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Second-language acquisition of the English past-tense: From rules to analogy

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ABSTRACT

The present study investigates the production of novel morphologically inflected forms in second-language learners of English with Czech as L1. The study attempts to investigate which production model (single- or dual-route) best accounts for L2 learners' morphological productivity when forming regular past forms of novel words. Additionally, it explores the possible interference effects of L1. 88 English L2 learners and 9 native speakers heard sentences in which a new activity was described with a novel word (*The baby likes to dize. Look, there it is dizing. Everyday it dizes.*) and past-tense forms were elicited (*So yesterday it...*). The results revealed that for native speakers the likelihood of a verb being produced in a regular past-tense form was inversely related to its phonological similarity to existing irregular verbs (replicating previous studies). L2 speakers showed a development in this direction: While for the A1 to B1 participants similarity to existing irregulars did not matter, B2 and C1 participants appeared to be sensitive to these similarities and behaved comparably to native speakers. In addition to the form analysis, the reaction-times results showed that the lowest language levels used their L1 as a performance facilitator (with slower performance with novel words that do not respect the phonology of the participants' L1), while proficient learners and native speakers were not sensitive to this property of the novel words. The results suggest that the L2 acquisition of the English past-tense is characterized by a development from the mastery of mechanistic rules to the refinement of their application based on analogical patterns extracted from existing verbs, with Czech promoting the production at the earliest proficiency stages.

KEYWORDS

analogy, Czech, English, inflectional morphology, past-tense, rules, second-language acquisition

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1 INTRODUCTION

The baby likes to dize. Look, there it is dizing. Everyday, it dizes. So yesterday it...dized? Or *doze*? The answer to this question poses a number of difficulties. The nature of representations for inflectional morphology has fuelled a long-term and intense psycholinguistic debate, both in the study of perception and in the study of production. The discussion of whether novel morphologically inflected forms are generally produced by the application of rules (e.g. Prasada & Pinker 1993) or by analogy based on stored examples (e.g. Bybee & Slobin 1982) is continuously addressed in the field. Special attention is being paid to the difference between regular and irregular inflection, particularly that of the English past tense, since English encompasses a relatively clear-

cut distinction between the two forms and therefore suits perfectly to the purpose of disentangling between these two approaches.

Regular past-tense inflection realized by the "add *-ed* to the verb stem" rule (as in *jump — jumped* or *cook — cooked*) applies to thousands of verbs and is often productively used in the generalization of new word-forms (as in *rick — ricked* in Berko, 1958), while irregular past-tense forms (such as *fall — fell*) apply only to circa 180 known irregular verbs and often fall victim to overgeneralization by children (as in **sitted* instead of *sat*) (Pinker & Ullman 2002). These irregular forms have been traditionally assumed to be acquired and stored as compact units in our memory (Prasada & Pinker 1993). However, the simple idea that regular past-tense forms are obtained from rules and irregular past-tense forms are stored as units has proved problematic in several aspects: irregular verbs, for instance, form families of similar verbs such as *cut* and *put* whose past tense remains the same as the present form and thus allows for analogical generalization of novel verbs (see, for instance, Bybee & Moder 1983). English also includes many quasi-regular inflections (Cilibrasi et al. 2019: 750): such past-tense forms are "obtained following a productive pattern that is, however, less frequent than that normally labelled as regular." Examples of quasi-regular past-tense forms would be *feel/felt, keep/kept*, or *build/built*. The main question of the above-mentioned debate thus centres around whether "regular and irregular past tense forms are generated by two qualitatively distinct mechanisms or whether all forms are produced in a single, associative process" (Westermann & Ruh 2012: 649). Despite the length of the debate, the question remains partly unanswered, and the views differ diametrically. Generativist theories often attribute generalization to rules, connectionist theories attribute it to association based on analogy, while hybrid theories attribute regular generalization to rules and irregular generalization to analogy, but they also suggest that frequent regular verbs may be stored in memory with their inflection (Prasada & Pinker 1993).

As a consequence, two models have been proposed for past-tense production: (i) the single-route model (see, for instance, Bybee & Moder 1983), which assumes that both regular and irregular past-tense forms are produced by analogy across word forms that already exist in our mental lexicon, and (ii) the dual-route model (see, for instance, Prasada & Pinker 1993), which assumes that the two past-tense forms are produced by two different processes: the generation of regular past-tense forms is governed by the application of a basic rule for past-tense inflection (i.e. adding *–ed* to the verb stem), while irregulars are stored as units and used in analogical generalization. It is evident that both models assume that the same mechanism is used in the generation of irregular past-tense forms, stating that if our mind does not retrieve the irregular form directly from our mental lexicon as a unit, analogy steps in and the irregular form in question is produced based on its phonological similarity to existing forms that are already stored in our memory. Investigating irregular verbs, therefore, does not help us decide which model is a better description of how past-tense forms are produced, and regular inflection needs to be studied instead.

The majority of psycholinguistic studies generally use novel words to test morphological productivity (e.g. Prasada & Pinker 1993; Albright & Hayes 2003; Ambridge 2010; Blything et al. 2018) since such a procedure requires generalization and avoids

effects related to the lexical access (Blything et al. 2018). This assumption is also at the foundation of studies such as Albright and Hayes (2003) and Blything et al. (2018) who used an elicited production task to investigate which of the two models is better at describing morphological productivity in native speakers of English. This experiment builds on these two previous studies and aims to additionally explore (i) the development of morphological productivity of second-language learners of English and (ii) the effect of their L1 (Czech) on the L2 production.

2 THEORETICAL FRAMEWORK AND HYPOTHESES

Albright and Hayes (2003), Ambridge (2010), and Blything et al. (2018) addressed these issues using acceptability judgement and novel-verb production tasks, testing adults and children with a clear intention to distinguish between the two aforementioned models. Albright and Hayes' study (2003) created novel verbs that showed phonological similarity or dissimilarity to existing regular and irregular English verbs. Using an elicited production task, the authors found that novel words that resemble existing regular verbs were more likely to be produced and judged as regular past forms by adult English speakers and that novel words that resemble existing irregular verbs were similarly more likely produced and judged as irregular past forms, in line with the single-route model. Replicating the judgement section of Albright and Hayes's study (2003), Ambridge (2010) tested children aged 6–7 and 9–10. Again, he found that the participants favourably judged novel irregular past forms that phonologically resembled existing irregular verbs. The older group of the English-speaking children also more often accepted regular past forms of novel verbs that highly resemble existing regular verbs, again in line with the single-route model. Blything et al.'s study (2018) builds on the two previous studies. Using the novel verbs created by Albright and Hayes (2003), the authors investigated the mechanisms that underlie morphological productivity, focusing on verbal morphology of the English past tense and recruiting groups of children from 3 up to 10 years of age. Their results have shown that "the likelihood of a novel verb being produced in a regular past-tense form is positively associated with its phonological similarity to existing regular verbs" (Blything et al., 2018: 3), in line with the single-route model.

All three studies found that both past forms of novel verbs are generated by analogy across existing word forms stored in our mental lexicon and ruled by their similarity to these stored forms (Ambridge 2019). These findings provide us with tentative evidence that the single-route model might be better at describing the morphological production of novel forms in comparison to the dual-route model, and, consequently, that (structural) analogy prevails over rules in regular past-tense production. The authors investigated both adults and older children of 9–10 years of age, and also smaller children at the peak rate of over-generalization, not only paying attention to mature linguistic systems, but also to the systems still undergoing development (Blything et al. 2018). This experiment aims to explore a similar step in the acquisition of past-tense production by focusing on second-language learners of English, and it also attempts to describe any potential difference from native speakers of English.

Previous studies on L2 morphological development show that the dual-route model is not capable of fully explaining and describing the production patterns of L2 learners. Studying frequency effects on regular verbs, Beck (1997) and Ellis & Schmidt (1998) reported findings inconsistent with the dual-route model. In their studies, the authors crucially showed that the frequency effects do not apply only to irregular verbs but also to regular ones, suggesting a prevalence of analogical processing. These results match those presented in Murphy (2000), who showed that the assumptions of the dual-route model are difficult to apply to L2 data. Her results are better explained by an alternative, associative model. Even though her L2 participants (similarly to native speakers) did add past-tense suffixes to novel regular verbs more than to the irregular ones, both native and non-native speakers used the novel verb's phonological resemblance to existing (ir)regulars as a decisive factor in producing past-tense forms — a finding not predicted by the dual-route model. These results thus undermine the claims of the dual-route mechanism that supports a complete dissociation of the processes behind the two past-tense forms (regular vs. irregular) and of the learning systems underlying language representation. Murphy (2000: 112) proposes "a more parsimonious account invoking a single set of associative learning mechanisms" instead. In more recent years, Cuskley et al. (2015) examined the difference between native and L2 production of past tense using a novel-word task, showing that both groups of participants show sensitivity towards phonological similarities between the novel and existing verbs. Their results in fact show that it is more probable that the participants will produce (ir)regular past forms with novel verbs that phonologically resemble existing (ir)regular verbs, in line with the single-route model. In addition, the authors have also noted that instead of showing a straightforward preference for the default regular past-tense rule, the L2 learners were generally more prone to using sub-rules for the production of various types of irregular past-tense forms. Similarly to Murphy (2000), Agathopoulou (2009) found that adult Greek L2 learners of English and English native speakers produced past tense forms of novel verbs that cannot be fully captured by the dual-route model (due to an apparent similarity effect found in the elicited forms) and noted no qualitative difference between how native and non-native speakers of English handled English (ir)regular verb morphology. These studies offer interesting insights into morphological processing in L2 learners.

Building on them, the present research aims at exploring how these processing strategies are achieved by L2 learners of English with Czech as L1 and thus at describing the development of their L2 morphological system. In comparison to the English past-tense morphology, Czech creates past-tense forms through the combination of the past stem of a verb and the addition of the so-called past-tense "*l*-forms," i.e. suffixes *-l, -la,-lo,-li/y*. These forms vary according to gender and number of the subject, offering thus larger variability in comparison to English inflection. In addition, number and person may be expressed by an auxiliary verb, which appears with the main verb and thus contributes to the morphological complexity of the sentence. Finally, the past stem can undergo stem alteration (Čechová 1996), depending on the verb employed (e.g. *brát — bral* or *chtít — chtěl*). Since Czech is a language with such a complex inflectional system, it creates an interesting contrast with the notoriously poor inflectional system of English and therefore provides a suitable ground for in-

vestigating possible interference effects of Czech on the acquisition of English inflectional morphology.

To achieve our aims, this study uses a production task with novel verb stimuli and tests participants with various proficiencies, including participants in the initial stages of learning, participants with rather mature systems of the target language, and the range in between. The inclusion of a progression of language levels in our study is what strengthens our argument in comparison to other L2 studies that usually work with L2 learners as a unit or with two or three selected language proficiencies. Testing participants from the A1 to the C1 level allows us to properly map the development of inflectional morphology in L2 learners and describe its specifics.

2.1 HYPOTHESES

Based on the previous research outlined above, our tentative hypothesis was that the dual-route model would not fully explain the production of L2 learners and that the native speakers would perform similarly to the participants tested in Albright and Hayes (2003) and Blything et al. (2018). Regarding language proficiency, the study also operated with the tentative hypothesis that the lower levels might be more inclined to use rules due to lesser experience with L2, while the higher language levels might be more inclined to use analogy (and therefore resemble more native speakers of English) due to having more significant experience with the language and the analogical rules underlying past-tense formation.

As far as Czech interference effects are concerned, there were two possible outcomes: (i) the reaction times may be quicker for the novel words that are phonotactically legal in Czech (referred to as the A-set in the study) for the L2 learners since they will be in a way familiar with the word structure from their mother tongue, and (ii) the novel words phonotactically legal in Czech (A-set) may, on the contrary, cause inhibitory effects and slow the reaction times since the L2 learners will be faced with both their L1 and L2 at the same time.

3 DATA AND METHODOLOGY

3.1 PARTICIPANTS

88 English second-language learners with Czech as their first language at A1–C1 proficiency levels[1] and a control group of 9 native speakers[2] were recruited. None of the

1 The participants were divided into proficiency levels based on a placement test created on the basis of the English Grammar and Vocabulary Profiles that describe which lexical and grammatical aspects of English are typically learned at each proficiency level.

2 A control group consisting of only 9 native speakers may not seem as a sufficiently large group for any comparison with the L2 speakers; however, our group of native speakers truly served the control purpose and our findings could be further compared to the previous work by Albright and Hayes (2003) and Blything et al. (2018) who focused on adult native speakers of English, using the exact same task.

participants had been diagnosed with any language impairment. The mean age was 37 years, standard deviation 9.4 years. 73 participants were female, 24 were male. All subjects were recruited from the faculty language school at the Faculty of Arts, Charles University, and testing occurred at this location in a private room.

3.2 STIMULI

The study adopted 32 novel verbs that were deemed phonotactically legal in English[3] (e.g. *bize*, *drice*, *spling*) from Albright and Hayes' (2003) and Blything et al.'s (2018) studies. Some of the original novel words were excluded due to their existence in Present-Day English[4] (since the novel words were created in 2003 and some of them have already entered the language as real words since) and the need for a balanced dataset. Albright and Hayes (2003) started with the creation of a control corpus of existing English verbs which were all sourced from the English part of the CELEX lexical database (Baayen et al., 1995), with a special focus on those verbs whose lemma frequency equalled or exceeded 10. If the verb had more than one past-form variant (such as *dive-dived/dove*), both alternatives were included separately. The resulting corpus of existing English verbs consisted of 4,035 regular and 218 irregular verbs. These verbs served as evidence of real phonotactic properties and phonological changes in past-tense forms and were used for counting the (dis)similarity of the created novel-verb stimuli to the existing English (ir)regular verb. In order to do that, the phonemic transcriptions of these verbs were fed into Albright and Hayes' rule-based model (Albright & Hayes 2003). Albright and Hayes used the same model for the creation of the novel verbs. They created a dataset of 2,344 novel-verb forms by "concatenating combinations of relatively common syllable onsets and syllable rhymes" (Albright & Hayes 2003: 135). The full list of novel-verb forms was then uploaded back into the model, which then produced (ir)regular past forms for each novel verb and also rated their similarity to existing (ir)regulars (Albright & Hayes 2003). For each novel word, Albright and Hayes (2003) and Blything et al. (2018) employ two ways of counting the novel word's similarity to existing (ir)regulars — based on (i) the Generalized Context Model (hereby GCM; see Nosofsky 1990) and (ii) the Minimal Generalization Learner (hereby MGL; see Albright & Hayes 2003). GCM provides values of (i) "variegated" similarity, while MGL outputs (ii) "structured" similarity (Albright & Hayes 2003; Blything et al. 2018).

To ensure findings are compatible with Albright and Hayes (2003) and Blything et al. (2018), the current study also employed a measure of the novel verbs' similarity to existing regular and irregular past-tense verbs. Since Albright and Hayes (2003) and Blything et al. (2018) introduce two different models of similarity measures (the

3 Phonotactically legal English novel words follow the restrictions on the permissible combinations of English phonemes (e.g. Pitt 1998).

4 Albright and Hayes created the novel words in 2003 and since then some of their monosyllabic novel verbs have come into existence as English words, e.g. *rife* (nowadays a frequently-used adjective), which is not a surprising phenomenon for a monosyllabic English novel word. The whole dataset was thus checked by three native speakers to eliminate such instances.

aforementioned MGL and the GCM), it was necessary to decide which of the two models to use in the data analysis. As Blything et al. (2018: 6) argue, GCM compares "phonological segments across entire words such that phonological similarities at the beginning, middle, and end of a word have equal weighting, and each comparison form can be similar to the novel verb in its own way." The stimulus' similarity to each related word is compared "feature-by-feature" (Ambridge 2019: 12) (e.g. the change from *i* to *a* in *sit, spit,* or *swim* when forming past tense) and is then divided by its feature-by-feature comparison to all existing verbs stored in out mental lexicon. The result yields the probability of a given word being a part of the specific class. For that reason, variegated similarity is sometimes regarded as a "pure" analogy by some linguists (Albright & Hayes 2003: 122). On the contrary, MGL (Albright & Hayes 2003), working with the structured similarity, pays attention "only to phonological properties that are shared uniformly among comparison verbs (e.g. the verb *cling* shares its final two segments with *string*, *sting*, and *fling,* etc.)" (Blything et al. 2018: 10) and thus assess the similarity to the phonological properties based on the features "most relevant to a verb's past-tense form (e.g. the past tense of *cling* is *clung* because it shares a final segment with *string*, *sting*, and *fling*)" (Blything et al. 2018: 10), creating explicit micro-rules for each sub-regularity (Ambridge 2019). Measures of variegated similarity of *cling* may be thus misled by irrelevant segments of a word. Blything et al. (2018: 7) conclude that as such, "structured similarity is compatible with more sophisticated conceptions of analogy such as schema-based approaches" (see, for instance, Langacker 2000). Considering possible shortcomings of the variegated similarity measure obtained from GCM, the analysis of the current study will use the structured similarity measure as a primary decisive metric.

Since the article also attempts to explore the effect of L1 on second-language production, cross-language interference effects have been taken into consideration. The 32 novel verbs were further divided into 16 phonotactically legal (A set) and 16 phonotactically illegal (B set) novel words for Czech (for the full table of novel word stimuli, see the Appendix).[5] Since there is no existing calculator of a novel word's similarity to an existing Czech word, Šturm and Lukeš (2017)'s paper "Fonotaktická analýza obsahu slabik na okrajích českých slov v mluvené a psané řeči" was used as a reference. This study investigates Czech "syllable onsets and final codas" (Šturm & Lukeš 2017: 99) both in spoken and written Czech texts imported from the Czech National Corpus. Along with a detailed study on the complexity of Czech syllable onsets and codas, the authors have also compiled a list of all phonotactically legal Czech syllable onsets and codas.[6] Using this reference list, and more specifically its spoken part (since the experiment was equipped with an aural prompt), our stimuli were further divided into 16 words that were phonotactically legal in Czech (i.e. both the syllable onset and coda were deemed phonotactically legal in Czech) and into 16 words phonotactically illegal in Czech (i.e., either the syllable onset or coda or both parts were deemed

5 Phonotactically legal Czech novel words follow the restrictions on the permissible combinations of Czech phonemes (e.g. Pitt 1998 — an experimental study done on English but whose findings are replicable also on Czech).

6 Available at https://fonetika.ff.cuni.cz/vyzkum/materialy/fonotaktika/.

phonotactically illegal in Czech). One of the major downsides of this division (and the study in general) is that Šturm and Lukeš's paper does not investigate syllable nuclei, and our stimuli division therefore could not provide a full and complex picture of Czech phonotactic (il)legality. However, given the lack of any automatized calculator that would allow stimuli importation and export the word's similarity or dissimilarity to existing Czech words, this phonotactical analysis was the only relevant reference point that could be used for the division. Therefore, even though we are fully aware of its drawbacks, using this paper was the only suitable reference for the inclusion of Czech interference effects available. Any assumptions on the effect of Czech, however, need to be read with this in mind.

The novel words were then incorporated into frame sentences sourced from Blything et al. (2018). The original sentences needed to be adapted lexically (using the English Vocabulary Profile[7]) for the lowest-level participants, i.e. the A1 level, to ensure the study's applicability and participants' understanding. Each frame sequence contained four sentences presenting the novel word in a bare-infinitive, present-progressive, and present-simple form of the following template: "The (agent) likes to VERB. Look, there he is VERBing. Everyday he VERBs. So yesterday he…" (e.g. *The baby likes to dize. Look, there it is dizing. Everyday it dizes. So yesterday it…*). To avoid semantic effects of the surrounding words (as documented, for instance, in Ramscar, 2002) on the choice of the past-tense form, each novel word was inserted into three different frame sentences (e.g. *This person/the waitress/my father likes to dize. Look, there s/he is dizing. Everyday s/he dizes. So yesterday s/he…*). The pairing of verbs and frames was randomized and different for each participant.

3.3 PROCEDURE

In an elicited production paradigm, each participant was presented with the 32 novel verbs inserted into frame sentences in a mixed (both within- and between-subjects) design. The participants were told they would hear sentences in which someone would perform an activity described with a novel word. They were then instructed to finish the sentence when the recording stopped. The participants were thus prompted to say what the agent "did yesterday", and the past-tense forms elicitation was ensured. The recorded measures obtained from this experiment included the produced forms and reaction times to the presented novel word (i.e. the time between the end of the stimulus sentence and the participant's response).

4 RESULTS

4.1 ANALYSIS OF THE PRODUCED FORMS

This analysis attempts to answer the question of whether the produced form is somehow influenced by the novel word's similarity to existing (ir)regulars or not. 3,094 trials were recorded in total. Responses were coded adopting the response scale used by Blything et al. (2018), i.e., based on whether the recorded output was (i) a regular

7 Accessible at https://www.englishprofile.org/wordlists/evp.

past-tense form (e.g. *blafed*), (ii) an irregular past-tense form[8] (e.g. *blofe*), (iii) a form without any formal change (e.g. *blafe*), (iv) a third-person singular of present simple (e.g. *blafes*), (v) a progressive form (e.g. *blafing*), or (vi) a form unclassifiable under (i)–(v) (e.g. *blafest*). The mean proportion of each output form by language level is given in Table 1 below.

	Regular (vs. irregular only)	Regular (vs. all)	Irregular (vs. all)	No change (vs. all)	Third-person present (vs. all)	Past progressive (vs. all)	Unclassified (vs. all)
A1 level	94% (vs. 6%)	86%	5%	1.6%	0%	0.14%	6%
A2 level	91% (vs. 9%)	82%	8%	3%	0.6%	0%	7%
B1 level	87% (vs. 13%)	68%	12%	2%	0.3%	0%	2%
B2 level	83% (vs. 17%)	79%	16%	2%	0%	0.3%	2%
C1 level	82% (vs. 18%)	79%	17.5%	2%	0%	0.8%	1%
Native speakers	66% (vs. 34%)	65.5%	33%	0.7%	0%	0%	0.3%
L2 learners	87% (vs. 13%)	82%	12%	2%	0.2%	0.5%	3%
All participants	85% (vs. 15%)	80%	14%	2%	0.2%	0.5%	3%

TABLE 1. Mean percentage of regular, irregular, no-change, third-person singular of present-simple tense, past progressive, and unclassified forms produced by each language level (the table outline is sourced from Blything et al., 2018).

Since this study is concerned with the development of the past-tense system, our analysis focused solely on the investigation of regular and irregular forms, and responses (iii)–(v) were excluded from the analysis. To investigate whether the learner data showed similar outcomes to Albright & Hayes (2003) and Blything et al. (2018), the data were analysed with a binomial linear mixed-effects model (using the

8 Contrary to the approach adopted in Blything et al. (2018), we have decided to include not only irregular forms of the novel words with the most favourable irregular score in Albright and Hayes's (2003) study (as Blything et al. (2018) did), but also all the other possible irregular past forms cited in Quirk et al. (1985: 104). As a consequence, the irregular past forms of verbs *drit*, *gude*, and *nold* were homophonous with the stem form analogically to no-change forms such as *cut*, *put*, or *hit*. Such past forms of these three novel words were then coded as "irregular" rather than "no change".

lme4 package; see Bates et al. 2015) in the R environment (R Core Team 2013). Linear mixed-effect models were chosen because they are a powerful statistical method that works with individual trials (rather than means), is robust against missing data and against abnormal data distribution, and enables us to treat participants and individual novel verbs as random effects (Baayen et al. 2008).

The dependent variable used was the production of either regular or irregular past forms; the independent variables then included (a) the level (coded as an ordinal variable), (b) the similarity to existing regulars, and (c) the similarity to existing irregulars. We followed a well-established procedure to obtain the most explanatory model (see Pérez et al. 2016). We evaluated the optimal fixed structure by starting with the most complex three-way interaction of level, similarity to existing regulars, and similarity to existing irregulars, and compared it with simpler interactions using a stepwise model comparison (see Pérez et al. 2016). The deletion of the three-way interaction led to a statistically significant difference ($p < .001$); therefore, the full three-way interaction was kept in the model. The random structure was then chosen using maximal models, with random slopes for as many predictors as allowed model convergence (Barr, Levy, Scheppers & Tily 2013). The final model selected with this procedure was:

```
Mfull <- glmer(acc ~ Level * MGL_R * MGL_IR + (Level|part)+
    +(MGL_R|item)+(MGL_IR|item)
```

Results of the coefficients for this analysis (the summary function) are reported in Table 2 below. An Anova was then performed on the model to better understand the direction of the main effects and interactions. The results of the Anova can be seen in Table 3 below.

The results show a significant effect of the language level and a significant interaction between level and the novel word's similarity to existing irregulars, indicating that participants at different levels performed differently and that the novel verb's similarity to existing irregulars influenced the performance differently at different language levels. However, it is important to notice that the p-values presented in Table 2 might simply suggest that the significant interaction between language level and the novel word's similarity to existing irregulars (as observed in Table 3) may be due to differences between lower-proficiency L2 speakers and native speakers. To ensure that there are indeed differences among L2 speakers, we ran a similar model, comparing only the A1 and C1 second language learners. The analysis of variance showed a significant interaction between language level and similarity to existing irregulars ($p = .021$). This finding may give enough statistical evidence for our claim that there is a significant difference in the performance of L2 learners (and the interaction is not a reflection of differences between L2 learners and native speakers). For each novel word in each language level, the mean proportion of regular inflections was counted and included in a scatter plot alongside the similarity to existing irregulars, to visually explore the main effect of level and the interaction between level and similarity to irregulars. Figure 1 plots the mean proportion of regular inflection and its dependence on the novel verb's similarity to existing irre-

	Estimate	SE	z	p
Intercept	−3.378	8.130	−0.415	0.677
LevelA2	2.346	7.840	0.299	0.764
LevelB1	−1.536	7.033	−0.218	0.827
LevelB2	−7.266	6.8644	−1.059	0.289
LevelC1	−3.936	6.5899	−0.597	0.550
LevelNS	−1.700	7.8558	−0.216	0.828
MGL_R	6.770	8.4401	0.802	0.422
MGL_IR	26.111	24.9162	1.048	0.294
LevelA2:MGL_R	−2.556	8.0616	−0.317	0.751
LevelB1:MGL_R	0.846	7.2421	0.117	0.906
LevelB2:MGL_R	7.050	7.0827	0.995	0.319
LevelC1:MGL_R	3.401	6.7901	0.501	0.616
LevelNS:MGL_R	−0.210	8.0766	−0.026	0.979
LevelA2:MGL_IR	−19.619	23.4124	−0.838	0.402
LevelB1:MGL_IR	−22.719	23.7233	−0.958	0.338
LevelB2:MGL_IR	−8.535	22.4107	−0.381	0.703
LevelC1:MGL_IR	−6.644	20.3917	−0.326	0.744
LevelNS:MGL_IR	−57.194	24.8322	−2.303	0.021 *
MGL_R:MGL_IR	−25.956	26.0562	−0.996	0.319
LevelA2:MGL_R:MGL_IR	18.509	24.3860	0.759	0.447
LevelB1:MGL_R:MGL_IR	22.849	24.7696	0.922	0.356
LevelB2:MGL_R:MGL_IR	6.603	23.3525	0.283	0.777
LevelC1:MGL_R:MGL_IR	4.013	21.2026	0.189	0.849
LevelNS:MGL_R:MGL_IR	57.554	25.8873	2.223	0.026 *

TABLE 2. Main effects as obtained from the full model having chosen form as outcome variable and level, MGL_R (similarity to regulars) and MGL_IR (similarity to irregulars) as predictors.

	F	DF	p
Level	16.115	5	0.006 *
Similarity to regulars	2.780	1	0.095
Similarity to irregulars	0.512	1	0.474
Level:similarity to regulars	4.642	5	0.461
Level:similarity to irregulars	11.807	5	0.037 *
Similarity to regulars: similarity to irregulars	0.380	1	0.537
Level:similarity to regulars: similarity to irregulars	0.770	5	0.056

TABLE 3. The analysis of variance table with the language level, the similarity to regulars, and the similarity to irregulars as independent variables.

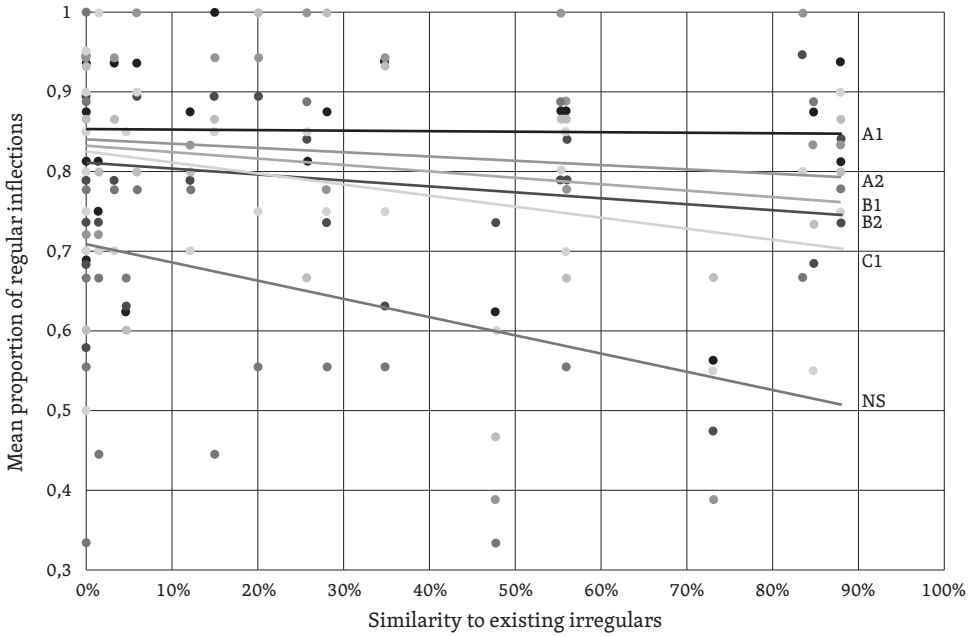

FIGURE 1. Mean proportion of the past forms with regular inflection based on the novel verb's similarity to existing irregulars, divided into language levels.

gulars for each language group separately, using a trending line to see the possible development of each group.

The plot shows that, out of the language levels, the A1 participants produced the highest number of regular past-forms, followed closely by B1 level, A2 level, B2 level, C1 level (notice the relative order of proficiency progression), and finally by the native speakers. The flattest trending line belongs to the A1 level: The A1-level learners are seemingly not sensitive to the novel word's similarity to irregulars when producing the past form, with the proportion of regular inflection staying always relatively high. Other trending lines show more steepness, although the angle, and consequently the awareness towards the similarity to existing irregulars, differs. The only group that seemed truly sensitive to the similarity to irregulars is the control group consisting of native speakers: They produced less regular past-forms with novel words more similar to existing irregulars, while producing more regular past-forms with novel words less similar to existing irregulars. The evident steepness of the trending line indicates real awareness towards the novel word's (dis)similarity to existing irregulars. The L2 learners, on the contrary, tended to produce more regular past-forms in general.

Figure 1, therefore, suggests that for the native speakers the likelihood of a verb being produced in regular past-tense form is negatively associated with its phonological similarity to existing irregular verbs, as predicted by the single-route model (and as shown both in Albright & Hayes (2003) and Blything et al. (2018)). L2 learners seem to be less dependent on the verb's similarity to existing irregulars when decid-

ing on its past form. However, L2 groups show a growing sensitivity to this system, with more proficient speakers displaying a steeper line, and less proficient speakers displaying a flatter line. The variation in slope is almost perfectly predicted by language level, with the exception of A2 and B1, which appear in opposite order.

The results indicate that the L2 acquisition of the English past-tense is characterized by a development from the mastery of mechanistic rules (at the A1 level especially) to the gradual refinement of their application when the learner starts spotting analogical patterns of existing verbs (peaking at the B2 and C1 levels that behave similarly to native speakers). In the development of inflectional morphology, the performance of second-language speakers thus comes closer to native speakers only with the higher proficiency of the B2 and C1 levels.

4.2 REACTION-TIMES ANALYSIS

The reaction-times analysis is designed to answer the question of whether reaction times, i.e. the length of time taken for a participant to respond to a given stimulus, are different for novel words phonotactically legal and illegal in Czech. This would offer us a closer look into possible interference effects at play during language production. The type of form produced (regular or irregular) was also included as a predictor, in an attempt to answer the additional question of whether regular past forms produce quicker reaction times or not, and also in an attempt to understand whether regularity modulated effects of Czech phonotactic probabilities. A total of 3,094 reaction times were recorded. The trials were first checked for outliers, i.e. observations "that lie outside the overall pattern of a distribution" (Moore & McCabe 1999: 21) and "fall more than 1.5 times the interquartile range above the third quartile or below the first quartile" (Ambrus et al. 2020: 3). For the presented data, all data points that did not fit into the range of –0.436 and 1.644 seconds were considered outliers and deleted from the final dataset. Since our primary interest was the difference between the reaction times of produced regular and irregular past-forms, the reaction times to other coded responses (i.e. no change or past progressive) were excluded from the dataset as well. After the omission of the outliers and superfluous responses, the dataset had the characteristics depicted in Table 4.

To investigate whether the data showed significant effects of the various independent variables on reaction times, the results were analysed with a linear mixed--effects model in the R environment. The dependent variable used was the reaction times to the presented stimuli; the independent variables included were (a) the level (coded as an ordinal variable), (b) the produced form, and (c) the set (i.e., the novel word's (il)legality in Czech)[9]. Again, we followed Pérez et al. (2016)' procedure of obtaining the most precise and explanatory models. We started the analysis with the highest number of possibly interacting independent variables: the level, the set, and the produced form, and compared it with simpler interactions through a stepwise model comparison (see Pérez et al. 2016). Since the deletion of the three-way interaction did not lead to a statistically significant difference ($p = 0.71$), it was removed from the model. Following the same procedure, other interactions were removed from the

9 The A set consists of novel words phonotactically legal in Czech, while the B set consists of novel words phonotactically illegal in Czech.

	N	Mean reaction time (s)	Minimum reaction time (s)	Maximum reaction time (s)	Standard deviation (s)	Mean reaction times of regular forms (s)	Mean reaction times of irregular forms (s)
A1 level	440	0.617	0.06	1.64	0.344	0.614	0.665
A2 level	401	0.594	0.12	1.55	0.311	0.593	0.598
B1 level	502	0.566	0.06	1.64	0.345	0.552	0.682
B2 level	532	0.530	0.08	1.64	0.306	0.520	0.589
C1 level	569	0.569	0.12	1.58	0.302	0.565	0.591
Natives	263	0.597	0.13	1.63	0.341	0.633	0.526
L2 learners	2,444	0.573	0.06	1.64	0.322	0.567	0.615
All particip.	2,707	0.575	0.06	1.64	0.324	0.572	0.594

TABLE 4. Descriptive statistics of the dataset used for the reaction-times analysis, including the number of items, mean reaction times, minimum and maximum reaction times, standard deviation, and mean reaction times of regular and irregular past-forms produced by each language level.

	Estimate	SE	t
Intercept	0.182	0.191	0.955
LevelA2	–0.064	0.222	–0.290
LevelB1	–0.002	0.243	–0.009
LevelB2	–0.211	0.221	–0.958
LevelC1	–0.120	0.201	–0.597
LevelNS	0.054	0.298	0.181
SetB	0.220	0.095	2.302
formR	–0.107	0.061	–1.746
LevelA2:SetB	–0.071	0.116	–0.617
LevelB1:SetB	–0.319	0.110	–2.898
LevelB2:SetB	–0.159	0.108	–1.471
LevelC1:SetB	–0.160	0.107	–1.500
LevelNS:SetB	–0.308	0.132	–2.335

TABLE 5. Coefficients from the full model having RTs as outcome variable and level, set, and form as predictors.

model as well: the interaction between the level and the produced form (p = 0.67) and between the set and the produced form (p = 0.92), keeping only the interaction between the level and the set (p = 0.04), and level, set and produced form as fixed effects. The random structure was then chosen using maximal models, with random slopes for as many predictors as allowed model convergence (Barr, Levy, Scheppers & Tily 2013). The final model selected with this procedure was thus:

```
Mfull <- lmer (RTs ~ Level:Set+Level+Set+produced_form + (Level|part) +
(produced_form|item)
```

Coefficients results (the summary function) from this model are provided in Table 5 above.

To better understand the direction of the main effects and the interactions, we ran an Anova on the model. The analysis also used the *lmerTest* package (Kuznetsova et al. 2015) to generate the p-values from the Anova.

	Chisq	DF	p
Level	2.489	5	0.778
Set	0.576	1	0.447
Produced form	6.042	2	0.048 *
Level:set	11.485	5	0.042 *

TABLE 6. The analysis of variance (ANOVA) table with the language level, the set, and the produced form as independent variables.

The analysis of variance (as shown in Table 6 above) showed a significant interaction between the language level and the set and a significant main effect of the produced form. These results suggest that participants at different language levels reacted differently to the novel words of the two datasets (set A and set B, related to a novel word's phonotactic (il)legality in Czech), which hints at possible interference effects at certain language levels. The results also suggest that the reaction times of the individual language levels are roughly similar and that they are influenced by the produced form, i.e. that the amount of time needed for the production of regular and irregular past-forms is different (regulars were significantly faster than irregulars, as can be seen from the negative estimate in Table 5 above).

For each set (A and B) at each language level, mean reaction times were counted and included in a bar plot. Figure 2 then shows how the language levels differ in their reaction to novel words of the two sets. The plot shows that the L2 learners took longer to produce past forms of novel words from the B set, i.e. novel words that are phonotactically illegal in Czech, while the native speakers took longer to produce the A-set novel words, i.e. novel words phonotactically legal in Czech. These results would suggest that in the case of the L2 learners, Czech has a facilitatory effect, i.e. it helps the participants react more quickly.[10]

To explore the interaction and see how the results differ at each language level, post-hoc tests were performed. The post-hoc group tests showed that the A1-level learners, alongside the A2-level learners (though with a weaker effect), took significantly less amount of time with words phonotactically legal in Czech (A1: $p = .035$, A2: $p = .056$), thus indicating that Czech functions as a facilitator in their performance. The B1, B2, and C1 levels showed no significant effect of the set on the reaction times. Similarly to the B1-, B2-, and C1-level participants, the native speakers did not significantly distinguish between the two languages during past-form production and

10 Also notice how the quickness of reaction to the presented stimuli rises with proficiency in the L2 learners, except for the B2 and the C1 level.

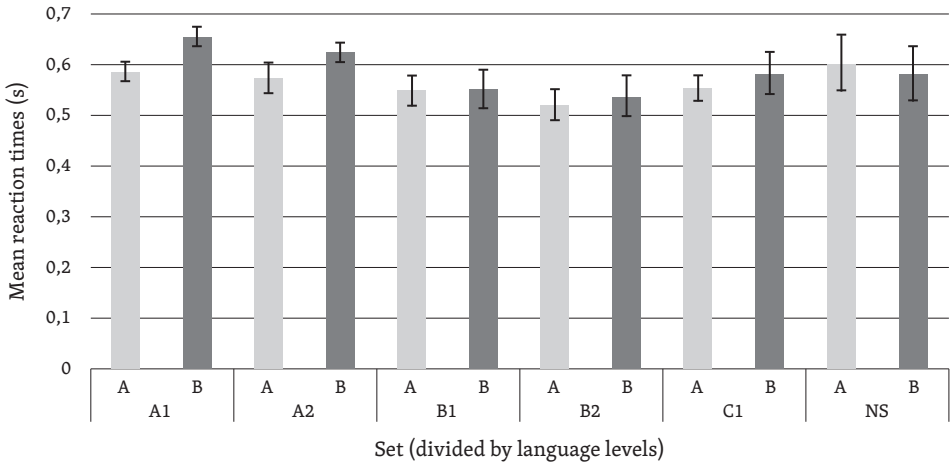

FIGURE 2. Mean reaction times to novel words of the two sets divided by language levels.

Czech had no effect on their performance. These four language groups thus made no difference between the novel words in the two sets and consequently between the two languages: This suggests that there were no interference effects at play and Czech functioned neither as a facilitator nor as an inhibitor.

4.3 QUALITATIVE ANALYSIS

The data obtained also called for qualitative analysis to explore a few interesting features and their changes over the process of second-language acquisition. In the qualitative analysis, attention was paid to (i) different past forms produced by the participants, their mean proportion, and distribution over language levels; (ii) the pronunciation of the bound past-tense morpheme and its changes during L2 development; and (iii) the addition of superfluous morphemes to the past-tense endings.

4.3.1 PRODUCED FORMS

Since this study is focused on the development of the past-tense system, it also raises the question of which forms are produced more frequently at each language level, if this production changes over the course of L2 acquisition, and if it is fuelled by any specific strategies. The analysis of past forms showed that at all language levels the production of regular forms highly surpasses the production of irregulars, and that the production of regular forms declines with proficiency, while the production of irregular forms rises (see Figure 3 below).

Three occurring types of irregular past forms have been identified in the collected data:

1. an internal change (IC; exemplified by the change of /eɪ/ into /əʊ/ in *to chake — choke*)

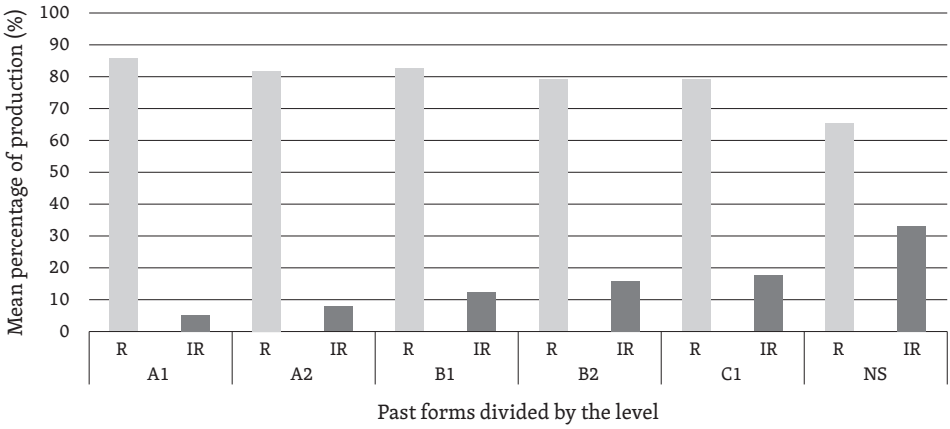

FIGURE 3. Mean percentage of production as a function of produced past forms divided into language levels (R refers to a regular past form, IR refers to an irregular past form).

2. an internal change accompanied by the addition of the past bound morpheme *-d, -t*, or *-ed* (IC + *-ed*; exemplified by *to teep — tept* or *to bredge — bridged*)
3. an irregular no-change form (IR NC; exemplified by *to drit — drit* or *to gude — gude*)

The investigation of the types of irregular past forms showed that the internal change accompanied by the addition of a past bound morpheme *-ed* (e.g. *to bredge* into *bridged*) seemed to be a dominant production pattern at the lower levels of the L2 learners and its use slowly declined with higher proficiency. Similar instances of this type have already been mentioned in the literature. Bybee and Slobin (1982), for example, suggested that the final *t/d* may serve as an aid in acquiring the vowel change, i.e. as an important clue that the form is in fact expressing the past tense. In the earliest stages, children (and in our case the lower-level L2 students) have the knowledge of the regular *-ed* rule. Using it does not force them to rely so heavily on the surrounding context (as in the case of a sole internal past-tense change, e.g. in *sing-sang* or *break-broke*) to distinguish the past tense. The production of the past form both with the internal change and the *-t/d* suffixation may thus be understood as an intermediate mastery of the internal-change production. L2 speakers may also be influenced by such models as *sleep/slept* or *keep/kept* (Rumelhart & McClelland 1986). Rumelhart and McClelland (1986) noted that three of their four responses with this type of past-tense change were verbs ending in /p/, similarly to the *sleep/keep* models above. They understand this as the participants' "sensitivity to the regular and sub-regular patterns of the English past tense" (Rumelhart & McClelland 1986: 34). At the lowest levels, this production was closely followed by irregular no-change forms (e.g. *drit — drit*); this strategy, too, shows a steady decline with higher proficiency. On the contrary, the internal change (e.g. *chake* into *choke*) was not frequent at the lowest levels and gathered noticeable strength with higher proficiency. The distribution is visualized in Figure 4 below:

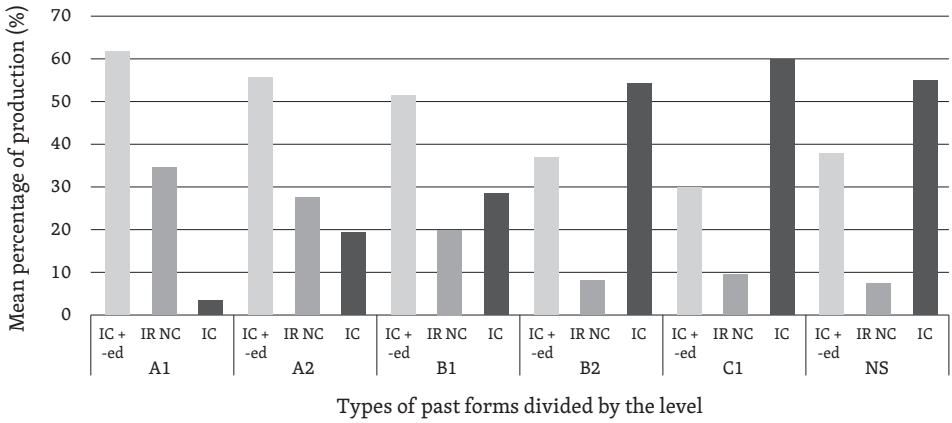

FIGURE 4. Mean percentage of production as a function of past-form types divided by language level (IC + -ed stands for an internal change accompanied by the addition of a past bound morpheme, IR NC stands for an irregular no-change form, and IC stands for an internal change).

The analysis of the no-change past forms (e.g. *drit*, *gude*, or *nold*) then showed that the recurrent no-change novel words have a common denominator, a final alveolar phoneme, and this choice may thus be phonetically conditioned. The reason for the no-change past form may be (i) the analogy with other existing no-change forms such as *cut*, *put*, or *hit*, or (ii) the participants' unintentional feeling that the novel word already ends with an alveolar phoneme and no other past bound morpheme is needed, since the bound morpheme blends with the final alveolar phoneme of the verb stem in their minds. This type of irregular past-tense formation has also been previously mentioned in literature. Stemberger (1981) has shown that inflectional languages commonly avoid adding a bound inflectional morpheme to a stem that already seems to contain such an affix. This would explain why the unchanged past-tense forms originally ended in an alveolar phoneme. Bybee and Slobin (1982) conclude that it is not accidental that words whose past-tense form remains unchanged end their stem in either *t* or *d* (e.g. *hit* or *shed*), since the speakers may simply use a schema [...t/d] $_{\text{verb/past}}$ in which the form of the stem and its past form would be identical. Berko (1958) has also described this phenomenon in her classic study, noting that the tested children showed a prominent tendency not to add the regular past-tense suffix to novel verbs that ended in an alveolar. She understands this finding as an incomplete acquisition of the /ɪd/ allomorph. Bybee and Slobin (1982) counter this interpretation with the claim that such findings have more to do with the phonological shape of the novel form than with the late acquisition of the allomorph. Anisfeld and Gordon (1968) have shown that children are more likely to accept bare novel forms as their own past forms if the final phoneme of the stem shares some features with *t* or *d*. Slobin (1971) pointed out that children also tend not to regularize verbs whose past forms remain unchanged from the stem. Consequently, Kuczaj (1978) suggested that children are even more likely to accept unchanged past-forms of such verbs (and reject any such regularized forms, e.g. *hitted*). Both Berko (1958) and Bybee and Slobin

(1982) then find a significant difference in this application between children and adults, who add the suffix more consistently. Bybee and Moder (1983) hypothesized that speakers tend to understand the verbs with the *-d* or *-t* stem ending as irregular in some respect and therefore supply past-tense forms identical to the stem. In their computer simulation of past-tense production, Rumelhart and McClelland's model (1986) also produced some strong no-change forms with verbs ending either in *-d* or *-t*. It is interesting to note that in the early stages of their simulation, the model was more prone to regularization (i.e. adding *-ed* to the stem); however, in the later stages, the no-change past-forms appeared as a part of the learning process. The authors also make an interesting note by pointing out that the words ending in *t/d* in the previous studies were all monosyllabic and it would be beneficial to see if the same phenomenon can be observed also in multisyllabic words such as *devote* or *decide*.

4.3.2 PRONUNCIATION OF THE FINAL *-ED* MORPHEME

Another interesting feature appears to be the full pronunciation of the final bound morpheme *-ed* as /ɪd/ — in places where the phonological surrounding asks for a regular /t/ or /d/ pronunciation (after any phoneme except for the alveolar ones[11]) — for instance, the full pronunciation of *daped* as /deɪpɪd/ instead of /deɪpt/. The mean percentage of its production was calculated alongside the percentage of a regular pronunciation to see the ratio of the regular vs. full pronunciation. The production was also divided by language level to see if this phenomenon possibly evolves over the process of language acquisition. A visualization of its distribution over levels can be seen in Figure 5 below.

The graphical visualization shows that the mean percentage of the full pronunciation in places where regular pronunciation should be is the highest (and also the most prominent) in the lowest A1 level and its distribution steadily declines with higher proficiency. Not surprisingly, native speakers did not produce any instance of full pronunciation. Similarly, the regular (i.e. correct, not full) pronunciation rises with higher proficiency, reaching almost 100% production at the C1 level. Yet, it is interesting to notice that even the highly proficient C1 participants produced some past forms with the full pronunciation (while the native speakers did not). Another question thus arises of whether its production be phonetically conditioned for L2 learners, i.e. whether the full pronunciation could be triggered by the final phoneme of the preceding stem.

After analysing the phonological area preceding the past bound morpheme, i.e. the quality of the final phoneme of the stem, six types of word-final phonemes were identified: plosives (i.e. /p/, /k/, /b/, and /g/ — excluding /t/ and /d/); nasals (i.e. /m/, /n/, and /ŋ/); liquids (only /r/, /l/ did not appear); fricatives (i.e. /s/, /z/, /f/, /ʒ/ and /ʃ/); affricates (i.e. /dʒ/ and /tʃ/); and also collectively sibilants (/s/, /z/, /ʒ/, /ʃ/, /dʒ/, and /tʃ/), which overall covered an ample share of full pronunciation. The high

11 Instances of the full pronunciation after dentals were not investigated as full pronunciation and counted under regular pronunciation since the full pronunciation of *-ed* after dentals is considered phonologically correct.

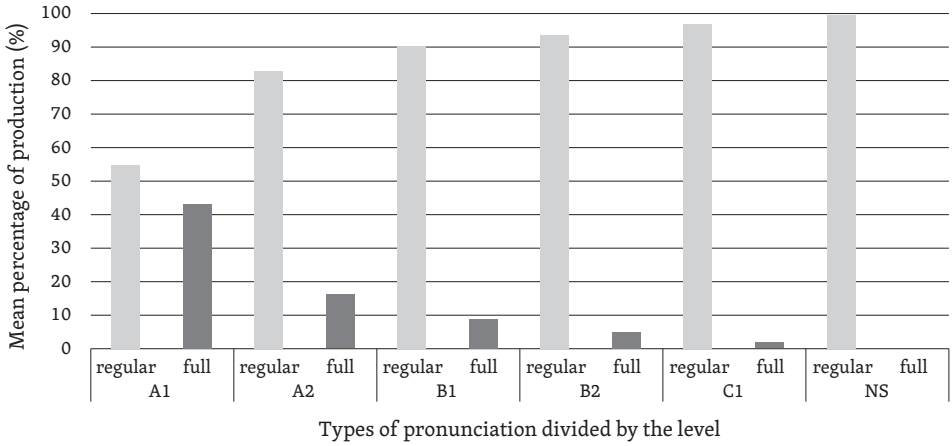

FIGURE 5. Mean percentage of production of regular vs. full pronunciation of the morpheme *-ed* as a function of the language level.

proportion of full pronunciation with stem-final sibilants could be explained by an unintended priming that originates from the uttered sentence preceding the one in the past: for instance, in *The baby likes to dize. Look, there it is dizing. Everyday it dizes. So yesterday it…*, the full pronunciation of *-es* in *dizes* /daɪzɪz/ (which is phonologically correct after a sibilant fricative) could have primed the subsequent pronunciation of *dized* as /daɪzɪd/. The participants might have simply re-applied the full pronunciation to a wrong phonological position. The other phonological surroundings (i.e. plosives, nasals, and liquid /r/) also led to full pronunciations, though more rarely. These instances are very interesting in that they cannot be easily explained referring to repetition; one of the possible explanations is that they are caused by hypercorrection. The L2 speaker may generally believe, through a misunderstanding of the rules, that the full form is more preferable or formal (see Selinker 1972). Another possible explanation is that the particular consonantal sequence may be hard to pronounce for the L2 speaker (since it is phonotactically illegal in their L2), and the learners may resort to the full form to make the pronunciation easier.

4.3.2 INSERTED *S/T/D* PHONEMES

In the process of transcribing the produced past-forms, an interesting and re-occurring phenomenon has arisen — the insertion of *-s-, -t-,* or *-d-* between the stem and the bound morpheme of the past tense, e.g. *glip**s**ed* or *pank**t**ed*. Its frequency is relatively low but there seems to be a progressive development from a higher frequency at the lowest levels to a minimal frequency at the C1 level. However, again, also the C1-level participants seem to be inserting the /s/ phoneme in between the stem and the bound morpheme on some occasions, and it is thus interesting to look at a possible stem-final phonetic conditioning in the L2 learners (since the native speakers produced none of these insertion forms). Similarly to the full pronunciation phenomenon, four stem-final phoneme types were identified: plosives, nasals, liquid /r/, and

fricatives. There seems to be a rather prominent frequency of stem-final plosives and nasals that might trigger this specific phoneme insertion. The insertion of the *-s-* phoneme after these phonemes could be potentially explained by yet another unintentional priming (e.g. *glipsed* after *Everyday he glips*) when the participant might have incorrectly used the inflected form *glips* as the stem. This insertion might be also implicitly conditioned phonetically by a number of similar phonemes attached one after another. In such cases, the speaker may use such insertion forms to differentiate the phonemes, a phenomenon known as dissimilation. Such instances have also been previously described in classic literature as double past markers (in the case of *-t-* insertions) and using affixes for both present and past (in the case of *-s-* insertions). In their computer simulation, Rumelhart and McClelland (1986), too, found the double past marking on seven responses to the input word. Even though they attribute such forms to errors that children and adults occasionally make, they also notice that the doubling occurred for those verbs whose stem ended in /p/ or /k/ and whose correct past-tense form should be created by the addition of /t/ and whose stem ended in /p/ or /k/ (e.g. /dript'd/). Interestingly enough, Berko (1958) also noted that several of the tested children retained the 3rd-person-singular /s/ or /z/ phoneme in addition to the past-tense suffix, as in /spouzd/.

5 DISCUSSION AND CONCLUSION

The results of this experiment extend previous research (e.g. Albright & Hayes 2003, Ambridge 2010, and Blything et al. 2018) to second-language learners of English and bring new insights into the acquisition of L2 morphology. The analysis of the produced forms has shown that for the native speakers the likelihood of a verb being produced in a regular past-tense form is negatively associated with its phonological similarity to existing irregular verbs, as predicted by the single-route model. However, L2 learners have shown lesser dependency on the verbal similarity to irregulars when deciding on its past form. Further analysis has shown that the L2 acquisition of the English past-tense is characterized by a development from the mastery of mechanistic rules (in line with the dual-route mechanism at the A1, A2, and B1 levels) to the refinement of their application when the learner starts spotting analogical patterns of existing verbs (in line with the single-route analogical mechanism at the B2 and C1 levels, similarly to native speakers). The second-language speakers thus come closer to native speakers with the higher proficiency of B2 and C1 levels, while lower levels seem to adopt an alternative strategy. The analysis of the reaction times has also shown that, for the lowest language levels, Czech implicitly functions as a facilitator in their performance, with participants being faster with novel words that are phonotactically legal in both Czech and English. L2 speakers with higher proficiency and native speakers, instead, did not show any effect of Czech phonotactic probabilities. Finally, the qualitative analysis has shown some specific pronunciation issues, such as the use of full pronunciation of bound morphemes where a single phoneme is expected, or the insertion of additional phonemes in the bound morpheme, possibly due to priming. Recent production tasks using novel words (e.g. Albright & Hayes

2003; Ambridge 2010; and Blything et al. 2018) have provided some evidence that the production of the English past tense shows signs of analogical processes associated with the single-route model, without the universal application of the default past-tense rule. So far, the role of the similarity to existing (ir)regular verbs in the production of novel verbs has been observed both in native English-speaking children (Ambridge 2010; Blything et al. 2018), in adults (Albright & Hayes 2003) and also in L2 learners of English (Lee 1994; Beck 1997; Ellis & Schmidt 1998; Murphy 2000; Agathopoulou 2009; Cuskley et al. 2015). Our study further investigates whether evidence for the analogical morphological productivity extends to second-language learners of English with Czech as L1 and whether the process behind the production differs among various language levels, starting with a proficiency sample that has just started learning English and moving to the language sample closest to English native speakers. The data suggest that the lowest proficiency groups (A1, A2, and B1) generate regular past forms by the default rule of adding *-ed* to the novel verb's stem, seemingly irrespective of the novel verb's phonological similarity to existing (ir)regular verbs. In contrast, the more proficient groups (B2 and C1) and native speakers of English rely on a morphological system in which the production of regular past forms depends on the novel verb's phonological similarity to existing verbs. These findings extend previous studies that spoke in support of analogical processes associated with morphological productivity (e.g. Albright & Hayes 2003, Ambridge 2010, or Blything et al. 2018) to proficient second-language learners of English. Blything et al. (2018: 14) use their findings to show that "overregularization errors made by children [...] need not be attributed to a rule-based mechanism [...] and, indeed, are better explained in terms of analogy across stored exemplars." Similarly, our results suggest that this claim could be extended to the L2 learners at the B2 and C1 levels.

In their study, Blything et al. (2018) make a thick dividing line between the effects of the single- and dual-route model, trying to distinguish the former from the latter. However, given the results of our research that point to a gradual progression from rule application to the use of analogy, and in line with previous research (e.g. Cilibrasi et al. 2019), this paper attempts to propose a less dividing conclusion: redundancy. Redundant models (Schreuder et al. 1999) hold that inflectional processing generally involves two types of analyses that seem to operate simultaneously: single- (rote-based parsing) and dual-route mechanisms (rule-based parsing). These analyses operate in parallel, but each system has a varying importance connected to how frequently a given item is generally used: "frequent items tend to be parsed with the rote system, while infrequent items tend to be parsed with the rule system" (Cilibrasi et al. 2019: 769). A mechanism of this kind may be at play in second-language learners of English. Albright and Hayes (2003: 120) themselves argue for a new (third) "model of morphology that makes use of multiple, stochastic rules", and our results suggest that these rules may equally apply to L2 learners, with the combined contribution of simple rules and generalizations based on analogy. These two mechanisms may be present at all levels but have varying importance depending on proficiency.

In conclusion, this experiment has enabled us to look more closely into the processes underlying morphological productivity in second-language learners of Eng-

lish and also into its potential development with higher proficiency. The most important contribution of this study lies in showing that the L2 acquisition of past-tense morphology is characterized by a gradual progression from the application of default rules to the application of analogical patterns.

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APPENDIX

APPENDIX 1: THE SET OF THE 32 NOVEL VERBS ADOPTED FROM ALBRIGHT & HAYES (2003) AND BLYTHING ET AL. (2018)

No.	Verb	Pronunciation	Set	Similarity to regulars	Similarity to irregulars
1	blafe	bleɪf	A	0.998	0.000
2	dape	deɪp	A	0.993	0.000
3	nace	neɪs	A	0.998	0.046
4	tesh	teʃ	A	0.998	0.000
5	chake	t͡ʃeɪk	A	0.900	0.835
6	drit	drɪt	A	0.944	0.477
7	plim	plɪm	A	0.872	0.348
8	teep	tiːp	A	0.963	0.559
9	drice	draɪs	A	0.998	0.848
10	glip	glɪp	A	0.988	0.059
11	stin	stɪn	A	0.972	0.280
12	stip	stɪp	A	0.988	0.149
13	pank	pæŋk	A	0.958	0.000
14	preak	priːk	A	0.941	0.033
15	rask	raːsk	A	0.982	0.000
16	trisk	trɪsk	A	0.963	0.559
17	bredge	bred͡ʒ	B	0.995	0.000
18	gezz	gez	B	0.988	0.000
19	stire	staɪə	B	0.985	0.000
20	wiss	wɪs	B	0.998	0.000
21	blig	blɪg	B	0.961	0.880
22	gleed	gliːd	B	0.872	0.000
23	skride	skraɪd	B	0.887	0.731
24	spling	splɪŋ	B	0.925	0.880
25	bize	baɪz	B	0.988	0.121
26	dize	daɪz	B	0.988	0.554
27	flidge	flɪd͡ʒ	B	0.995	0.200
28	gare	geə	B	0.985	0.257
29	gude	guːd	B	0.989	0.014
30	nold	nəʊld	B	0.900	0.014
31	nung	nʌŋ	B	0.925	0.000
32	shilk	ʃɪlk	B	0.982	0.000