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Word Associations in a Minoritised Language: The Case of Cymraeg (Welsh)

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ABSTRACT

As with many research strands in linguistics, word association (WA) literature is dominated by English language data. This paper (i) explores the extent to which methodologies developed to date are applicable to other languages—specifically, Welsh (Cymraeg)—and (ii) investigates what WA analysis can reveal about lexical organisation and retrieval in bilinguals' two languages; its minoritised language context means that Welsh speakers are bilingual with English. Two complementary datasets are used. The first comprises responses to 900 Welsh cues from 85 expert users of Welsh, and forms the basis of the first Welsh language WA norms list. The second is bilingual, comprising responses from 85 Welsh speakers and learners to two lists of 100 cue words, one in Welsh and one in English. Language-specific methodological challenges emerge, including management of mutated word forms, diacritics, and orthographic variation. Decisions relating to these, as the first dataset was converted into a norms list (now informing Welsh language teaching materials), are documented. Language-specific features that facilitate understanding of WA processes, such as grammatical mutation and inflection, are also reported. Bilingual data associations were categorised to obtain 'profiles' for each dataset. Systematic differences between the profiles for each task (Welsh and English) were identified. A pairwise comparison of profiles revealed that while individuals' profiles are distinct from each other, their own profiles are similar across each of their two languages; this closeness is most pronounced in expert users of Welsh.

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Yn debyg i lawer o drywyddau ymchwil mewn ieithyddiaeth, mae'r llenyddiaeth cysylltu geiriau (CG) wedi'i dominyddu gan ddata yn yr iaith Saesneg. Mae'r papur hwn yn (i) archwilio i ba raddau mae'r methodolegau a ddatblygwyd hyd yn hyn yn gymwys ar gyfer ieithoedd eraill—yr iaith Gymraeg yn benodol—a (ii) yn ymchwilio i beth y gall dadansoddi CG ei ddatgelu am drefniadaeth ac adalw geirfaol yn nwy iaith siaradwyr dwyieithog; golyga ei chyd-destun fel iaith leiafrifoledig fod siaradwyr y Gymraeg yn ddwyieithog gyda'r Saesneg. Defnyddir dwy set ddata gyflenwol. Mae'r un gyntaf yn cynnwys ymatebion i 900 o giwiau Cymraeg gan 85 o ddefnyddwyr Cymraeg hyfedr, a dyma sail y rhestr normau CG gyntaf yn y Gymraeg. Mae'r ail un yn ddwyieithog, ac yn cynnwys ymatebion gan 85 o siaradwyr a dysgwyr Cymraeg i ddwy restr o 100 gair ciw, un yn Gymraeg ac un yn Saesneg. Mae heriau methodolegol iaith-benodol yn dod i'r fei, gan gynnwys ymdrin â geiriau wedi'u treiglo, diacritigau ac amrywiadau orgraffyddol. Cofnodir penderfyniadau sy'n ymwneud â'r rhain wrth i'r set ddata gyntaf gael ei throi'n rhestr normau (rhestr sydd erbyn hyn yn hysbysu deunyddiau addysgu Cymraeg). Sonnir hefyd am nodweddion iaith-benodol sy'n hwyluso deall prosesau

CG, fel treigladau a ffurfdroadau. Cafodd cysylltiadau data dwyieithog eu categoreiddio er mwyn dod o hyd i "broffiliau" ar gyfer pob set ddata. Nodwyd gwahaniaethau systematig rhwng y proffiliau ar gyfer pob tasg (Cymraeg a Saesneg). Er bod proffiliau unigolion yn wahanol i'w gilydd, datgelodd cymhariaeth fesul pâr o broffiliau, fod eu proffiliau eu hunain yn debyg ar draws eu dwy iaith; mae'r agosrwydd hwn yn fwyaf amlwg ymhlith defnyddwyr Cymraeg hyfedr.

1 | Background

Since the mid-19th century, word association (WA) data have been scrutinised for insights into the ways in which we store and retrieve words. Researchers have claimed that individuals' spontaneous lexical responses to cue words are influenced by factors including age, cognitive function, personality, and language proficiency (e.g., Dubossarsky et al. 2017; Gollan et al. 2006; Merten and Fischer 1999; Meara 2009, respectively), as well as by experiences, recency of encounter and features of the cue word (e.g., Szalay and Deese 1978; de Bot and Lowie 2010; Nissen and Henriksen 2006). Many findings have been tentative or have not withstood replication, but some relatively consistent data patterns from bilingual respondents and language learners suggest that WA analysis has the potential to tease out new information about interaction and acquisition of languages (Fitzpatrick and Thwaites 2020).

This paper is the first to examine WA in Welsh (Cymraeg), and the first, to our knowledge, focusing on WAs in a minoritised language context. Although findings from WA research have been dominated by English language data[1], there are important exceptions to this. Notably, De Deyne and Storms' *Small World of Words* project currently hosts data from 15 languages (https://smallworldofwords.org/en/project) and has generated analyses of WA in, for example, Chinese (Li et al. 2024) and Slovene (Vintar et al. 2025). These studies, along with others such as Kim (2013) working with Korean and Lakhzoum et al. (2023) with French, have drawn attention to language-specific challenges of preparing WA data for analysis, especially where analytic frameworks have been derived from work with English data sets. The extent to which the network properties observed in WA data are applicable across languages is also unclear; De Deynes and Storms' work with Dutch WA data (2008) indicates that network clusters differ somewhat between languages, bearing out Steyvers and Tenenbaum's caution that small world properties detected in English associative networks may not extend to other languages (2005, 55). Questions around the effects of language-specific features, and indeed of how these manifest in bilingual indigenous communities, are still to be fully examined. This paper helps to address that shortcoming by reporting two studies that focus on WA data in Welsh.

To aid comparisons with other minority languages, it is useful to note some details about the status and use of Welsh. Welsh was made an official language of Wales, alongside English, in 2011. Nevertheless, it remains a minoritised (or minority) language, and is classed as "vulnerable" in the UNESCO endangered languages list. There are no lifelong monolingual speakers of Welsh; Welsh speakers in Wales are bilingual with English. Estimates of the number of people identifying as Welsh speakers vary between 538,300 (17.8% of the population of Wales) in the 2021 UK Census (ONS 2022) and 843,500 (27.4%) in the 2024 Annual Population Survey (Welsh Government 2025). Welsh is a compulsory school subject, and around 23% of children attend Welsh medium schools (Welsh Government 2021). Approximately 17,000 adult learners annually attend Welsh language classes (Learn Welsh 2024). It is compulsory for public communication and signage in Wales to be in both languages, and there are Welsh-language TV and radio stations. Welsh and English are thus closely connected in the linguistic landscape, and are often found quite literally side-by-side.

Specific linguistic features of Welsh will be considered later in this paper; for readers unfamiliar with the language, we outline key elements here. Welsh has seven vowels: five that are shared with English, plus *y* and *w*. The Welsh alphabet contains eight letters not used in English: *ch, dd, ff, ng, ll, ph, rh* and *th*; although represented by digraphs, these are distinct characters. Welsh uses diacritics, in particular the circumflex ˆ to denote, for example, vowel elongation. The letters *j, k, q, v, x* and *z* are not used in Welsh (except occasionally in borrowed words). Welsh has two grammatical genders that can affect the presentation of nouns, adjectives and some numerals. Words in Welsh may undergo *mutation*, meaning that the initial letter of the radical (base) form changes under certain grammatical conditions. There are three systems of mutation; hence, *cath* (cat) may appear as *gath, chath* or *nghath* depending on its grammatical circumstances. The canonical word order in Welsh is verb–subject–object (VSO).

There are four persuasive reasons for investigating WA patterns in Welsh: (i) It enables us to expose unwarranted assumptions that WA patterns in English language data are replicated in other languages. (ii) Minoritised languages are typically ill-resourced. WA data in English has been used (though not without controversy) as an indicator of, for example, cognitive function, consumer perceptions and language proficiency, and as a tool to create language tests. The WA data reported here enables similar routes of exploration in Welsh. (iii) WA responses are known to be influenced by multiple factors, including experience, environment and context, and these can confound findings when comparing data from different languages. Speakers of minoritised languages such as Welsh are bilingual with the majority language. They tend to use both their languages frequently and often within broadly similar environmental, social and transactional spaces. This is often not the case with people whose movement (between countries) has driven their bilingualism; for them, a comparison of associative responses in each language reveals environment-, context- or stage-of-life-related differences (e.g., linked to food, brand names, TV programmes or locations). That these factors are somewhat neutralised in minoritised language contexts

increases the likelihood of identifying associations driven by linguistic factors. (iv) WA research is concerned with the connection between two lexical items (cue and response), and many analytic approaches require the researcher to decide what that connection was in the mind of the respondent. In English, a very weakly inflected language, a single word carries relatively little information about its relationship with other words. Welsh is more strongly inflected, meaning that gender, grammatical relationships, parts of speech, etc., are often marked in individual lexical items. Potentially, then, there is more information available to inform researchers about the connection between cue and response than in a less inflected language such as English.

2 | Key Aims and Research Questions

This paper reports two connected studies. The aim of Study One was to extend the capacity of WA research by creating a Welsh language WA norms list, and in doing so, to systematically identify language-specific features that impact data processing. This aim was addressed using the *Cymraeg–900 Word Association Data*, a monolingual dataset consisting of associations to approximately 900 frequently-used Welsh words.[2] Study One focused on the following research question:

1. What language-specific challenges arise when processing Welsh WA data (to create a norms list), and how can these be addressed?

Through addressing that question, principles were established for the consistent processing of Welsh WA data. These were then applied in Study Two, which aimed first to understand the impact on WA analysis/categorisation of features specific to Welsh, and second to pursue new insights into the ways in which lexical items are stored and retrieved in bilingual contexts. Study Two used WA data from Welsh–English bilinguals and learners in both their languages—the *Cymraeg–English–100 Word Associations*—in order to address four further research questions:

2. Are there language features specific to Welsh that can impact the analysis/categorisation of WAs?
3. Are there language-specific features that influence the type of WA responses given?
4. Are individual bilinguals' WA profiles consistent across both their languages?
5. What can WA analysis reveal about the developing L2 lexicon?

The research reported here encompasses methodologies from the two principal approaches to analysing WA data: the norms list approach and the categorisation approach. The first approach compiles group data into norms lists, which rank participants' responses to each cue from those given most often to those given least often. A very common response (such as *cold* to the cue *hot*) may be given by over 50% of respondents, but a long tail of unique responses is also typical of these data. Patterns of closely connected words can emerge from these norm lists, and they also provide group reference data against which an individual's WA responses can be measured for stereotypy. Study One entailed the creation of a Welsh language norms list.

The second approach requires the researcher to categorise the connection between cue and response. Taxonomies of connection types range from two or three categories (e.g., Ervin 1961) to 17 or more (e.g., Fitzpatrick 2006), but most use some form(s) of paradigmatic, or meaning-based, category (typically where cue and response share a grammatical class and are conceptually related) and some form(s) of syntagmatic, or position-based, category (where cue and response are found close together in natural discourse). The resulting tally of responses in each category is sometimes conceptualised as a *response profile* for each (individual or group) dataset. This approach was used in Study Two, which entailed categorisation of WA responses in Welsh and in English from bilingual speakers and language learners. The categorisation framework used here (see Appendix) was developed by Fitzpatrick et al. (2015).

The sets of WA data used in this paper can be accessed at https://mental-lexicon.swansea.ac.uk/.

3 | Study One: Creation of the *Cymraeg-900* WA Norms

The aim of Study One was to create a set of Welsh language WA norms, and in doing so, to identify and address methodological challenges specific to Welsh language data. The study used the *Cymraeg–900* dataset, comprising 900 cue words,[3] with three responses to each from approximately 85 participants.[4]

3.1 | Method (Study One)

The *Cymraeg-900* data were originally collected as part of a project to create a pedagogical word list at the CEFR B1 level (https://www.coe.int/en/web/common-european-framework-reference-languages). Below, we report details of the data collection and of the processing of data for this study.

3.1.1 | Cue Words

The cue words used in this study were extracted from A1 and A2 (CEFR) core vocabulary lists (see Morris 2011). For the creation of a B1 list, the WA method was considered fitting; evidence from previous studies indicated that WA would elicit a high proportion of response words that collocate with, are similar in meaning to, or form lexical sets or conceptual links with, the A1 and A2 cues that B1 learners already knew (see, e.g., Fitzpatrick 2007), thus growing their vocabulary in a systematic way. The resulting set of WA responses was edited and curated to create a B1 core vocabulary list.[5]

The A1 and A2 lists from which the cues were extracted comprised 768 and 538 words, respectively. After function words, English borrowings and multi-word items were removed, 895 words remained, comprising nouns ($n = 590$), verbs ($n = 169$), adjectives ($n = 126$) and adverbs ($n = 10$). Mean word length was 5.76 letters

(SD = 1.87). The words were randomly distributed into 30 sets of ~30 cues in order to be presented to participants in manageable chunks.

The list of cue words can be found at https://mental-lexicon.swansea.ac.uk/cymraeg-data-and-norms/.

3.1.2 | Participants and Task Administration

Eighty-five participants were recruited for the WA task. They were all fluent adult users of Welsh; approaches to recruitment meant that many were Welsh language tutors. To ensure coverage of different dialects/varieties of Welsh, they were required to indicate the region of Wales they identified with, and whether they were L1 or fluent L2 "new speakers" of the language.

Every 3–4 days, participants were emailed a link to an online form where they were instructed to enter three responses—the first words that came to mind—to each of 30 cue words. After 4 months, participants had responded to 30 sets of cues. The resulting database of approximately 190,000 responses to 895 cues was used for Study One.

3.1.3 | Processing the Data

The dataset required an extensive cleaning process, which was conducted as follows:

- The original .txt data files were converted into a single Excel file.
- For each cue, the responses were organised according to frequency of occurrence in the data, and the number of occurrences of each response was noted.
- Responses given only once to a particular cue were extracted and moved to a separate list (see the tab "$n = 1$" in the Dataset.xlsx file at https://mental-lexicon.swansea.ac.uk/cymraeg-data-and-norms/).
- All other responses ($n > 1$) were subjected to a manual spellchecking process whereby the research team corrected and normalised the spelling throughout the dataset according to criteria set out in the following section; 24,349 corrections were made.
- All responses ($n > 1$) were then organised into a norms list. The norms can be found at https://mental-lexicon.swansea.ac.uk/cymraeg-data-and-norms/ as an interactive image, a list and a downloadable file, including, for each response, the number of occurrences both as a raw count and as a percentage of total responses to that cue.
- Finally, a list of "hub words" was extracted from the data. These are words that are given as a response to many different cues, and are thought to be important to the growth and organisation of the mental lexicon (Steyvers and Tenenbaum 2005; De Deyne and Storms 2015, 477). The webpages referenced above present a list of all responses organised by "Count of Response" (the number of times in the dataset this word was given as a response, i.e., tokens) and "Count of Cue" (the number of different cues to which this word was given as a response, i.e., types).

The processing decisions necessitated during the stages listed above are reported in the following section, directly addressing our first research question.

3.2 | Results: What Methodological Challenges Arise When Processing Welsh WA Data (to Create a Norms List), and How Can These be Addressed? (RQ1)

All approaches to WA data entail processing challenges and principled decision-making. Fitzpatrick et al. (2015) outline the management of English WA data across a range of studies. Processing the Welsh language data for this study exposed language-specific challenges that have not been encountered in English-focused research, and which, to our knowledge, have not been systematically documented in WA studies of other languages. Below, we set out those challenges and the methodological decisions made to address them.

3.2.1 | Orthographic Standardisation

All WA datasets we have worked with have contained misspellings and, in electronically collected data, typos. This Welsh language dataset was no exception. Our approach to cleaning the data followed Fitzpatrick et al. (2015, 31); we corrected spellings wherever the intended word was unambiguous.

To ensure consistency and to avoid the separate listings of responses with small orthographic variations, responses were given a standardised orthography and punctuation (following Ifans 2006; Lewis and Lewis 2016). Standardisation of punctuation included hyphenation to indicate stress, for example, in *pen-blwydd* (birthday) and *di-waith* (unemployed). Proper nouns were all given capital initials. Standardisation of orthography included inclusion of final *-f* in words like *tre(f)* (town) and *nesa(f)* (next); the plural affix *-au* (*pethe/petha>pethau*) (things); and initial *y-* in, for example, *stafell>ystafell* (room) and *sgrifennu>ysgrifennu* (to write). While orthography of responses requires attention in most WA data, the deep-rooted dialectic differences in minoritised languages, and histories including periods where the written language was suppressed, often manifest in a high number of orthographic variations.

3.2.2 | Diacritics

Many words in Welsh are differentiated in meaning by diacritics (typically the circumflex), for example:

ffon (stick)	*ffôn* (telephone)
gem (jewel)	*gêm* (game)

The following (accurately rendered) sample responses illustrate how diacritics, along with capitalisation and grammatical mutation, are essential to minimise ambiguity:

gŵyr	3rd person sing. present tense of *gwybod* (to know) OR mutated form of *cwyr* (wax)
gwŷr	plural of *gŵr*—husband
Gŵyr	Gower
ŵyr	grandson OR *gŵyr* mutated
wŷr	*gwŷr* mutated

The dataset revealed inconsistency in the inclusion of the circumflex; this is not unusual when typing Welsh on an English-language keyboard. Whereas in discursive text the context enables differentiation between these meanings even where diacritic/capitalisation/mutation is omitted, in single WA responses, differentiation is problematic. Given that leaving responses as they were would likely lead to norms lists including unintended items, the approach taken was to manually check each one and decide which response was most likely to be intended. If a clear distinction could not be made, responses were left as they were.

3.2.3 | Homonymy

WA data provide no contextual evidence to help disambiguate word forms with multiple meanings. In Welsh, this is compounded by mutations; while the radical form of a word may have a distinct orthographic form, its mutated form may be homonymous with another word. Examples of ambiguous (homonymous) responses in our data, with their possible meanings, include

de	south	or	right
lonydd	plural of *lôn* (lane)	or	mutated form of *llonydd* (still)
lo	mutated form of *llo* (calf)	or	mutated form of *glo* (coal)

In our data, responses were recorded as they were given, with any inherent homonymy retained.

3.2.4 | Mutated Word Forms

Mutations in Welsh present methodological challenges, as indicated above. If a cue produces responses which are the same lexical item but sometimes in the radical and sometimes in the mutated form, should these be treated as separate responses or amalgamated/lemmatised into one? For example, adjectives undergo soft mutation when following feminine singular nouns. *Draig* (dragon) is a singular feminine noun, so a following adjective would mutate; *coch* (red) would combine with *draig* to give *draig goch*. The processing decision made here was to retain both mutated and non-mutated responses, because the existence (or not) of a mutation in a response might tell us something about the strength or kind of relationship between it and the cue. For example, both *goch* and *coch* were given as responses to *draig* in our data (25% and 11% of responses, respectively). This might suggest that some participants *(draig + goch)* were making a collocational association (the red dragon has a particular cultural meaning in the context of Welsh, referring not only to the heraldic red dragon on the national flag but also, symbolically, to Wales itself[6]), while others *(draig + coch)* made a looser connection, linked to a visual imagining of a dragon. Listing the mutated and non-mutated responses separately supports the investigation of associations through categorisation; we discuss further the impacts of mutation on categorisation analysis in Section 4.

3.2.5 | The *Yn* Particle

Welsh has a predicative particle *yn*, which is used before nouns and adjectives, is untranslatable into English, and is always followed by a mutation. It is also the way in which adjectives are changed into adverbs:

Mae'r car yn goch	(Lit. Is + the + car + *yn* + red)	The car is red
Aeth y car yn gyflym	(Lit. Went + the + car + *yn* + quick)	The car went quickly

Some WA responses included this predicative particle. Others retained the mutation of the initial consonant but not the predicative *yn*, and sometimes the initial consonant is left without a mutation. The response *cynnar* (early) to the cue *codi* (to get up) therefore appeared in the dataset in three different forms: *yn gynnar*; *gynnar*; *cynnar*. In order to minimise multi-word entries, *yn gynnar* and *gynnar* responses were amalgamated as *gynnar* in our lists.

3.2.6 | Summary of Methodological Challenges and Decisions

The principal systematic change that we made to responses was in the standardisation of orthography, including diacritics. Methodological decisions were guided by the principle of preserving response forms given; no lemmatisation was imposed and lexical dialect variants were retained. Features of Welsh including the mutation system and use of diacritics, together with relatively strong dialectic markers, confront the researcher with challenges. However, as seen in Study Two, these features can also aid the researcher, as they carry information about grammatical and semantic construal that indicate the intention behind a response.

4 | Study Two: Analysis of a Bilingual Word Association Dataset

In Study Two, the data cleaning processes established above were applied to a new dataset, the *Cymraeg–English–100*, which comprised WA responses from Welsh-English bilinguals/learners in both their languages. The main aim of this study was to

compare patterns of associations in both languages, first in terms of general language-specific features (i.e., comparing WAs in Welsh with WAs in English), and then in terms of individual bilinguals' lexicons (how similar is a bilingual's Welsh WA profile to their English WA profile?). WA patterns/profiles were generated by categorising the data into response types. That categorisation process addressed a further aim: to determine how specific Welsh language features might facilitate accurate categorisation of responses.

4.1 | Method (Study Two)

Below, we report details of the data collection, data processing, and data analysis (categorisation) methods applied in Study Two.

4.1.1 | Cue Words

Two lists of 100 cue words were created, one in Welsh and one in English. The source of the cue words was the Academic Word List (AWL, Coxhead 2000), an English language resource compiled from a corpus of academic texts. Word families represented in the AWL occur disproportionately more frequently in academic than in general texts, and are divided into 10 frequency-ranked sub-lists. Using the AWL enabled us to select cues of mid-frequency and relatively low imageability, that is, words which, according to Meara (1982), are likely to elicit less predictable responses than highly frequent, imageable cues. One of our aims in this study was to investigate individual lexicons, and strongly predictable responses (such as *white* to the cue *black*) can mask individual differences.

Two sets of 100 words were selected from the AWL sub-lists 1–4. Selection was random, but the sets were matched for frequency and word class; each contained 40 verbs, 40 nouns, 15 adjectives and 5 adverbs.[7] In the absence of a Welsh language equivalent to the AWL, one set was then translated into Welsh. Mean word lengths in the resulting lists were 7.7 (SD 2.18) for the English list and 7.6 (SD 2.25) for the Welsh. The sets of cue words can be found at https://mental-lexicon.swansea.ac.uk/bilingual-welsh-english/.

4.1.2 | Participants and Task Administration

The *Cymraeg–English–100* WA responses were provided by 85 participants (different participants from Study One) who self-identified as speakers of both Welsh and English. Participants indicated whether they were L1 speakers of Welsh, which in this context equates to balanced Welsh–English bilinguals (n = 36), or L2 speakers of Welsh (n = 49). Those identifying as L2 speakers of Welsh self-defined their proficiency according to CEFR descriptors.

Data were collected on paper. Participants were given the lists of cue words and instructed to write the first word that they thought of in association with each cue. They completed the Welsh language task first, then were given a distraction task, and finally completed the English language task. The entire session took approximately 30 min.

TABLE 1 | Respondents' Welsh Language Proficiency Profiles.

Welsh language proficiency (CEFR level)	Original *n*	*n* after exclusions from analysis
L1 (first language)	36	36
C2	11	9
C1	14	13
B2	6	5
B1	13	6
A2	1	1
A1	2	2
No response	2	0
Total	85	72

Thirteen sets of data were excluded from further analysis, either because information about Welsh language status/proficiency was missing, or because they included 30 or more "blank" responses in the English or Welsh data; the data were to be used to create response type profiles, and at least 70 responses were considered necessary for profiles to be broadly reliable. The resulting dataset used for analysis comprised responses in both languages from 72 participants; their Welsh language levels are summarised in Table 1.

4.1.3 | Processing the Data

The Welsh language data were cleaned using the process established in Study One. The English language data preparation followed the process set out in Fitzpatrick et al. (2015).

4.1.4 | Response Categorisation

The data were then categorised according to the taxonomy presented in Fitzpatrick et al. (2015) (see Appendix). The Fitzpatrick categorisation framework has been tested across a range of studies (including Cremer et al. 2010; Eguchi et al. 2022; Fitzpatrick 2006; Fitzpatrick 2007; Fitzpatrick and Izura 2011), and its fine-grained approach generates rich profile data. The categorisation process was supported by the WADP software (Word Association Data Processor, Buerki 2025). WADP semi-automates coding by creating a database of users' manual categorisation decisions and applying these to further instances of the same cue-response pairs. As well as improving the speed of analysis, WADP ensures within-rater coding consistency. Its *reporter* module generates an inter-rater agreement report. In this study, two independent raters achieved an initial inter-rater agreement of 76% and full agreement following discussion.

As noted above, the majority of WA research has worked with English language data (see also Hippolyte et al. 2025). While this facilitates replication and comparisons, it can also lead to false assumptions and missed opportunities; some languages may reveal more than others in a single word response. With this in mind, during the categorisation process, we were able to address

our question (RQ2) about language-specific features that may impact the analysis/categorisation of WAs.

4.2 | Results

The results from Study Two, as they relate to our research questions 2, 3, 4, and 5, are set out below.

4.2.1 | Are There Language Features Specific to Welsh That Can Impact the Analysis/Categorisation of WAs? (RQ2)

In categorising WA data, the researcher attempts to understand the spontaneous process by which the respondent connected the cue and the response. The decontextualised nature of the task means that this must be gleaned from a single word. Languages encode meaning in different ways; English relies heavily on word order to denote syntactic relations, whereas other languages, including Welsh, encode some syntactic information within a lexical item. Three structural features of Welsh, grammatical class, mutated word forms and grammatical markers, were identified as impacting categorisation analysis, as reported below. We also note a further consideration that is pertinent to Welsh (and other minoritised languages) data: the interplay between dominant and minoritised languages.

4.2.1.1 | Grammatical Class. The grammatical class of cue and response is central to most WA categorisation frameworks. Osgood proposed that 'the highest associative strength will be between words of the same form class' (1954, 116), and a criterion of paradigmatic responses is that they are in the same grammatical class as the cue (e.g., Ervin 1961). Many studies select cue words according to grammatical class (e.g., Cremer et al. 2010; Fitzpatrick and Floccia 2024) or analyse responses according to the grammatical class of the cue (e.g., Nissen and Henriksen 2006).

In studies focusing on English, attention to grammatical class can be problematic. The grammatical class of a single word can be ambiguous, with the same orthographic form often used for nouns and verbs (e.g., *research*). In Welsh, the presence of an affix (sometimes coupled with vowel affection) typically denotes a verb. *Ymchwil* corresponds to the English noun 'research' but *ymchwilio* is unmistakably a verbal form. This grammatical marking in Welsh language data reduces ambiguity and aids accuracy in analyses dependent on word class.

4.2.1.2 | Mutated Word Forms. The system of mutations in Welsh necessitates careful decision-making when processing data, as noted in Study One.

However, there are instances where mutations can be helpful in WA analysis. In a similar way to the example of *draig coch/goch* noted above, the cue *cymuned* (community) in our data elicited the response *clòs* (close) in both its radical form and its mutated form, *glòs*. This difference likely reflects the way participants perceive the link between the cue and response. *Cymuned glòs* suggests the concept of a 'close-knit community', with the mutated response indicating a collocative relationship with the cue. The response *clòs* suggests a looser, conceptual, connection. In frameworks that include 'collocation' as a distinct category, such as the one used here, the researcher can be confident that a mutated response fits that category.

Nouns which follow feminine singular nouns, adding a descriptive element, are also required to mutate. The cue *adran* (department) is a feminine noun. When combined with *cyllid* (finance), *adran gyllid* equates to 'finance department/section' (of an organisation); the mutation *cyllid*>*gyllid* indicates a 'collocation'. The response *cyllid* to the cue *adran* can be viewed as a looser association (e.g., imagining departments in an organisation makes me think of finance/budgets), and categorised as 'other conceptual' in our taxonomy.

The default position of the adjective in Welsh is after a noun. However, it is worth noting that some adjectives, for example, *unig* (only/lonely), can either follow or precede a noun, with the placement conveying different meanings. When an adjective precedes a noun, that noun always mutates. So, the response *plentyn* (child) to *unig* suggests a lonely child (*plentyn unig*) whereas the response *blentyn* (the mutated form of *plentyn*) suggests an only child (*unig blentyn*). The former can confidently be categorised as a 'response-cue collocation' (where the response precedes the cue in discursive use) and the latter a 'cue-response collocation'.

The presence or absence of a mutation, then, can convey useful information about the relationship between a cue and a response.

4.2.1.3 | Grammatical Markers. Simple repetition of a cue is typically classed as an 'erratic' response, and that was the decision made in this study. However, in the Welsh language data, a response occasionally repeated the cue, but preceded it with the predicative *yn*. For example, the cue *cyson* (consistent) produced the response *yn gyson*, which equates to the adverb 'consistently'. Adding *yn* in this example changed the cue adjective into a response adverb in the same way as the addition of -ly in English turns consistent into an adverb; consistent>consistently would be classed as an 'affix change' response in Fitzpatrick's framework. Similarly, the cue *cynnwys* (to contain/include) produced the response *gan* (a preposition meaning by/with); *gan gynnwys* means 'including'. Again, in English data include>including would be categorised as 'affix change'. While *yn* and *gan* in these Welsh examples have the same function as an affix in English, the result is a two-word unit, and because of this, we categorised it here as a collocation.

The different application of word boundaries in Welsh, though, encourages us to revisit Fitzpatrick's 'affix change' category, to consider creating further subcategories, or to broaden the definition, for example into 'grammatical markers' (see Wray 2002, 263). Our analyses here sought to fit Welsh language responses into the existing category system. However, the observations above encourage a critical review of categorisation frameworks regarding their capacity to accommodate multiple languages and their structures.

4.2.1.4 | Interplay of Minoritised and Dominant Languages. Fitzpatrick et al. (2015, 41)'s taxonomy of response

categories includes 'two-step associations', whereby 'cue and response appear linked only through another word'. In a monolingual context, the cue, response and connector will be in the same language (e.g., *owe>mine*, via *own*). Our Welsh language data suggest that in a bilingual context where all speakers of the target (minoritised) language are also speakers of the dominant language, a different kind of multi-step associative process can occur, whereby the cue and response are linked through an association with the dominant language translation of the cue. For example, the cue *cyfrol* is translated by the English 'volume', but solely in the sense of a published volume of work (i.e., a book). However, the English word 'volume' may also refer to a liquid measurement. The response *dŵr* (water) was given by many participants in response to *cyfrol* and can be explained thus: *cyfrol* activates the word 'volume', which activates meanings including 'volume of liquid', which activates *dŵr*. As with the English examples, we categorised these as 'two-step associations', but note that the linking step is not necessarily from the same language as the cue (see also Fitzpatrick and Izura (2011)'s proposal that L2 associations are mediated through L1 translation equivalents in low-proficiency language learners). The multiple instances of language interaction in our data from Welsh bilinguals may be attributed to the habitual activation and synchronisation of two languages. This also might explain the few cases where the response was a translation (into the dominant language) of the cue. Those were categorised as erratic in our study, but there is a case for categorising them separately, or as synonyms, depending on the research focus.

4.2.1.5 | Summary: The Universality of Categorisation Frameworks. Kim (2013), analysing WA in Korean, found that analytic frameworks originally devised for English did not accommodate some elements of Korean language structure. In her study, she adapts and augments Fitzpatrick (2006)'s categorisation framework to address this. Like Kim with Korean, we found that some features of Welsh data were difficult to map onto Fitzpatrick's categorisation system. The parameters of the 'affix change' category in particular might be reviewed in order to accommodate lexical adverbial markers, and the introduction of a 'translation' category might be considered when analysing data from bilingual participants.

4.2.2 | Are There Language Features Specific to Welsh That Influence the Type of WA Responses Given? (RQ3)

The *Cymraeg–English–100* data, comprising responses from the same participants to cues in both Welsh and English, enables us to investigate our third research question, that is, whether features inherent to a language might increase/decrease the likelihood of responses being given in certain categories. Having categorised the data as described above, we compared the percentage of responses in each category for each language to identify any significant language-specific differences (see Table 2; categories with fewer than three responses are omitted).

A Wilcoxon signed rank test found a significant difference ($p < 0.001$), with a medium or large effect size, for seven categories as indicated in the right-hand column of Table 2. Some of these can be predicted from the language differences we have noted in previous sections:

- Affix change: the greater distinction between verb and noun forms in Welsh may lead to a greater number of affix-related responses.
- Two-step association: the phenomenon whereby some Welsh responses are mediated through an English association may lead to a greater number of two-step associations in Welsh.

For other categories, possible contributors to the differences may include:

- Synonym: English includes more loan words than Welsh, and there is more likely to be semantic overlap between them.
- Lexical set: Some participants had learned Welsh as a second language, and teaching methods tend to group vocabulary items in lexical sets.

Differences in the four collocation-related categories may be associated with word order (Welsh word order is VSO, and adjectives typically follow nouns), but we note that numbers in those categories are very small.

This analysis serves as a caution that differences found in the WA patterns in bilinguals' two languages cannot be straightforwardly attributed to the different organisation of two languages in individuals' mental lexicons; structural differences inherent to those languages are also a likely causal factor.

4.2.3 | Are Individual Bilinguals' WA Profiles Consistent Across Both Their Languages? (RQ4)

Our fourth research question addressed the hypothesis that individual bilinguals' WA profiles are consistent across their languages (despite differing between individuals). Categorising the Study Two data as outlined above enabled us to create and compare individuals' WA profiles in both of their languages. Fitzpatrick (2007), comparing profiles of L1 English speakers on two different WA tasks one week apart, found that within-subject profiles were significantly closer to each other than between-subject profiles. In other words, while individuals' profiles differ from each other, they demonstrate consistency in their own response profiles. A small-scale study of L1 and L2 WA profiles has hinted that this individual consistency may hold true across participants' two languages (Fitzpatrick 2009).

Two examples of participant profiles generated in this study can be seen in Figure 1. These examples have been selected because they illustrate clearly (i) the differences between the two individuals' profiles and (ii) the similarities between each participant's own English and Welsh profiles.

Statistical analysis was conducted to test the hypothesis that there would be more similarity between participants' own two profiles (Welsh and English) than between their profile in Welsh and all the other participants' English profiles. Because we were comparing profiles (rather than single scores), we used a Euclidean distance measure of proximity.[8] The proximity measure between each set of responses and every other set of responses (i.e., the English and Welsh responses of each of the 72 participants) was entered into a 144 × 144 matrix. From

TABLE 2 | Percentage responses in each category (see Appendix for detailed category descriptors).

	Welsh		English		*W*	*p*
Category	**Mean**	**SE**	**Mean**	**SE**		
Synonym	7.19	0.48	19.09	1.07	2538.5	<0.001
Synonym in wider sense	13.80	0.68	15.16	0.72	1521	= 0.034
Lexical set	5.34	0.36	2.18	0.22	43.5	<0.001
Other conceptual (OC) association	33.29	1.32	32.29	1.27	1067.5	= 0.307
Cue–response (CR) collocation	17.67	1.22	16.32	1.01	1063	= 0.295
Response–cue (RC) collocation	4.53	0.31	5.04	0.35	1249	= 0.249
Affix change	5.02	0.5	1.92	0.34	79.5	<0.001
Erratic	3.03	0.51	1.28	0.15	290.5	<0.001
Similar in form only	0.69	0.18	0.49	0.09	245.5	= 0.367
Two-step association	2.24	0.17	0.89	0.1	134.5	<0.001
OC + CR	3.64	0.23	1.98	0.18	336.5	<0.001
OC + RC	0.54	0.11	2.54	0.21	1874	<0.001

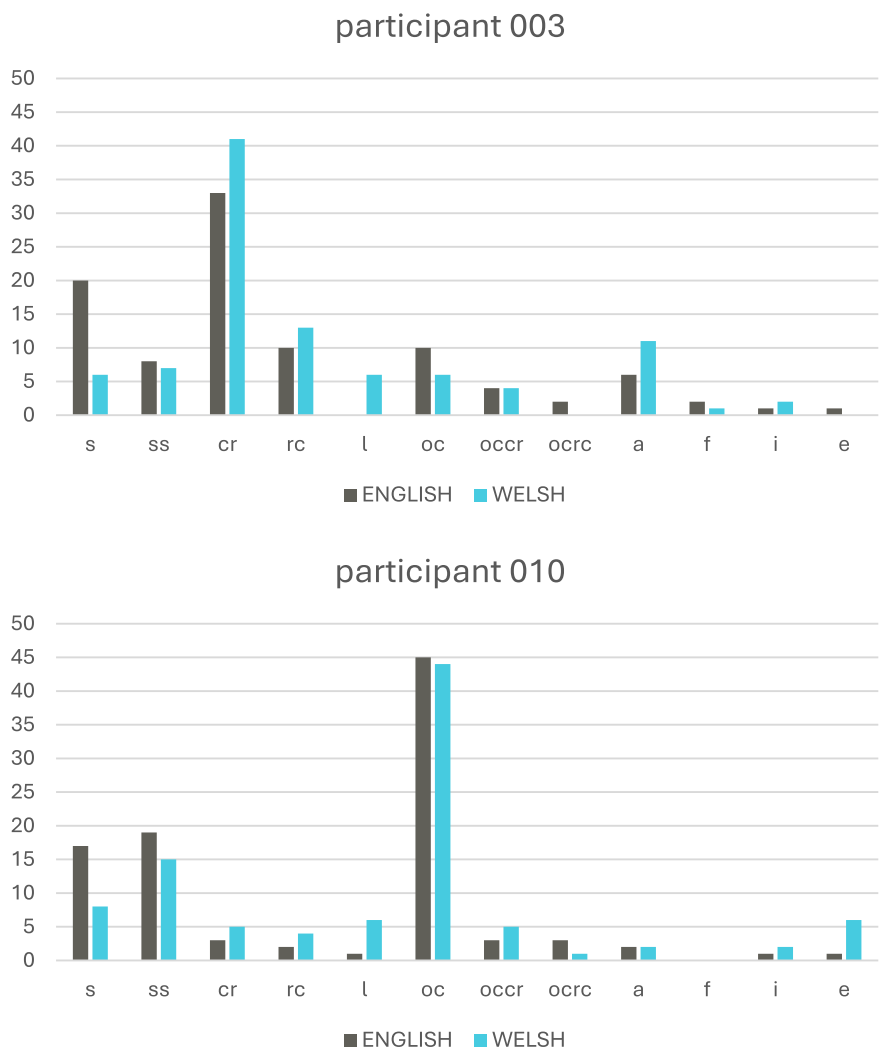

FIGURE 1 | Sample English and Welsh WA profiles. Category key: s = synonym; ss = partial synonym; cr = cue-response collocation; rc = response-cue collocation; l = lexical set; oc = other conceptual link; occr = oc+cr; ocrc = oc+rc; a = affix change; f = similar in form only; i = two-step link; e = erratic (see Appendix). [Color figure can be viewed at wileyonlinelibrary.com]

TABLE 3 | Distance values of data pairs (higher score = greater distance).

	Between-subject	Within-subject
N	5041	72
Median	25.768	19.215
Mean	27.231	20.592
SD	10.036	7.455
MAD	6.543	4.530

TABLE 4 | Within-subject distance values between Welsh and English profiles of expert users and learners of Welsh (higher score = greater distance).

	Expert users	Learners
n	45	27
Median	17.776	24.413
Mean	18.611	23.895
Std. deviation	5.984	8.546
MAD	3.607	6.030

the matrix, we extracted the 72 within-subject proximity scores; these denoted, for each participant, the distance between their Welsh WA profile and their own English WA profile. We then extracted 5041 between-subject proximity scores, that is, the distance between each participant's Welsh profile and every other participant's English profile. We compared the mean within-subject distance score with the mean between-subject distance score. Because the number of data points was unequal (72 and 5041), a Mann–Whitney U test was used, and descriptive statistics (Table 3) include median and MAD scores.

The difference in between-subject and within-subject values was significant ($U = 255881$; $p < 0.001$) with a medium effect size ($rB = 0.41$); within-subject proximities were significantly closer than between-subject. In other words, although individual bilinguals' WA profiles differ from each other, they are somewhat consistent across their two languages.

4.2.4 | What Can WA Analysis Reveal About the Developing L2 Lexicon? (RQ5)

Because the Study Two participants included both expert users and language learners, it was possible to test the between-language profile consistency for individuals at different points on the bilingual continuum (Lovell 2011). So, having established that participants' WA profiles in Welsh were more similar to their own English profiles than to those of others, we then explored whether this is equally the case for expert users of Welsh and for those identifying as learners. Our 72 participants were split into two groups: 45 who identified as L1 Welsh or highly proficient (CEFR C2+) and 27 who identified as having a proficiency level below C2 (see Table 1). Table 4 shows within-subject distance values for the two groups.

A Mann–Whitney U test was conducted (following a Brown–Forsythe test significant at $p < 0.05$). It revealed a significant different between the two groups ($U = 207$, $p < 0.01$), with a modest effect size ($rB = -0.365$). This indicates that within-subject proximities of expert users of Welsh are moderately but significantly closer than within-subject proximities of learners. One possible explanation for this is that as learners become more proficient, their L2 WA profile becomes more similar to their L1 profile; a longitudinal study could explore this hypothesis further.

5 | General Discussion: Implications and Applications

Key outcomes from the studies reported above can be summarised as follows:

- A Welsh WA norms list for 895 core vocabulary items was created (available at https://mental-lexicon.swansea.ac.uk/cymraeg-data-and-norms/).
- Processing Welsh WA data in preparation for a norms list or for further analysis necessitates standardisation of orthography, and attention to the mutation system and diacritics.
- Preservation of word forms, including mutations and diacritics, in responses is helpful to the categorisation/analysis of Welsh WA data; inflected forms carry valuable information about the causal relationship between cue and response.
- Systematic differences are found between WA responses in the Welsh and English data: the Welsh data contain significantly
  - more instances of the response using the stem of the cue and adding, removing or changing an affix;
  - more instances of 'two-step' association whereby the cue and response are linked by an 'invisible' mediating item;
  - more responses in the same lexical set as the cue;
  - fewer synonymous responses.
- Individual bilinguals' WA profiles differ from each other but are consistent across their two languages.
- This consistency is more pronounced in expert users of Welsh than in learners.

These findings have implications both for the methodologies employed in WA research and for our understanding of the bilingual lexicon, particularly in the case of minoritised language + dominant language bilinguals. We have found that features of a language can impact WA responses and should be accounted for when comparing WA data from different languages. Language features also make different demands on the preparation of data for analysis; in Welsh, features such as diacritics, mutations and orthographic variation necessitate informed decision-making. Documentation of these will inform methods for WA research in Welsh and in (and beyond) other Celtic languages that share similar features.

The WA literature has given much attention to categorisation frameworks; the Fitzpatrick framework used here has undergone multiple adaptations (e.g. Fitzpatrick 2006; Fitzpatrick and Izura 2011; Fitzpatrick et al. 2015) to maximise its effectiveness. However, its focus has almost exclusively been on English

language data; our analysis of the Welsh language data here has demonstrated that WA tasks in languages other than English generate data that even a framework with 17 categories (i.e., the one used here, from Fitzpatrick et al. 2015) struggles to accommodate. This encourages us to consider the feasibility and potential value of designing a categorisation framework that accommodates multiple languages.

The resources and findings reported here can further our understanding of the distinct psycholinguistic and sociolinguistic contexts of minoritised languages. As is the case in many minoritised language contexts, bilingual Welsh–English speakers will not all have acquired their languages at the same stage of life, or through the same routes. The extent to which their Welsh is used on a daily basis is likely to have varied through life stages, for example, through periods living outside Wales or with non-Welsh speakers. These differences are apparent in some of the WA responses in our data. For example, in the *Cymraeg–900* data, the response *ysgol* (school) to the cue *cloch* (bell) represented 19% of responses, but these items were unlikely to have a strong connection for those who acquired Welsh as adults, or who attended English medium schools. While it is not uncommon for WA responses to be driven by experiences and memories, the particular bilingual circumstance of Welsh may reflect deeper demographic divisions between lexical connections. Study One has generated the creation of the first comprehensive WA norms list for Welsh (https://mental-lexicon.swansea.ac.uk/cymraeg-data-and-norms/), extending resource capacity for both pedagogy and research. Learners can access these lists to find which words have a close association with a specific cue, and thus expand their lexical networks, building connections with the A1 and A2 cues, and informing vocabulary acquisition beyond A2. Vocabulary activities and games using the norms list are already being developed (e.g.https://linci.cymru), and lists of collocation responses and of hub words (responses with strong connections to multiple cues) are informing the Learn Welsh curriculum. The norms list enables researchers to analyse lexical features of responses and hub words and provides a benchmark to investigate, for example, lexical networks of specific demographic groups, the influence of English, and language-related idiosyncrasies that may reveal more about the psycholinguistic manifestation of language structures and the richness of word connections. This last, in the case of minoritised languages, may be relatable to language vitality.

Finally, our analysis of the *Cymraeg–English–100* data in Study Two challenges previously held notions of 'native speaker norms' to which learners 'should' aspire. Rather, it suggests that lexical acquisition and organisation follow individual trajectories, and that an individual's developing L2 network will be shaped to mimic that of their own L1 rather than a generic model. This has implications for the learning and teaching of languages in general, and for our understanding of second language acquisition processes.

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Data Availability Statement

Data reported here are available at https://mental-lexicon.swansea.ac.uk/.

Peer Review

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Ethics Statement

Data collection, processing and storage methods were approved by the Swansea University COAH Research Ethics Committee.

Endnotes

[1] To give an approximate sense of language representation in WA research: a Linguistics and Language Behaviour Abstracts database search for [noft("word association*") AND noft(*language*)], with *language* replaced by each of the top 20 most spoken languages (Ethnologue 2025) in turn, returned 683 hits for 'English'. The other 19 languages returned 264 hits in total (mean 13.9, minimum 0, maximum 55).

[2] A note about word frequency measures in Welsh: Until recently, estimates of word frequency were impeded by a lack of comprehensive Welsh language corpora. Resources such as corcencc.org (Knight et al. 2020) and van Heuven et al. (2023) are now helping to address this. However, as discussed in Knight et al. (2023), the use of raw frequency measures, especially in languages with mutations and complex word families, necessitates careful contextual and methodological reflection, and can fail to reflect users' word knowledge and word use. Therefore, the studies reported here have focused on words likely to be well-known and often used by Welsh speakers (Study One), and words that are less often used and therefore likely to produce a range of responses (Study Two). As noted below, A1 and A2 pedagogical wordlists (Study One) and translations of Academic Word list items (Study Two) were used in the generation of the respective cue word lists.

[3] Five cue words were removed because of duplication, so the eventual norms list contained 895 cues.

[4] Some participants did not give three responses to every cue.

[5] 757 items were selected at that time for the B1 core vocabulary list. The B1 list at Morris et al. (2019) is an updated version of the original set.

[6] In the legend of king Gwrtheyrn and Myrddin, two dragons, one red (symbolising the Welsh) and one white (the Saxons), fought a battle which, ultimately, the red dragon won.

[7] Although the distribution of word classes here is an approximate reflection of items in the AWL, we note that often in English and occasionally in Welsh, items in isolation can fit more than one word class.

[8] The Euclidean distance between two profiles is calculated by squaring the differences between each component of the two profiles (in our case, the category scores), and then taking the square root of the sum of those squares.

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Appendix: WA categories (from Fitzpatrick et al. 2015).

Category	Definition	Example (English)	Example (Welsh)
Synonym (S)	Cue and response are synonymous in some situations	*delay* > *impede*	*anaf* > *clwyf*
Synonym in wider sense (SS)	Not necessarily same grammatical class or number	*joint* > *unification*	*diffinio* > *eglurhad*
Lexical set (L)	Cue and response share a hypernym, or one word in the pair is an example of the other; includes antonyms	*bean* > *pea*	*elfen* > *dŵr*
Other conceptual (OC)	Cue and response are related in meaning, but are not synonyms or in the same lexical set	*fence* > *field*	*cymuned* > *Cymru*
Cue-response collocation (CR)	Cue is followed by the response in common usage; includes compound nouns	*fence* > *post*	*mater* > *difrifol*
Response-cue collocation (RC)	Cue is preceded by the response in common usage; includes compound nouns	*fence* > *electric*	*sifil* > *gwas*
CR + RC (CRRC)	Cue could precede or follow the response in a common phrase(s)	*rock* > *hard*	*gwaith* > *gosod*
Affix change (A)	Cue is the response with the addition, deletion or changing of an affix	*irony*> *ironic*	*cytundeb* > *cytuno*
Similar in form only (F)	Cue and response similar in orthography/ phonology but do not share meaning	*fence* > *hence*	*cryn* > *croen*
Two step association (I)	Cue and response appear linked only through another word	*weak* > *monday* (via *week*)	*arolwg* > *edrych* (via *golwg*)
Erratic (E)	The link between cue and response seems illogical; response is a repetition of cue	*wolf* > *and*	*dibynadwy* > *geni*
L + CR (LCR)		*gold* > *silver*	*nefoedd* > *uffern*
L + RC (LRC)		*cheese* > *bread*	*halen* > *pupur*
S + CR (SCR)		*torch* > *light*	*dethol* > *dewis*
S + RC (SRC)		*shove* > *push*	*trafod* > *trin*
OC + CR (OCCR)		*long* > *corridor*	*cyswllt* > *ffôn*
OC + RC (OCRC)		*attack* > *knife*	*cyswllt* > *person*