

## Implicit detection of poetic harmony by the naïve brain

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**Running title**

Spontaneous recognition of poetry

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### **Abstract**

The power of poetry is universally acknowledged, but it is debatable whether its appreciation is reserved for experts. Here we show that readers with no particular knowledge of a traditional form of Welsh poetry unconsciously distinguish phrases conforming to its complex poetic construction rules from those that violate them. We studied the brain response of native speakers of Welsh as they read meaningful sentences ending in a word that either complied with strict poetic construction rules, violated rules of consonantal repetition, violated stress pattern, or violated both these constraints. Upon reading the last word of each sentence, participants indicated sentence acceptability. As expected, our inexperienced participants did not explicitly distinguish between sentences that conformed to the poetic rules from those that violated them. However, in the case of orthodox sentences, the critical word elicited a distinctive brain response characteristic of target detection –the P3b– as compared to the other conditions, showing that speakers of Welsh with no expertise of this particular form of poetry implicitly detect poetic harmony. These results show for the first time that before we even consider literal meaning, the musical properties of poetry speak to the human mind in ways that escape consciousness.

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### **Keywords:**

**Language, neuroaesthetics, poetry, event-related potentials, P3b**

## Introduction

T.S. Eliot famously argued that “genuine poetry can communicate before it is understood” (Scofield, 1988; pp2). Was this an attempt to provoke controversy or can some aspects of poetry indeed be processed implicitly and independently of meaning? Poetry is a literary expression of feelings, thoughts and ideas, traditionally accentuated by metric constraints, rhyme, and alliteration. Recent scientific research looking into the effects of poetry has highlighted emotional responses to rhyme (Obermeier et al., 2013) and better memory recall as a result of alliteration (Hanauer, 2001; Lea et al., 2008). Rhyme violations, in particular, have been shown to increase pupillary responses (Scheepers et al., 2013) and modulate the amplitude of the N400, a brain potential index of semantic processing (Hoorn, 1996). Whilst there is little doubt that some poetic forms, often centuries old, impact human cognition (see Jacobs, 2015, for a recent review), we have yet to discover the extent to which such sensitivity may rely on automatic and implicit neural processing.

Here, we investigated event-related brain potentials (ERPs) elicited by the final word of sentences written in *Cynghanedd* (‘harmony’ in Welsh), an ancient poetic form that requires precise consonantal repetition (and/or internal rhyme) in conjunction with distinct stress patterns (Greene, 2012). In certain sub-types of *Cynghanedd*, consonants are repeated across the first and second parts of the line, and are always in the same order: *A daeth i ben | deithio byd* (‘And it came to an end | travelling the world’, as cited in Llwyd, 2010, critical consonants in bold). A line such as *\*A daeth i ben | deithio cwm* (‘And it came to an end | travelling the valley’) features a ‘c’ rather than a ‘b’, which constitutes a consonantal repetition violation. Traditional *Cynghanedd* rules also dictate a precise stress pattern: *Ein lluniaeth | a’n llawenydd* (‘Our sustenance and joy’, Llwyd, 2010, stress vowels underlined and critical consonants in bold). In contrast, the line *\*Ein lluniaeth | a’n llu newydd* (‘Our sustenance and new host’) violates traditional rules because ‘n’ in part one comes after the stress, but ‘n’ in part two precedes the final stress. *Cynghanedd* sentences thus consist of foregrounding features at the sublexical (phonological salience) and lexical (stress pattern) levels (Jacobs, 2015). Each of these features is known to independently influence aesthetic appreciation (e.g. Aryani, Jacobs & Conrad, 2013; Chen, Zhang, Xu, Scheepers, Yang & Tanenhaus, 2016), but their interactive effect is unclear. In the present investigation, test sentences were constructed which either adhered to the rules of *Cynghanedd*, or violated its rules in terms of consonantal repetition, stress pattern, or both consonantal repetition and stress pattern (Table 1). Each condition was pseudo-randomly presented in equal proportion, resulting in an oddball paradigm with *Cynghanedd*-orthodox sentences occurring only 25% of the time.

The P3b is an ERP component commonly observed during oddball paradigms thought to reflect a context-updating process whereby a comparison is made between the currently processed stimulus, and the previous representation held in working memory (see Polich, 2007, for a review). We anticipated that participants would show greater P3b amplitudes when singling out the infrequent target combination of consonantal repetition and stress pattern conforming to *Cynghanedd* from the other three non-*Cynghanedd* conditions. We were keen to know, however, whether such potential detection of the *Cynghanedd*-orthodox targets would be accompanied by signs of conscious evaluation as indexed by behavioral data and at debriefing.

## Materials and methods

### Participants

Twenty-five fluent native speakers of Welsh (9 males; 16 females), with no prior knowledge of the rules of Cynghanedd, were included in the analysis. Of the initial participant pool, one participant was excluded due to prior knowledge of Cynghanedd and its underlying rules; two participants were excluded as they had too few uncontaminated epochs per condition; and a further four participants were removed as a result of overall excessive noise in the data. All participants possessed normal or corrected-to-normal vision. Ethical approval was granted by the School of Psychology, Bangor University ethics committee, and participants gave written consent before the experiment session started.

### Stimuli and procedure

Experimental sentences belonged to 36 sets each consisting of four sentences, resulting in a total of 144 sentences. Twenty-five percent of the experimental sentences followed the rules of Cynghanedd whilst the remaining 75% violated the Cynghanedd rules in terms of consonantal repetition (25%), stress pattern (25%), or both consonantal repetition and stress pattern (25%; see Table 1). The experiment thus conformed to a classical oddball paradigm with Cynghanedd as the target condition. Where possible, sentence final words were rotated across conditions. However, due to the strict rules of Cynghanedd, it was not possible to fully rotate all items between conditions. Word frequency (from the *Cronfa Electroneg o Gymraeg*; Ellis et al., 2001) and length did not differ significantly between conditions ( $F(3,140) = 1.86, p = 0.14$ ;  $F(3,140) = 0.76, p = 0.52$ ).

*Insert Table 1 about here!*

Participants viewed all 144 sentences in three sections, segmented such that they adhered to the natural rhythm of the Cynghanedd line, with the final, critical word presented in isolation. On each trial, the first two segments were presented for 500ms each, with an inter-stimulus interval (ISI) of 300ms. A varying ISI (ranging between 400-700ms) was used between the second segment and the sentence final word, which remained on the screen for a maximum of 2000ms, or until a response was made, whichever was the shortest (Figure 1). Presentation order was pseudorandomized, such that sentences from the same sentence set never appeared in the same experimental block. Upon presentation of the final word, participants were asked to indicate as quickly and as accurately as possible, whether or not the sentence sounded ‘good’ by pressing designated buttons on a serial response box. Upon completion of the experimental task, participants were presented with a list of the 36 sentence sets and were asked to rank the sentences in each set in a decreasing order of preference (1 = most preferred; 4 = least preferred).

*| Insert Figure 1 about here |*

### ERP recording

Electrophysiological data was recorded from 32 Ag/AgCl electrodes set according to the extended 10-20 convention at a rate of 1 kHz in reference to the left mastoid. The electroencephalogram (EEG) activity was filtered online with a band-pass filter between 0.1-200 Hz and again offline with a band-pass zero-phase shift filter set between 0.1-

152 20Hz. Eye blink artifacts were modeled and mathematically corrected (Gratton et al.,  
153 1983) and remaining artifacts were removed manually. Epochs ranging from -100 to  
154 1,000ms after the onset of the target word were extracted from continuous EEG  
155 recordings. Epochs with activity exceeding  $\pm 75\mu\text{V}$  at any electrode site were  
156 automatically discarded. There was a minimum of 30 epochs per condition for every  
157 participant. Baseline correction was performed in reference to pre-stimulus activity, and  
158 individual averages were digitally re-referenced to the algebraic mean of the left and  
159 right mastoids.

160

### 161 **Data analysis**

162 For the online categorization task, the percentage of ‘good’ responses was analyzed by  
163 means of a one-way repeated measures analysis of variance (ANOVA) with ‘Sentence  
164 Type’ (Cynghanedd, Consonantal violation, Stress violation, Double violation) as an  
165 independent variable. Reaction times were analyzed by means of a two (Categorization:  
166 ‘good’, ‘not good’) -by-four (Sentence Type: Cynghanedd, Consonantal violation,  
167 Stress violation, Double violation) repeated measures ANOVA.

168

169 For the offline ranking task, responses were scored such that they were given a 1 if they  
170 correctly ranked Cynghanedd sentences as the ‘best’ sentence, and a 0 if they did not.  
171 Responses were then analyzed by means of a one-sample t-test.

172

173 For the ERP data, P3b mean amplitude was predictively extracted between 240-340ms  
174 at six electrodes where the P3b is known to be maximal in amplitude (CP3, CPz, CP4,  
175 P3, Pz, P4) and maximal sensitivity was verified by inspecting the global field power  
176 produced across the scalp in the Cynghanedd condition. P3b mean amplitudes were  
177 analyzed by means of a one-way repeated measures ANOVA with ‘Sentence Type’  
178 (Cynghanedd, Consonantal violation, Stress violation, Double violation) as an  
179 independent variable. Post-hoc tests were conducted using Bonferroni corrections.

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## 181 **Results**

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### 182 **Behavioral results**

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#### 183 **Online categorization task.**

We found a significant main effect of Sentence Type;  $F(3,72) = 8.63, p < 0.001, n^2_p =$   
.26 (Figure 2.a.). Pairwise comparisons revealed that Cynghanedd sentences were more  
likely to be categorized as ‘good’ ( $M = 65\%$ ; 95% CI [60, 70]) compared with  
Consonantal violation sentences ( $M = 58\%$ ; 95% CI [51, 65];  $p = 0.005$ ) and Stress  
violation sentences ( $M = 55\%$ ; 95% CI [50, 60],  $p < 0.001$ ), but not Double violation  
sentences ( $M = 63\%$ ; 95% CI [58, 69],  $p = 0.38$ ). Furthermore, Double violation  
sentences were more likely to be categorized as ‘good’ than Consonantal violation  
sentences ( $p = 0.04$ ) and Stress violation sentences ( $p = 0.001$ ). Comparisons of  
categorization score against chance revealed that responses significantly differed from  
chance for Cynghanedd, the Double violation condition, and the Consonantal violation  
condition ( $t(24) = 2.325, p = .029$ ), but not the Stress violation condition ( $t(24) = 1.905,$   
 $p = .069$ ). Critically, whereas the greater than chance performance in the Cynghanedd  
condition was felicitous (these were the Cynghanedd-orthodox sentences), it was  
infelicitous in the Double violation and the Consonantal violation conditions.

For the reaction time data, a main effect of Categorization was found ( $F(1,24) = 33.58,$   
 $p < .001, n^2_p = .58$ ; Figure 2.b.): Sentences that were perceived as ‘good’ were  
responded to faster ( $M = 653\text{ms}$ , 95% CI [568, 738]) than sentences perceived as ‘not  
good’ ( $M = 774\text{ms}$ , 95% CI [678, 869]). There was also a main effect of Sentence Type

203 ( $F(3,72) = 3.24, p = 0.03, n^2_p = .12$ ), but none of the corrected pairwise comparisons  
204 reached significance.

205

### 206 **Offline sentence ranking task.**

207 A one sample t-test revealed that participants did not rank Cynghanedd sentences as the  
208 best option significantly better than chance ( $M_{accuracy} = 28\%; t(24) = 1.87, p = 0.07$ ).

209 Since this result was approaching significance, we further tested whether participants  
210 showed any inclination to rank Cynghanedd sentences in the top two choices by coding  
211 the response as 1 if Cynghanedd sentences were ranked 1<sup>st</sup> or 2<sup>nd</sup>, or as 0 if Cynghanedd  
212 sentences were ranked 3<sup>rd</sup> or 4<sup>th</sup>. In this case, a one sample t-test revealed that  
213 participants did perform significantly greater than chance on this task ( $M_{accuracy} = 62\%;$   
214  $t(24) = 6.93, p < 0.001$ ).

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| *Insert Figure 2 about here* |

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| *Insert Figure 3 about here* |

218

### 219 **Electrophysiological data.**

220 We found a significant main effect of Sentence Type;  $F(3,72) = 3.149, p = 0.03, n^2_p =$   
221  $.12$ ; with Cynghanedd sentences eliciting greater mean amplitudes ( $M = 5.93, 95\% CI$   
222  $[4.86, 7.01]$ ) than Consonantal violation sentences ( $M = 5.01, 95\% CI [3.92, 6.10]; p =$   
223  $0.01$ ), Stress violation sentences ( $M = 4.88, 95\% CI [3.58, 6.17]; p = 0.002$ ), and Double  
224 violation sentences ( $M = 5.00, 95\% CI [3.90, 6.09]; p = 0.007$ ), respectively (Figure 3).  
225 Analyses in earlier time windows (P1 & N1) did not show any significant differences as  
226 a result of the experimental conditions. As expected the distribution of the effect was  
227 centroparietal (Figure 4). Furthermore, the topographic maps show that participants  
228 were not sensitive to the consonantal repetition and stress pattern rules when presented  
229 independently; rather, they were only sensitive to constructions that complied with *both*  
230 consonantal repetition and stress pattern rules.

231

232 Upon visual inspection, the topography of the P3 appeared to be right-lateralized, whilst  
233 the experimental effect seemed more left-lateralized. In order to determine whether the  
234 interaction was significant, we conducted an additional ANOVA, with Sentence Type  
235 (Cynghanedd, Consonantal violation, Stress violation, Double violation) and  
236 ‘Laterality’ (Left [CP3;P3], Right [CP4;P4]) as independent variables. We found a  
237 significant effect of Laterality;  $F(1,24) = 27.66, p < .001, n^2_p = .54$ , with greater P3b  
238 mean amplitudes elicited on the Right ( $M = 6.05, 95\% CI [5.01, 7.09]$ ) than on the Left  
239 ( $M = 4.37, 95\% CI [3.39, 5.36]$ ). The Sentence Type \* Laterality interaction did not  
240 reach significance ( $F(1,24) = 1.05, p = .377, n^2_p = .04$ ), however, indicating that the  
241 experimental effect was not modulated by electrode site.

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243

| *Insert Figure 4 about here* |

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245

## 245 **Discussion**

246 Here we investigated whether naïve readers of a traditional form of Welsh poetry are  
247 able to unconsciously distinguish phrases conforming to its poetic construction rules  
248 from those that violate them. In line with our predictions, words correctly completing a  
249 sentence in Cynghanedd elicited significantly greater P3b mean amplitudes than words  
250 completing other sentence types, indicating a shift of attention associated with target  
251 recognition (Polich, 2007).

252

253 The P3b modulation observed here had a typical centroparietal distribution and a time-  
254 range comparable to that observed in simple target detection tasks, consistent with the  
255 classic P3b effect (Knight, 1996). Thus, participants' brains treated correct completion  
256 words as targets and implicitly categorized Cynghanedd-orthodox sentences as  
257 sounding 'good' compared to sentences violating its construction rules. Strikingly,  
258 however, and in contrast with ERP results, participants showed no overt knowledge or  
259 conscious awareness of Cynghanedd rules in the online categorization task since (a)  
260 they failed to discriminate between Cynghanedd and Double Violation sentences, and  
261 (b) their performance was either at chance level (Stress violation condition) or  
262 infelicitous with regard to Cynghanedd rules in the other violation conditions. There  
263 was some differentiation between sentence types, with participants rating Cynghanedd  
264 sentences as sounding better than those from single violation conditions. It is possible  
265 that this difference occurred due to participants perceiving the rule violations in these  
266 conditions, however this interpretation cannot account for the fact that participants did  
267 not consider Cynghanedd sentences as sounding better than Double violation sentences.  
268 Participants did, however, demonstrate a preference towards Cynghanedd sentences  
269 during the offline judgement task. Given that the ranking task was of a very different  
270 nature to the online task (involving direct comparison between the different alternatives  
271 of each sentence) and that it was not time constrained, it is highly likely that participants  
272 changed cognitive strategy in this task, and focused on elements of the stimuli that were  
273 not attended to during the online categorization task.

274

275 Interestingly, the results of the online decision task are somewhat incongruent with  
276 recent research emphasizing the influence of foregrounded features on aesthetic  
277 appreciation (Aryani, Jacobs & Conrad, 2013). For example, Aryani et al., (2013)  
278 demonstrated, via use of a text analysis tool, that the salience of particular sublexical  
279 features (e.g., phonological repetition) correlates with the semantic and aesthetic  
280 properties of poetic phrases. Given that a 'sound good' judgment could be influenced by  
281 such foregrounding properties, Cynghanedd and Stress violation sentences should be  
282 judged as 'good' more than the other two sentence types, but this was not the case in our  
283 data. Whilst participants considered Cynghanedd sentences as sounding better than  
284 those from single violation conditions, they did not consider Cynghanedd sentences as  
285 sounding better than Double violation sentences. This finding could be interpreted in  
286 one of two ways; 1) the consonantal repetition manipulation was too subtle to influence  
287 participants' explicit judgments, or 2) the 'sound good' decision task implemented in  
288 this study did not depend on the affective qualities of the repeated phonemes. In  
289 addition, the ERP results suggest that appreciation of Cynghanedd depends on a  
290 combination of subtle consonantal repetition *and* stress pattern, rather than consonantal  
291 repetition alone.

292

293 The P3b effect observed here may be considered counter-intuitive, since P3b amplitude  
294 is classically reduced with repeated occurrences of stimuli. Here, the presence of  
295 consonantal repetition patterns in the Cynghanedd condition may have been expected to  
296 reduce the amplitude of the P3b rather than increase it. Thus, the enhanced P3b response  
297 to Cynghanedd appears to indicate a kind of attentional orienting response, specifically  
298 when both the stress pattern and consonantal repetition rules are observed, thus making  
299 this particular sentence a target. This is congruent with recent electrophysiological  
300 evidence showing that lyrical stanzas that contain consistent meter *and* rhyme facilitate  
301 processing compared with those that contain only one, or neither of these patterns  
302 (Obermeier et al., 2016). Another recent study has shown that electrophysiological  
303 responses to poetry can be modulated by prosodic elements (e.g., rhyme) alone (Chen,



304 Zhang, Xu, Scheepers, Yang & Tanenhaus, 2016). Our findings are somewhat  
305 incongruent with this conclusion, since stress pattern alone failed to generate a main  
306 effect on P3b mean amplitudes.

307

308 Recent eye-tracking studies have also shown that literary stylistic features in sentences  
309 increase attentional engagement (see Jacobs, 2015, for a review). Our data crucially  
310 show that this attentional orienting effect occurs as early as 240ms, and is therefore  
311 likely to reflect implicit processing. Recall that participants were unable to overtly  
312 identify the Cynghanedd forms, and we found no correlation between reaction times and  
313 P3b mean amplitudes, contra previous findings (Conroy & Polich, 2007; Ramchurn et  
314 al., 2014; but see McCarthy & Donchin, 1981). Thus, whereas previous studies have  
315 shown that the explicit, aesthetic appreciation of poetry can be linked to implicit  
316 responses (e.g. Jacobs, 2015; Obermeier et al., 2016), the current findings provide the  
317 first tangible evidence that this link is permeable: our participants were able to *implicitly*  
318 detect correct poetic forms, even though they could not *explicitly* differentiate between  
319 conditions (cf. Renault, Signoret, Debrulle, Breton & Bolgert, 1989).

320

321 Furthermore, despite the relatively complex nature of the processes underlying the  
322 decision task, the observed P3b had a latency akin to that typical of simple shape-  
323 matching tasks (Kok, 2001), occurring much earlier than typical responses to linguistic  
324 stimuli (Kutas & Hillyard, 1980). This suggests that spontaneous recognition of poetic  
325 harmony is a fast, sublexical process, and is not strategic nor cognitively effortful.  
326 Finally, our findings show that the brain responds to *combinations* of poetic – or  
327 foregrounding - features at the sublexical (phonological salience) and the lexical (stress  
328 pattern) levels (cf. Jacobs' 2015 4x4 model of neurocognitive poetics). That is, our data  
329 suggest that the interactive effects of poetic features are more potent than that of  
330 features presented in isolation.

331

332 Taken together, our results demonstrate the ability of the human brain to process poetic  
333 forms spontaneously, quickly, and implicitly, in the absence of any formal knowledge  
334 or instruction regarding underlying construction rules. This study shows for the first  
335 time that before we even consider literal meaning, the musical properties of poetry  
336 instinctively speak to the human mind in ways that escape consciousness.

337

338

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343

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## Tables

**Table 1.** Experimental conditions

Sentence	Rule adherence	Condition label
Y geiriau brwd ger y bryn	Consonantal repetition+ Stress pattern+	Cynghanedd
Y geiriau brwd ger y bont	Consonantal repetition– Stress pattern+	Consonantal violation
Y geiriau brwd ger y border	Consonantal repetition+ Stress pattern–	Stress violation
Y geiriau brwd ger y clawdd	Consonantal repetition– Stress pattern–	Double violation

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*English translation: The fervent words near the hill / trees / border / bank*

## Figure legends

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**Figure 1.** Structure of an experiment trial and response required from participants

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**Figure 2.** Online categorization results. **(a)** Sentence categorization performance.

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**(b)** Reaction times.

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**Figure 3** ERP results. P3b mean amplitudes elicited by all four sentence types were computed and compared between 240-340 ms after the onset of the final word (grey box).

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**Figure 4.** Topographic maps of ERP difference waves in the P3b analysis window (240-340ms

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after the onset of the final word). *Cynghanedd* topographies depict differences between Double

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violation and *Cynghanedd* conditions. *Correct stress patterns* topographies depict differences

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between Double violation and Consonantal violation conditions. *Correct consonantal repetition*

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topographies depict differences between Double violation and Stress violation conditions.