***Good, gooder, goodest (da, daach, daaf)*: A frequency effect for overregularization errors with Welsh comparative adjectives.**

A growing body of evidence suggests that frequency effects are ubiquitous in first language acquisition. The present study investigated whether such an effect is observed in a previously unstudied domain: overregularization errors with Welsh irregular comparative adjectives (e.g., *da/\*daach, ‘good/\*gooder’*). Comparative forms of regular adjectives (fillers) and irregular adjectives were elicited from 32 first language learners of Welsh aged 5;6-7;6, *M*=6;7, using a picture-description task. As predicted, a significant negative correlation was observed between the corpus frequency of the irregular form and the relative production probability of an overregularized (e.g., *\*daach*, ‘\*gooder’) versus correct form (e.g., *[g]well*, ‘better’). This finding constitutes support for frequency-sensitive accounts of language acquisition in general, and, in particular, for the prevent error thesis: High frequency forms prevent (or at least reduce) errors in contexts in which they are the target.

***Good, gooder, goodest (da, daach, daaf)*:**

**A frequency effect for overregularization errors with Welsh comparative adjectives.**

**1. Introduction**

It is uncontroversial that, under any theoretical account of language acquisition, a considerable amount of input-based learning must take place. Much more controversial, of course, is the nature of the learning mechanism. In a recent review paper, Ambridge, Kidd, Rowland & Theakston (2015: 239) presented evidence for “the ubiquity of frequency effects in first language acquisition”. This evidence included data on the acquisition of **individual words** (Smiley & Huttenlocher, 1995; Naigles & Hoff-Ginsberg, 1998; Theakston, Lieven, Pine & Rowland, 2004; Goodman, Dale & Li, 2008), **morphologically inflected forms** (e.g., Marchman, 1997; Marchman, Wulfeck & Weismer, 1999; Leonard, Caselli & Devescovi, 2002; Maslen, Theakston, Lieven & Tomasello, 2004; Theakston, Lieven, Pine & Rowland, 2005; Matthews & Theakston, 2006; Dabrowska & Szczerbinski, 2006; Theakston & Lieven, 2008; Theakston & Rowland, 2009; Räsänen, Ambridge & Pine, 2014), **multiword strings** (Bannard & Matthews, 2008; Matthews & Bannard, 2010; Arnon & Snider, 2010; Arnon & Clark, 2011), **simple syntactic constructions** (e.g., Ninio, 1999; Akhtar, 1999; Abbot-Smith, Lieven & Tomasello, 2001; Theakston, Lieven, Pine & Rowland, 2001, 2004; Matthews, Lieven, Theakston & Tomasello, 2005, 2007; Ambridge, Pine & Rowland, 2012; Ambridge, Pine, Rowland & Chang, 2012), **questions** (e.g., Rowland, Pine, Lieven & Theakston, 2003; Ambridge, Rowland, Theakston & Tomasello, 2006; Rowland, 2007; Ambridge & Rowland, 2009; Rowland & Theakston, 2009) and **relative clauses** (e.g., Kidd, Brandt, Lieven & Tomasello, 2007; Brandt, Kidd, Lieven & Tomasello, 2009).

 On the basis of this evidence, Ambridge et al (2015: 240) concluded that “any successful account of language acquisition, from whatever theoretical standpoint, must be frequency sensitive”. However, this conclusion is not universally accepted. First, at least one theoretical proposal explicitly denies the importance of frequency effects in language acquisition (Roeper, 2007). Second, and more commonly, a number of accounts – while not explicitly ruling out frequency effects – posit learning mechanisms that would not appear to yield these effects, at least at the lexical level. For example, parameter setting accounts of the acquisition of basic word order (e.g., Sakas & Fodor, 2012) and tense-marking morphology (e.g., Legate & Yang, 2007), are sensitive to input frequency at the level of abstract morphosyntax (e.g., the number of VO vs OV phrases, or of phrases bearing TENSE marking), but not at the level of lexical verb+noun combinations (e.g,. *eat it*) or tensed verb forms (e.g., *plays*). Third, in a response to Ambridge et al’s review, Yang (2015) highlights a number of apparent exceptions to the claim of ubiquitous frequency effects, including structure dependence, island constraints and binding, and cases where “the effect of the input must be indirect” (p.290), including null-subject and Optional Infinitive errors (but for input-frequency effects in these domains see Ambridge, Rowland & Pine, 2008; Dąbrowska, 2008; Dąbrowska, Rowland & Theakston, 2009; Freudenthal, Pine & Gobet, 2010). Thus it is certainly not the case that all accounts of language acquisition predict ubiquitous frequency effects.

 The goal of the present article is to contribute to this debate over the ubiquity or otherwise of frequency effects in first language acquisition, by investigating a phenomenon for which any frequency-sensitive account would seem to clearly predict such an effect, but which has not yet – to our knowledge – been studied: overregularization errors involving Welsh comparative adjectives. Although this is perhaps a rather modest goal, it is nevertheless an important one for two reasons.

First, although many would consider frequency effects – perhaps especially in the domain of irregular inflection – to be a well-established phenomenon, the so-called replicability crisis in psychology (just 36% of replications conducted by the Open Science Foundation, 2015, were successful) means that we should be cautious before declaring any effect “well-established”. Presumably, a frequency effect for irregular inflection is no exception to widespread problems such as publication bias, low power and inappropriate statistical tests. Thus this effect, like any other, demands replication in many domains, a reasonable number of subjects and items, and state-of-the-art statistical analysis (i.e., crossed random effects for subjects and items). The present study is not a direct replication of a previous study, but a conceptual replication of studies that have found frequency effects in the domain of irregular morphology; e.g., Marchman, 1997; Marchman et al, 1999).

 Second, if as Ambridge et al (2015) argue, any successful learning mechanism must be frequency-sensitive to its core, then there is no room for exceptions. Provided it is possible to identify and control for any confounds, to obtain sufficiently sensitive independent and dependent measures, and to ensure sufficient experimental power, then lexical frequency effects should be observed in every domain of language acquisition, for every language of the world. It will not have escaped the reader’s attention that the vast majority of evidence for frequency effects cited above comes from studies of English. The present study therefore constitutes one small step towards redressing that balance, by focusing on a typologically-unrelated, and under-studied, language: Welsh.

Regular Welsh adjectives (e.g., *cryf*, ‘strong’) have a comparative form ending in *–ach* (e.g., *cryfach*, ‘stronger’), analogous to *–er* comparative forms in English. However, a number of adjectives have irregular comparative forms that constitute an exception to this pattern. For example, the comparative form of *da* (‘good’) is not *\*daach* (‘\*gooder’) but *[g]well* (‘better’). (As this example shows, English also has irregular comparative adjectives, but considerably fewer than Welsh. It is presumably for this reason that, to our knowledge, no study analogous to the present one has been conducted in English). Further examples of regular and irregular comparative adjectives (11 of each) are given in Table 1. Anecdotally, Welsh-speaking children produce overregularization errors, in which the regular comparative morpheme –ach is attached to adjectives that, in fact, have an irregular comparative form (e.g., *\*daach* for *[g]well*), though these errors do not seem to have been documented in the literature. In fact, we have been able to find only a single previous study of Welsh adjective production (Nicoladis & Gavrila, 2015), which focused on adjective placement (and the cross-linguistic influence of English thereof), and did not investigate comparatives.

 The relevant prediction of the frequency-sensitive account is summarized by Ambridge et al’s (2015: 242) “*Prevent Error Thesis*: High frequency forms prevent (or at least reduce) errors in contexts in which they are the target”. In the context of the present elicitation study, the prediction is of a negative correlation across adjectives between the frequency of the irregular comparative form (e.g., *[g]well*) and the rate at which children produce overregularization errors (e.g., *\*daach*) versus correct irregular forms (e.g., *[g]well*). Although we are aware of no previous studies of this type investigating either (a) adjectives or (b) Welsh, the predicted negative correlation between the frequency of irregular forms (e.g., *drank, blew; feet, shelves*) and the production probability of overregularization errors (e.g., *\*drinked, \*blowed; \*foots, \*shelfs*) has been observed for English past-tenses and noun plurals (e.g., Marchman, 1997; Marchman, Wulfeck & Weismer, 1999; Maslen, Theakston, Lieven & Tomasello, 2004).

**2. Method**

*2. 1. Participants.*

Participants were 32 children aged 5;6-7;6 (*M*=6;7), all first language speakers of Welsh. Although, like virtually all Welsh speakers, these children will have had considerable exposure to English, all attended a primary school where Welsh was spoken exclusively. All children, and the experimenter, spoke entirely in Welsh throughout the study, and no child produced an English adjectival form.

*2.2. Design and Materials.*

Eleven adjectives that have an irregular comparative form (e.g., *da/[g]well*, ‘good/better’) were selected for use in target trials (see Table 1). However, the data for *hŷn*, ‘older’ were subsequently excluded because it proved impossible to obtain frequency counts that were not grossly overinflated by the high frequency of *hyn*, ‘this’, which is a homograph in the corpus that we used to obtain frequency information. Eleven adjectives with a regular (-*ach*) comparative form were selected for use in filler trials[[1]](#footnote-1), and also served the function of priming children to produce over-regularization (*-ach*) errors for the adjectives with an irregular comparative form[[2]](#footnote-2). For each bare/comparative adjective pair we created a card showing two pictures, the ‘bare’ picture on the left, the ‘comparative’ picture on the right (e.g., a *big* house and a *bigger* house; a *good* drawing and a *better* drawing; a *clean* car and a *cleaner* car). Corpus counts of each comparative form (e.g., *[g]well*) were obtained from the 1 million word *Cronfa Electroneg o Gymraeg* (CEG) corpus (Ellis, O'Dochartaigh, Hicks, Morgan, & Laporte, 2001), taking care to count both forms in cases of mutation (e.g., *gwell* and *well*). Mutation is a morphophonological system whereby a closed set of word-initial consonants undergo phonological change in certain syntactic contexts (see, e.g., Thomas & Mayr, 2010; Thomas & Gathercole, 2007, for reviews). Although it would have been preferable to use a corpus of child-directed speech, there exist – to our knowledge – no corpora that are sufficiently large to yield reliable counts of these relatively infrequent forms.

**INSERT TABLE 1 ABOUT HERE**

*2.3 Procedure.*

The experimenter began by explaining (in Welsh) that she and the child would work together to describe the pictures on each card, with the experimenter describing the left-hand picture and the child the right-hand picture. The game was illustrated using a single training trial with the adjective *anodd*, ‘hard/difficult’. This adjective was chosen in order to minimize the extent to which the training trial would bias children towards the production of either irregular or regular comparative forms, as, for this particular adjective, both forms (*anos* and *anoddach*) are acceptable for most speakers (though the latter is certainly more common in everyday speech). First, the experimenter pointed to the left-hand picture (a relatively difficult sum: 1+3+8) and said *mae’r sym yma’n anodd,* ‘this sum is hard’. She then pointed to the right-hand picture (a much more difficult sum: 7x3x5) and said *Ond mae’r sym YMA yn…,* ‘but THIS sum is…’. In every case, the child produced either *anos/anoddach* or a periphrastic comparative *mwy anodd* (like its English equivalent ‘more hard’, this form is borderline ungrammatical – or at least, pragmatically very odd – given the existence of the simple lexical comparative form ‘harder’). The experimenter did not give any feedback (other than generic encouragement), and then proceeded to complete the test trials in the same way. Test trials were presented in pseudo-random order, with the constraint that no more than two irregular or two regular adjectives could be presented sequentially. Children completed all 22 test trials in a single sitting.

*2.4 Scoring.*

Each trial was scored as

* **Correct (*N*=386)**: Target comparative adjective form (i.e., irregular for the target trials, regular for the filler trials).
* **Overregularization error (*N*=67)**: Target adjective, but produced in incorrect adjective*+ach* form (e.g., \**da+ach*), possible for irregular adjectives only.
* **Periphrastic (*N*=196)**: *Mwy*+ target adjective (e.g., *mwy da*, ‘more good’)
* **Other (*N*=55)**: Non-target adjective (e.g., *hapus*, ‘happy’), whether in bare or comparative form.

These counts suggest that children clearly understood the task, with some kind of comparative form (either lexical or *mwy*) produced on all but 55 of 704 trials (8%). On the assumption that periphrastic *mwy* and “other” responses represent an evasion strategy for items where the target comparative form is of low frequency, it may be justifiable to treat such responses as errors. However, in order to be maximally conservative, we decided to exclude these responses as missing data, and retain only correct comparative adjectives and overregularization errors.

**3. Results**

Because overregularization errors are, by definition, impossible for adjectives with a regular comparative form, the analysis was conducted on the data for irregulars only, with regulars treated as fillers. We also excluded the data for the irregular adjective/comparative pair *hen/hŷn*, (‘old’/‘older’) because it proved impossible to obtain frequency counts that were not grossly overinflated by the high frequency of *hyn*, ‘this’, which is a homograph in the input corpus. The remaining data consisted of 167 correct irregular forms and 57 overregularization errors (as outlined above, all other responses were treated as missing data).

 The data were analysed using binomial mixed-effects models (lme4 package; Bates, Maechler & Bolker, 2012) in R (R Core Team, 2014). A simple by-items correlation (i.e., frequency by proportion correct for each adjective) would be severely under-powered for this study, given that we have only ten datapoints (i.e., the ten irregular adjectives), and that it would not be possible to obtain more (Welsh has only a handful more, and none are likely to be known to children). Such an analysis would also be insensitive to the sample size in terms of participants, as it involves aggregating data (i.e., mean proportion correct) across participants. Mixed effects models allow for full crossing of items and participants, and so provide sufficient power for a study of this type. We therefore used binomial mixed-effects models with random intercepts for participant and item (adjective) and correlated by-participant random slopes for the independent variable: corpus frequency of the irregular comparative adjective form (log transformed):

glmer(Correct ~ Log\_Adj\_Freq + (1+Log\_Adj\_Freq|Participant) + (1|Adjective), family=binomial)

Note that this fully-specified random-effects structure (e.g., Barr, Levy, Scheepers & Tily, 2013) yields an analysis that is maximally conservative (perhaps inappropriately so; Bates, Kliegl, Vasishth & Baayen, submitted). The dependent measure was whether an overregularization error (1) or correct irregular form (0) was produced on each trial. *P* values were calculated using the model comparison (chi square) procedure (i.e, comparison against a baseline model with random effects only).

 This analysis yielded a significant effect of log frequency of the irregular comparative adjective form in the predicted (negative) direction, *M*= -1.97, *SE*=1.08, chi2[1]=4.49, *p*=0.034, Intercept: *M*= 2.98, *SE*=2.49. The variance for the random effects was Participant(Intercept)=15.02, Adjective(Intercept)=0.65, Frequency| Participant=2.39. Note that because all other responses were excluded as missing data, the finding of a negative correlation between irregular comparative frequency and the rate of overregularization errors is also equivalent to a positive correlation between irregular comparative frequency and the rate of correct irregular production. This relationship is illustrated in Figure 1. Error bars show 95% confidence intervals, corrected for within-subjects comparisons (using the method outlined by Morey, 2008).

**INSERT FIGURE 1 HERE**

**4. Discussion**

In the present study, irregular comparative adjective forms were elicited from Welsh-speaking children. In support of the predictions of a frequency-sensitive account of language acquisition, a significant negative correlation was observed between the corpus frequency of the irregular form and the production probability of an overregularized versus correct form.

 It is important to acknowledge that, although statistically significant, the correlation observed is relatively small, and certainly does not demonstrate a one-to-one relationship between the rank order of frequency and rates of overregularization error versus correct production. However, a one-to-one relationship is not to be expected, as no frequency-sensitive account posits that frequency is the *only* factor that affects acquisition. In their review of frequency effects, Ambridge et al (2015) list a number of other factors that have been shown to interact with simple token frequency including position in the utterance (words that appear in isolation or utterance finally are most salient), imageability, type frequency (the more items follow a particular pattern, the better) phonology (acquisition is easier for words that are easier to pronounce, and that have many phonological neighbours), cognitive complexity (e.g., presumably adjectives that describe simpler attributes are easier to learn) and communicative function (e.g., presumably children have more occasion to talk about things that are *bigger* and *better* than *earlier* and *easier*). Indeed, it is a powerful demonstration of the robustness of input frequency effects that they are observed even when no attempt has been made to control or partial out these other relevant factors, as is the case for the present study.

 Of course, it would not be wise to draw wide-ranging theoretical conclusions on the basis of a single small-scale study. However, the present findings closely mirror those observed for similar cases of overregularization errors, such as for English past-tenses and noun plurals (e.g., Marchman, 1997; Marchman, Wulfeck & Weismer, 1999; Maslen, Theakston, Lieven & Tomasello, 2004), and are also consistent with studies that have found frequency effects in the domain of morphological acquisition more generally (e.g., Leonard, Caselli & Devescovi, 2002;; Theakston, Lieven, Pine & Rowland, 2005; Matthews & Theakston, 2006; Dabrowska & Szczerbinski, 2006; Theakston & Lieven, 2008; Theakston & Rowland, 2009; Räsänen, Ambridge & Pine, 2014).

 Thus the present study adds to a considerable body of research which suggests that frequency effects are indeed ubiquitous in first language acquisition. This raises the question of what type of theoretical account is needed to explain such effects. As Ambridge et al (2015: 261-264) note, there is nothing in principle to prevent accounts that assume early abstract knowledge of morphosyntax (i.e., generativist accounts) from positing some additional mechanism that would yield lexical frequency effects (e.g., the additional storage and use of some rote learned-lexical forms). Indeed, this is exactly the approach taken by the highly influential dual-route model of past-tense acquisition, particularly in its more recent incarnations (e.g., Alegre & Gordon, 1999; Pinker & Ullman, 2002; Hartshorne & Ullman, 2006), which allow for storage of (some) regular, as well as irregular, lexical past-tense forms. The challenge for such accounts is to incorporate these assumptions without discarding the core mechanistic assumptions of the account. For example, if regular past-tense forms can be stored and produced by rote, what is the point of the default “add *–ed*” rule that differentiates this account from a purely input-based account in the first place? Constructivist accounts, on the other hand, yield frequency effects by virtue of – rather than by discarding – their core mechanistic assumption: probabilistic, frequency-sensitive, input-based learning. It is for this reason that we suggest that frequency effects of the type observed in the present study can be explained more naturally, though by no means exclusively, by constructivist accounts.

 In conclusion, whether or not the present data provide any basis for choosing between existing theoretical accounts, they certainly constitute evidence of yet another frequency effect – in a hitherto unstudied domain – that any successful account of language acquisition must explain. To this extent, they contribute to the growing body of evidence which suggests that frequency effects are indeed ubiquitous – or, at least, widespread – in child language acquisition, and hence must be explained by accounts of all theoretical stripes.

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**Tables**

**Table 1. Stimuli for irregular (target) and regular (filler) trials.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Type** | **Bare (non-** **comparative)** **adjective** | **Comparative** **(*yn + ADJ,*** **‘is ADJ-er’)** | **Comparative adjective frequency** |
| Irregular | agos, ‘close/near’ | nes, ‘closer’ | 523 |
| (Target | bach, ‘small’ | llai, ‘smaller’ | 337 |
| trials) | cynnar, ‘early’ | cynt/gynt, ‘earlier’ | 143 |
|  | hawdd, ‘easy’ | haws, ‘easier’ | 81 |
|  | ~~hen, ‘old’~~ | ~~hŷn, ‘older’~~ | ~~3464~~ |
|  | isel, ‘low’ | is, ‘lower’ | 113 |
|  | uchel, ‘high’ | uwch, ‘higher’ | 231 |
|  | llydan, ‘wide’ | lletach, ‘wider’ | 8 |
|  | drwg, ‘bad/naughty’ | gwaeth/waeth, ‘worse’ | 171 |
|  | mawr, ‘big/large’ | mwy/fwy, ‘bigger’ | 1541 |
|   | da, ‘good’ | gwell/well, ‘better’ | 459 |
| Regular | cryf, ‘strong’ | cryfach/gryfach, ‘stronger’ | 31\* |
| (Filler | glân, ‘clean’ | glanach/lanach, ‘cleaner’ | 3 |
| trials) | llawn, ‘full’ | llawnach, ‘fuller’ | 11 |
|  | ysgafn, ‘light (weight)’ | ysgafnach, ‘lighter’ | 7 |
|  | gwlyb, ‘wet’ | gwlypach/wlypach, ‘wetter’ | 1 |
|  | byr, ‘short’ | byrrach/fyrrach, ‘shorter’ | 13 |
|  | poeth, ‘hot’ | poethach/boethach, ‘hotter’ | 4 |
|  | gwyn, ‘white’ | gwynnach/wynnach, ‘whiter’ | 0 |
|  | coch, ‘red’ | cochach/gochach, ‘redder’ | 0 |
|  | rhad, ‘cheap’ | rhatach, ‘cheaper’ | 7 |
|  | oer, ‘cold’ | oerach, ‘colder’ | 1 |

**\***Corpus counts of regular comparative adjectives (targets for filler trials) are provided for information only, and were not used in the analysis.

1. It is not possible to look for a frequency effect amongst regulars as, even though we selected the most frequent regulars we could find, they were of uniformly low frequency (see Table 1). [↑](#footnote-ref-1)
2. This raises the question of whether we primed the children to produce errors at unrealistically high rates. The answer to this question is “probably, to some extent”, but, given the absence of suitable corpus data, we simply do not know. In any case, when testing the prediction of a correlation with the input, it does not matter if the *overall* rate of errors is shifted up or down by a particular paradigm, as long as the paradigm does not impact differently upon different items, and we see no reason why this should be the case. [↑](#footnote-ref-2)