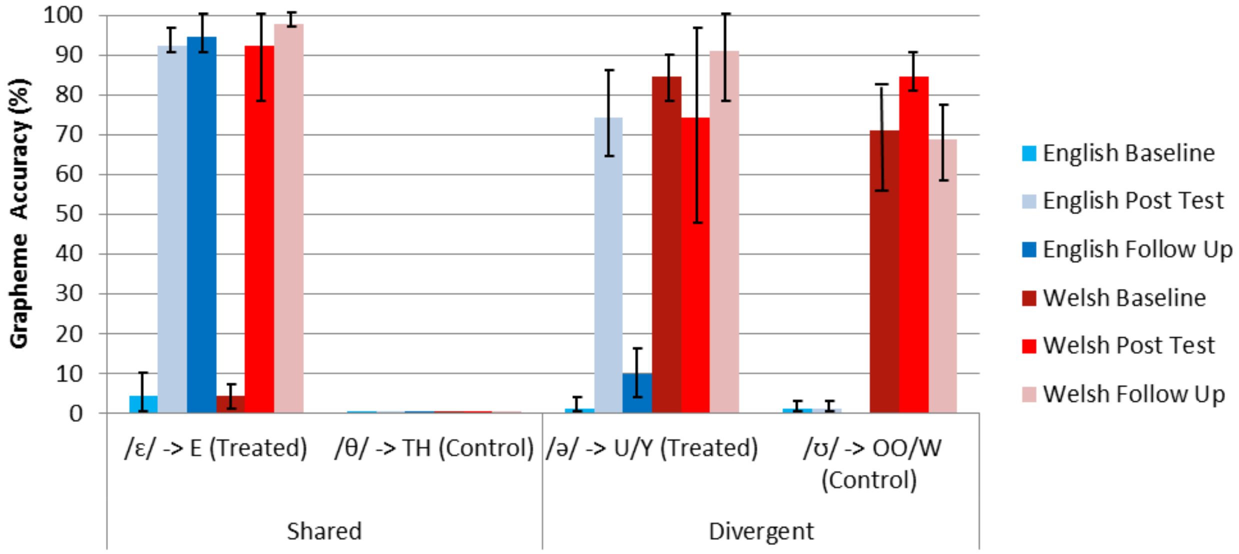

Figure 5.2: Spelling to dictation accuracy (%) of each mapping at baseline, post-test and follow-up (n=90 [3 administrations amalgamated] for each language). Error bars represent the accuracy range over the 3 administrations per stage.

Treated 'shared' phoneme: /ɛ/

The phoneme /ɛ/ corresponds to the same grapheme in both English and Welsh (e.g. bet/het). Baseline scores were low for spelling of both English and Welsh nonword lists, with the grapheme E almost consistently substituted for A in both languages. Treating /ɛ/ -> E in English led to a significant improvement in correct written production of the mapping between baseline and post-test (McNemar's test, p<.0001), with maintenance of gains remaining at 6-week follow-up (McNemar's test, p<.0001). In other words, the treatment of this mapping was successful in the treated language, English. As predicted, this improvement generalised to untreated Welsh spelling, where an improvement as large as that observed in English was observed subsequent to treatment (McNemar's test, p<.0001), with lasting effects at 6-week follow-up (McNemar's test, p<.0001).

Control 'shared' phoneme: /θ/

The phoneme /θ/ maps onto the grapheme TH (three/peth) in both English and Welsh. Baseline spelling performance for this mapping was 0% in both languages, with the majority of substitution errors being TH->F, or TH-> FH. As expected as this mapping was not treated, no change was seen in performance between baseline and post-testing, nor at 6-week follow-up. This confirms the specificity of treatment.

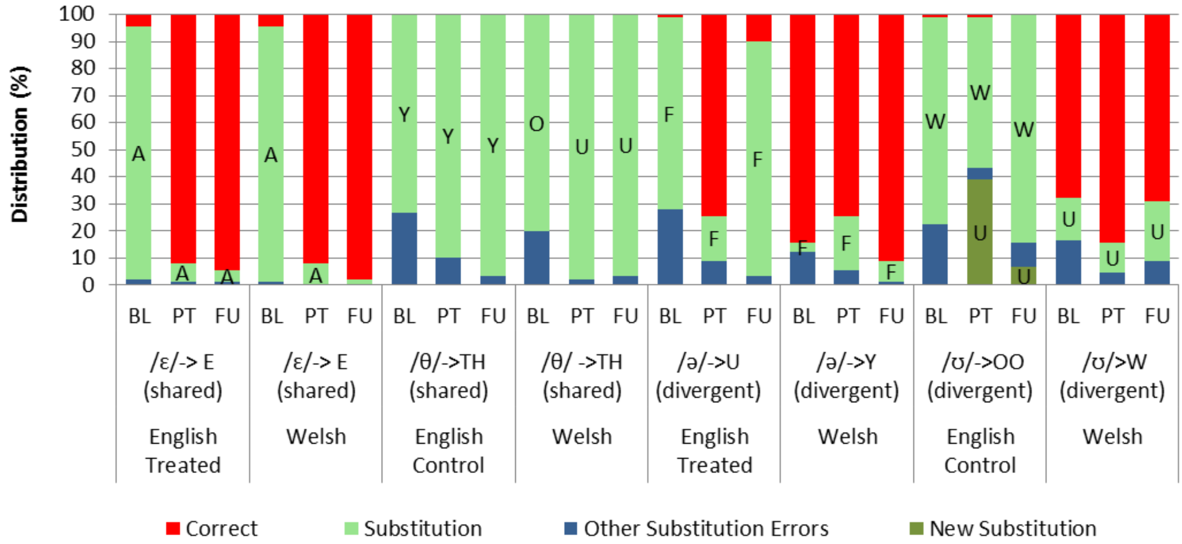

Figure 5.3: The distribution of responses at each stage of testing for target mappings in English and Welsh. Errors are scored as: 'Substitutions' – the most consistent substitution error for each phoneme [graphemes in bars represent the error]; 'other' substitution errors - those that are different from the more consistent ones; 'new substitution' errors - those that appeared subsequent to therapy. For each stage (BL - baseline; PT – post-test; FU – follow-up), n=90 (3 administrations amalgamated).

Treated 'divergent' phoneme: /ə/

The phoneme */ə/* corresponds to different graphemes in English and Welsh (English, cup; Welsh, hydref). At baseline, CWS primarily used the grapheme suitable for the Welsh spelling when attempting to write in either language (i.e. the grapheme 'Y' was used mostly). Thus, baseline scores for */ə/*->Y were high on average for Welsh (85% [range 77-90%]), but */ə/*->U was low for English (average of 1% correct). Following treatment in English, the correct production of the mapping in English spelling improved by an average of

73% (McNemar's test, $p<.0001$), so here again treatment was successful in the treated language, though not as much as for the shared mapping */ɛ/.* Between post-test and 6-week follow-up, production of the correct correspondance in English (*/ə/* -> U) dropped from 74% to 10% (McNemar's test, p<.0001 [negative change]) and CWS reverted back to using the incorrect Welsh mapping.

Accuracy of the mapping /ə/->Y dropped by 10% for Welsh (McNemar's test, $p=.061$, 1-tailed), which is consistent with the hypothesis that accuracy may decline in divergent mappings in the untreated language, due to possible competition from its cross-language equivalent. The majority of substitution errors in Welsh at post-test were influenced by the English therapy (Y -> U). In addition, contrary to the treated 'shared' mapping, these results were not lasting. For Welsh (*/ə/* ->Y) correct production increased significantly between post-test and follow-up (from 74% at post-test to 91% at follow-up; McNemar's test, $p=.003$).

Control 'divergent' phoneme: /ʊ/

The phoneme /ʊ/ corresponds to the grapheme 'OO' (b<u>oo</u>k) in English and 'W' (p<u>w</u>ll) in Welsh. At baseline, CWS most often produced the Welsh mapping, regardless of the language in which he was spelling, but also occasionally used 'U' for 'OO' (note: this can be a plausible transcription in English, very infrequently, which could be an influence). Subsequent to the treatment phase (in which /ʊ/ was not treated), there was no change in correct production of the grapheme 'oo' in English at either post-test or follow-up (all McNemar tests, *p*=N.S). However, there was a notable shift in the substitution errors made for this phoneme. At post-testing, substitutions were no longer consistently /ʊ/->W in

English, but almost half of the errors became /ʊ/->U. The pattern reverted to baseline at follow-up.

In Welsh, on the other hand, changes were observed. Although baseline performance was high for Welsh (correct production of /ʊ/->W at an average of 68% correct, the most common substitution being W->U), significant improvement was made on the correct production of the mapping (/ʊ/->W) between baseline and post-testing (McNemar's test, p=.036). However, this effect was not maintained, and there was a significant drop in correct performance between post-testing and the 6 week follow-up (McNemar's test, p=.015).

Analysis of differences between treated mappings

Chi-square analysis revealed that the treated divergent mapping did not improve to the same extent as the treated shared phoneme in English */ɛ/* (positive vs. negative/no changes: /ɛ/ 79:11, /ə/ 66:24 χ^2 (1) = 5.99, p=.01). This supports the prediction that shared mappings would be more responsive to therapy than divergent mappings, due to cross-language facilitation of the shared mapping, but interference of the divergent mapping.

In summary, as predicted, the treated 'shared' phoneme led to significant improvement in spelling to dictation of the mapping /ɛ/ -> E in both English and Welsh, with the gains still evident at 6-weeks follow-up. The treated 'divergent' mapping, */ə/*->U, improved significantly between baseline and post-test, but performance had declined by 6-week follow-up. There was no change in accuracy for the control 'shared' mapping /θ/->TH in either language. The untreated 'divergent' mapping /ʊ/->OO/W showed no change in accuracy for English spelling, but Welsh spelling accuracy increased between baseline and post-test, and declined back to baseline level by 6-week follow-up.

5.5. PHASE 2: WELSH TREATMENT

In Phase 2, Welsh was the language of treatment. The aim was to replicate the findings of Phase 1, and to compare shared mappings with 'unique' mappings. Much of the methodology was the same as that used in Phase 1. Some differences exist, and these are highlighted below.

5.5.1. Stimuli

The stimulus selection criteria were the same as for Phase 1: two low accuracy (below 20%) 'shared' phoneme-grapheme mappings (treated: /θ/->TH [because there was no difference subsequent to Phase 1 in this mapping] and untreated: /I/->I), and two 'divergent' mappings, that are impaired in Welsh, but relatively unimpaired in English (treated: /ʃ/->SH/SI, and untreated: /f/->F/FF) were selected. In addition, in Phase 2, two extra mappings were selected; mappings that are unique to Welsh: one treated (/r̥/-> RH) and one control (/əɨ/-> EU). Both Welsh-specific mappings were at floor level for baseline accuracy.

Nonword lists created for baseline testing in Phase 2 differed to Phase 1. 'Shared' mapping (both 'English' and 'Welsh' nonword), treatment and control, lists were matched in terms of position of target, by whether it appeared as an onset or coda. The same was done for 'divergent' and for 'Welsh only' sets. Phase 2 nonword baseline lists also included disyllabic items, due to the constraints of using certain mappings (Ratio of monosyllabic:disyllabic in baseline nonwords - /θ/ Welsh 23:7, English 23:7; /ɪ/ Welsh 21:9, English 21:9; /ʃ/ Welsh 12:18, English 13:17; /f/ Welsh 12:18, English 15:15; /r̥/ Welsh 11:19;

/əɨ/ Welsh 5:25). See Appendices N and O for baseline nonword lists and treatment stimuli for Phase 2.

5.5.2. Design and Procedure

Target mappings were each tested three times at baseline in 12 sets of nonwords (30 'English' and 30 'Welsh' for each of the 6 mappings), in order to establish stable performance prior to treatment. As per Phase 1, nonword sets were collapsed, randomised, spelled to dictation in separate sessions per language, and counterbalanced between sessions. These nonwords were re-tested in six post-test sessions (3 English; 3 Welsh). Follow-up sessions could not be carried out for Phase 2.

Treatment took place three times per week, using the same treatment protocol and scoring methods as described for Phase 1, with the addition of another mapping for therapy (Welsh only mapping). Treatment was ceased after 20 sessions, with one set at ceiling, /θ/->TH, and no further improvement over 4 sessions in the other two sets. It must be noted that CWS was having difficulties sleeping during Phase 2, and was often sleeping no more than 3-4 hours per night.

5.5.3. Results

Figure 5.4 depicts baseline and post-test performance for each mapping in Welsh and English, and Figure 5.5 illustrates the distribution of substitution errors. Baseline accuracy was low for all Welsh mappings (all below 10% correct). Baseline accuracy for English was equivalent to that of Welsh for the sets with 'shared' phoneme-grapheme mappings (both sets at floor), and was high (over 90%) for sets where the phoneme-grapheme mapping is divergent between the two languages.

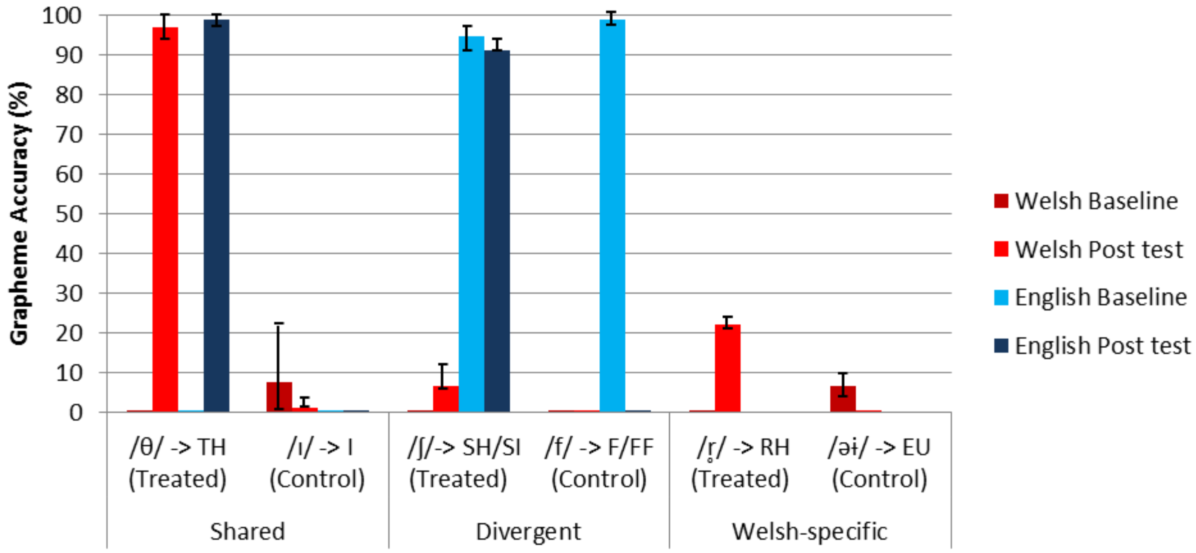

Figure 5.4. Phase 2: The percentage of each phoneme spelled with the target correct corresponding grapheme at each stage of treatment in each language, averaged over 3 sessions (N=30 per condition). Error bars represent the accuracy range over the 3 administrations per stage.

Treated 'shared' phoneme: /θ/

As predicted, treatment of the shared mapping /θ/->TH led to a significant improvement in accuracy in both languages, with Welsh improving by 97% (McNemar's test p<.001) and English by 99% (McNemar's test, p<.001), supporting the results of Phase 1 for the treated shared mapping.

Control 'shared' phoneme: /ɪ/

There was a small decline in accuracy for spelling to dictation of the mapping /ɪ/->I in Welsh (McNemar's test, p=.07 [2-tailed]). There was no significant difference between baseline and post-testing for spelling to dictation of this mapping in English nonwords (0% at baseline and post-testing). The substitution was almost always /ɪ/->E in both Welsh and English at baseline and post-testing (348/352 errors were /ɪ/->E substitutions). This lack of significant difference in the control 'shared' mapping is consistent with the findings for the same set in Phase 1.

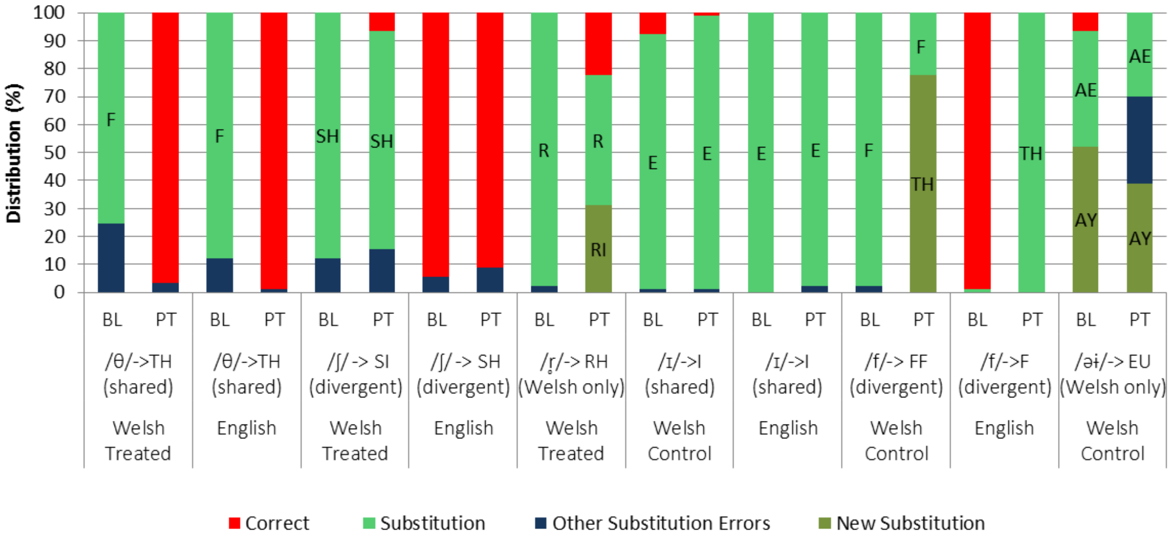

Figure 5.5: The distribution of responses at each stage of testing for target mappings in Welsh and English. Errors are scored as: 'Substitutions' – the most consistent substitution error for each phoneme [graphemes in bars represent the error]; 'other' substitution errors - those that are different from the more consistent ones; 'new substitution' errors - those that appeared subsequent to therapy. For each stage (BL - baseline; PT – post-test), n=90 (3 administrations amalgamated).

Treated 'divergent' phoneme: /ʃ/

There was a small increase in accuracy between baseline and post-test subsequent to treating the /ʃ/->SI correspondence in Welsh (McNemar's test, p=.031) with an average of 7% improvement (6 positive changes versus 0 negative, out of 30). Note that though significant, the improvement is much smaller than for the shared mapping and that of the divergent mapping in Phase 1.

Accuracy remained high between baseline and post-testing for the English mapping /ʃ/->SH (average of 94% correct at baseline, 91% at post-test).

Control 'divergent' phoneme: /f/

As predicted, Welsh spelling accuracy for the control 'divergent' mapping */f/*->FF remained at floor at baseline and post-testing (both 0%). However, performance dropped significantly in accuracy of the English equivalent /f/->f. Baseline accuracy was high, with an average of 99% across three baselines, but dropped to 0% by post-test (McNemar's test, p<.001), with all of the errors being /f/->TH substitutions. This is not consistent with the predictions for this set, particularly with regards to the substitution errors. To clarify: at baseline, CWS mainly used /f/->F for both Welsh and English, but at post-test he swapped to using /f/->TH for both, which suggests a decrease in the influence of English in this case. The change was possibly connected to him being discouraged to use 'F' for treated /θ/, and reinforcement of 'TH' as a spelling. Note that /f/ and /θ/ are very close phonologically.

Treated Welsh specific phoneme: /r̥/

There was a significant increase from 0-22% in accurate production of the mapping /r̥/->RH between baseline and post-testing (McNemar's test, p<.001). There was also a shit in the substitutions made, with /r̥/->RI errors occurring at post-test (as well as /r̥/->R), suggesting interference from the other treated mapping, /ʃ/->SI.

Control Welsh specific phoneme: /əɨ/

Accuracy dropped from an average of 7% to 0% for the mapping /əɨ/->EU, which was significant (6 negative changes in accuracy, 0 positive; McNemar's test, *p*=.031). Again, this is not consistent with the predictions for the control sets. In spelling /əɨ/->EU, CWS separated it into two phonemes, rather than one diphthong. For this reason, this mapping was not the optimum control mapping.

Analysis of differences between treated mappings

The treated shared mapping improved more than the other treated mappings subsequent to treatment (positive vs. negative/no changes: /θ/ 87:3; /ʃ/ 6:84; /r̥/ 20:70).

Chi-square analysis revealed a very large advantage of the treated shared mapping /θ/ ->TH over the treated divergent mapping /ʃ/->SI (χ^2 (1) = 146, p<.0001), and over the Welsh-specific mapping /r̥/->RH (χ^2 (1) = 103, p<.0001). The Welsh-specific mapping also showed an advantage over the divergent mapping (χ^2 (1) = 8.81, p=.003), supporting the hypothesis that divergent mappings may be more resistant to therapy due to cross-language interference, and that language-specific mappings would have an intermediary effect.

In summary, at first glance it appears that the results for the ‘shared’ mapping in Phase 1 have been replicated. Increases in accuracy for both other treated sets were significant but much smaller than for the shared mapping, and smaller than for all treated mappings in Phase 1. As predicted there was no difference in performance in English or Welsh for the control ‘shared’ mapping. However, contrary to predictions there were changes in the other two control sets, with accuracy dropping significantly in for English in the control ‘divergent’ set, and also for nonwords in the control Welsh-specific set.

5.6. DISCUSSION

This is the first study that directly compares shared and divergent mappings in bilingual acquired sublexical impairments. It explores cross-linguistic treatment generalisation at the phoneme-grapheme correspondence level, and also provides the first insight into the status of bilingual sublexical spelling. The purpose of this study was to examine the effects within and across languages of a treatment protocol targeting sublexical spelling in a bilingual with a deficit at the level of phoneme-grapheme conversion. The specific research questions were: can treating one language lead to improvement in the untreated language? If so, would this cross-language generalisation depend on the aspects of sublexical spelling that are targeted (shared versus divergent mappings)? Can patterns of treatment generalisation in bilingual phonological dysgraphia inform theories of normal bilingual spelling? These questions where addressed using a multiple-baseline treatment protocol (three baseline, post-test and follow-up sessions in Phase1, three baseline and post-test sessions in Phase 2). As we will see below, and although some aspects of the results are less clear-cut than others, the answer to the three questions above appears to be yes.

It was hypothesised that treating phoneme-grapheme mappings shared between languages in one language only would lead to gains in both languages. In contrast, we predicted that treatment of divergent phoneme-grapheme mappings would lead to improvement in the treated language only. Additionally, it was proposed that treated mappings that are specific to only one language may show an intermediary effect by receiving neither support nor interference from the other language. Control mappings were not expected to fluctuate in accuracy.

The results of Phase 1 provide the most accurate account of the effects of therapy of impaired mappings in bilingual sublexical spelling deficits, because during Phase 2 problems were encountered. In Phase 2, CWS was experiencing difficulties sleeping, and he found the task of trying to re-learn three (as opposed to 2 in Phase 1) mappings too difficult. Thus, although similar patterns of improvement were observed in both phases, the improvements in treated items in Phase 2 were much smaller than they were in Phase 1 (bar the treated shared mapping).

5.6.1. Implications for models of bilingual spelling

The results of Phase 1 have more robust implications for informing models of bilingual spelling, whereas the results of Phase 2 are less clear, and it is not known to what extent tiredness, and the additional difficulty of learning three mappings, contributed to the unexpected results in spelling.

Figure 5.6 represents a working model of bilingual sublexical processing (Tainturier, Roberts & Roberts, 2011). This study is the first investigation of bilingual sublexical spelling that provides an account of the cognitive neuropsychological framework of this process in multiple languages, thus the model is preliminary.

It is proposed that mappings that are shared between languages are processed via a shared mechanism. The results of Phase 1 (and Phase 2 to some extent) suggest that this be the case because the same extent of improvement was observed in both languages subsequent to therapy. Training the shared mapping facilitated activation in both languages.

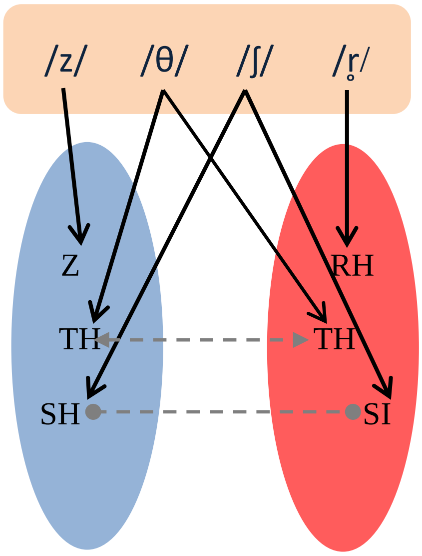

Figure 5.6. A working model of bilingual sublexical processing.

The processes involved in sublexical spelling of divergent mappings are less clear. Divergent phonemes are far more resistant to therapeutic gains than their ‘shared’ counterparts, suggesting that interference comes from the competing representation in the untreated language, which in the case of CWS, is less impaired. It is thus suggested that, while divergent mappings may be processed via distinct mechanisms, competing activation between languages is activated in spelling. Neurological damage appears to have left CWS processing via a non-language-specific sublexical system: he often has a single phoneme-grapheme representation for each phoneme, regardless of that language in which he is spelling. Some preserved mappings are English, others Welsh.

The results of treating a language-specific phoneme in Phase 2 suggest that their representations may be resistant to change than those that are shared between languages. This suggests an advantage for processing phoneme-grapheme mappings that appear in both languages. Essentially, it appears that stronger representations exist for shared mappings as opposed to 'monolingual' mappings.

5.6.2. Shared mappings

As predicted, the spelling of treated shared mappings (/ɛ/ -> E, /θ/->TH) improved in both languages subsequent to treatment while no change was observed for control shared mappings. Thus, the improvement was due to targeted treatment rather than to general spelling improvement. Also, note that the effect was not item specific as the improvement on shared mappings was measured on a different set of stimuli as those used for treatment.

These results support previous findings from monolingual therapy research showing that treatment of impaired mappings can generalise to untreated items (Brunsdon, Hannan, Nickels & Coltheart, 2002; Kiran, Thompson & Hashimoto, 2001; Kohnen, Nickels, Brunsdon & Coltheart, 2008; Kohnen, Nickels & Coltheart, 2010; Rowse & Wilshire, 2007), and extend them to include untreated words in an untreated language. They also support the findings from bilingual dyslexia therapy, of success in treating shared processes (Laganaro & Venet, 2001), extending findings of cross-language generalisation in bilingual sublexical deficits to the written modality, and adding evidence of an advantage for treating mappings that are shared between languages.

Thus, it seems that cross-linguistic generalisation of treatment effects can be elicited in sublexical spelling, by treating mappings that are shared between languages. However, this is to be taken with caution, as unexpected patterns of generalisation are highlighted below, which have implications for these findings, particularly with respect to Phase 2.

5.6.3. Divergent mappings

As predicted, treatment of the divergent mapping /ə/ -> U in English (Phase 1) elicited gains in the treated language, but not in the untreated language, where a trend towards a decline was observed instead for Welsh /ə/->Y. However, and contrary to shared mappings, this improvement was not maintained at 6 week follow-up.

Interestingly, when accuracy of /ə/ -> U increased in English, there was a co-occurring trend towards a decline in accuracy for the Welsh mapping /ə/ -> Y between baseline and post-testing, with the majority of substitution errors being Y->U. Also, at 6-week follow-up testing when the accuracy for English had dropped, accuracy for /ə/ -> Y had increased significantly, to above baseline level. Therefore, treatment of divergent mappings may lead to gains in the treated language but perhaps to over-generalisation with an adverse effect on the untreated language.

CWS is often restricted to having one preserved graphemic representation for phonemes that correspond to divergent mappings in both languages, in cases such as /ə/->U/Y. In this case, for CWS the phoneme /ə/ most often maps on to the grapheme Y, irrespective of the language in which he is spelling. Therapy was successful in increasing accuracy initially, but at the expense of the accuracy of the Welsh mapping, and performance reverted to baseline by 6-week follow-up. Thus, the representation for /ə/ -> U may have been weaker than /ə/ -> Y subsequent to neurological damage, with the compensatory mapping being resilient to change and hence reverting back to the stronger mapping by follow-up. However, there was a point where production of U for English and Y for Welsh was comparable (see error bars in Figure 5.2). It is proposed that CWS may have partial use of two sublexical systems, with activation of the English mapping, and inhibition of Welsh, was more accessible subsequent to treatment.

The results of the treated divergent mapping in Phase 2 support the findings from Phase 1 that impaired divergent mappings are more resistant to therapy than shared mappings. As a matter of fact, treatment of the divergent mapping was even less successful than in Phase 1 as only minimal improvement was observed at immediate post-test. After 20 treatment sessions, correct production of the Welsh mapping /ʃ/->SI improved from 0 to 7% (average). This was significant, but 78% of the substitution errors at post-test were still SI->SH. Follow-up testing was not possible, but it is likely that even this minimal improvement would have failed to maintain, as was observed in Phase 1.

It is proposed that this resistance to change in divergent mappings is due to competition from the relatively unimpaired corresponding mapping in the other language interfering with re-learning the impaired mapping. Additionally, CWS has a frontal lesion, which consistent with his difficulty in task-switching in spelling divergent mappings. Whereas shared phonemes require re-learning one corresponding grapheme, re-learning impaired divergent phonemes requires an ability to switch between graphemes according to language

Accuracy in spelling of the untreated control divergent mapping /ʊ/-> OO/W in Phase 1 did not change between evaluation sessions in English (/ʊ/-> OO) as expected. However, for Welsh, accuracy of /ʊ/->W improved significantly between baseline and post-test, and reverted back to baseline accuracy at follow-up. At baseline, W->U was the most common substitution error, thus it is suggested that treatment of /ə/ -> U may have temporarily reduced interference caused by this grapheme in spelling of the mapping /ʊ/->W, where U became, for a while, more restricted to /ə/ -> U, which was being treated.

In Phase 2 there was no change in accuracy of the Welsh control divergent mapping /f/->FF. However, there were some unexpected results. Accuracy of the English mapping /f/->F dropped to 0%, with the substitution errors being consistently F->TH. The substitution errors in Welsh changed from 98% FF->F at baseline, to 22% FF->F and 78% FF->TH at post-test. These findings have implications for the treated 'shared' mapping /θ/->TH. Because /θ/ and /f/ are very phonologically close, hearing /θ/ may have led to activation of <TH>, resulting in these phonologically based errors.

5.6.4. Language-specific mappings

In Phase 2 a condition was added whereby a mapping corresponding to a Welsh-specific phoneme was treated. As predicted, treatment of a Welsh-specific mapping /r̥/->RH stimulated improvement in Welsh, more so than the treated divergent mapping, but not to the same extent as mappings shared between languages.

There was also an unpredicted decrease in accuracy for the control Welsh-specific mapping /əɨ/->EU. Accuracy was very impaired at baseline, but dropped further at post-test, with seemingly no influence from treated mappings. The small but significant decrease is attributed to tiredness, because CWS was experiencing difficulties sleeping in Phase 2.

It was also suggested that treatment may not be as effective for this condition as for the treated 'shared' mappings, due to facilitation from one language rather than two.

The significant increase in accuracy from 0 to 22% supports these predictions. In contrast to the improvement levels of over 90% for the treated 'shared' mappings in Phases 1 and 2, this accuracy did improve, but not to the same extent. This could be used as evidence that shared mappings are more readily accessed than those restricted to one language, due to combined activation from two languages.

5.6.5. Limitations

The deficit of CWS is severe and well-established, at 12-years post-onset. Being in the chronic stage of his illness, the impairment was resistant to change, particularly for divergent mappings. Also, there was an additional difficulty of having three mappings to learn (rather than 2, in Phase 1) together with difficulties sleeping in Phase 2; sometimes having had 3 hours sleep before a session. This undoubtedly affected performance. Despite this there were encouraging findings in terms of both within and between-language gains.

Training three digraphs (<TH>; <SI>; <RH>) in Phase2 appears to have led to confusion between <SI> and <RH> as to which used an <I> and which used a <H>. Although there would have been massive interference from the English mapping <SH> in treatment of Welsh /ʃ/-SI, he seems to have learned from training of this rule that an <I> should appear in some words. This resulted in RH->RI substitution errors.

5.6.6. Future perspectives

To overcome the problem of confusion due to training multiple mappings simultaneously, it is suggested that focusing exclusively on one mapping at a time may be more effective. Short, intense bouts of therapy working on a single mapping may be beneficial, with participant and experimenter proceeding to the next impaired mapping once there is agreement that the rule had be re-learned.

CWS reported particularly enjoying step 3 of the protocol, in which he was asked to select and arrange tiles to produce target words and nonwords, before copying them in a jotter. This method he found interesting, but it also allowed him to correct his errors. The majority of stimuli used in therapy were real words, and because his real word reading is good, he was able to read his responses and recognise when they were incorrect. He could then replace tiles until he was satisfied that he had produced the correct spelling. A future study may wish to focus on this step on the protocol only, to compare its effectiveness with the combined method (including minimal pairs) used in the present study.

From a theoretical perspective it would be interesting to explore treatment of mappings in bilingual sublexical spelling with reading to further understanding of the processes underlying both. Similar predictions might be made from both localist and distributed representation perspectives: based on the cross-language effects in spelling of shared mappings in this study, it could be predicted that treatment of shared mappings may generalise across modalities as well as between languages. The dual route framework would explain parallel improvements in both reading and spelling due to feedback between orthography and phonology, whereas the connectionist approach would argue a strengthening of links between phonology and orthography that underpin both reading and spelling. If no generalisation were found, the dual route framework could account for this because it assumes distinct processing for reading and spelling. The triangle model would not be able to account for this outcome as easily, because it would assume a common origin for reading and spelling.

5.6.7. Conclusions

As the first study exploring treatment of sublexical spelling deficits in bilingual dysgraphia, we present some interesting initial findings. Treating phoneme-grapheme mappings that are shared between two languages can elicit cross-linguistic generalisation, whereas divergent mappings are more resistant to therapy. Language-specific mappings can be treated, but may be less responsive than shared mappings.

The contribution to developing models of bilingual sublexical spelling is that shared mappings may be activated in parallel between languages. Divergent mappings may be processed separately, with inhibition depending on the language in use. Deficits at this level can lead to interference from the not-in-use language.

In terms of clinical conclusions, treatment of mappings that are shared between English and Welsh can yield positive effects in spelling in both languages. Given the high proportion of shared mappings that exist between these two languages, treatment in one language for shared mappings could potentially result in marked widespread spelling improvement in bilinguals with phonological dysgraphia.

CHAPTER 6: GENERAL DISCUSSION

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Three model-based treatment studies investigated the effects of language therapy on deficits in spelling and spoken naming in Welsh-English bilingual aphasia. Based on the dual-route model, orthographic output lexicon, phonological output lexicon, graphemic buffer and sublexical spelling system deficits were diagnosed and targeted for treatment, with the aim of answering the following questions: 1) Could cross-linguistic treatment generalisation occur in Welsh-English bilingual aphasia? 2) If so, would generalisation differ as a function of deficit type, language of treatment, and stimuli used? 3) Could patterns of generalisation inform theories of bilingual word processing?

6.1. Main contributions

This research includes the two first studies of bilingual dysgraphia therapy, with treatment targeting lexical orthographic output, graphemic buffer, and sublexical spelling deficits. It also contributes to the unresolved debate regarding the use of cognates in bilingual naming therapy, providing the first report of a deficit-based approach. It provides detailed background testing for each participant, with deficit diagnosis being guided by a working model of bilingual language processing, and treatment designed accordingly. This has not been done in previous bilingual aphasia treatment studies (and for that matter, many monolingual studies). In addition, the experimental control used in this work is superior to that of most treatment studies, both in bilingual and monolingual research: it makes use of either two or three baseline sessions, careful selection of stimuli, carefully matched sets for contrasting effects of treatment with items that have not been exposed to therapy, letter-level analysis of spelling (for a more fine-grain account), and uses appropriate statistics for treatment studies.

Another main contribution of this research is that it includes a condition in which items were repeatedly attempted, which has not previously been done in bilingual therapy studies. This was to explore whether the treatment effects went beyond repeated testing.

This work provides the first evidence from bilingual aphasia therapy that the effect of treatment interacts with level of deficit: contrasting the effects of a single treatment protocol on different deficits yields differing patterns of generalisation. The research also suggests that cross-language generalisation patterns may not apply across all deficits, but that it can be promoted in sub-classes of items such as cognates and shared mappings.

6.2 Treatment generalisation

All treatment protocols were successful in eliciting item-specific treatment gains. As predicted, patterns of within and between-language generalisation varied according to deficit, language of treatment, and stimuli used. Patterns of within-language generalisation will be discussed first, before addressing the between-language effects of therapy.

6.2.1 Within-language effects

In addition to improvement in the treated items, treatment of the orthographic output lexicon deficit yielded improvement from repeated testing of untreated items, suggesting that repeated attempts can aid activation of orthographic representations. This effect of repeated testing was also observed in the phonological output lexicon deficit. This is consistent with the findings from monolingual therapy (Rapp & Kane, 2002; Rapp 2005). It is proposed that factors such as difficulty of items and degree of deficit severity may contribute to different rates of success in repeated testing. For example, the orthographic transparency of the Welsh language may elicit a greater effect of repeated testing due to the regularity of their spelling.

The within-language pattern of generalisation that arose following treatment of the graphemic buffer supports the findings of Rapp and Kane (2002), and Rapp (2005): in both phases all sets in the treated language improved significantly.

Treatment of a sublexical spelling deficit directly contrasting the effects of treating mappings that are shared between languages and those that are divergent also showed improvements. Treatment of shared mappings was most effective, whereas divergent mappings were more resistant to therapy. An intermediary effect (to the shared and divergent mappings) was observed in when a language-specific mapping was added to the protocol. The within language generalisation effect of treating mappings support findings from monolingual studies sublexical therapy (Brunsdon, Hannan, Nickels & Coltheart, 2002; Kiran, Thompson & Hashimoto, 2001; Kohnen, Nickels, Brunsdon & Coltheart, 2008; Kohnen, Nickels & Coltheart, 2010; Rowse & Wilshire, 2007).

Thus, the robustness of the data presented in this thesis is supported by the fact that it has been able to replicate the within language effect in monolingual treatment studies.

6.2.2. Between-language effect

No cross-language generalisation was observed in the orthographic output lexicon deficit (CWS), whereas the phonological output lexicon deficit (HBL) displayed significant improvement in the untreated language, but only of cognates, supporting the results of Kohnert (2004). No cognates were included in the treatment in the first study, thus it remains a question for future research whether a similar effect would be observed in spelling.

Treatment of a graphemic buffer deficit yielded benefits in the untreated language, but only in Phase 2 where Welsh was the language of treatment: there was an improvement in English translations of the treated items, and a trend towards improvement in English control items.

The sublexical treatment protocol elicited cross-language gains of treating shared mappings. However, treatment of divergent mappings appeared to have an adverse effect on accuracy of cross-language equivalents, particularly in Phase 1, where treatment of /ə/-> U led to fluctuation in the accuracy of /ə/-> Y in Welsh, which had been high at baseline. Thus, treatment of shared mappings can be beneficial, with lasting benefits (at 6-weeks follow-up), whereas treatment of divergent mappings is more resistant to treatment effects, and does not lead to long term benefits. This study highlights the importance of considering the characteristics of stimuli in assessing cross-linguistic generalisation patterns.

Some bilingual treatment studies have had more success in cross-linguistic generalisation when therapy was provided in the recipient's L2 (e.g. Edmonds & Kiran, 2006; Fredman, 1975; Goral, Rosas, Conner & Maul, 2012; Kiran & Roberts, 2010; Miertsch, Meisel & Isel, 2009). Both dysgraphia treatment studies used a cross-over design. All participants were pre-morbidly highly proficient bilinguals, and had similar language backgrounds: they all learned Welsh first, and were taught both Welsh and English formally from primary school (age 5-6), and used both thereafter. Spoken language was predominantly via Welsh, whereas reading, writing and media use was mainly English. Therefore, it is suggested that L1 and L2 differ according to modality: L1 in spoken language is Welsh, but L1 in reading and spelling is likely to be English. RON (GB deficit) showed evidence of cross-language gains in Phase 2, where the language of treatment was Welsh (L2 in spelling); HBL (phonological output deficit) showed cross-language improvement in cognates when the language of treatment was what she considered to be her L2 in oral communication (English); and treatment of the sublexical deficit of CWS yielded cross-language improvements subsequent to both L1 and L2 therapy. Therefore, the findings support previous claims that cross-language treatment generalisation is more likely to occur subsequent to treatment of L2.

6.3. Theoretical implications

The findings of the present studies contribute towards further understanding of bilingual word processing. The cross-linguistic generalisation of cognate stimuli in the POL deficit supports the cognate facilitation effect proposed by Costa, Caramazza and Sebastian-Galles (2000; provided again below for clarification [Figure 6.1]), that posits an advantage for processing cognates over non-cognates due to additional feedback activation from phonology (as well as semantics). It can also be explained by the revised hierarchical model in terms of stronger co-activation of translation equivalents between lexicons, when words are similar in meaning and form. Moreover, the translation errors made by HBL subsequent to therapy also support co-activation of corresponding lexical representations, with the incorrect representations being activated in attempting to name some items.

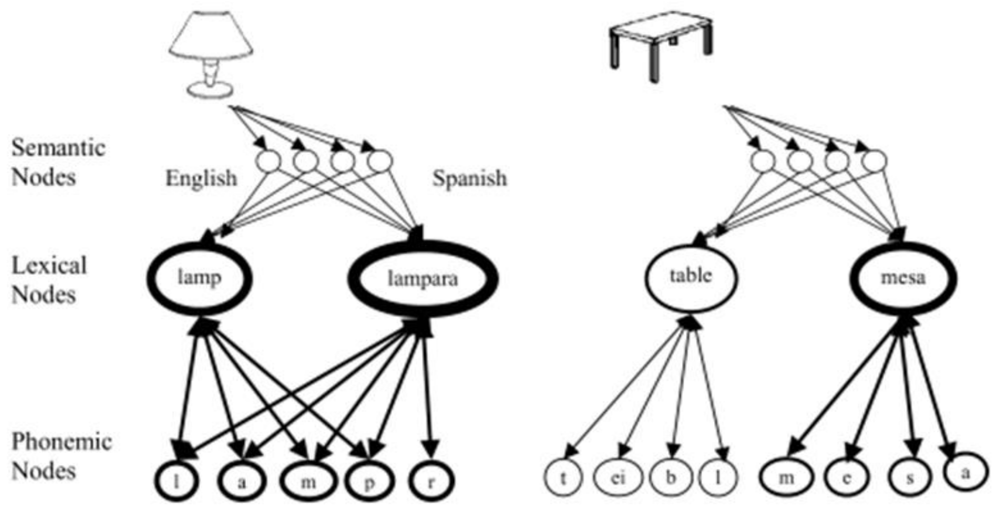

Figure 6.1. The cognate facilitation effect (from Costa et al., 2005)

This non-parallel deficit cannot either be explained by age of acquisition: note that, for HBL, despite her self-reported higher use of Welsh in spoken communication, pre-treatment assessment revealed significantly better spoken naming in English, as opposed to Welsh. This is inconsistent with the predictions of models of bilingual lexical access that propose an integrated lexicon (e.g. The BIA/BIA+), where neurological impairment should elicit parallel deficits in both languages.

Because there is currently no model of bilingual spelling, a working model of bilingual spelling was created (represented below [Figure 6.2]). Like models of bilingual spoken naming, it is a localist model, positing a shared semantic system, and distinct lexicons that are jointly activated by semantics or phonology when a stimulus is heard. It proposes that corresponding units across languages (translations) are inter-connected and that co-activation of these units is stronger when words are also orthographically close (i.e. cognates) due to feedback from the grapheme level. Sublexical processing is thought to be partly shared and partly distinct because some phoneme-grapheme mappings are shared between languages, whereas others are divergent.

This work supports the predictions of distinct but interconnected lexical access: the item-specific benefit of treatment of the orthographic lexical deficit suggests separate lexical access for each language, because training did not facilitate retrieval of cross-language translation equivalents.

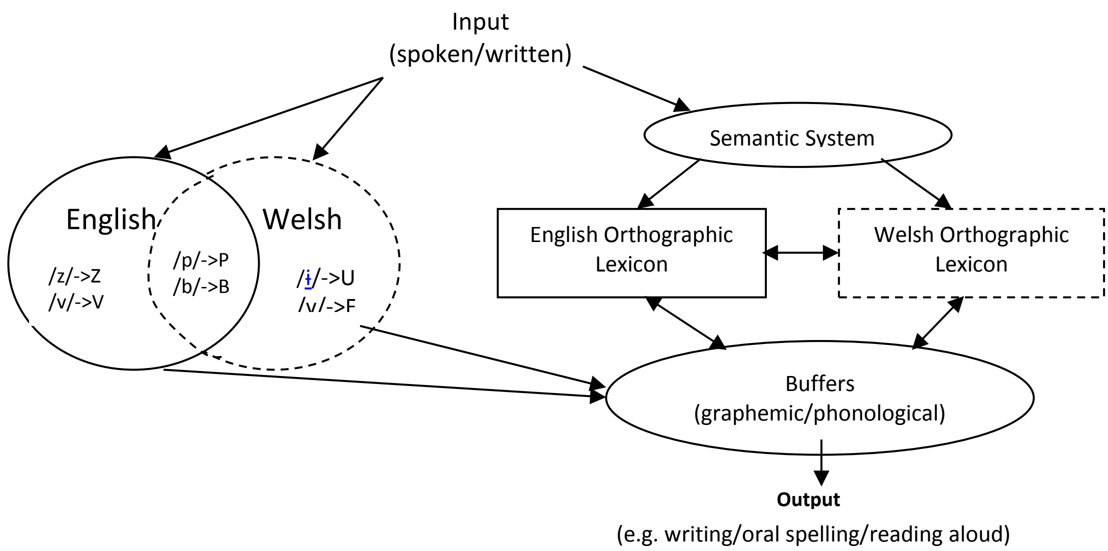

Figure 6.2: A working model of bilingual word processing using English and Welsh as examples (Tainturier, Roberts & Roberts, 2011).

It is suggested that the graphemic buffer is shared for both languages in bilinguals. RON showed cross-linguistic generalisation Phase 2 of the delayed-copy treatment protocol, which is consistent with the hypothesis that a single graphemic working memory store should suffice for both languages. He did not, on the other hand, display generalisation to translations of the treated items in Phase 1. Because there is, as yet, no established method for treating graphemic buffer deficits, and the treatment used was one predominantly used with lexical deficits, it may be the case that the treatment itself had limited impact on the buffer, resulting in limited cross-language generalisation.

It is suggested that in sublexical spelling, mappings that are shared between languages may be activated in parallel between languages. This is supported by the cross-language generalisation of treated shared mappings in both English and Welsh spelling. Divergent mappings may be processed separately, with inhibition depending on the language in use. This is proposed because divergent mappings were much more resistant to treatment effects than shared mappings, suggesting interference from the divergent cross-language counterpart was inhibiting activation of the correct grapheme.

Although localist models of spoken and written word production were used as a basis for the treatment studies presented in this thesis, connectionist models could also be used to explain the patterns of generalisation observed. The generalisation effects of cognates would be explained by reinforcement of links between overlapping units between phonology and semantics; the improvement in the graphemic buffer case can be explained by the strengthening of a system that generates serial order in the output stages of orthography; and the improvement subsequent to sublexical training was due to strengthening links between phonology and orthography. Note that this is largely speculative, as we are not aware of the existence of non-localist distributed models of bilingual language processing, and certainly none for treatment studies. As stated by Li and Farkas (2002), “Unfortunately, connectionist models or modeling have had very limited impact on the field of bilingualism as a whole” (pp. 59). Ultimately, specific predictions would depend on how the two languages would be represented in such models (e.g. as fully integrated or as distinct networks). The connectionist approach does not, however, explain the aphasia that CWS presents with (mixed dysgraphia with phonological dyslexia), nor his lesion, which is right hemisphere frontal.

6.4. Limitations

There are limitations to using a single case study approach. It is difficult to generalise the results when data come from single subjects, and there are also issues of incomplete data sets. For example, the anomia treatment study was intended as a cross-over design, but HBL was unable to continue after Phase 1, thus the effects of treating Welsh could not be measured and contrasted with treatment of English. A case-series design can provide more generaliseable results. However, using a single-case study approach allowed investigation of participants' deficits in great detail, and to provide treatment accordingly. This was particularly important for the first studies of bilingual acquired dysgraphia therapy.

> *"Individuals with aphasia often show intra-subject variability, i.e., performance varies from one day to another as well as inter-subject variability. Neurological, psychological, social/motivational factors are just some of the factors that may influence heterogeneity. This is precisely why single subject experimental designs are well suited to examine rehabilitation outcomes as individual variability is revealed as a function of time" (Kiran et al., 2013; pp. 339).*

There were some difficulties in matching baselines. In creating multiple sets (five for each participant in the delayed-copy spelling and the anomia studies, per phase; and 4 and 6 per phase in the sublexical treatment study), it was not always possible to match baseline accuracy. This was because the aim was primarily to match for frequency and length. As accuracy is a more objective measure of item difficulty for a given individual, and because it is not known how well frequency counts can be applied to bilingual people, in future, matching should focus more on baseline performance level.

Another limitation is the omission of cognate stimuli in the first experimental study. The stimuli were selected from a large corpus of spelling data of each participant, with previously erroneous items being selected for therapy. As mentioned previously, it remains a question for future research in spelling therapy.

6.5. Future Perspectives

Semantic feature analysis has been found to be a successful approach to therapy (Boyle 2010; Boyle & Coelho, 1995; Boyle, 2004; Coehlo et al., 2000). This approach could be used in a future study, and contrasted with the phonological cueing approach. In contrast to the comparison of a single type of therapy on two deficits, treatment of a single deficit type may respond differently to contrasting treatment methods (as Croft et al. 2011 reported). One might expect generalisation to semantically related items in the untreated language, using the SFA approach.

Also, in future research, it would be interesting to include orthographic/phonological neighbours as a category of stimuli for observation of generalisation, both within and between languages. Treatment of orthographic neighbours has been successfully implemented in monolingual research (e.g. Sage & Ellis, 2006). Future work may wish to contrast the effects of treating orthographic neighbours with cognates. It may be that treatment of neighbours and cognates yield similar effects; but it may also be the case that treatment of cognates would elicit a stronger effect, due to the additional input from semantics.

Homework-based therapy has been shown to be effective (e.g. Beeson, 1999; Beeson, Hirsch & Rewega 2002; Nickels & Best, 1996). Given the limited resources available to therapists, this should be encouraged in future therapy studies. Also, given that computer use is now commonplace, it is suggested that, particularly for spelling therapy, treatment using computer aids would be beneficial, and easily adapted for home use. This is likely to increase motivation in people who use computer-based communication, but also for spelling in general. Spell-check programmes would encourage people to self-correct, but use of ‘games’ could also be motivating. CWS reported particularly enjoying the anagram sorting in the sublexical training programme: including enjoyable tasks is likely to encourage self-motivated treatment.

6.6. Concluding remarks

This research demonstrates successful application of cognitive neuropsychological models and methods to the assessment and treatment of acquired bilingual dysgraphia and anomia. This thesis provides the first reports of bilingual dysgraphia therapy, with patterns of cross-language generalisation that have implications for models of bilingual word processing. It also provides a model-based anomia treatment study, which contributes to the limited existing literature concerned with exploiting cognates in therapy.

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APPENDICES

A. EXAMPLE OF MCNEMAR CALCULATION

B. HBL LANGUAGE BACKGROUND QUESTIONNAIRE

C. STIMULUS LISTS FOR HBL ENGLISH THERAPY

D. CWS LANGUAGE BACKGROUND QUESTIONNAIRE

E. RON LANGUAGE BACKGROUND QUESTIONNAIRE

F. ENGLISH REAL AND NONWORD LIST

G. WELSH REAL AND NONWORD LIST

H. CWS STIMULUS LISTS FOR PHASE 1

I. CWS STIMULUS LISTS FOR PHASE 2

J. RON STIMULUS LISTS FOR PHASE 1

K. RON STIMULUS LISTS FOR PHASE 2

L. BASELINE STIMULUS LISTS FOR CWS SUBLEXICAL THERAPY PHASE 1

M. STIMULI USED IN THERAPY SESSIONS FOR CWS SUBLEXICAL THERAPY PHASE 1

N. BASELINE STIMULUS LISTS FOR CWS SUBLEXICAL THERAPY PHASE 2

O. STIMULI USED IN THERAPY SESSIONS FOR CWS SUBLEXICAL THERAPY PHASE 2

APPENDIX A. EXAMPLE OF MCNEMAR CALCULATION

Treated Set CWS Phase 1 Delayed Copy Treatment

	Accuracy		Change		Accuracy		Change	
Stimulus	**Baseline 1**	**Post Test 1**	**PT-BL**	**PosNeg**	**Baseline 2**	**Post Test 2**	**PT-BL**	**PosNeg**
two	1	1	0	No change	1	1	0	No change
five	0	1	1	Positive	0	0	0	No change
eight	0	1	1	Positive	0	1	1	Positive
three	0	0	0	No change	0	0	0	No change
four	0	0	0	No change	0	0	0	No change
six	0	1	1	Positive	1	1	0	No change
seven	0	0	0	No change	0	0	0	No change
ten	1	1	0	No change	1	1	0	No change
nine	0	0	0	No change	0	0	0	No change
august	0	0	0	No change	0	1	1	Positive
december	0	1	1	Positive	0	0	0	No change
september	0	0	0	No change	0	0	0	No change
january	0	0	0	No change	0	0	0	No change
october	0	1	1	Positive	0	1	1	Positive
Saturday	0	1	1	Positive	0	1	1	Positive
twelve	0	0	0	No change	0	0	0	No change
twenty	0	0	0	No change	0	0	0	No change
eighteen	0	1	1	Positive	0	1	1	Positive
june	0	0	0	No change	0	0	0	No change
march	1	1	0	No change	1	1	0	No change
lamb	0	1	1	Positive	0	1	1	Positive
danger	0	0	0	No change	0	0	0	No change
animal	0	0	0	No change	0	1	1	Positive
effort	0	0	0	No change	0	0	0	No change

Change (total)	**BL1 PT1**	**BL2 PT2**	**Total**
Positive	8	7	**15**
Negative	0	0	**0**
No change	16	17	33

McNemar Test; p<.0001

APPENDIX B. HBL LANGUAGE BACKGROUND QUESTIONNAIRE

Please answer the questions on the following pages. If you want to add any further comments on any of the questions, please use an additional sheet. Thank you.

I. GENERAL INFORMA

Name: *(optional)* HBL

Date of birth: 28/01/49 **Place of birth:** Bangor

Handedness: ☐ left ☑ right ☑ left&right *(please explain below)*
(please tick relevant boxes)

(pot/caring stroke)

Are you ☐ male ☑ female

Are you retired? ☑ YES ☐ NO (21 years ago)

if yes, at what age did you retire? 42

Have you always lived in North Wales? ☑ YES ☐ NO
(please tick relevant boxes)

If you were born outside of North Wales, or spent some time living in another area, where did you live and for how long?

Region / Country: ________, from _____ years of age, until _____ years of age.

Region / Country: ________, from _____ years of age, until _____ years of age.

Region / Country: ________, from _____ years of age, until _____ years of age.

II. CHILDHOOD:

a) languages I spoke during my childhood:
(please tick the relevant boxes)

☑ **English:** I began speaking English at about 5. years of age.

☑ **Welsh:** I began speaking Welsh at _____ years of age.

☐ **other** *(please specify)* _____ : I began speaking that language at _____ years of age.

1

b) family members:

My mother's (guardian's) native language: Cymraeg

The language(s) she spoke to me*:

ages	English	Welsh	other language(s)
0-4	% of time	100 % of time	% of time
5-12	% of time	100 % of time	% of time
12-16	% of time	100 % of time	% of time
16+	% of time	100 % of time	% of time

My father's (guardian's) native language: Cymraeg

The language(s) he spoke to me*:

ages	English	Welsh	other language(s)
0-4	% of time	100 % of time	% of time
5-12	% of time	1 % of time	% of time
12-16	% of time	% of time	% of time
16+	% of time	% of time	% of time

Language(s) I used with my brothers and sisters:

ages	English	Welsh	other language(s)
early childhood	% of time	100 % of time	% of time
late childhood	% of time	100 % of time	% of time

Were there other people living in the household? YES ☐ NO ☑

if yes,
what was their relation to you? ______

and what language(s) did they speak with you?

ages	English	Welsh	other language(s)
early childhood	% of time	% of time	% of time
late childhood	% of time	% of time	% of time

c) friends

Language(s) I used with my friends as a child:

ages	English	Welsh	other language(s)
early childhood	% of time	100 % of time	% of time
late childhood	% of time	100 % of time	% of time

d) community

Language(s) I used in the local community as a child:

ages	English	Welsh	other language(s)
early childhood	% of time	100 % of time	% of time
late childhood	% of time	100 % of time	% of time

IV.

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III. ADULT LIFE:

I spoke:

ages	English	Welsh	other language
generally, during my whole adult life	50 % of time	50 % of time	% of ti
during the last year	0 % of time	100 % of time	% of tir

a) **Home / Family life:**

What language(s) do you speak / did you speak

with:	English	Welsh	other language(s)
your partner	% of time	100% of time	% of tir
former partner *(if applicable)*	% of time	100 % of time	% of tir
your children at the present time	% of time	100% of time	% of tir
your children at an earlier time *(if different from now*)*	% of time	% of time	% of tir

*if you have used a different language / different languages with your children at an earlier t please state when that was:

b) **Work / Employment:**

Please list your main occupation(s) since leaving school:

Milk marketing board, Bryn Crug Farm,
Hospital Cleaner / Supervisor.

What language(s) do / did you use at work?*

ages		English	Welsh	other language(
from	until	% of time	100 % of time	% of tin
from	until	% of time	100 % of time	% of tin
from	until	% of time	100 % of time	% of tin
from	until	% of time	100 % of time	% of tin

*you only need to fill in one line if you have always spoken the same language(s) at work

Write in Eng — Some Eng to monolingual speakers

c) Community / Social Life:

What language(s) do / did you speak in your community and social life as an adult?

English	Welsh	other language(s)
50 % of time	50 % of time	% of time

V. USE OF MEDIA:

a) **How often do you read newspapers and/or magazines?**

choose one of these letters to indicate:
A – daily D – occasionally
B – weekly E – never .
C – monthly

in English: ______ **in Welsh:** ______

b) **How often do you read books?**

choose one of these letters to indicate:
A – daily D – occasionally
B – weekly E – never .
C – monthly

in English: ______ **in Welsh:** ______

c) **How often do you watch the television?**

choose one of these letters to indicate:
A – daily — incl. D – occasionally
B – weekly E – never .
C – monthly

in English: ______ **in Welsh:** ______

d) **How often do you listen to the radio?**

choose one of these letters to indicate:
A – daily D – occasionally
B – weekly E – never .
C – monthly

in English: ______ **in Welsh:** ______

VI. LANGUAGE USE, ABILITIES AND ATTITUDES:

a) **Please indicate how well you feel you speak*:** *(Please note, we are only asking about speaking ability, not reading or writing ability.)*

English: A- Welsh: A (before stroke)

Poorer after S

**choose one of these letters to indicate:*
A – Native speaker or native-like; can carry out extended conversations
B – Not a native speaker, but can carry out basic conversations
C – Not a native speaker, only know some words and expressions

Prefer to write than speak

b) **What language do / did you typically use to write:**

choose one of these letters to indicate: (A – all / most in English
B – about half in English, half in Welsh
C – all / most in Welsh)

informal / personal letters A

short notes A

formal / official letters & documents ______

cheques A

other *(please specify:* ____________________) ______

c) **Of the following, which ones best describe you?** *(tick the appropriate ones)*

I feel I am generally better and more comfortable at speaking:

☐ English ☑ Welsh ☐ no difference

In informal situations I prefer to speak:

☐ English ☑ Welsh ☐ equally happy with both

In formal situations I prefer to speak:

☐ English ☑ Welsh ☐ equally happy with both

When writing in a personal / informal style I prefer to use:

☑ English ☐ Welsh ☐ equally happy with both

When writing in a formal style I prefer to use:

☑ English ☐ Welsh ☐ equally happy with both

c) **How important is it to you to be able to*:**

speak English well,

for your social and family life: C

for your profession: ______

speak Welsh well,

for your social and family life: A (now after stroke)

for your profession: ______

**choose one of these letters to indicate:* A – Extremely important C – Somewhat important
B – Very important D – Not important

THANK YOU FOR TAKING THE TIME TO COMPLETE THIS QUESTIONNAIRE.

APPENDIX C. HBL STIMULUS LISTS FOR PHONOLOGICAL CUEING THERAPY

Item No.	Target	Set	Length (Phon)	F-K frequency
1	Duck	E Treated (NC)	3	6
2	Sheep	E Treated (NC)	3	24
3	Nose	E Treated (NC)	3	65
4	Foot	E Treated (NC)	3	361
5	Cheese	E Treated (NC)	3	9
6	wine	E Treated (NC)	3	72
7	potato	E Treated (NC)	6	15
8	Candle	E Treated (NC)	6	23
9	Bridge	E Treated (NC)	4	114
10	Nest	E Treated (NC)	4	22
11	Flower	E Treated (NC)	5	78
12	Heart	E Treated (NC)	3	199
13	Envelope	E Treated (NC)	7	24
		Mean:	4.08	77.85
14	Cat	E Treated Cognate	3	23
15	Monkey	E Treated Cognate	5	9
16	Skirt	E Treated Cognate	4	21
17	hat	E Treated Cognate	3	56
18	Carpet	E Treated Cognate	5	13
19	Saucepan	E Treated Cognate	6	3
20	Plate	E Treated Cognate	4	22
21	Bottle	E Treated Cognate	4	76
22	baby	E Treated Cognate	4	62
23	Basket	E Treated Cognate	6	17
24	Cross	E Treated Cognate	4	55
25	Paper	E Treated Cognate	4	157
26	Train	E Treated Cognate	4	82
		Mean:	4.31	45.85

Item No.	Target	Set	Length (Phon)	F-K frequency
117	chwadan	W Trans (NC)	6	7
127	dafad	W Trans (NC)	5	25
124	Trwyn	W Trans (NC)	5	106
125	troed	W Trans (NC)	4	97
116	Caws	W Trans (NC)	4	30
120	gwin	W Trans (NC)	4	57
121	taten	W Trans (NC)	5	4
122	cannwyll	W Trans (NC)	6	30
119	pont	W Trans (NC)	4	103
123	Nyth	W Trans (NC)	3	21
128	blodyn	W Trans (NC)	6	19
129	calon	W Trans (NC)	5	245
118	amlen	W Trans (NC)	5	12
		Mean:	4.77	58.15
96	Cath	W Trans Cognate	3	57
112	Mwnci	W Trans Cognate	5	7
101	Sgert	W Trans Cognate	5	11
107	Het	W Trans Cognate	3	49
97	Carped	W Trans Cognate	6	23
100	Sosban	W Trans Cognate	6	11
113	Plât	W Trans Cognate	4	4
115	Potel	W Trans Cognate	5	23
110	babi	W Trans Cognate	4	35
109	Basged	W Trans Cognate	6	16
105	Croes	W Trans Cognate	4	131
99	papur	W Trans Cognate	5	261
98	Tren	W Trans Cognate	4	2
		Mean:	4.62	48.46

Item No.	Target	Set	Length (Phon)	F-K frequency
27	Fish	E repeated	3	33
28	Butterfly	E repeated	7	3
29	Horse	E repeated	3	203
30	Bone	E repeated	3	53
31	Tongue	E repeated	3	39
32	Shoe	E repeated	2	58
33	Cherry	E repeated	4	6
34	Mushroom	E repeated	6	4
35	soup	E repeated	3	16
36	Iron	E repeated	3	46
37	Bed	E repeated	3	139
38	Key	E repeated	2	71
39	Window	E repeated	5	172
40	Tent	E repeated	4	30
41	Road	E repeated	3	262
42	Fountain	E repeated	6	18
43	King	E repeated	3	98
44	soap	E repeated	3	22
45	Pipe	E repeated	3	27
46	Roots	E repeated	4	53
47	clover	E repeated	5	16
48	star	E repeated	3	25
49	Ruler	E repeated	4	3
50	Ladder	E repeated	4	19
51	boat	E repeated	3	72
52	Saddle	E repeated	5	26
		Mean:	3.73	58.23

Item No.	Target	Set	Length (Phon)	F-K frequency
53	Frog	E untreated Control	4	2
54	chicken	E untreated Control	6	37
55	snake	E untreated Control	4	44
56	Finger	E untreated Control	5	106
57	Hair	E untreated Control	2	160
58	Tie	E untreated Control	2	27
59	Grapes	E untreated Control	5	10
60	bread	E untreated Control	4	41
61	Kettle	E untreated Control	5	3
62	Roof	E untreated Control	3	64
63	Bell	E untreated Control	3	23
64	Comb	E untreated Control	3	6
65	mirror	E untreated Control	4	27
66	shower	E untreated Control	3	15
67	lake	E untreated Control	3	54
68	Bedroom	E untreated Control	6	57
69	Money	E untreated Control	4	275
70	Ball	E untreated Control	3	123
71	Whistle	E untreated Control	5	3
72	Leaf	E untreated Control	3	33
73	Circle	E untreated Control	5	91
74	Letter	E untreated Control	4	260
75	Rake	E untreated Control	3	8
76	Submarine	E untreated Control	8	35
77	Wheel	E untreated Control	3	77
		Mean:	4.00	63.24

Item No.	Target	Set	Length (Phon)	F-K frequency
78	cwningen	W control	7	18
79	buwch	W control	4	60
80	llygoden	W control	7	25
81	llew	W control	3	40
82	llygad	W control	5	155
83	cwpan	W control	5	52
84	sannau	W control	4	10
85	crys	W control	4	36
86	llefrith	W control	6	19
87	moron	W control	5	2
88	cwrw	W control	4	43
89	llwy	W control	3	14
90	golau	W control	4	207
91	grisiau	W control	5	89
92	glaw	W control	4	124
93	cae	W control	3	132
94	cegin	W control	5	98
95	ysbyty	W control	6	142
96	beibl	W control	6	192
97	Coron	W control	5	59
98	celyn	W control	4	13
99	gwair	W control	5	44
100	morthwyl	W control	6	6
101	rhaw	W control	3	13
102	rhaff	W control	3	34
103	berfa	W control	5	24
		Mean:	4.65	63.5

APPENDIX D. CWS LANGUAGE BACKGROUND QUESTIONNAIRE

LANGUAGE BACKGROUND QUESTIONNAIRE

Please answer the questions on the following pages. If you want to add any further comments on any of the questions, please use an additional sheet. Thank you.

I. GENERAL INFORMATION:

Name: *(optional)*
__________CWS____

Date of birth: _20/04/1948_____________ **Place of birth:** __Bangor_________________

Handedness: ☐ **left** X **right** ☐ **left&right** *(please explain below)*
(please tick relevant boxes)

Are you X **male** ☐ **female**

Are you retired? X **YES** ☐ **NO**

if yes, at what age did you retire? 48___

Have you always lived in North Wales? X **YES** ☐ **NO**
(please tick relevant boxes)

II. CHILDHOOD:

a) languages I spoke during my childhood:
(please tick the relevant boxes)

☐ **English:** I began speaking English at ____6____ years of age.

☐ **Welsh:** I began speaking Welsh at ____1____ years of age.

b) family members:

My mother's (guardian's) native language: ____Welsh__________________________

The language(s) she spoke to me*:

ages	English	Welsh	other language(s)

0-4	% of time	100 % of time	% of time
5-12	% of time	100 % of time	% of time
12-16	% of time	100 % of time	% of time
16+	% of time	100 % of time	% of time

My father's (guardian's) native language: ______**Welsh**________________________________

The language(s) he spoke to me*:

ages	**English**	**Welsh**	**other language(s)**
0-4	% of time	100 % of time	% of time
5-12	% of time	100 % of time	% of time
12-16	% of time	100 % of time	% of time
16+	% of time	100 % of time	% of time

Language(s) I used with my brothers and sisters:

ages	**English**	**Welsh**	**other language(s)**
early childhood	% of time	100 % of time	% of time
late childhood	% of time	100 % of time	% of time

Were there other people living in the household? **YES** ☐ **NO** X
if yes,
what was their relation to you? _____N/A____

and what language(s) did they speak with you?

ages	**English**	**Welsh**	**other language(s)**
early childhood	% of time	% of time	% of time
late childhood	% of time	% of time	% of time

c) friends

Language(s) I used with my friends <u>as a child</u>:

ages	**English**	**Welsh**	**other language(s)**
early childhood	% of time	100 % of time	% of time
late childhood	% of time	100 % of time	% of time

d) community

Language(s) I used in the local community <u>as a child</u>:

ages	**English**	**Welsh**	**other language(s)**
early childhood	% of time	100 % of time	% of time
late childhood	% of time	100 % of time	% of time

III. ADULT LIFE:

I spoke:

ages	**English**	**Welsh**	**other language(s)**
generally, during my whole adult life	60% of time	40% of time	% of time
during the last year	40% of time	60 % of time	% of time

a) Home / Family life:

What language(s) do you speak / did you speak

with:	**English**	**Welsh**	**other language(s)**
your partner	10% of time	90% of time	% of time
former partner *(if applicable)*	80% of time	20% of time	% of time
your children at the present time	% of time	100% of time	% of time
your children at an earlier time *(if different from now*)*	% of time	100% of time	% of time

*if you have used a different language / different languages with your children at an earlier time, please state when that was: ____**Former partner from London**______________________

b) Work / Employment:

Please list your <u>main</u> occupation(s) since leaving school: ___Builder________________

What language(s) do / did you use at work?*

ages	**English**	**Welsh**	**other language(s)**
from 15 until 48	30% of time	70% of time	% of time
from until	% of time	% of time	% of time
from until	% of time	% of time	% of time
from until	% of time	% of time	% of time

*you only need to fill in one line if you have always spoken the same language(s) at work

c) Community / Social Life:

What language(s) do / did you speak in your community and social life as an <u>adult</u>?

English	**Welsh**	**other language(s)**
20% of time	80% of time	% of time

IV. EDUCATION:

Please tick the levels of education you have completed, and note the language(s) in which you were taught *(<u>use choices from underneath the table</u>)*:

tick	**level of education:**	**ages**	**language of**	**language used**

here		*(e.g. 5-12)*	**instruction***	**by other children / students***
☐	**Primary ___**	**5-11**	**A**	**A**
☐	**Secondary:** ______________________________________ (*please specify* highest level completed, e.g. CSE, GCSE, A-Level, etc)	**11-15**	**C**	**B**
☐	**Further Education** *(e.g. technical college, …)*			
☐	**Professional training**			
☐	**other** (*please specify*: ____Sunday school e.g. Sunday school, evening classes, …)	**5-14**	**A**	**A**

* <u>*choose one of these letters to indicate*</u>:
A – only English
B – mostly English
C – about half English, half Welsh
D – mostly Welsh
E – only Welsh

F – combination involving another language, *please give details*:
____

____
Were you formally taught (i.e. by a teacher) to read and write:

English? ☐ **YES**, at __7______ years of age,

☐ **NO** (if not formally taught *but* learned some other way, please tick here ☐)

Welsh? **(a) literary / formal style**

☐ **YES**, at ____5____ years of age,

☐ **NO** (if not formally taught *but* learned some other way, please tick here ☐)

(b) colloquial / informal style

☐ **YES**, at ____5____ years of age,

☐ **NO** (if not formally taught *but* learned some other way, please tick here ☐)

V. Use of Media:

a) How often do you read newspapers and/or magazines?

choose one of these letters to indicate:
A – daily **D** – occasionally
B – weekly **E** – never .
C – monthly

in English: _____B_____ **in Welsh:** ____C______

b) How often do you read books?

choose one of these letters to indicate:
A – daily **D** – occasionally
B – weekly **E** – never .
C – monthly

in English: ___E_______ **in Welsh:** ____E______

c) How often do you watch the television?

choose one of these letters to indicate:
A – daily **D** – occasionally
B – weekly **E** – never .
C – monthly

in English: ____A______ **in Welsh:** ____D______

d) How often do you listen to the radio?

choose one of these letters to indicate:
A – daily **D** – occasionally
B – weekly **E** – never .
C – monthly

in English: __E________ **in Welsh:** __E________

VI. Language Use, Abilities and Attitudes:

a) Please indicate how well you feel you speak*: *(Please note, we are only asking about speaking ability, not reading or writing ability.)*

English: __B______ **Welsh:** ____B____

**choose one of these letters to indicate:*
A – Native speaker or native-like; can carry out extended conversations
B – Not a native speaker, but can carry out basic conversations
C – Not a native speaker, only know some words and expressions

b) What language do / did you typically use to write:

choose one of these letters to indicate:

A – all / most in English
B – about half in English, half in Welsh
C – all / most in Welsh)

informal / personal letters	___B_____
short notes	_____C___
formal / official letters & documents	____B____
cheques	______A__
other (*please specify*: ______________________)	_________

c) Of the following, which ones best describe you? *(tick the appropriate ones)*

I feel I am generally better and more comfortable at speaking:

☐ English X Welsh ☐ no difference

In informal situations I prefer to speak:

☐ English X Welsh ☐ equally happy with both

In formal situations I prefer to speak:

☐ English X Welsh ☐ equally happy with both

When writing in a personal / informal style I prefer to use:

☐ English ☐ Welsh X equally happy with both

When writing in a formal style I prefer to use:

☐ English ☐ Welsh X equally happy with both

c) How important is it to you to be able to*:

speak English well,

for your social and family life: ____C__

for your profession: _______

speak Welsh well,

for your social and family life:____C__

for your profession: _______

choose one of these letters to indicate*: **A – Extremely important **C** – Somewhat important
B – Very important **D** – Not important

APPENDIX E. RON LANGUAGE BACKGROUND QUESTIONNAIRE

LANGUAGE BACKGROUND QUESTIONNAIRE

Please answer the questions on the following pages. If you want to add any further comments on any of the questions, please use an additional sheet. Thank you.

I. GENERAL INFORMATION:

Name: *(optional)* _____RON____

Date of birth: ________11/04/1950______ **Place of birth:** BANGOR__________________

Handedness: ☐ **left** X **right** ☐ **left&right** *(please explain below)*
(please tick relevant boxes)

____

____

Are you X **male** ☐ **female**

Are you retired? ☐ **YES** X **NO**

if yes, at what age did you retire? ___(disability)

Have you always lived in North Wales? X **YES** ☐ **NO**
(please tick relevant boxes)

If you were born outside of North Wales, or spent some time living in another area, where did you live and for how long?

Region / Country: _______________________ , from _____ years of age, until _____ years of age.

Region / Country: _______________________ , from _____ years of age, until _____ years of age.

Region / Country: _______________________ , from _____ years of age, until _____ years of age.

II. CHILDHOOD:

a) languages I spoke during my childhood:
(please tick the relevant boxes)

☐ **English:** I began speaking English at ___6______ years of age.

☐ **Welsh:** I began speaking Welsh at _____1____ years of age.

☐ **other** *(please specify)* _____________ **:** I began speaking that language at ______ years of age.

b) family members:

My mother's (guardian's) native language: _____WELSH___________________________

The language(s) she spoke to me*:

ages	**English**	**Welsh**	**other language(s)**
0-4	% of time	100% of time	% of time
5-12	% of time	100% of time	% of time
12-16	% of time	100% of time	% of time
16+	% of time	100% of time	% of time

My father's (guardian's) native language: ____N/A__________________________________

The language(s) he spoke to me*:

ages	**English**	**Welsh**	**other language(s)**
0-4	% of time	% of time	% of time
5-12	% of time	% of time	% of time
12-16	% of time	% of time	% of time
16+	% of time	% of time	% of time

Language(s) I used with my brothers and sisters:

ages	**English**	**Welsh**	**other language(s)**
early childhood	% of time	100% of time	% of time
late childhood	% of time	100% of time	% of time

Were there other people living in the household? **YES** X **NO** ☐
if yes,
what was their relation to you? _____Grandmother, Stepfather________________________

and what language(s) did they speak with you?

ages	**English**	**Welsh**	**other language(s)**
early childhood	% of time	100% of time	% of time
late childhood	% of time	100% of time	% of time

c) friends

Language(s) I used with my friends <u>as a child</u>:

ages	**English**	**Welsh**	**other language(s)**
early childhood	% of time	100% of time	% of time
late childhood	% of time	100% of time	% of time

d) community

Language(s) I used in the local community as a child:

ages	English	Welsh	other language(s)
early childhood	% of time	100% of time	% of time
late childhood	% of time	100% of time	% of time

III. ADULT LIFE:

I spoke:

ages	English	Welsh	other language(s)
generally, during my whole adult life	50% of time	50% of time	% of time
during the last year	80% of time	20% of time	% of time

a) Home / Family life:

What language(s) do you speak / did you speak

with:	English	Welsh	other language(s)
your partner	100% of time	% of time	% of time
former partner *(if applicable)*	% of time	% of time	% of time
your children at the present time	100% of time	% of time	% of time
your chidren at an earlier time *(if different from now*)*	% of time	% of time	% of time

*if you have used a different language / different languages with your children at an earlier time, please state when that was: _____________ __________________________

b) Work / Employment:

Please list your main occupation(s) since leaving school: _______________________________

_________ Civil engineer, builder _______________________________

What language(s) do / did you use at work?*

ages	English	Welsh	other language(s)
from until	25% of time	75% of time	% of time
from until	% of time	% of time	% of time
from until	% of time	% of time	% of time
from until	% of time	% of time	% of time

*you only need to fill in one line if you have always spoken the same language(s) at work

c) Community / Social Life:

What language(s) do / did you speak in your community and social life as an adult?

English	Welsh	other language(s)
100% of time	% of time	% of time

IV. EDUCATION:

Please tick the levels of education you have completed, and note the language(s) in which you were taught *(use choices from underneath the table)*:

tick here	**level of education:**	**ages** *(e.g. 5-12)*	**language of instruction***	**language used by other children / students***
☐	**Primary ___**	**5-11**	**E**	**E**
☐	**Secondary:** ________________________ *(**please specify** highest level completed, e.g. CSE, GCSE, A-Level, etc)*	**11-15**	**C**	**E**
☐	**Further Education** *(e.g. technical college, …)*			
☐	**Higher Education** *(e.g. University)*			
☐	**Professional training**			
☐	**other** *(**please specify**:* ________________________ *, e.g. Sunday school, evening classes, …)*			

* *choose one of these letters to indicate*:

A – only English
B – mostly English
C – about half English, half Welsh
D – mostly Welsh
E – only Welsh

F – combination involving another language, *please give details*:
____
____

Were you formally taught (i.e. by a teacher) to read and write:

English? ☐ **YES**, at __5______ years of age,

☐ **NO** (if not formally taught *but* learned some other way, please tick here ☐)

Welsh? **(a) literary / formal style**

☐ **YES**, at ___7_____ years of age,

☐ **NO** (if not formally taught *but* learned some other way, please tick here ☐)

(b) colloquial / informal style

☐ **YES**, at ____5____ years of age,

☐ **NO** (if not formally taught *but* learned some other way, please tick here ☐)

V. USE OF MEDIA:

a) How often do you read newspapers and/or magazines?

choose one of these letters to indicate:
A – daily **D** – occasionally
B – weekly **E** – never .
C – monthly

in English: ____B______ **in Welsh:** _____E_____

b) How often do you read books?

choose one of these letters to indicate:
A – daily **D** – occasionally
B – weekly **E** – never .
C – monthly

in English: ____A______ **in Welsh:** ___A_______

c) How often do you watch the television?

choose one of these letters to indicate:
A – daily **D** – occasionally
B – weekly **E** – never .
C – monthly

in English: ____A______ **in Welsh:** _____B_____

d) How often do you listen to the radio?

choose one of these letters to indicate:
A – daily **D** – occasionally
B – weekly **E** – never .
C – monthly

in English: ___A_______ **in Welsh:** ___A_______

VI. LANGUAGE USE, ABILITIES AND ATTITUDES:

a) **Please indicate how well you feel you speak*:** *(Please note, we are only asking about speaking ability, not reading or writing ability.)*

English: ____A____ **Welsh:** ____A/B____

**choose one of these letters to indicate:*
A – Native speaker or native-like; can carry out extended conversations
B – Not a native speaker, but can carry out basic conversations
C – Not a native speaker, only know some words and expressions

b) **What language do / did you typically use to write:**

choose one of these letters to indicate:

A – all / most in English
B – about half in English, half in Welsh
C – all / most in Welsh)

informal / personal letters _____A___

short notes _____A___

formal / official letters & documents _____A__

cheques _____A___

other (*please specify*: ______________________) ________

c) **Of the following, which ones best describe you?** *(tick the appropriate ones)*

I feel I am generally better and more comfortable at speaking:

X English ☐ Welsh ☐ no difference

In informal situations I prefer to speak:

X English ☐ Welsh ☐ equally happy with both

In formal situations I prefer to speak:

XEnglish ☐ Welsh ☐ equally happy with both

When writing in a personal / informal style I prefer to use:

X English ☐ Welsh ☐ equally happy with both

When writing in a formal style I prefer to use:

X English ☐ Welsh ☐ equally happy with both

c) How important is it to you to be able to*:

speak English well,

for your social and family life: ___A____

for your profession: _______

speak Welsh well,

for your social and family life:___A____

for your profession: _____

choose one of these letters to indicate: **A** – Extremely important **C** – Somewhat important
B – Very important **D** – Not important

THANK YOU FOR TAKING THE TIME TO COMPLETE THIS QUESTIONNAIRE.

APPENDIX F. ENGLISH REAL AND NONWORD LIST

number	word	type	index	number	word	type	index
1	**Padent**	NW	77	61	**Flang**	NW	79
2	**Consider**	R	25	62	**Spring**	R	36
3	**Both**	IW	87	63	**Machine**	IW	105
4	**Know**	IW	96	64	**Present**	R	20
5	**State**	R	21	65	**Clospit**	NW	80
6	**Ather**	NW	41	66	**Rext**	NW	47
7	**Shree**	NW	55	67	**Pravent**	NW	60
8	**Cosp**	NW	75	68	**Stop**	R	16
9	**Control**	R	26	69	**Floor**	IW	98
10	**Plinch**	NW	76	70	**Money**	IW	89
11	**Next**	R	7	71	**Purpose**	IW	111
12	**Busy**	IW	114	72	**Number**	R	3
13	**Period**	IW	85	73	**Front**	R	24
14	**Cantral**	NW	66	74	**Croblen**	NW	52
15	**Asper**	NW	46	75	**Champagne**	IW	109
16	**Am**	R	10	76	**Aspect**	R	33
17	**Animal**	R	29	77	**Munder**	NW	43
18	**Foreign**	IW	93	78	**Odem**	NW	54
19	**Three**	R	15	79	**Vomily**	NW	71
20	**Blam**	NW	67	80	**Bureau**	IW	113
21	**Blood**	IW	112	81	**Plan**	R	27
22	**Clont**	NW	64	82	**Blank**	R	39
23	**Doubt**	IW	104	83	**Other**	R	1
24	**Public**	R	8	84	**Daughter**	IW	103
25	**Dublit**	NW	48	85	**Frominank**	NW	78
26	**After**	R	6	86	**Ominal**	NW	69
27	**Plup**	NW	70	87	**Black**	R	32
28	**Character**	IW	97	88	**Stomach**	IW	120
29	**Under**	R	4	89	**Modern**	R	9
30	**Unifervidy**	NW	57	90	**Work**	IW	86
31	**Moment**	R	23	91	**Women**	IW	91
32	**University**	R	17	92	**Hold**	R	34
33	**Enough**	IW	88	93	**Problem**	R	12
34	**Shorsh**	NW	45	94	**Data**	R	22
35	**Club**	R	30	95	**Nothing**	R	13
36	**Into**	IW	81	96	**Apom**	NW	68
37	**Brock**	NW	72	97	**Spall**	NW	51
38	**Matter**	R	18	98	**People**	IW	82
39	**Prominent**	R	38	99	**Heart**	IW	95
40	**Move**	IW	107	100	**Half**	IW	110
41	**Ostect**	NW	73	101	**Fotter**	NW	58
42	**Open**	R	14	102	**Raka**	NW	62
43	**Cost**	R	35	103	**Sergeant**	IW	118
44	**Small**	R	11	104	**Said**	IW	84
45	**Suit**	IW	115	105	**Naching**	NW	53
46	**Ostim**	NW	44	106	**Answer**	IW	99
47	**Island**	IW	100	107	**Family**	R	31
48	**Bomb**	IW	119	108	**Country**	IW	92
49	**Ponsiter**	NW	65	109	**Petweem**	NW	42
50	**Caderk**	NW	49	110	**Friend**	IW	116
51	**Church**	R	5	111	**Program**	R	19
52	**Between**	R	2	112	**Spirit**	R	37
53	**Skob**	NW	56	113	**Through**	IW	83
54	**Do**	IW	90	114	**Four**	IW	94
55	**Hangrep**	NW	59	115	**Plastic**	R	40
56	**Ap**	NW	50	116	**Hour**	IW	108
57	**Horp**	NW	74	117	**Fact**	R	28
58	**Shoe**	IW	102	118	**Spape**	NW	61
59	**Colonel**	IW	117	119	**Rorent**	NW	63
60	**Column**	IW	106	120	**Woman**	IW	101

APPENDIX G. WELSH REAL AND NONWORD LIST

index	spelling	phonetic	w / nw?	English	index	spelling	phonetic	w / nw?	English
1	**Cymru**	‘kəmrɨ	w	*Wales*	64	**geibr**	‘geib(i)r	nw	n/a
46	**y*th*yn**	‘əθɨn	nw	n/a	58	**dial*th***	‘dialθ	nw	n/a
36	**trae*th***	tra·ɨθ	w	*beach*	34	**pont**	pɔnt	w	*bridge*
62	**emes**	‘ɛmɛs	nw	n/a	35	**nant**	nant	w	*stream*
38	**llifogydd**	ɬi‘vɔgɨð	w	*floods*	73	**hifle**	‘hivlɛ	nw	n/a
55	**tapil**	‘tapil	nw	n/a	72	**sbrêd**	sbrɛːd	nw	n/a
49	**ogrwys**	‘ɔgruɨs	nw	n/a	57	**isgafddog**	i‘sgavðɔg	nw	n/a
65	**conwrfam**	kɔ‘nurvam	nw	n/a	48	**tiwell**	‘tiu̯ɛɬ	nw	n/a
6	**allan**	‘aɬan	w	*out*	21	**dinas**	‘dinas	w	*city*
2	**Cymraeg**	kəm‘ra·ɨg	w	*Welsh*	32	**stryd**	strɨːd	w	*street*
80	**llimesg**	‘ɬimɛsg	nw	n/a	56	**tluf**	tlɨː(v)	nw	n/a
60	**cynpref**	‘kɨnprɛ(v)	nw	n/a	74	**twmp**	tump	nw	n/a
68	**elef**	‘ɛlɛ(v)	nw	n/a	40	**ffenest**	‘fɛnɛst	w	*window*
13	**mer*ch*ed**	‘mɛrxɛ(i)d	w	*women*	23	**mynydd**	‘mənɨð	w	*mountain*
33	**heddlu**	‘hɛðlɨ	w	*police*	7	**gwlad**	gwlaːd	w	*country*
20	**pentref**	‘pɛntrɛ(v)	w	*village*	12	**Saesneg**	‘s(ə)ɨsnɛg	w	*English*
61	**genos**	‘gɛnɔs	nw	n/a	10	**tŷ**	tɨː	w	*house*
27	**siop**	ʃɔp	w	*shop*	76	**proe*ch***	prɔ·ɨx	nw	n/a
25	**canolfan**	ka‘nɔlvan	w	*centre*	18	**diol*ch***	‘diɔlx	w	*thanks*
77	**coforn**	‘kɔvɔrn	nw	n/a	67	**siac**	ʃak	nw	n/a
28	**araf**	‘ara(v)	w	*slow*	45	**gymian**	‘gəmi̯an	nw	n/a
14	**afon**	‘avɔn	w	*river*	69	**agurug**	a‘gɨrɨg	nw	n/a
15	**capel**	‘kapɛl	w	*chapel*	70	**gren**	grɛn	nw	n/a
22	**ynys**	‘ənɨs	w	*island*	3	**ffordd**	fɔr(ð)	w	*road, way*
4	**ysgol**	‘əsgɔl	w	*school*	30	**bryn**	brɨn	w	*hill*
59	**dodlyff**	‘dɔdlɨf	nw	n/a	71	**asgwty**	as‘gutɨ	nw	n/a
54	**wfom**	‘uvɔm	nw	n/a	47	**gwrûn**	gwrɨːn	nw	n/a
43	**llwrdd**	ɬwr(ð)	nw	n/a	19	**gogledd**	‘gɔglɛð	w	*north*
9	**eglwys**	‘ɛgluɨs	w	*church*	11	**llyfr**	‘ɬɨ·vr	w	*book*
37	**tafarn**	‘tavarn	w	*pub*	31	**ysbyty**	əs‘bətɨ	w	*hospital*
29	**agored**	a‘gɔrɛd	w	*open*	24	**Beibl**	‘beib(i)l	w	*Bible*
50	**cŵ**	cuː	nw	n/a	51	**ffefl**	‘fe·vl	nw	n/a
53	**nel*ch*eig**	‘nɛlxɛig	nw	n/a	5	**dynion**	‘dəni̯ɔn	w	*men*
41	**canlu**	‘kanlɨ	nw	n/a	16	**tref**	trɛː(v)	w	*town*
66	**neffter**	‘nɛftɛr	nw	n/a	75	**pamp**	pamp	nw	n/a
8	**diwedd**	‘diu̯ɛð	w	*end*	44	**estwl**	‘estul	nw	n/a
79	**bem**	bɛm	nw	n/a	26	**milltir**	‘miɬtir	w	*mile*
42	**tymrôed**	təm‘rɔ·ɨd	nw	n/a	78	**lleddogef**	ɬɛ‘ðɔgɛv	nw	n/a
39	**dim**	dim	w	*nothing, zero*	63	**nimedd**	‘nimɛð	nw	n/a
52	**husmag**	‘hɨsmag	nw	n/a	17	**eisteddfod**	(e)i‘stɛðvɔd	w	*eisteddfod*

APPENDIX H. CWS STIMULUS LISTS FOR PHASE 1 OF THERAPY

English treated			**English repeated controls**			**English untreated controls**			**Welsh translations of English treated**			**Welsh unrelated control**		
Item	***Frequency***	***Length***	***Item***	***Frequency***	***Length***	***Item***	***Frequency***	***Length***	***Item***	***Frequency***	***Length***	***Item***	***Frequency***	***Length***
two	1412	3	one	3292	3	may	1400	3	dau	1399	3	Dweud	1045	5
five	286	4	million	204	7	special	250	7	pump	136	4	Mwy	1541	3
eight	104	5	hundred	171	7	Sunday	101	6	wyth	141	4	brwydr	110	6
three	610	5	question	257	8	problem	314	7	tri	462	3	ateb	356	4
four	359	4	power	342	5	open	319	4	pedwar	242	6	dyfodol	226	7
six	220	3	evil	72	4	unit	103	4	chwech	123	6	chwaer	117	6
seven	113	5	poem	48	4	july	65	4	saith	173	5	cegin	98	5
ten	165	3	zero	24	4	give	391	4	deg	326	3	Lliw	170	4
nine	81	4	Friday	60	6	ready	143	5	naw	136	3	Cae	132	3
august	53	6	thirty	59	6	Tuesday	59	7	awst	115	4	Ddoe	26	4
december	62	8	fifteen	56	7	travel	61	6	rhagfyr	82	7	chwefror	71	8
september	56	9	thousand	97	8	november	74	8	medi	161	4	Bwyd	352	4
january	53	7	learn	84	5	soldier	39	7	ionawr	122	6	agwedd	179	6
october	51	7	forty	36	5	cross	55	5	hydref	174	6	Cadair	155	6
Saturday	67	8	mountain	33	8	sixty	21	5	(dydd) sadwrn	122	6	Cyflym	151	6
twelve	48	6	jury	67	4	surprise	51	8	deuddeg	63	7	Diwrnod	414	7
twenty	80	6	april	71	5	lady	80	4	ugain	205	5	gwlad	861	5
eighteen	17	8	check	88	5	trade	143	5	deunaw	28	6	ffrae	19	5
june	93	4	tiger	7	5	talk	154	4	mehefin	111	7	tachwedd	93	8
march	120	5	ready	143	5	potato	15	6	mawrth	203	6	cerdded	302	7
lamb	7	4	head	24	4	value	200	5	oen	18	3	Bys	51	3
danger	70	6				group	390	5	perygl	106	6	Troed	97	5
animal	68	6							anifail	75	7	Chwith	97	6
effort	145	6							ymdrech	130	7	Dant	12	4
Mean:	180.83	5.50	**Mean:**	249.29	5.48	**Mean:**	201.27	5.41	**Mean:**	202.21	5.17	**Mean:**	278.13	5.29

APPENDIX I. CWS STIMULUS LISTS FOR PHASE 2 OF THERAPY

Welsh treated			**Welsh repeated attempt**			**Welsh untreated control**			**English Translations of Welsh Treated**			**English unrelated control**		
Item	***Frequency***	***Length***	***Item***	***Frequency***	***Length***	***Item***	***Frequency***	***Length***	***Item***	***Frequency***	***Length***	***Item***	***Frequency***	***Length***
to	190	2	**awst**	115	4	Mwy	1541	3	roof	59	4	may	1400	3
oer	122	3	iau	89	3	Cae	132	3	cold	171	4	special	250	7
dwr	253	3	naw	136	3	haf	267	3	water	442	5	Sunday	101	6
llwy	14	4	Dant	12	4	Ddoe	26	4	spoon	6	5	problem	314	7
crys	36	4	cath	57	4	pump	136	4	shirt	27	5	open	319	4
coes	72	4	medi	161	4	wyth	141	4	leg	58	3	unit	103	4
Lliw	170	4	hydref	174	6	ateb	356	4	colour	141	6	july	65	4
cryf	178	4	afon	366	4	mawrth	203	6	strong	202	6	give	391	4
drws	406	4	gwynt	217	5	brawd	200	5	door	312	4	twenty	80	6
sgwar	14	5	ffrae	19	5	rhaff	34	5	square	143	6	ready	143	5
cwpan	52	5	blino	44	5	Troed	97	5	cup	45	3	Tuesday	59	7
munud	225	5	bwrdd	273	5	hawdd	234	5	minute	53	6	december	62	8
anodd	300	5	cerdded	302	7	dyfodol	226	7	difficult	161	9	travel	61	6
llyfr	472	5	gweld	1662	5	Dweud	1045	5	book	193	4	november	74	8
deilen	15	6	afal	25	4	Bys	51	3	leaf	12	4	soldier	39	7
blodyn	19	6	oen	18	3	caws	30	4	flower	23	6	cross	55	5
aderyn	67	6	chwefror	71	8	rhagfyr	82	7	bird	31	4	sixty	21	5
gwyrdd	75	6	cegin	98	5	perygl	106	6	green	116	5	surprise	51	8
ffrind	84	6	Cyflym	151	6	chwech	123	6	friend	133	6	lady	80	4
ennill	246	6	Bwyd	352	4	pedwar	242	6	win	55	3	trade	143	5
hanner	560	6	Diwrnod	414	7	gwlad	861	5	half	275	4	talk	154	4
ffrwyth	57	7	deuddeg	63	7	anifail	75	7	fruit	35	5	potato	15	6
Cadair	155	6	ionawr	122	6	chwaer	117	6	chair	66	5	value	200	5
gwallt	107	6	coeden	115	6	Chwith	97	6	hair	148	4	group	390	5
Mean:	162.04	4.92	**Mean:**	210.67	5.00	**Mean:**	267.58	4.96	**Mean:**	121.13	4.83	**Mean:**	190.42	5.54

APPENDIX J. RON STIMULUS LISTS FOR PHASE 1 OF THERAPY

English treated			English repeated attempt			English control			Welsh translations of English treated			Welsh unrelated control		
Item	*Frequency*	*Length*	*Item*	*Frequency*	*Length*	*Item*	*Frequency*	*Length*	*Item*	*Frequency*	*Length*	*Item*	*Frequency*	*Length*
ghost	11	5	brisk	7	5	baggage	4	7	llyfryn	39	7	Rhoid	3	5
fork	14	4	dissolve	6	8	mystery	39	7	cyflymu	14	7	ychwanegiad	9	11
queen	41	5	blank	14	5	Engine	50	6	eliffant	6	8	ffenest	10	7
Danger	70	6	smoke	41	5	talk	154	4	cleddyf	33	7	tisian	12	6
technical	120	9	broke	72	5	purpose	149	7	ysbryd	188	6	Pys	13	3
feeling	172	7	doubt	114	5	natural	156	7	nerf	10	4	Ffrae	19	5
woman	224	5	Progress	120	8	department	225	10	Styfnig	6	7	Cyferbyn	14	8
number	472	6	leave	205	5	service	315	7	fforch	7	6	absennol	14	8
between	730	7	Brought	253	7	work	760	4	sigaret	11	7	Amserlen	17	8
brochure	2	8	country	324	7	adjust	16	6	cerbyd	75	6	Beichiog	19	8
february	45	8	Bouquet	4	7	Residence	29	9	amserlen	17	8	Cadeiriau	21	9
Culture	58	7	cemetery	15	8	Blanket	30	7	brenhines	62	9	bwthyn	58	6
column	71	6	Whiskey	17	7	tongue	35	6	chwefror	71	8	llifogydd	21	9
Success	93	7	access	24	6	Forest	66	6	Absenoldeb	18	10	caniatau	56	8
movement	128	8	market	155	6	several	377	7	afiechyd	37	8	ymddygiad	56	9
foreign	158	7	Nuisance	5	8	Province	15	8	diwylliant	185	10	Collodd	61	7
people	847	6	appendix	10	8	pumpkin	2	7	perygl	108	6	Bysedd	64	6
Nerve	12	5	currency	12	8	mustache	5	8	colofn	34	6	Anifail	75	7
sword	7	5	sketch	16	6	descend	4	7	Caniatau	56	8	Estyn	67	5
Stubborn	12	8	recommend	25	9	ledge	6	5	llwyddo	135	7	peiriant	70	8
Cigarette	25	9	Extend	31	6	negotiate	10	9	proffesiynol	79	12	Gweithgaredd	42	12
Vehicle	35	7	colonel	37	7	mileage	15	7	Cymeriad	141	8	Gwragedd	96	8
Absence	53	7	bureau	43	6	Instinct	14	8	crefydd	152	7	disgyn	107	6
Religion	119	8	Belief	64	6	Sincere	15	7	technegol	29	9	ymestyn	111	7
Knowledge	145	9	November	74	8	thorough	21	8	symudiad	63	8	Ymdrech	130	7
College	267	7	Kitchen	90	7	sauce	20	5	tymheredd	30	9	Canlyniad	231	9
program	394	7	enough	430	6	Excess	42	7	gwybodaeth	474	10	penodol	155	7
Schedule	36	8	through	969	7	atmosphere	79	10	dieithr	103	7	cynnydd	136	7
disease	53	7	university	214	10	Create	54	6	teimlad	81	7	milltir	163	7
professional	105	12	fascinate	3	9	daughter	72	8	dynes	42	5	amryw	169	5
character	118	9	apparatus	29	9	campaign	81	8	coleg	382	5	Beibl	192	5
temperature	135	11	Attitude	107	8	Patient	86	7	sicr	266	4	gogledd	249	7
Elephant	7	8	devour	2	6	bridge	98	6	rhaglen	261	7	Ystyried	296	8
Allow	72	5	Missile	48	7	mackerel	2	8	rhif	123	4	Cerdded	302	7
accelerate	5	10	adequate	66	8	continue	107	8	rhwng	1045	5	gwasanaeth	305	10
certain	313	7	Professor	57	9	specific	115	8	Pobl	1440	4	Doedd	631	5
Mean:	143.58	7.22	**Mean:**	102.86	7.00	**Mean:**	90.78	7.08	**Mean:**	161.75	7.11	**Mean:**	110.94	7.22

APPENDIX K. RON STIMULUS LISTS FOR PHASE 2 OF THERAPY

Welsh treated			Welsh repeated attempt			Welsh Control			English translations of Welsh treated			English unrelated control		
Item	***Frequency***	***Length***	***Item***	***Frequency***	***Length***	***Item***	***Frequency***	***Length***	***Item***	***Frequency***	***Length***	***Item***	***Frequency***	***Length***
gwahanu	23	7	Rhoid	3	5	llyfryn	39	7	separate	79	8	challenge	36	9
cyfeiriad	272	9	ychwanegiad	9	11	cyflymu	14	7	address	77	7	bicycle	5	7
cefndir	131	7	ffenest	10	7	eliffant	6	8	background	67	10	arrest	19	5
dryswch	17	7	tisian	12	6	cleddyf	33	7	confusion	44	9	rhythm	22	6
erthygl	118	7	Pys	13	3	ysbryd	188	6	Article	68	7	barbecue	13	8
sylw	406	4	Ffrae	19	5	nerf	10	4	attention	179	9	glamorous	5	9
mynychu	83	7	Cyferbyn	14	8	Styfnig	6	7	attend	54	6	lightning	14	9
diflannu	100	8	absennol	14	8	fforch	7	6	disappear	11	9	Wednesday	35	9
ein	1510	3	Amserlen	17	8	sigaret	11	7	our	1252	3	carriage	11	8
paratoi	219	7	Beichiog	19	8	cerbyd	75	6	prepare	35	7	judge	77	5
sydyn	219	5	Cadeiriau	21	9	amserlen	17	8	sudden	38	6	attractive	39	10
cymdogaeth	50	10	bwthyn	58	6	brenhines	62	9	neighbourhood	1	13	cheerful	10	8
adeiladwaith	8	12	llifogydd	21	9	chwefror	71	8	construction	95	12	Diabetes	4	8
dyweddiad	1	9	caniatau	56	8	Absenoldeb	18	10	engagement	22	10	festival	27	8
trydan	90	6	ymddygiad	56	9	afiechyd	37	8	electricity	26	11	mayonnaise	2	10
dal	665	3	Collodd	61	7	diwylliant	185	10	catch	43	5	Television	50	10
disgrifio	138	9	Bysedd	64	6	perygl	108	6	describe	41	8	Accept	72	6
poblogaeth	136	10	Anifail	75	7	colofn	34	6	Population	136	10	Deliver	18	7
awydd	86	5	Estyn	67	5	lleidr	30	6	Desire	79	6	Purple	13	6
addasu	80	6	peiriant	70	8	llwyddo	135	7	Adapt	5	5	Practice	94	8
cefnogaeth	116	10	Gweithgaredd	42	12	proffesiynol	79	12	Support	180	7	Disturb	10	7
cynllunio	282	9	Gwragedd	96	8	Cymeriad	141	8	Design	114	6	Aggressive	17	10
persawr	11	7	disgyn	107	6	crefydd	152	7	Perfume	10	7	Engage	14	6
effeithiol	172	10	ymestyn	111	7	technegol	29	9	effective	129	9	Plumber	4	7
rhybuddio	47	9	Ymdrech	130	7	symudiad	63	8	caution	19	7	Horizon	27	7
penderfynu	201	10	Canlyniad	231	9	tymheredd	30	9	Decide	40	6	Receive	76	7
oherwydd	715	8	penodol	155	7	gwybodaeth	474	10	because	883	7	Generous	25	8
gwahoddiad	52	10	cynnydd	136	7	dieithr	103	7	Invite	11	6	Achieve	51	7
profiad	329	7	milltir	163	7	teimlad	81	7	Experience	276	10	Eventually	52	10
prydferth	38	9	amryw	169	5	dynes	42	5	Beautiful	127	9	Paddock	1	7
basged	16	6	Beibl	192	5	coleg	382	5	Basket	17	6	Autumn	22	6
trefnu	233	6	gogledd	249	7	sicr	266	4	Organise	14	8	Valentine	2	9
cyferbyn	14	8	Ystyried	296	8	rhaglen	261	7	Opposite	81	8	Clutch	5	6
corfforol	37	9	Cerdded	302	7	rhif	123	4	Physical	138	8	Business	392	8
penodol	155	7	gwasanaeth	305	10	rhwng	1045	5	Particular	179	10	Government	417	10
siffrwd	8	7	Doedd	631	5	Pobl	1440	4	shuffle	3	7	Believe	200	7
Mean:	188.28	7.58	**Mean:**	110.94	7.22	**Mean:**	161.03	7.06	**Mean:**	127.03	7.83	**Mean:**	52.25	7.72

APPENDIX L.CWS BASELINE AND POST-TEST STIMULUS LISTS FOR SUBLEXICAL THERAPY PHASE 1

/ɛ/ Baseline nonwords (Treated similar)					
English			*Welsh*		
Stimulus	structure	Position	Stimulus	Structure	Position
twed	ccvc	3	**gleb**	ccvc	3
sned	ccvc	3	**smep**	ccvc	3
skeg	ccvc	3	**gren**	ccvc	3
pret	ccvc	3	**dret**	ccvc	3
chrep	ccvc	3	**grell**	ccvc	3
plet	ccvc	3	**llnet**	ccvc	3
treg	ccvc	3	**crech**	ccvc	3
smed	ccvc	3	**creg**	ccvc	3
slep	ccvc	3	**clep**	ccvc	3
sen	cvc	2	**mell**	cvc	2
med	cvc	2	**meb**	cvc	2
chet	cvc	2	**rhet**	cvc	2
ket	cvc	2	**ceb**	cvc	2
ped	cvc	2	**ged**	cvc	2
weg	cvc	2	**neg**	cvc	2
teb	cvc	2	**seb**	cvc	2
dep	cvc	2	**dell**	cvc	2
zeg	cvc	2	**def**	cvc	2
geck	cvc	2	**rhep**	cvc	2
pem	cvc	2	**ffen**	cvc	2
zep	cvc	2	**tem**	cvc	2
cheps	cvcc	2	**llesg**	cvcc	2
setch	cvcc	2	**sels**	cvcc	2
besp	cvcc	2	**sellt**	cvcc	2
mest	cvcc	2	**rend**	cvcc	2
selb	cvcc	2	**nent**	cvcc	2
kend	cvcc	2	**pens**	cvcc	2
fent	cvcc	2	**llent**	cvcc	2
mens	cvcc	2	**gerch**	cvcc	2
deps	cvcc	2	**perll**	cvcc	2

/ə/ Baseline nonwords (Treated not similar)					
English			*Welsh*		
Stimulus	structure	Position	Stimulus	Structure	Position
grust	ccvc	3	**cryp**	ccvc	3
druss	ccvc	3	**chryt**	ccvc	3
brun	ccvc	3	**ffryn**	ccvc	3
drup	ccvc	3	**dryll**	ccvc	3
chruss	ccvc	3	**cryb**	ccvc	3
frus	ccvc	3	**chryn**	ccvc	3
crus	ccvc	3	**dryff**	ccvc	3
pruch	ccvc	3	**pryn**	ccvc	3
grush	ccvc	3	**dryp**	ccvc	3
bup	cvc	2	**nyg**	cvc	2
cug	cvc	2	**cyf**	cvc	2
cun	cvc	2	**llyp**	cvc	2
dup	cvc	2	**gys**	cvc	2
guz	cvc	2	**fyn**	cvc	2
chup	cvc	2	**hyd**	cvc	2
gug	cvc	2	**gyf**	cvc	2
pum	cvc	2	**hyp**	cvc	2
fut	cvc	2	**llyg**	cvc	2
gutch	cvc	2	**syg**	cvc	2
sug	cvc	2	**gyr**	cvc	2
lun	cvc	2	**chym**	cvc	2
nust	cvcc	2	**syrc**	cvcc	2
lunt	cvcc	2	**llysg**	cvcc	2
pust	cvcc	2	**cyst**	cvcc	2
fust	cvcc	2	**byrg**	cvcc	2
bund	cvcc	2	**cysg**	cvcc	2
sust	cvcc	2	**hynd**	cvcc	2
mund	cvcc	2	**llynt**	cvcc	2
nunt	cvcc	2	**gyrs**	cvcc	2
runk	cvcc	2	**pysg**	cvcc	2

/θ/ Baseline nonwords (Untreated similar)					
English			***Welsh***		
Stimulus	Structure	Position	Stimulus	Structure	Position
throt	ccvc	1	**trath**	ccvc	4
prath	ccvc	4	**grath**	ccvc	4
thros	ccvc	1	**proth**	ccvc	4
thran	ccvc	1	**throp**	ccvc	1
gruth	ccvc	4	**dreth**	ccvc	4
prouth	ccvc	4	**throd**	ccvc	1
thron	ccvc	1	**snaeth**	ccvc	4
thray	ccvc	1	**cryth**	ccvc	4
troth	ccvc	4	**graeth**	ccvc	4
soth	cvc	3	**rhaeth**	cvc	3
meeth	cvc	3	**llath**	cvc	3
thab	cvc	1	**paith**	cvc	3
lath	cvc	3	**gaeth**	cvc	3
thap	cvc	1	**coth**	cvc	3
loth	cvc	3	**paeth**	cvc	3
zouth	cvc	3	**thig**	cvc	1
lith	cvc	3	**rhoth**	cvc	3
thall	cvc	1	**roeth**	cvc	3
poth	cvc	3	**thoer**	cvc	1
peeth	cvc	3	**swth**	cvc	3
reth	cvc	3	**rhath**	cvc	3
ganth	cvcc	4	**barth**	cvcc	4
tonth	cvcc	4	**gerth**	cvcc	4
danth	cvcc	4	**marth**	cvcc	4
merth	cvcc	4	**pwrth**	cvcc	4
donth	cvcc	4	**gwanth**	cvcc	4
charth	cvcc	4	**morth**	cvcc	4
sarth	cvcc	4	**chanth**	cvcc	4
sirth	cvcc	4	**llanth**	cvcc	4
santh	cvcc	4	**tarth**	cvcc	4

/ʊ/ Baseline nonwords (Untreated not similar)					
English			***Welsh***		
Stimulus	structure	Position	Stimulus	Structure	Position
croot	ccvc	3	**drwt**	ccvc	3
grook	ccvc	3	**grwm**	ccvc	3
trook	ccvc	3	**crwd**	ccvc	3
snook	ccvc	3	**prwb**	ccvc	3
scoon	ccvc	3	**grwdd**	ccvc	3
plook	ccvc	3	**llnwt**	ccvc	3
spook	ccvc	3	**crwp**	ccvc	3
broop	ccvc	3	**prwll**	ccvc	3
frook	ccvc	3	**chrwt**	ccvc	3
soop	cvc	2	**mws**	cvc	2
hoos	cvc	2	**swch**	cvc	2
dook	cvc	2	**mwn**	cvc	2
mook	cvc	2	**swd**	cvc	2
foos	cvc	2	**gwt**	cvc	2
lood	cvc	2	**bwd**	cvc	2
woot	cvc	2	**pwg**	cvc	2
hoog	cvc	2	**rwn**	cvc	2
bood	cvc	2	**twg**	cvc	2
gooch	cvc	2	**lwt**	cvc	2
doop	cvc	2	**llwn**	cvc	2
boop	cvc	2	**llwp**	cvc	2
koogs	cvcc	2	**twmp**	cvcc	2
poods	cvcc	2	**llwmp**	cvcc	2
grooz	ccvc	3	**chwrs**	cvcc	2
roosk	cvcc	2	**bwlt**	cvcc	2
sooks	cvcc	2	**dwrch**	cvcc	2
kroop	ccvc	3	**bwnt**	cvcc	2
glook	ccvc	3	**cwnc**	cvcc	2
blook	ccvc	3	**swnt**	cvcc	2
stook	ccvc	3	**bwlg**	cvcc	2

APPENDIX M. CWS STIMULUS LISTS FOR SUBLEXICAL TREATMENT PHASE 1

Phoneme	Word type	Stimulus	Length	Frequency	Minimal Pair
/ɛ/	Word	beg	3	11	bog
/ɛ/	Word	bet	3	20	but
/ɛ/	Word	cress	5	0	cross
/ɛ/	Word	get	3	750	got
/ɛ/	Word	leg	3	58	log
/ɛ/	Word	mess	4	22	moss
/ɛ/	Word	net	3	34	nut
/ɛ/	Word	pen	3	18	pan
/ɛ/	Word	pet	3	8	pot
/ɛ/	Word	crest	5	12	crust
/ɛ/	Word	send	4	74	sand
/ɛ/	Word	ten	3	165	tan
/ɛ/	Word	let	3	384	lot
/ɛ/	Word	best	4	12	bust
/ɛ/	Nonword	chent	5	N/A	chont
/ɛ/	Nonword	cret	4	N/A	crat
/ɛ/	Nonword	glep	4	N/A	glop
/ɛ/	Nonword	snep	4	N/A	snup
/ɛ/	Nonword	sench	5	N/A	sunch
/ɛ/	Nonword	gret	4	N/A	grut
Means:			3.75	112	

Phoneme	Word type	stimulus	Length	frequency	Minimal Pair
/ə/	Word	bug	3	4	bag
/ə/	Word	bun	3	1	ban
/ə/	Word	bus	3	34	boss
/ə/	Word	cup	3	45	cap
/ə/	Word	cut	3	192	cot
/ə/	Word	dug	3	15	dog
/ə/	Word	gut	3	1	got
/ə/	Word	grunt	5	2	grant
/ə/	Word	hut	3	13	hot
/ə/	Word	crush	5	4	crash
/ə/	Word	must	4	1013	mast
/ə/	Word	rust	4	13	rest
/ə/	Word	Rug	3	13	rag
/ə/	Word	flush	5	11	flesh
/ə/	Nonword	vum	3	N/A	vom
/ə/	Nonword	glut	4	N/A	glat
/ə/	Nonword	rupt	4	N/A	rept
/ə/	Nonword	Pug	3	N/A	pog
/ə/	Nonword	slup	4	N/A	slep
/ə/	Nonword	trub	4	N/A	treb
Means:			3.6	97.21	

APPENDIX N.CWS BASELINE AND POST-TEST STIMULUS LISTS FOR SUBLEXICAL THERAPY PHASE 2

/θ/ Baseline nonwords (Treated Shared)

Welsh			*English*		
Stimulus	Structure	position	Stimulus	Structure	position
grath	ccvc	c1	gruth	ccvc	c1
proth	ccvc	c1	prouth	ccvc	c1
dreth	ccvc	c1	troth	ccvc	c1
snaeth	ccvc	c1	soth	cvc	c1
cryth	ccvc	c1	meeth	cvc	c1
graeth	ccvc	c1	lath	cvc	c1
llwth	cvc	c1	zouth	cvc	c1
paith	cvc	c1	lith	cvc	c1
baeth	cvc	c1	poth	cvc	c1
coth	cvc	c1	peeth	cvc	c1
paeth	cvc	c1	reth	cvc	c1
rhoth	cvc	c1	ganth	cvcc	c1
swth	cvc	c1	danth	cvcc	c1
barth	cvcc	c1	merth	cvcc	c1
marth	cvcc	c1	sorth	cvcc	c1
chanth	cvcc	c1	santh	cvcc	c1
llanth	cvcc	c1	heth	ccvc	c1
thaer	ccvc	o1	chreeth	ccvc	c1
throd	ccvc	o1	thray	ccvc	o1
brath	cvc	c1	thab	cvc	o1
thoer	cvc	o1	thall	cvc	o1
rhaethu	cvcv	o2	noath	cvc	c1
gerthau	cvccv	o2	zeeth	cvc	c1
chwanth	cvcc	c1	thappen	cvcvc	o1
roethell	cvcvc	o2	donthet	cvccvc	o2
rhathor	cvcvc	o2	charthet	cvccvc	o2
thoes	cvc	o1	prathom	ccvcvc	o2
gwanth	cvcc	c1	lother	cvcvc	o2
thaell	cvc	o1	donther	cvccvc	o2
tartho	cvccv	o2	thritch	ccvcc	o1

/ɪ/ Baseline nonwords (Control Shared)

Welsh			*English*		
Stimulus	Structure	position	Stimulus	structure	position
clin	ccvc	c1	drit	ccvc	c1
prid	ccvc	c1	spick	ccvc	c1
blig	ccvc	c1	stit	ccvc	c1
prip	ccvc	c1	spint	ccvc	c1
chrit	ccvc	c1	spid	ccvc	c1
trich	ccvc	c1	grick	ccvc	c1
prill	ccvc	c1	chit	cvc	c1
llin	cvc	c1	sig	cvc	c1
gip	cvc	c1	nin	cvc	c1
llip	cvc	c1	mig	cvc	c1
rhit	cvc	c1	rit	cvc	c1
dit	cvc	c1	diff	cvc	c1
niff	cvc	c1	lig	cvc	c1
cill	cvc	c1	chig	cvc	c1
ffic	cvc	c1	litch	cvc	c1
lirch	cvcc	c1	cilp	cvcc	c1
dimp	cvcc	c1	ling	cvcc	c1
chrip	ccvc	c1	sids	cvcc	c1
llimp	cvcc	c1	kint	cvcc	c1
sild	cvcc	c1	pisck	cvcc	c1
hirch	cvcc	c1	hicks	cvcc	c1
crillor	ccvcvc	c1	umprit	vcccvc	c1
sliffau	ccvcvc	c1	lilla	cvcv	c1
arlim	vccvc	c2	pilpot	cvccvc	c1
rhigio	cvcvc	c1	brigger	ccvcvc	c1
nimedd	cvcvc	c1	krippick	ccvcvc	c1
diraf	cvcvc	c1	widrop	cvccvc	c1
dinllas	cvccvc	c1	bishet	cvcvc	c1
tistri	cvcccv	c1	sinter	cvccvc	c1
climor	ccvcvc	c1	gispeck	cvccvc	c1

/ʃ/ Baseline nonwords (Treated Divergent)					
Welsh			*English*		
Stimulus	Structure	position	Stimulus	structure	position
sial	cvc	o1	closher	ccvcvc	o2
siog	cvc	o1	pratesh	ccvcvc	o2
siod	cvc	o1	troshet	ccvcvc	o2
siem	cvc	o1	preeshy	ccvcc	o2
siet	cvc	o1	loshet	cvcvc	o2
sioll	cvc	o1	mishley	cvccvc	o2
sieg	cvc	o1	shib	cvc	o1
sieng	cvc	o1	kosh	cvc	c1
siwn	cvc	o1	pashor	cvcvc	o2
siont	cvcc	o1	zash	cvc	c1
siost	cvcc	o1	shree	ccv	o1
sioch	cvc	o1	shrip	ccvc	o1
sianag	cvcvc	o1	shong	cvc	o1
grisio	ccvcv	o2	shoop	cvc	o1
grosia	ccvcv	o2	shig	cvc	o1
crisior	ccvcv	o2	shill	cvc	o1
drysiag	ccvcv	o2	shab	cvc	o1
lisio	cvcv	o2	sheb	cvc	o1
rwsion	cvcv	o2	shawp	cvc	o1
dasior	cvcv	o2	shest	cvcc	o1
mosiap	cvcvc	o2	sharny	cvccv	o1
misian	cvcvc	o2	cleeshock	ccvcvc	o2
bision	cvcvc	o2	croshib	ccvcvc	o2
llesial	cvcvc	o2	heship	cvcvc	o2
mawnsio	cvvccv	o2	prushat	ccvcvc	o2
geisiau	cvvcv	o2	mishy	cvcv	o2
asiog	vcvc	o2	pashy	cvcv	o2
isian	vcvc	o2	goshing	cvcvc	o2
wesian	vvcvc	o2	nashom	cvcvc	o2
eisior	vvcvc	o2	losher	cvcvc	o2

/f/ Baseline nonwords (Control Divergent)					
Welsh			*English*		
Stimulus	structure	position	Stimulus	structure	position
afflor	vccvc	c1	cloafet	ccvcvc	o2
offter	vccvc	c1	fleck	ccvc	o1
moffau	cvcvc	o2	grafet	ccvcvc	o2
fflon	ccvc	o1	fap	cvc	o1
ffraw	ccvv	o1	keaf	cvc	c1
dafflas	cvccvc	o2	toufet	cvcvc	o2
ffrid	ccvc	o1	coufer	cvcvc	o2
ffrwt	ccvc	o1	nayf	cvc	c1
fflomp	ccvcc	o1	frun	ccvc	o1
peffyr	ccvcc	o2	flep	ccvc	o1
ffet	cvc	o1	trayf	ccvcc	c1
ffeig	cvc	o1	frat	ccvc	o1
ffod	cvc	o1	froom	ccvc	o1
ffwll	cvc	o1	floup	ccvc	o1
ffot	cvc	o1	flimp	ccvcc	o1
ffwyr	cvvc	o1	flant	ccvcc	o1
fflwm	ccvc	o1	fim	cvc	o1
ffaru	cvcc	o1	fean	cvc	o1
ffolwr	cvcvc	o1	froop	cvc	o1
trwffa	ccvcv	o2	fragan	ccvcvc	o1
loffi	cvcv	o2	frotter	ccvcvc	o1
neffon	cvcvc	o2	teafell	cvcvc	o2
seffag	cvcvc	o2	treefam	ccvcvc	o2
llaffor	cvcvc	o2	plofing	ccvcvc	o2
taffer	cvcvc	o2	dafer	cvcvc	o2
toffan	cvcvc	o2	preefy	ccvcc	o2
loffar	cvcvc	o2	sleefy	ccvcc	o2
hoffon	cvcvc	o2	snoofick	ccvcvc	o2
gwffos	cvcvc	o2	pleafet	ccvcvc	o2
rwffog	cvcvc	o2	moofeg	cvcvc	o2

/r̥/ Baseline words (Treated Welsh-specific) *Welsh*			**/əɨ/ baseline words (Control Welsh-specific)** *Welsh*		
Stimulus	structure	position	Stimulus	structure	position
rhyp	cvc	o1	eur	vc	o1
rhwys	cvcc	o1	eug	vc	o1
enrhap	vccvc	o2	eull	vc	o1
rhaen	cvc	o1	doleus	cvcvc	o2
rhwll	cvc	o1	euos	vvc	o1
rhed	cvc	o1	lleuam	cvvc	c1
enrhag	vccvc	o2	taleus	cvcvc	o2
onrheg	vccvc	o2	gomeur	cvcvc	o2
rhwll	cvc	o1	eurog	vcvc	o1
anrhodd	vccvc	o2	euglo	vccv	o1
rhig	cvc	o1	eusor	vcvc	o1
rhwyn	cvc	o1	caleus	cvcvc	o2
rhaes	cvc	o1	eurweg	vcvc	o1
rhwg	cvc	o1	lleus	cvc	c1
rhym	cvc	o1	daleug	cvcvc	o2
rhwyta	cvcv	o1	tolleus	cvcvc	c2
rhetio	cvcv	o1	eugor	vcvc	o1
rhafu	cvcv	o1	eumell	vcvc	o1
rhalig	cvcv	o1	eullgor	vcvc	o1
anrhoes	vccvc	o2	cofeus	cvcvc	o2
rhagwt	cvcv	o1	dwleu	cvcv	c2
rhufo	cvcv	o1	eugamp	vcvcc	o1
rhigar	cvcv	o1	euom	vvc	o1
penrhaw	cvccv	o2	eullog	vcv	o1
rhillan	cvcvc	o1	eugrwy	vccv	o1
rhalis	cvcv	o1	eull	vc	o1
anrhydd	vccvc	o2	eulan	vcvc	o1
rhothu	cvcv	o1	eullder	vccvc	o1
rhegor	cvcvc	o1	eudot	vcv	o1
panrhew	cvccvc	o2	eugen	vcvc	o1

APPENDIX O. CWS STIMULUS LISTS FOR SUBLEXICAL TREATMENT PHASE 2

Phoneme	Word type	Stimulus	Frequency	Minimal Pair
/θ/	Word	gwerth	302	gwers
/θ/	Word	chwaith	177	chwain
/θ/	Word	chwith	97	chwil
/θ/	Word	traeth	75	traed
/θ/	Word	maith	73	main
/θ/	Word	poeth	66	poer
/θ/	Word	cath	57	caf
/θ/	Word	llwyth	53	llwyr
/θ/	Word	llath	19	llan
/θ/	Word	serth	26	serch
/θ/	Word	pwyth	6	pwys
/θ/	Nonword	poth	N/A	poch
/θ/	Nonword	thos	N/A	ros
/θ/	Nonword	thel	N/A	gel
/θ/	Nonword	orth	N/A	orf
/θ/	Nonword	morth	N/A	morch

Phoneme	Word type	Stimulus	Frequency	Minimal Pair
/ʃ/	Word	siwr	236	dw+r
/ʃ/	Word	siop	159	top
/ʃ/	Word	sian	13	ta+n
/ʃ/	Word	sioc	43	toc
/ʃ/	Word	siap	42	hap
/ʃ/	Word	siawns	35	dawns
/ʃ/	Word	sied	17	lled
/ʃ/	Word	siart	12	smart
/ʃ/	Word	sio+n	50	ton
/ʃ/	Word	siol	5	no+l
/ʃ/	Word	siom	51	tom
/ʃ/	Nonword	siod	N/A	wod
/ʃ/	Nonword	siob	N/A	llob
/ʃ/	Nonword	siem	N/A	chem
/ʃ/	Nonword	siad	N/A	llad
/ʃ/	Nonword	siech	N/A	dech

Phoneme	Word type	Stimulus	Frequency	Minimal Pair
/r̥/	Word	rhed	16	lled
/r̥/	Word	rhag	431	gwag
/r̥/	Word	rhaw	13	daw
/r̥/	Word	rhwd	9	mwd
/r̥/	Word	rhew	45	tew
/r̥/	Word	rhys	122	pys
/r̥/	Word	rheg	3	deg
/r̥/	Word	rhif	123	llif
/r̥/	Word	rhes	57	nes
/r̥/	Word	rhad	43	gad
/r̥/	Word	rhiw	30	lliw
/r̥/	Nonword	rhwn	N/A	rwn
/r̥/	Nonword	rhac	N/A	dac
/r̥/	Nonword	rhop	N/A	sop
/r̥/	Nonword	rheb	N/A	peb
/r̥/	Nonword	rhwc	N/A	swc