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L2 irregular verb morphology: Exploring behavioral data from intermediate English learners of German as a foreign language using generalized mixed effects models

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Abstract

This paper examines possible psycholinguistic mechanisms governing stem vowel changes of irregular verbs in intermediate English learners of German as a foreign language (GFL). In Experiment 1, nonce-infinitives embedded in an authentic fictional text had to be inflected for German preterite, thus testing possible analogy-driven pattern associations. Experiment 2 explored the psycholinguistic reality of the so-called apophonic path by prompting two inflections for one given nonce-word. Data were analyzed using generalized mixed effects models accounting for within-subject as well as within-item variance. The results of Experiment 1 and 2 support the notion of a pattern associator and yield only scarce evidence for the psycholinguistic reality of a universal apophonic path. Therefore, the organization of irregular verb morphology in the mental lexicon of intermediate GFL learners might best be captured by the linguistic notion of structured lexical entries as well as the psycholinguistic mechanism of an analogy-based pattern associator.

Keywords: mental lexicon; irregular verb morphology; analogy; pattern associator; apophony

1. Introduction

After around 130 years of research into the human mental lexicon (Whitaker, 2006), the semi-regular paradigm of German irregular verbs, combining rule-like as well as idiosyncratic processes, has become the fruit fly in psycholinguistic research. It is thought to offer invaluable insights into storage and retrieval of words in the human mental lexicon. In fact, these insights promise to shed light on the nature of human cognition in general.

Over the last two decades, German irregular verb morphology has been explored from various perspectives. Data come from behavioral L1 studies of both children and adult speakers (Clahsen, Hadler, & Weyerts, 2004; Smolka, Zwitserlood, & Rösler, 2007), impaired speakers studies (Marusch, von der Malsburg, Bastiaanse, & Burchert, 2012; Penke, Wimmer, Hennies, Hess, & Rothweiler, 2014), electrophysiological studies (Smolka, Khader, Wiese, Zwitserlood, & Rösler, 2013), neuroimaging (Lück, Hahne, & Clahsen, 2006), constructivist neural network modelling (Ruh & Westermann, 2008) and corpus studies (Köpcke, 1998). The above studies focus on processing differences, reporting and discussing possible evidence for qualitatively distinct mechanisms of inflection. While some findings suggest that all German verbs are inflected by the same psycholinguistic mechanism, there is evidence pointing towards two qualitatively distinct processing routes in the speakers' mental lexicon. Overall, current findings appear to remain inconclusive in this respect.

Most studies concur, though, that some sort of pattern- and analogy-driven mechanisms would be necessary to handle a key component of German verb inflection, namely vowel change, a systematic stem vowel alternation in verbal inflection. Like in English, a lot of irregular German verbs exhibit such stem vowel alternations when inflected for the German past tense and past participle, such as *singen-sang-gesungen* 'sing-sang-sung.' Modern single-route approaches model vowel change through analogical or connectionist networks, while the dual-route model accounts for vowel change by means of a so-called pattern associator. The psycholinguistic reality of such a pattern associator has been explored in L1 speakers in a number of studies (Bybee & Moder, 1983; Bybee & Slobin, 1982; Prasada & Pinker, 1993), but, unlike English, German as a foreign language (GFL) behavioral evidence is scarce. While recent studies focus on processing differences (Hahne, Müller, & Clahsen, 2006; Neubauer & Clahsen, 2009; Pliatsikas & Marinis, 2013; Strobach & Schönpflug, 2011), the intricacies of German vowel change remains largely unexplored. In a similar vein, Strobach and Schönpflug (2011) concluded that prior behavioral evidence appears inconclusive at best, suggesting further research was needed especially with regard to L2.

The present study tries to fill this gap. It reports findings from two well-established nonce-word research designs in which 82 intermediate English GFL learners provided preterite, participle, and infinitive formations to given German nonce-words. The rationale behind this study was to test in how far GFL vowel change was governed by a pattern associator, operating on prototypical schemas (Bybee & Slobin, 1982; Köpcke, 1998; Pinker, 1999), or by the so-called universal apophonic path (Ségéral & Scheer, 1998). If universal apophony were psycholinguistically real, GFL interlanguage patterns could not be attributed to transfer phenomena but would instead be the result of universal developmental effects.

2. German irregular verb morphology and models of inflection

There are about 160 simplex irregular verbs in modern German, although, depending on the choice of reference corpora, counts vary considerably. While Middle High German exhibited about 400 irregulars, the number decreased steadily, yielding today's moderate type-frequency of roughly 4% of all verbs (Köpcke, 1998; Bittner, 1996). Their token-frequency, however, is remarkable, and roughly resembles that of the regulars (Clahsen, 1997; Clahsen, Eisenbeiß, & Sonnenstuhl-Henning, 1997).

The verbal paradigm in German is traditionally categorized as consisting of regular (weak) and irregular (strong) forms, combining rule-based affixation with irregular stem vowel changes. German participles, for instance, involve three morphological processes: a prosodically constrained *ge-* prefixation, optional stem vowel allomorphy, as well as *-(e)n* or *-t* suffixation, both occurring with roughly the same token frequency in adult and child corpora (Clahsen, 1997). Recently, however, analyses have become more complex with regard to form and function of stem vowel change or apophony within the paradigm (Trompelt, Bordag, & Pechmann, 2013; Wiese, 2008), resulting in regular, hybrid, and irregular classes. Table 1 illustrates the most common inflectional patterns.

Table 1 German vowel change patterns

	Regular, one stem vowel only	Hybrid, change in participle and preterite	Irregular, change in present, preterite, and participle	Mixed, vowel change + suffix
Infinitive	*spiel-en* 'to play'	*trink-en* 'to drink'	*sprech-en* 'to speak'	*renn-en* 'to run'
Present tense 3rd person	*spiel-t* 'plays'	*trink-t* 'drinks'	*sprich-t* 'speaks'	*renn-t* 'runs'
Preterite 3rd person	*spiel-te* 'played'	*trank* 'drank'	*sprach* 'spoke'	*rann-te* 'ran'
participle	*ge-spiel-t* 'played'	*ge-trunk-en* 'drunk'	*ge-sproch-en* 'spoken'	*ge-rann-t* 'run'

German stem vowel alternations for preterite and participle inflection form a patterned semi-regular paradigm. From a diachronic perspective, these patterns are a mere artefact of older variants (Bybee & Newman, 1995) and appear opaque and unpredictable (Nübling, Dammel, Duke, & Szczepaniak, 2006), once even apostrophized as "one of the classic chestnuts of morphological analysis" (Anderson, 1988, p. 157).

Due to this unpredictability, German irregular verbs exhibit restricted generalization properties, and there is little consensus about the distinctiveness of attested vowel change classes. The phonological patterns, for example, are neither necessary nor sufficient to predict to which class a verb should conform. A verb such as *sinken* 'to sink,' for instance, readily joins the irregular pattern displayed by *trinken* 'drink' (*trinken* : *trank* : *getrunken* :: *sinken* : *sank* : *gesunken*), while *winken* 'to wave' and *blinken* 'to blink' do not. Accordingly, attempts to define vowel change categories vary considerably, ultimately treating almost each and every variant of vowel change as a class of its own.

German verb morphology has been a controversial object of enquiry in psycholinguistics. Studies throughout the last 30 years have resulted in the long-standing past-tense-debate (Pinker & Ullman, 2002; Wagner, 2010). From this debate, two approaches emerged. Single-route models suggest one mechanism to account for storage and retrieval of both regular and irregular forms in the mental lexicon. Such mechanisms are either symbolic or non-symbolic in nature. Symbolic models (Albright & Hayes, 2003; Bittner, 1996) are inherently rule-based and deterministic, which creates a number of disadvantages: They are not, for instance, convincing in capturing vowel change as a concatenative process, they do not allow for a gradual transition between regular and irregular mechanisms, and they often lack the psycholinguistic underpinning from behavioral data (Becker, 1990). Analogical learners and connectionist networks, in contrast, model both regular and irregular verbal inflection entirely rule-free, conceiving linguistic representations in the mental lexicon as graded and domain-general phenomena (Eddington, 2000; Goebel & Indefrey, 2000; Westermann, Willshaw, & Penke, 1999). Connectionist models do this by cyclically building and relating weighted connections of parallelly distributed phonological and semantic information about verb infinitives and their inflections. Analogical learners store huge databases of individual exemplars and calculate generalization properties among these on the basis of near-neighbourhood similarities.

Trying to synthesize symbolic and associationist processing, the dual-route model assigns different mechanisms to regular and irregular morphology. Regular verbs would be processed by abstract symbolic rules, while irregular and thus lexicalized German verbs would be stored undercomposed in memory and processed by associative patterning, not unlike what Ullman (2001) called declarative knowledge. Such an architecture would, as proponents of this approach claim, represent the two core characteristics of human cognition (Clahsen, 1999; Lück, Hahne, & Clahsen, 2006; Pinker, 1999).

3. German irregular verb morphology in L2 acquisition

German verb morphology has not only been controversial in psycholinguistics, but it has also been the bane of countless language learners (Neubauer & Clahsen, 2009; Pinker, 1999). In order to trace possible difficulties in the acquisition of German irregular verb morphology, studies looked at processing differences. However, as with L1 speakers, there is conflicting evidence. Advanced Greek learners of German, for instance, employed two different mechanisms for regular and irregular inflection (Pliatsikas & Marinis, 2013), while Polish learners relied more on lexical storage and retrieval compared to German L1 speakers (Neubauer & Clahsen 2009). And Strobach and Schönpflug (2011) report that their data from English learners of German were consistent with a single-route connectionist account. GFL vowel change, however, has not been examined in detail yet. For English L2, there is evidence in favour of an analogical or prototypical organization in the mental lexicon of advanced German learners of English (Wagner, 2010). At the heart of such prototype models are output-oriented morphophonological schemas, governing each vowel change class. Such classes emerge through exemplars sharing various morphophonological properties to varying degrees, thus following the principles of family resemblance (Rosch, 1975). For German L1, prototypical schemas have been suggested, too (Bybee, 1995; Wagner, 2010), but there is evidence that, contrary to English, analogical formations in German rely almost exclusively on a verb's rhyme (Penke, 2006).

An intriguing alternative to prototypical schemas comes from Ségéral and Scheer's (1998) universal apophonic path. They claim that apophony across all types of languages followed a unidirectional five-part vowel change sequence [Ø→i→a→u→u], providing all the necessary information in order to predict German stem alternations. This is possible only because the authors sophisticatedly reanalyze the German verb paradigm as consisting of an infra-segmental level. The alleged universality of their path is challenging, though, especially since both English and German provide additional supportive evidence from children's nursery rhymes, onomatopoeic expressions, and expletives. Amongst these, apophonic vowel changes such as [ɪ-ʌ] are remarkably frequent. The pattern [ɪ-a-ʊ] is, in fact, the most frequent type of a three-vowel-change pattern in German. If this apophonic path were to be psycholinguistically real, it would seriously challenge both single- and dual-route-models.

The two nonce-word elicitation experiments reported in this paper are supposed to test these competing approaches. If a universal vowel change mechanism were psycholinguistically real, we should see learners of German (a) predominantly, or even exclusively, use vowel changes faithful to the apophonic path, and (b) adhere to its mono-directionality, thus rejecting vowel-changes prompted in the reverse direction. If German verb morphology were governed by prototypical schemas, we should expect (a) a strong influence of the verb's constituents on vowel change, (b) a complete overlap of the prototypical test item with the statistically most effective constituents, and (c) an insensitivity towards directionality effects.

4. General method

4.1. Overview

Both experiments employed a repeated measure elicitation task, using nonce-words either embedded in an authentic fictional text or as part of a sentence completion frame. Although nonce-word elicitation cannot be controlled as thoroughly as, for instance, priming, lexical decision or eye-movement experiments, this research paradigm was used because of its natural setting and its long history in psycholinguistics (Berko, 1958; Bybee & Moder, 1983; Lemhöfer & Radach, 2009). In Experiment 1, 34 participants inflected 28 nonce infinitives and 15 distractors for preterite. In Experiment 2, 48 participants inflected either 28 irregular nonce-infinitives for preterite and participle, or 28 nonce preterites for infinitive and participle. The order in which items were presented varied across the test questionnaires in both experiments, thus helping counterbalance possible sequence effects (Prasada & Pinker, 1993; Ramscar, 2002).

4.2. Stimuli

Based on the lexical statistics reported in Köpcke (1998), the 28 most prototypical vowel change triggering nonces were filtered out of 344 phonotactically well-formed constituent combinations. A subset of Experiment 2 used preterite forms by transposing the infinitive stems [iː] and [ɪ] into [a]-, [oː]-, or [ɔ]-vowel-change preterites, depending on the most frequent analogies to existing verbs. Thus, a nonce like *strießen* would result in *stross* by analogy to *schließen* 'to close, to lock;' *schloss* 'closed, locked.' In both experiments, test items' constituent variants included onset structures C*,* CC, [ʃ], [ʃ]C, and [ʃ]CC*,* as well as coda variants [g], [m/m], [ŋ], [ŋk], and [s/ç]. All stimuli can be found in the appendix to this paper.

4.3. Participants

Data for Experiment 1 came from randomly recruited GFL speakers of the University of Maynooth, University of Edinburgh, and University of Leicester (*N* = 34). Data for Experiment 2 were randomly sampled among GLF speakers from

Dublin City University, Trinity College Dublin, the University of Manchester, and University of Hull (*N* = 48). Random sampling was done within one cohort of the respective study programs involving German, and participants were not nested within classes. The test questionnaires were administered in small groups. Among the 82 participants, there were 42 females and 40 males. They were all Irish or British citizens, their L1 was English, there were no bilinguals, and they had been residents in their respective countries from birth. The mean age of the participants was 19 years (*SD* = 1.19), with a range from 17 to 21 years. They all had been learning German in instructional settings as part of their school curricula for more than 4 years and approached intermediate level B1 (Council of Europe, 2001). They all studied German as part of their respective undergraduate degree programs. All subjects were unimpaired speakers. They did not receive any remuneration for their participation.

4.4. Procedure

For Experiment 1, participants were told that their data would feed into a new translation of Burgess' classic novel *A clockwork orange* (Burgess, 1962). The introduction pretended that the learners' intuition was deemed instrumental in finding adequate translations of the notorious *Nadsat*-slang verbs. Using such a real novel extract, riddled with artificial slang, was meant to avoid unwanted semantic associations and distract the attention away from the linguistic details. Overall, great care was taken to leave subjects in Experiment 1 deliberately naïve to the real purpose of the experiment. After two items for practice, an audio CD provided the text with the intended pronunciation of the nonces as well as the timing for the gap-filling. Contrary to Prasada and Pinker (1993), and following Orsolini and Marslen-Wilson (1997), it was deemed appropriate to present the stimuli only once and elicit only one response to a particular test item in both experiments. This was supposed to discourage strategic approaches and tap into retrieval processes as directly as possible.

The questionnaire of Experiment 2 informed participants that they were taking part in a genuine linguistic experiment about how German verbs are stored and organised in the mental lexicon. Then they were told that, in order to make the experiment more interesting, they would be asked to creatively inflect non-existing forms; thus, they were encouraged to rely on their linguistic intuition about the appropriate sound of the inflection. One subset of the participants in Experiment 2 were asked to inflect given infinitives for preterite and participle, while the other one was prompted to inflect given preterite forms for infinitive and participle. Prompting one subset to inflect backward was supposed to test directionality effects. Recall that the apophonic path defines rule-like input-output derivations of one vowel quality out of another. Such derivations are assumed to be directional, and hence they are not expected to work in the reverse order. In other words, if the apophonic path was real, English learners of German should prove to be able to complement a fragmentary apophonic path such as [i→x] with ease, whereas the reverse direction such as in [x←a] should prevent speakers from systematic vowel change inflections.

Using nonce participles for testing the apophonic path's directionality proved inadequate since, contrary to English, in German the choice of possible preterite inflections from a given participle in a reverse order is rather restricted. A given [ʊ] as a participle stem, for instance, would almost automatically elicit [a] in the preterite, since [i-a-ʊ] is the by far the most predominant German pattern. In order to test possible learners' preferences, German preterites and not participles were given. After two items for practice, a CD provided all sentence frames, thereby timing the filling of the gaps and controlling potential confusion about the pronunciation of a verb (like [ɔ] or [oː] in an item such as *plog*).

4.5. Data coding and analysis

Test items in both experiments were coded for *onset*, *nucleus*, and *coda* variants, covering onset structures C, CC, [ʃ], [ʃ]C, and [ʃ]CC, two nuclei, [iː] and [ɪ], as well as codas [g], [m/n], [ŋ], [ŋk], and [s/ç]. After inspection of frequency tables, onset was collapsed into [ʃ] with optional consonant versus consonant only, and coda into *consonant, velar,* and *fricative*.

Responses in Experiment 1 were coded for vowel changes in [a], [o], and [u], mixed inflections, and the residual category *others*. Wherever ATR contrasts were irrelevant for the present analyses, vowel variants such as [aː] versus [a], [iː] versus [ɪ], [oː] versus [ɔ], and [uː] versus [ʊ] were collapsed into [a], [i], [o], and [u] (Wiese, 2000). Responses in Experiment 2 were coded according to the type of vowel change series they produced as well as their well-formedness. Data were analyzed using generalized mixed regression models as well as non-parametric, conditional inference trees built through recursive partitioning. Both analyses were done using the statistical software R, version 3.3.1 (R Core Team, 2016). Mixed modelling was done using the package *lme4* (Bates, Maechler, Bolker, & Walker, 2015), and recursive partitioning employed the *party* package (Hothorn, Hornik, & Zeileis, 2006). Although multifactorial ANOVAs appear to have been the predominant tool of choice in numerous L1 and L2 studies related to the past tense debate, mixed models are much more suited to the present data (Cunnings & Finlayson, 2015; Cunnings & Linck, 2015; Gries, 2015; Jaeger, 2008). They can, for instance, handle non-orthogonal, unbalanced, and nested designs, typical of repeated measure experiments. They can also directly model dichotomous dependent variables and avoid unwarranted assumptions about sphericity, and they simultaneously incorporate random variance of test item and subject (Baayen, Davidson, & Bates, 2008).

5. Results and discussion of Experiment 1

In Experiment 1, participants produced, apart from regular inflections (41%), three vowel change patterns. The most prominent one was [i-a], with more than 28%, followed by [i-o] with around 15%, and vowel changes in [u] with 4%. Mixed inflections also covered around 4%. Overall, less than 50% of the responses follow the default, and only 7% of the responses are random. Both the high amount of non-default responses and the high amount of attested vowel changes are remarkable. The nonces *spingen, stingen*, and *schingen* attracted the highest vowel change response frequencies, producing predominantly [a]-vowel-change. This could be taken as a first indication of a schema with the form [ʃ (C)_ɪ_ŋ] being prototypical for the most productive vowel change class. In order to investigate whether this overall schema did in fact contain the most prototypical constituents, we first looked at the influence of each constituent on the choice between regular and vowel-changing preterites (excluding the residual *others*). The mosaic plot in Figure 1 illustrates the distribution of all preterites by constituents.

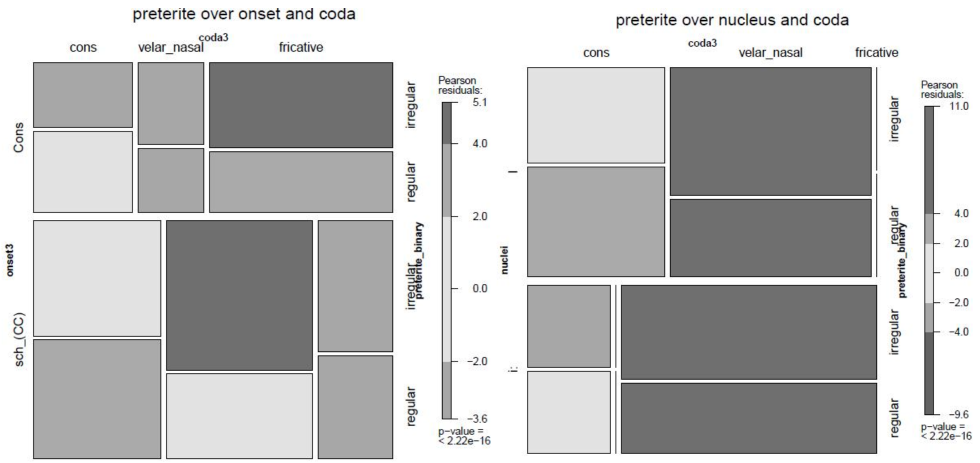

Figure 1 Mosaic plots of two log-linear independence models illustrating the choice of preterite by *onset* and *coda* (left panel), and preterite by *nucleus* and *coda* (right panel)

In the mosaic diagrams, both horizontal and vertical asymmetries indicate significant partial effects of the constituents on the type of preterite formation ($p < .001$). Size and shading of each tile in the diagrams represent frequencies as well as direction and significance of effects. The darkest grey shade indicates more observations than expected. In the left panel, the dark tiles in the middle and top-right illustrate significant effects for the schemas [ʃC_ŋ(k)] and [C_fricative]. Onset has almost no effect. In the right panel, effects for [#_iː_ ŋ(k)] and [#_ɪ_fricative] are visible (middle and top-right dark tiles). In order to explore the above effects in more detail, we performed a general linear mixed effects analysis of the relationship between the constituent variants and the binary choice of preterite. To estimate parameters, restricted maximum likelihood was used instead of penalized quasi-likelihood since the latter is reported to produce biased estimates with binary response variables (Thiele & Markussen, 2012). As fixed effects, we entered nucleus and coda without interaction term into the model. Their factor levels were treatment-coded, so coefficients in the model correspond to simple effects. Nucleus and coda were not crossed since some combinations, due to phonotactic reasons, were not represented with data points.

As random effects, we included intercepts for subjects and items as well as by-subject and by-item random slopes for coda since the effect of coda seemed to significantly vary across subjects and items, too. Moreover, including random slopes renders mixed models conservative and minimises α-errors. The dependent variable was coded binary (*regular* vs. *irregular*). Main effect *p* values were obtained by likelihood ratio tests (all *p* values < .005). It was also tested if both fixed and random effects were highly correlated, and if the model was overdispersed; neither was the case. Scaled residuals were distributed fairly symmetrically.

Table 2 Table of coefficients of the final model, estimated using Laplace approximation as well as the optimiser *bound by quadratic approximation* (bobyqua) instead of the heuristic default Nelder-Mead method

		Logits	*SE*	*z*	*p*
	Intercept	0.19	0.35	0.52	.60
Nucleus (effect size = 0.06)	iː	-0.25	0.30	-0.82	.41
Codas (effect size = 0.28)	ŋ(k)	-1.04	0.31	-3.39	< .001***
	s/ç	-0.59	0.43	-1.36	.17

Note. Logits are the log-odds of the parameter estimations; *SE* is the standard error; *z*-values come from the corresponding Wald statistics.

When building the final model, we first followed Barr, Levy, Scheepers, and Tilly (2013) and therefore tried to include all fixed effects with their interactions as well as all random intercepts and slopes. However, adding interactions and random slopes other than coda prevented models from converging, most likely because there were too little data for the number of parameters to be estimated. Given that there still is little consensus as to how to deal with convergence problems (Barr et al., 2013; Cunnings & Finlayson, 2015), these terms were dropped again. Table 2 summarises the partial main effects of the constituents' variants of the final model with a pseudo conditional R^2 of 0.62.

Table 2 illustrates a highly significant main effect for coda ($\chi^2(2) = 14.28$, $p < .001$), and a significant partial effect for codas with the velar nasal plus optional obstruent. In other words, [ŋ(k)] significantly affects the choice of preterite formations, decreasing the log odds for regulars by -1.04 (*SE* = 0.31), resulting in a decreased probability for regular responses of *p* = .30. Compared to nucleus, coda has a substantial effect size (range) of 0.28. Other than that, there are no significant partial effects. However, if we plot nucleus and coda as interactions, we can see the results presented in Figure 2. When looking at the simple main effects (left panel), we can see that the probability of regulars slightly decreases when we go from short (0.41) to long (0.35) nucleus. As for codas, probabilities of regulars decrease for velars (0.28) and fricatives (0.37) compared to other consonants (0.52). Note, though, the overlap of the error bars in both panels, indicating that we are dealing with merely mild effects. In the right panel we can see a substantial decline in probability for regulars (down to 0.30) for short nucleus [ɪ] followed by velars (solid line). Similar, but less pronounced, is the decline for long nucleus [i:] followed by fricatives (0.34, dashed line). In sum, the mixed effects analysis revealed effects for [#_ɪ_ŋ(k)] as well as [#_i:_fricative].

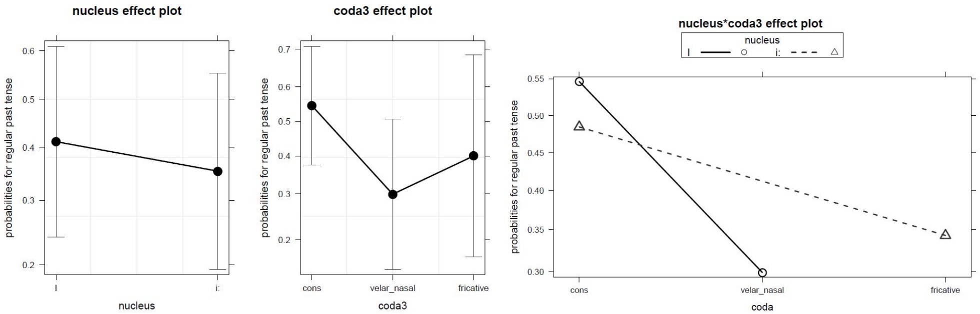

Figure 2 Effects plots for the individual partial effects in the final model (left panel) and the interaction of nucleus and coda (right panel)

The choice between the different vowel changes in the preterites the learners produced was modelled using conditional inference trees built through recursive partitioning. Figure 3 shows such a tree model for the different types of vowel change by *onset*, *nucleus*, and *coda*.

The tree in Figure 3 is the result of a split algorithm. Unlike traditional classification and regression tree modelling, however, in which algorithms attempt to increase information gain measures, conditional inference tree modelling uses inferential test statistics in order to retain significant predictors only. As a consequence, the above tree model does not contain any covariates that are independent of the choice of vowel change patterns. Tree growth is thus based on statistical stopping rules, so that neither pruning nor cross-validation are required, and the data cannot be overfitted.

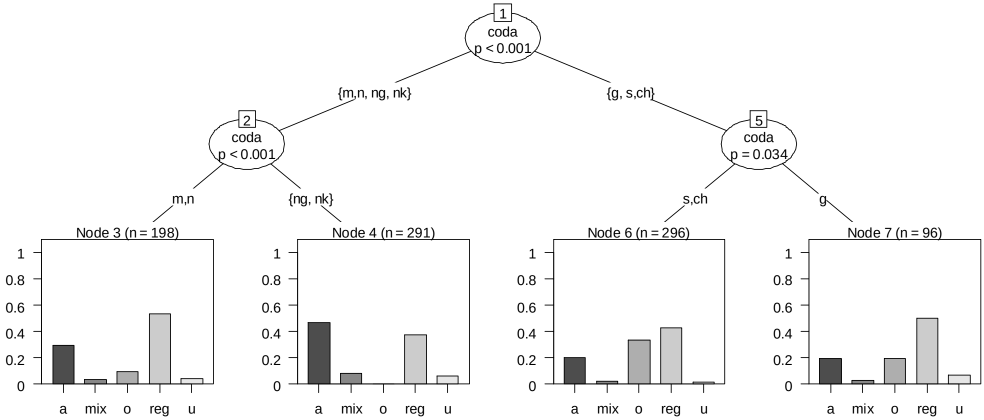

Figure 3 Conditional inference tree for the types of vowel change by onset, nucleus, and coda

The algorithm finds only one significant predictor, namely *coda* (topmost split in the tree, Node 1). This is in line with the mixed model above, where the only significant main effect occurred with coda, too. In the tree diagram, we can see that the distinction between nasal coda structures on the one hand (Node 2 on the left) and the fricatives and the velar obstruent on the other is highly significant ($p < .001$). The final level of the tree provides the proportional frequencies for the four kinds of vowel change. We find the highest proportion of regular responses for fricatives and the velar obstruent (Node 7) as well as codas [m] and [n] (Node 3). In contrast, most of the vowel change responses can be found for [ŋ(k)], favoring [a] (Node 4), and [s/ç], favoring [o] (Node 6). Overall, the tree model suggests a highly significant influence for coda on the choice between different vowel changes, with velar nasals favoring [a], and fricatives favoring [o].

To sum up, the nonces producing most vowel changes had the schema [ʃ(C)_ɪ_ŋ]. For vowel change versus the default, an independence model showed significant effects for [ʃC_ŋ(k)], [C_fricative], [#_iː_ŋ(k)] and [#_ɪ_fricative], while the generalized mixed model yielded a significant effect for the rhymes [#_ɪ_ŋ(k)] and [#_iː_s/ç]. When predicting the types of vowel change, *coda* was the only significant predictor, with [ŋ(k)] favoring vowel changes in [a] and fricatives favoring [o].

6. Results and discussion of Experiment 2

In Experiment 2, conditional inference trees modelling the type of vowel change also showed effects for coda, with [ŋ(k)] favoring [i-a-u] patterns, and fricatives favoring [i-o-o]. Recall, though, that Experiment 2 was supposed to test whether the participants' vowel changes were faithful to the predictions made by the apophonic path. Although there is a good deal of consistency between expected and elicited patterns (χ^2 (10) = 146.27, p < .001 for given infinitives, χ^2 (10) = 270.43, p < .001 for given preterites), there are quite a few inconsistencies.

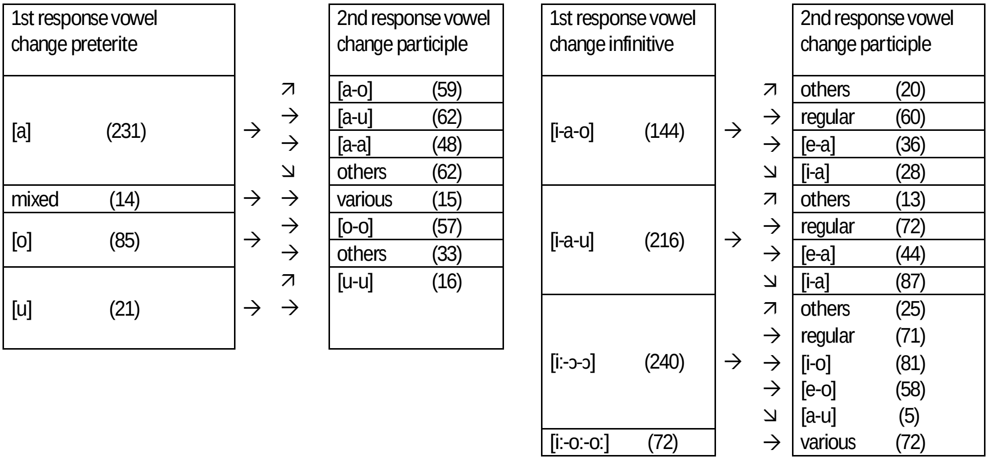

Figure 4 Interaction between preterite and participle response (left) and infinitive and participle responses (right), excluding regular first responses, with arrows marking the various paths of inflectional combinations

First, the learners produced 38% unattested vowel changes. For responses starting from a given infinitive, this is evidence against the apophonic path. Moreover, 32% of the responses to given nonce preterites were regular. While it is understandable for given infinitives to prompt learners to apply the default and not inflect it by analogy to a phonologically nearest neighbor, it is surprising when it comes to the nonce preterites. Those preterites, such as *schoch*, *stang*, or *schnoss* obviously lack regular suffixes. The 32% regular responses indicate either that the nonce's obvious irregular phonological shape must have been inaccessible to quite a few learners, or that the directionality of the apophonic path rules out reverse ablaut. However, more than 50% of the responses to a given nonce preterite show vowel change commensurate with attested patterns. This, in turn, is evidence against a directional apophonic path since, clearly, a lot of learners developed grammatical vowel change sequences starting backwards from a given nonce preterite. Figure 4 illustrates inconsistencies in further detail.

What we can see in Figure 4, left panel, is an erosion from [a]-vowel-changing patterns in the first (preterite) to the second (participle) response. 231 preterites branch out to four different participle patterns. And both [a]- and [o]-vowel-changes create unorthodox forms in the participle (others). On the right, we can see that given preterites prompted four different infinitive patterns, which, too, branch out heavily into various attested and unattested vowel changes (others).

In sum, evidence against the apophonic path lies in the inconsistencies when producing vowel change from nonce infinitive to preterite and participles, as well as in the analogically formed irregular infinitives from given nonce preterites.

In order to model the relationship between the nonce given, the two responses, and the overall grammaticality of the vowel change series, generalized mixed models with restricted maximum likelihood were fitted to the data. In all models, random intercepts were included for subject and items. Factor levels of predictors were treatment-coded. A maximal random-effects-structure with all random slopes as well as interactions of fixed effects prevented models from converging, so terms were dropped whenever this happened.

First of all, the tense given turned out to be a significant predictor for the first (χ^2 (1) = 9.57, p < .005) and second response (χ^2 (1) = 4.76, p < .03), but, interestingly, not for the grammaticality of the overall vowel change pattern (χ^2 (1) = 0.04, p = .84). In contrast, in a model with the two responses as fixed effects, both are highly significant (p < .001). It thus appears as though it was not the given nonce verb as such that predicted the grammaticality of the overall patterns, but the interplay between the two inflections the learners produced. This is again evidence against the apophonic path since the stimulus represented the directionality dimension of the apophonic path and should have resulted in well-formed vowel change patterns for given infinitives only.

The final model included both the tense given and the two responses as fixed effects. Fixed and random effects were tested for multicollinearity. The predictors' inflation factor was below 2.5, and the model was not overdispersed. Scaled residuals were distributed fairly symmetrically. Table 3 summarises the final model, with a pseudo conditional R^2 of 0.78.

Table 3 Table of coefficients of the final model, estimated using Laplace approximation as well as the optimizer *bound by quadratic approximation* (bobyqua) instead of the heuristic default Nelder-Mead method

		Logits	*SE*	*z*	*p*
	Intercept	-3.25	0.41	-7.96	< .001***
Nonce given (effect size = 0.13)	Preterite	0.63	0.48	1.31	.19
1st response (effect size = 0.85)	Ungrammatical	2.65	0.39	6.85	< .001***
1st response (effect size = 0.01)	Regular	-3.76	0.45	-8.41	< .001***
2nd response (effect size = 0.80)	Ungrammatical	5.60	0.44	12.66	< .001***
2nd response (effect size = 0.02)	Grammatical	0.28	0.95	0.29	.077

Note. Logits are the log-odds of the parameter estimations; *SE* is the standard error; *z*-values come from the corresponding Wald statistics; *** p < .001.

Table 3 shows that the given tense is again insignificant. Ungrammatical first responses, compared to grammatical ones (mapped onto the intercept), result, however, in a significant increase of log odds by 2.65, and thus in a probability for ungrammatical patterns of 0.93. Likewise, ungrammatical second responses show an increase in log odds by 5.6 and a probability of 0.99 for ungrammatical overall patterns. The ungrammatical second response has the largest effect size in this model.

In sum, the faithfulness to attested patterns is the result of the interplay between first and second response and not of the directionality prompted by the nonce verbs. It can therefore be concluded that the apophonic path cannot convincingly account for the present data.

7. Conclusion

How far do the data of the two experiments support a schema-based or universal apophonic organization of vowel change in GFL speakers? First of all, we do see certain constituent combinations, such as [ʃC_ŋ(k)] and [C_fricative], triggering non-default inflections. This observation is by no means trivial since apparently even a restricted, classroom-based exposure to German makes analogical formations possible already in intermediate learners (Murphy, 2004; Gor & Chernigovskaya, 2005 for similar results for learners of Russian). The learners' L1 could, though, have a positive effect, since English and German irregular verb morphology are not all that different (Clahsen, Felser, Neubauer, Sato, & Silva, 2010).

Second, there is an almost complete overlap between the nonces producing most of the attested vowel changes in Experiment 1 (*spingen, stingen*, and *schingen*) and the most effective constituent combinations, thus having the cue-validity one would expect from a prototype (Rosch & Mervis, 1975). However, contrary to English (Bybee & Moder, 1983; Bybee & Slobin, 1982), it is predominantly the verbs' rhymes, such as [#_ɪ_ŋ(k)] and [#_iː_s/ç], which account for vowel change patterns. So far, these findings are only partly in line with prototypical schemas. Instead, as Penke (2006) already suggested, the internal organization of irregular German verb schemata might rely solely on the rhyme.

Third, the double inflections in Experiment 2 illustrate processes incompatible with the apophonic path. Instead, they reveal a certain analogical productivity in a reverse fashion (Becker, 1990). It remains unclear, though, why there were so many default responses to given irregular nonce preterites. This is indeed surprising since both beginning and advanced learners are reported to pay considerable attention to stem-changes (Godfroid & Uggen, 2013), are less sensitive to a verb's morphological structure (Neubauer & Clahsen, 2009), and prefer declarative memory over symbolic processing. Overall, the present German L2 data support the notion of an analogical pattern associator, either as part of a dual-route model or as an analogy-based single mechanism.

From a theoretical point of view, it seems as though structured lexical entries from minimalist morphology might best provide a theoretical account for German

L2 vowel change (Clahsen, 1999; Wunderlich, 1996; Wunderlich & Fabri, 1995). Structured lexical entries are organized as hierarchical trees, with nodes and subnodes relating underspecified grammatical features to each other. However, those trees might not just organise individual underspecified entries, but the entire paradigm, or verb classes, as such. Therefore, inflectional classes, and even regular verb morphology, would have a psycholinguistic reality and would not merely be the by-product of their members (Trompelt, Bordag, & Pechmann, 2013).

From a processing point of view, promising avenues for further research could lie in micro-rules, analogical learners, connectionist networks, and probabilistic models. The efficiency of so-called micro-rules has been proven for English past tense (Albright & Hayes, 2003). They argue for a model inductively creating micro-rules for both regular and irregular verbs. It is difficult, though, to qualitatively distinguish instance-based input-output rules and analogical formations. Both processes might ultimately be just the two sides of the same coin. On the one hand, the entirety of exemplars and their related forms create patterns and thus facilitate new analogical formations, but, on the other hand, provide the basis for abstract micro-level subregularities and thus facilitate deterministic rules with the extent of one exemplar (Becker, 1990). In other words, rules could be interpreted as highly reinforced representational patterns and schemas (Bybee, 1988). Appropriate alternatives to such symbolic approaches might lie in analogical learners (Aha, Kibler, & Albert, 1991; Daelemans, Zavrel, van der Sloot, & van den Bosch, 1999; Eddington, 2004, Skousen, 1989), connectionist networks (Westermann, Willshaw, & Penke, 1999) or probabilistic models (Albright, 2009; Baayen, 2003; Baayen & Hay, 2005; Gor & Chernigovskaya, 2005). Probabilistic models might, in fact, turn out to be particularly suited since they can incorporate gradience and learning experience.

From an acquisitional perspective, the most important finding in this study is probably that verb inflections by analogy to existing patterns appear to be possible even at an intermediate learner level. The present GFL learners have, despite limited classroom-based exposure to the foreign language, accumulated enough exemplars of the verbal paradigm in their mental lexicons to generalise patterns, enabling them to productively handle new linguistic experiences. What, however, does this mean for the acquisition of German in instructional settings? On the one hand, if learners generally turned out to prefer lexical retrieval by means of analogical generalization, instructions revolving around morphological analyses of verb forms would be of little help; instead, massive exposure facilitating analogical inference would be called for. In that respect, further research should look into possible constraints and threshold levels for such generalization properties. On the other hand, English speaking learners of German, in particular, could benefit from a crosslinguistic focus on forms in order to make them aware of both the similarities and differences between the two verbal paradigms.

References

Aha, D. W., Kibler, D., & Albert, M. K. (1991). Instance-based learning algorithms. *Machine Learning, 6,* 37-66. doi: 10.1007/BF00153759

Albright, A. (2009). Modeling analogy as probabilistic grammar. In J. P. Blevins & J. Blevins (Eds.), *Analogy in grammar. Form and acquisition* (pp. 185-204). New York: Oxford University Press.

Albright, A., & Hayes, B. (2003). Rules vs. analogy in English past tenses: A computational/experimental study. *Cognition, 90*(2), 119-161. doi: 10.1016/S 0010-0277(03)00146-X

Anderson, S. R. (1988). Morphological theory. In F. J. Newmeyer (Ed.), *Linguistics: The Cambridge survey. Vol. I. Linguistic theory: Foundations* (pp. 146-191). Cambridge: Cambridge University Press.

Baayen, R. H. (2003). Probabilistic approaches to morphology. In R. Bod, J. B. Hay, & S. Jannedy (Eds.), *Probabilistic linguistics* (pp. 229-287). Cambridge, MA.

Baayen, R. H., & Hay, J. B. (2005). Shifting paradigms: Gradient structure in morphology. *Trends in Cognitive Sciences, 9(7),* 342-348. doi: 10.1016/j.tics.2005.04.002

Baayen, R. H., Davidson, D. J., & Bates, D. M. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language, 59*(4), 390-412. doi: org/10.1016/j.jml.2007.12.005

Barr, D. J., Levy, R., Scheepers, C., & Tily, H. J. (2013). Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and Language, 68*(3), 255-278. doi: 10.1016/j.jml.2012.11.001

Bates D., Maechler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software, 67*(1), 1-48. doi:10.18637/jss.v067.i01

Becker, T. (1990). *Analogie und morphologische Theorie.* München: Wilhelm Fink.

Berko, J. (1958). The child's learning of English morphology. *Word, 14,* 150-77. doi: http://dx.doi.org/10.1080/00437956.1958.11659661

Bittner, A. (1996). *Starke 'schwache' Verben, schwache 'starke' Verben. Deutsche Verbflexion und Natürlichkeit.* Tübingen: Stauffenburg.

Burgess, A. (1972). *A clockwork orange.* London: Penguin.

Bybee, J. (1988). Morphology as lexical organisation. In M. Hammond & M. Noonam (Eds.), *Theoretical approaches to morphology* (pp. 119-141). San Diego: Academic Press.

Bybee, J. (1995). Regular morphology and the lexicon. *Language and Cognitive Processes, 10*(5), 425-455. doi: http://dx.doi.org/10.1080/01690969508407111

Bybee, J., & Newman, J. (1995). Are stem changes as natural as affixes? *Linguistics, 33*(4), 633-654. doi: 10.1515/ling.1995.33.4.633

Bybee, J., & Moder, C. L. (1983). Morphological classes as natural categories. *Language, 59,* 251-270. doi: 10.2307/413574

Bybee, J., & Slobin, D. I. (1982). Rules and schemas in the development and use of the English past tense. *Language, 58,* 265-289. doi: 10.2307/414099

Clahsen, H. (1997). The representation of German participles in the German mental lexicon: Evidence for the dual-mechanism model. In G. Booij & J. v. Marle (Eds.), *Yearbook of morphology 1996* (pp. 73-96). Dodrecht: Kluwer Academic.

Clahsen, H. (1999). Lexical entries and rules of language: A multidisciplinary study of German inflection. *Behavioral and Brain Sciences, 22,* 991-1060. doi: 10.1017/S0140525X99002228

Clahsen, H., Eisenbeiß, S., & Sonnenstuhl-Henning, I. (1997). Morphological structure and the processing of inflected words. *Theoretical Linguistics, 23,* 201-249. doi: 10.1515/thli.1997.23.3.201

Clahsen, H., Felser, C., Neubauer, K., Sato, M., & Silva, R. (2010). Morphological structure in native and nonnative language processing. *Language Learning, 60,* 21-43. doi: https://doi.org/10.1017/S1366728912000648

Clahsen, H., Hadler, M., & Weyerts, H. (2004). Speeded production of inflected words in children and adults. *Journal Child Language, 31*(3), 683-712. doi: http://dx.doi.org/10.1017/S0305000904006506

Council of Europe (2001). *Common European framework of reference for languages: Learning, teaching, assessment.* Cambridge: Cambridge University Press.

Cunnings, I., & Finlayson, I. (2015). Mixed effects modeling and longitudinal data analysis. In L. Plonsky (Ed.), *Advancing quantitative methods in second language research* (pp. 159-181). New York: Routledge.

Cunnings, I., & Linck, J. A. (2015). The utility and application of mixed-effects models in second language research. *Language Learning, 65*(1), 185-207. doi: 10.1111/lang.12117

Daelemans, W., Zavrel, J., van der Sloot, K., & van den Bosch, A. (1999). *TiMBL: Tilburg Memory Based Learner, version 2.0, reference guide*. *Induction of linguistic knowledge technical report.* Tilburg, Netherlands: ILK Research Group.

Eddington, D. (2000). Analogy and the dual-route model of morphology. *Lingua, 110*(4), 281-298. doi: 10.1.1.123.9060

Eddington, D. (2004). Issues in modelling language processing analogically. *Lingua, 114*(7), 849-871. doi: 10.1016/S0024-3841(03)00063-9

Godfroid, A., & Uggen, M. S. (2013). Attention to irregular verbs by beginning learners of German. *Studies in Second Language Acquisition*, *35*(2), 291-322. doi: 10.1017/S0272263112000897

Goebel, R., & Indefrey, P. (2000). A recurrent network with short-term memory capacity learning the German *s*-plural. In P. Broeder & J. Murre (Eds.), *Models of language acquisition. Inductive and deductive approaches* (pp. 177-200). Oxford: Oxford University Press.

Gor, K., & Chernigovskaya, T. (2005). Formal instruction and the acquisition of verbal morphology. In A. Housen & M. Pierrard (Eds.), *Investigations in instructed second language acquisition* (pp. 131-166). Berlin: Mouton de Gruyter.

Gries, S. T. (2015). The most under-used statistical method in corpus linguistics: Multi-level (and mixed-effects) models. *Corpora, 10*(1), 95-125. doi: 10.3366/cor.2015.0068

Hahne, A., Müller, J., & Clahsen, H. (2006). Morphological processing in a second language: Behavioural and event-related potential evidence for storage and decomposition. *Journal of Cognitive Neuroscience, 18,* 121-134. doi: http://dx.doi.org/10.1162/089892906775250067

Hothorn, T., Hornik, K., & Zeileis, A. (2006). Unbiased recursive partitioning: A conditional inference framework. *Journal of Computational and Graphical Statistics, 15*(3), 651-674. doi: http://dx.doi.org/10.1198/106186006X133933

Jaeger, T. F. (2008). Categorical data analysis: Away from ANOVAs (transformation or not) and towards logit mixed models. *Journal of Memory and Language, 59*(4), 434-446. doi: 10.1016/j.jml.2007.11.007

Köpcke, K.-M. (1998). Prototypisch starke und schwache Verben in der deutschen Gegenwartssprache. *Germanistische Linguistik, 141-142,* 45-60.

Lemhöfer, K., & Radach, R. (2009). Task context effects in bilingual nonword processing. *Experimental Psychology, 56*(1), 41-47. doi: http://dx.doi.org/10.1027/1618-3169.56.1.41

Lück, M., Hahne, A., & Clahsen, H. (2006). Brain potentials to morphologically complex words during listening. *Brain Research, 1077,* 144-152. doi: http://dx.doi.org/10.1016/j.brainres.2006.01.030

Marusch, T., von der Malsbur, T., Bastiaanse, R., & Burchert, F. (2012). Tense morphology in German agrammatism. The production of regular, irregular and mixed verbs. *The Mental Lexicon, 7*(3), 351-380. doi: 10.1075/ml.7.3.05mar

Murphy, V. A. (2004). Dissociable systems in second language inflectional morphology. *Studies in Second Language Acquisition, 26*(3), 433-459. doi: https://doi.org/10.1017/S0272263104263033

Neubauer, K., & Clahsen, H. (2009). Decomposition of inflected words in a second language: An experimental study of German participles. *Studies in Second Language Acquisition, 31,* 403-435. doi: http://dx.doi.org/10.1017/S0272263109090354

Nübling, D., Dammel, A., Duke, J., & Szczepaniak, R. (2006). *Historische Sprachwissenschaft des Deutschen: Eine Einführung in die Prinzipien des Sprachwandels.* Tübingen: Gunter Narr.

Orsolini M., & Marslen-Wilson, W. D. (1997). Universals in morphological representation: Evidence from Italian. *Language and Cognitive Processes, 12,* 1-47. doi: http://dx.doi.org/10.1080/016909697386899

Penke, M. (2006). *Flexion im mentalen Lexikon.* Tübingen: Max Niemeyer.

Penke, M., Wimmer, E., Hennies, J., Hess, M., & Rothweiler, M. (2014). Inflectional morphology in German hearing-impaired children. *Logopedics Phoniatrics Vocology, 41*(1), 9-26. doi: 10.3109/14015439.2014.940382

Pinker, S. (1999). *Words and rules. The ingredients of language.* London: Phoenix.

Pinker, S., & Ullman, M. T. (2002). Combination and structure, not gradedness, is the issue. *Trends in Cognitive Sciences, 6,* 472-474. doi: http://dx.doi.org/10.1016/S1364-6613(02)02013-2

Pliatsikas, C., & Marinis, T. (2013). Processing of regular and irregular past tense morphology in highly proficient L2 learners of English: A self-paced reading study. *Applied Psycholinguistics, 34,* 943-970. doi:10.1017/S0142716412000082

Prasada, S., & Pinker, S. (1993). Generalization of regular and irregular morphological patterns. *Language and Cognitive Processes, 8,* 1-56. doi: http://dx.doi.org/10.1080/01690969308406948

R Core Team (2016). *R: A language and environment for statistical computing*. Vienna: R Foundation for Statistical Computing. Retrieved from https://www.R-project.org/

Ramscar, M. J. A. (2002). The role of meaning in inflection: Why the past tense does not require a rule. *Cognitive Psychology, 45,* 45-94. doi: 10.1016/S0010-0285(02)00001-4

Rosch, E. (1975). Cognitive representations of semantic categories. *Journal of Experimental Psychology: General, 104*(3), 192-232. doi: doi.apa.org/journals/xge/104/3/192.pdf

Rosch, E., & Mervis, C. B. (1975). Family resemblance: Studies in the internal structure of categories. *Cognitive Psychology, 7,* 573-605. doi: 10.1016/0010-0285(75)90024-9

Ruh, N., & Westermann, G. (2008). A Single-mechanism dual-route model of German verb inflection. In B. C. Love, K. McRae, & V. M. Sloutsky (Eds.), *Proceedings of the 30th annual conference of the cognitive science society* (pp. 2209-2214). Austin, TX: Cognitive Science Society.

Ségéral, P., & Scheer, T. (1998). A generalized theory of ablaut: The case of modern German strong verbs. In R. Fabri, A. Ortmann, & T. Parodi (Eds.), *Models of inflection* (pp. 28-59). Tübingen: Niemeyer.

Skousen, R. (1989). *Analogical modeling of language.* Dordrecht: Kluwer Academic.

Smolka, E., Khader, P. H., Wiese, R., Zwitserlood, P., & Rösler, F. (2013). Electrophysiological evidence for the continuous processing of linguistic categories of regular and irregular verb inflection in German. *Journal of Cognitive Neuroscience, 25*(8), 1284-1304. doi: 10.1162/jocn_a_00384

Smolka, E., Zwitserlood, P., & Rösler, F. (2007). Stem access in regular and irregular inflection: Evidence from German participles. *Journal of Memory and Language*, *57*(3), 325-347. doi: dx.doi.org/10.1016/j.jml.2007.04.005

Strobach, T., & Schönpflug, U. (2011). Can a connectionist model explain the processing of regularly and irregularly inflected words in German as L1 and L2*? International Journal of Bilingualism, 15*(4), 446-465. doi: 10.1177/1367006911403205

Thiele, J., & Markussen, B. (2012). Potential of GLMM in modelling invasive spread. *CAB Reviews, 7,* 1-10. doi: 10.1079/PAVSNNR20127016

Trompelt, H., Bordag, D., & Pechmann, T. (2013). (Ir)regularity of verbs revisited: Evidence for lexical entry complexity. *The Mental Lexicon, 8*(1), 26-52. doi: 10.1075/ml.8.1.02tro

Ullman, M. T. (2001). A neurocognitive perspective on language: The declarative/procedural model. *Nature Reviews. Neuroscience, 2*(10), 717-726. doi: 10.1038/35094573

Wagner, T. (2010). *Interlanguage morphology. Irregular verbs in the mental lexicon of German-English interlanguage speakers.* Tübingen: Narr-Francke-Attempto.

Westermann, G., Willshaw, D., & Penke, M. (1999). A constructivist neural network model of German verb inflections in agrammatic aphasia. In *Proceedings of ICANN99* (pp. 916-921). Edinburgh: IET Publishing.

Whitaker, H. A. (2006). Words in the mind, words in the brain: Preface to inaugural issue of The Mental Lexicon. *The Mental Lexicon, 1*(1), 3-5. doi: 10.1075/ml.1.1.02wh

Wiese, B. (2008): Form and function of verbal ablaut in contemporary standard German. In R. Sackmann (Ed.), *Explorations in integrational linguistics. Four essays on German, French, and Guaraní* (Current Issues in Linguistic Theory 285) (pp. 97-151). Amsterdam: John Benjamins.

Wiese, R. (2000). *The phonology of German.* Oxford: Oxford University Press.

Wunderlich, D. (1996). Minimalist morphology: The role of paradigms. In G. Booij & J. van Marle (Eds.), *Yearbook of morphology 1995* (pp. 93-114). Dodrecht: Kluwer Academic.

Wunderlich, D., & Fabri, R. (1995). Minimalist morphology: An approach to inflection. *Zeitschrift für Sprachwissenschaft, 14*(2), 236-294. doi: 10.1515/zfsw.1995.14.2.236

APPENDIX

Table of test items and distractors of Experiment 1 and 2

No.	Experiments					
	1		2a		2b	
	Test items	Distractors	Test items	Distractors	Test items	Distractors
1.	kniеßen		kniеßen		knoss	
2.	schrimmen		schrimmen		schramm	
3.		*luschen*		*nisseln*		*nisselte*
4.	spinken		spinken		spank	
5.	grießen		grießen		gross	
6.		*rabotten*		*pieben*		*piebte*
7.	stinnen		stinnen		stann	
8.	biechen		biechen		boch	
9.		*govoriten*		*witten*		*wittete*
10.	strinken		strinken		strank	
11.		*vidden*		*stiemen*		*stiemte*
12.		*loviten*		*stitzen*		*stitzte*
13.	schiechen		schiechen		schoch	
14.	schringen		schringen		schrang	
15.		*sotteln*		*miegeln*		*miegelte*
16.	stiechen		stiechen		stoch	
17.		*schmatten*		*hitteln*		*hittelte*
18.	strimmen		strimmen		stramm	
19.	spingen		spingen		spang	
20.		*pitschen*		*sicken*		*sickte*
21.	schliegen		schliegen		schlog	
22.		*kritschen*		*pitschen*		*pitschte*
23.	schingen		schingen		schang	
24.	fießen		fießen		foss	
25.	sprinken			*lichsen*		*lichste*
26.		*boppen*		*liepen*		*liepte*
27.		*schlippen*	sprinken		sprank	
28.	fiechen		fiechen		foch	
29.	stingen		stingen		stang	
30.	triechen		triechen		troch	
31.		*krasen*		*bristen*		*bristete*
32.	strießen		strießen		stross	
33.	schinnen		schinnen		schann	
34.	pliegen		pliegen		plog	
35.		*dengen*		*fritteln*		*frittelte*
36.	kingen		kingen		kang	
37.	friegen		friegen		frog	
38.		*wetschen*		*krietschen*		*krietschte*
39.	linnen		linnen		lann	
40.	schnießen		schnießen		schnoss	
41.		*harrken*		*fietzen*		*fietzte*
42.	schminnen		schminnen		schmann	
43.	frinken		frinken		frank	