Past Tense Verb Processing by Native Speakers and L2 Learners of English: Evidence from Masked Priming Experiment

Sanghee Kim

1. Introduction

When humans process a word form *walked*, for instance, it is easily understandable by linguists that the word would be decomposed into a root verb *walk*, and an inflectional suffix, *–ed*. The observation becomes complicated, however, when an irregular past tense verb comes into play. A word form such as *give* should be represented as *gave* in its past tense; the word itself changes instead of being inflected with an *–ed*. Such difference largely relates to the issue asking how humans process morphology during language comprehension in real-time. Psycholinguistic researchers have proposed two distinct models that account for humans' morphology processing.

One model posits that there are two separate systems that process morphologically complex words (Figure 1). For instance, a verb inflected with a regular past tense suffix *–ed* will be processed through a mechanism that is involved in (de)composing regularized forms. Irregulars, in contrast, are not concatenated with a grammar processor, but are retrieved via lexicon links related to linguistic factors. As such, irregular and regular word forms are claimed to be processed in two discrete mechanisms: a dual-mechanism model (Pinker & Ullman, 2002).

On the other hand, the other model that explains human's online morphology processing argues for a unified system: a single-mechanism model (McClelland & Patterson, 2002). From this account, regular and irregular

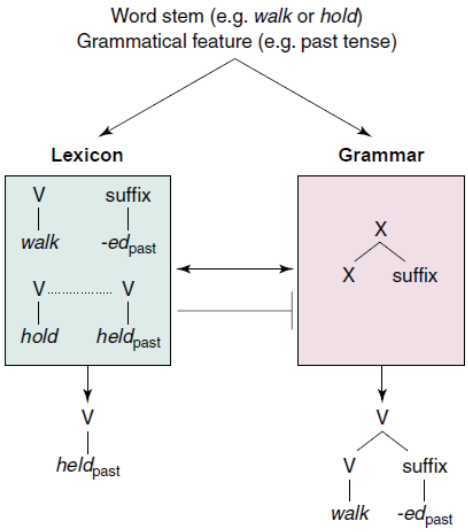

Figure 1. A simplified dual-mechanism model. Adopted from "The past and future of the past tense," by Pinker & Ullman, *Trends in Cognitive Sciences*, 2002, 6(11), p. 457.

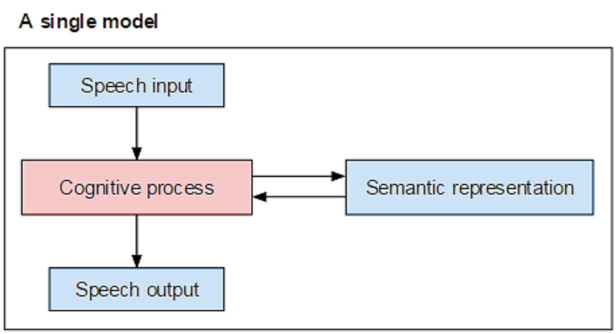

Figure 2. A simple schematization of a single-mechanism model for morphology processing. Redrawn from "Rules or connections in past-tense inflections: what does the evidence rule out?" by McClelland & Patterson, *Trends in Cognitive Sciences*, 2002, 6(11), p. 471.

past tense verbs, for example, are processed in fundamentally the same way. It is not the grammar system but different weights of orthographic, phonological, or semantic associations that compute morphology. In short, word forms are argued to be represented and accessed as a whole-word unit (Figure 2).

Meanwhile, studies have attempted to explain whether L2 learners comprehend and process the target language as native speakers do in real-time. Former works have reported that morphology acquisition for adult L2 learners is a notorious problem in that it is frequently reported among learners at an advanced level and even after a long period of immersion (Dekeyser, 2000; Johnson & Newport, 1989; White, 2003). There are two contrastive opinions concerning the performance by native speakers and L2 learners.

One line of approach attributes the difficulty in morphology acquisition to the deficit of grammatical representation or the failure to fully attain functional features of the target language (Hawkins & Chan, 1997; Franceschina, 2001; Tsimpli & Dimitrakopoulou, 2007). This argument is supported by a number of experimental studies. These studies compared performance of native speakers and L2 learners, and demonstrated the learners' insensitivity to grammatical representation of the target language (Jiang, 2004; 2007; Keating, 2009; Neubauer & Clahsen, 2009; Romanova & Gor, 2016; Sabourin & Stowe, 2008). On top of representational issue, further research observed how L2 learners compute grammatical forms and structures in real-time. Some researchers claimed that the processing of natives and L2 learners cannot converge—dubbed as the "shallow structure hypothesis" (Clahsen & Felser, 2006). From this stance, L2 learners are understood to have weak language representation and particularly weaker when they are given more complex syntactic structures (Felser, Cunnings, Batterham, & Clahsen, 2012).

On the contrary, a different stance posits that L2 learners can attain an ultimate state of grammatical forms, and that functional representation of the target language becomes accessible to learners throughout their language development (e.g., Schwartz & Sprouse, 1996). Empirical evidence showed that L2 learners perform in a similar way to native speakers even during online language comprehension (Friederici, 2002; Jegerski, 2016; Mueller, 2005; Song, 2015). Yet, it should be noted that it is not the case that all L2 learners show a similar performance to native speakers. Learners with a high proficiency, and better cognitive factors such as working memory, attention, and cognitive control are likely to perform in a similar way that native speakers do (Coughlin & Tremblay, 2013; Cunnings, 2016; Hopp, 2010; Lim & Christianson, 2015; McDonald, 2006; Sagarra & Herschensohn, 2010).

Against this theoretical and empirical background, we discuss whether native speakers and L2 leaners process inflectional morphology in the same way. In particular, their performance on morphology processing is compared. As results and conclusions diverge, we aim to provide experimental results that contribute to reaching a consensus on this issue.

2. The present study

For morphology processing measurement, a masked priming paradigm has been widely used to observe human's morphology computation. Morphological priming experiments with L1 speakers showed that the method is well-suited for examining the relationships between word forms with morphology (Frost, Deutsch, Gilboa, Tannenbaum, & Marslen-Wilson, 2000). The most typical masked priming paradigm usually consists of three visual representations. First, a series of Xs appears on the screen for a certain time. Next, a prime word is presented. Lastly, the target word is shown on the screen for certain amount of time.

The core idea of the masked priming paradigm is to compare how people react differently to the target word depending on the type of the prime condition that is presented. In a study investigating people's processing of past-tense forms, the most conventional experiment design would have three prime conditions: (i) 'Identical'—the same as the target, (ii) 'Related'—past tense form of the target, or (iii) 'Unrelated'—no relationship with the target.

Based on the experimental design, we can expect three different priming results: (i) full priming, (ii) partial priming, (iii) no priming (Table 1). Full priming indicates equal or similar degree of priming between the 'Identical' and 'Related' conditions and a longer reaction time (RT) in the 'Unrelated' condition. A partial priming refers to the 'Identical' condition being the fastest in reaction time, the 'Related' condition succeeding the next, followed by the 'Unrelated' condition. No priming shows that there was no priming

Table 1. Three types of priming

Type of priming	Comparison of RTs by prime condition
Full priming	Identical = Related 〈 Unrelated
Partial priming	Identical 〈 Related 〈 Unrelated
No priming	Identical 〈 Related = Unrelated

effect, meaning the 'Identical' or 'Related' condition shows no difference in reaction time from the 'Unrelated' condition.

Using a masked priming paradigm and other tools or measurements, previous studies have observed how L1 and L2 differ in morphological processing (Basnight-Brown, Chen, Hua, Kostić, & Feldman, 2007; Clahsen, Balkhair, Schutter, & Cunnings, 2013; Feldman, Kostić, Basnight-Brown, Djurdjević, & Pastizzo, 2010; Festman & Clahsen, 2016; Gor & Cook, 2010; Silva & Clahsen, 2008). In Silva and Clahsen (2008), German, Chinese, and Japanese learners of English were tested on how they process past tense of regular verbs differently compared to the native control group. The results from the masked priming paradigm were analyzed by comparing the degree of priming by each prime condition. The native control group showed full priming, but the tendency was not observed in any of the L2 groups, demonstrating that L2 learners of English rely less on combinatorial morphological processing than L1 speakers. Thus, it was claimed that L1 and L2 processing mechanism cannot be understood to be fundamentally the same.

In another morphology processing study (Feldman et al., 2010), unlike the L2 speaker group in Silva and Clahsen (2008), L2 learners showed full priming in the masked priming paradigm. In the study, Serbian learners of English participated in a lexical decision task where regular and irregular past tense verbs were used in a masked priming paradigm.[1)] A full priming effect was reported for processing regular past tense verbs, the trend of which was the same as the native group. This led to the argument that L2 learners process morphology in a similar way that natives do.

However, results from both studies need further examination as some fac-

1) Cross-modal priming paradigm was used in Experiment 2

tors that were not strictly controlled may have brought a different result. First, only regular past tense verbs were used in Silva & Clahsen (2008). Although the question of interest in the research was the comparison of native and nonnative speakers' morphology processing, inviting both regular and irregular past tense verbs would allow us to carefully examine both a single-mechanism model and a dual-mechanism model as well. The variation on verb types allows us to reevaluate the effect of verb type on morphology processing as Gor & Cook (2010) argued that the verb type influence was obscure for both native speakers and L2 learners. Secondly, L2 participants should be recruited with more caution. Although the researchers intended to invite highly proficient learners of English, it is unclear whether the level of English proficiency of L2 participants was strictly controlled. As different English proficiency assessment tools were used across L2 participants, a unified score would have served as a better standard to control their proficiency. This also applies to the experiments in Feldman et al. (2010), where L2 participants' proficiency was measured by self-rated scores. Without strictly controlling L2 learners' proficiency, we cannot clearly compare native and nonnatives' morphology processing.

Accordingly, in the present study, two factors were controlled with caution. First, verb types used included both regular and irregular past tense verbs to clearly compare a single-mechanism model to a dual-mechanism model within the native group. Second, the L2 group was divided into two groups by their English proficiency: intermediate, and highly proficient. We set a unified qualification score to clearly separate and make proficiency gap between the two L2 subgroups. By adjusting these two experimental designs, we can better answer the two research questions of the current study.

I. How are regular past tense verbs and irregular past tense verbs processed?
II. How is L2 learners' morphology processing of past tense verbs different from native speakers'?

For the first research question, a single-mechanism model and a dual-mechanism model will be tested. For the second research question, we examine whether L2 processing is fundamentally the same or different from L1 processing. The data from L2 learner group and the native control group will be compared.

3. Experiment

3.1. Method

3.1.1. Participants

Twelve Korean learners of English from Seoul National University participated in the experiment (Table 2). They were paid 2,000 won for compensation. None of them were bilinguals, and Korean was their dominant language. The L2 learners learned English in a classroom setting, and none of them spent more than one year abroad in any English speaking countries. Participants were controlled to have learned English in a Northern American dialect.

English proficiency was measured by official English proficiency assessment tools: TEPS, TOEIC, and TOEFL. The reported score was converted to TEPS scores based on TEPS-TOEFL-TOEIC conversion table (2011 version provided by Seoul National University). L2 intermediate proficiency group (henceforth 'L2-I') was controlled to have (converted) TEPS score ranging from 701 to 802, and L2 high proficiency group (henceforth 'L2-H') was qualified to have achieved (converted) TEPS score ranging from 900-990.

Additionally, twelve native English-speaking participants (age: 38.64 (9.26), range: 28-54, 5 males) were recruited through Amazon's Mechanical

Table 2. Information of L2 participants

Subgroup	*N*	Age[a,b]	AoA[a,b]	Years of study[a,b]	TEPS score[b,c]
L2-I	6 (3 males)	24.67 (2.21)	10.17 (2.40)	14.5 (2.63)	741.33 (22.89)
		22-28	7-15	12-20	710-763
L2-H	6 (2 males)	23.17 (1.46)	7.67 (2.21)	15.5 (2.87)	929.17 (27.75)
		21-26	4-10	13-20	910-990

[a] Presented in years; [b] Mean, standard deviation (in parentheses), and range (the second row); [c] Converted TEPS score

Turk (https://www.mturk.com), and they received $0.55 for participation. None of them are bilinguals, and English is their dominant language. All L1 participants spoke a Northern American dialect. Participants received formal education until secondary school in the U.S. and earned high school diploma.

3.1.2. Materials and design

Words for materials were extracted from 29 middle school English textbooks and 30 high school English textbooks to consider L2 learners' lexical frequency profile. We chose textbooks as a source of frequency information because frequency effect matters in L2 vocabulary acquisition especially through reading (Eckerth & Tavakoli, 2012). R *stats* package was used to calculate verb frequency. A Welch's Two-Sample t-test showed both types of verbs used as the prime and the target are not statistically different in their frequency: prime verbs, $t(24.97) = 1.47$, $p = .15$; target verbs, $t(27.99) = 1.50$, $p = .15$. Based on the frequency, we selected making 30 critical verbs in total (see Appendix).

These target verbs were preceded by prime words varied by three conditions: (i) 'Identical' (e.g., *walk-walk*), (ii) 'Related' (e.g., *walked-walk*), and (iii) 'Unrelated' (e.g., *give-walk*). For the 'Unrelated' condition, the presented prime words were semantically unrelated to the target words (e.g. Feldman et al., 2010). The length difference in prime words was unavoidable as regular past tense verbs always had two additional letters in the past form. However, the length of the target word did not differ between verb types ($M_{\text{irregular verbs}}=4.07$, $M_{\text{regular verbs}}=4.07$, $p = 1$). Filler items were added to prevent subjects from noticing the critical prime-target pair. There were four types of filler items: (i) real word – real word pair; (ii) real word – nonce word pair; (iii) nonce word – real word pair; (iv) nonce word – nonce word pair. A single set consisted of 30 critical items and 60 pairs of filler items. Critical items were counterbalanced and pseudo-randomly presented with filler items using a Latin Square design under Ibex Farm software (Drummond, 2013).

3.1.3. Procedure

The study used a type of forward masked visual priming paradigm (Forster & Davis, 1984). In the present experiment, we used an 'delayed masked priming task,' adopted from Clahsen et al. (2013). This type of task differed from a standard masked priming technique in two ways. First, the prime was presented for 60 ms while it is 30 ms in a standard paradigm. The lengthened presentation time was to compensate L2 learners' processing disadvantage as it was reported that learners have slower lexical decision times than native speakers (Scherag, Demuth, Rösler, Neville, & Röder, 2004). Using the extended time is validated by previous literature that showed priming effect even by L2 learners (Silva & Clahsen, 2008). Second, the adapted version had 500 ms delay between the prime and the target. Additional temporal delay was to compensate for L2 learners' overall slower processing speed. (Clahsen et al., 2013). A lexical decision task followed the visual presentation (Figure 3). Participants were to make a quick lexical decision on the target word by pressing a button—"Q" for "Yes", and "P" for "No."

The experiment used Ibex Farm (Drummond, 2013) to control visual presentation and to measure reaction time. The presented words were coded to

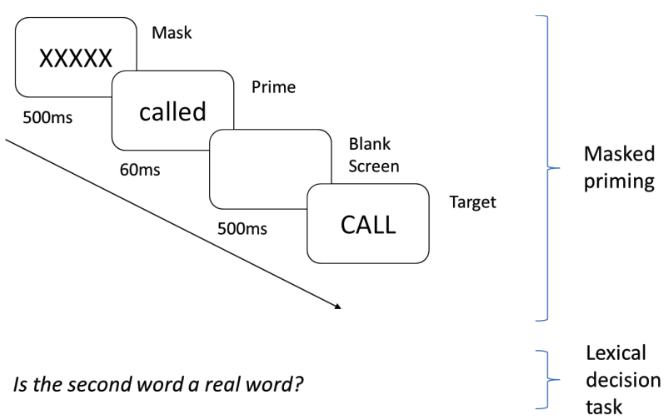

Figure 3. Delayed masked priming paradigm and a lexical decision task used for the experiment

appear in a white screen in black letters (font: Sans-serif, size: 54 points). The prime words were presented in lower case whereas the target words were shown in upper case. This was to minimize the visual overlap between primes and targets as much as possible. There were ten practice trials before the main experiment. The experiment took about 10 minutes without break.

3.2. Results

Among the data collected from 24 participants (12 natives and 12 L2 learners) we excluded the results from three L2 participants, who failed to reach 0.8 (80%) correct ratio in the lexical decision task (Table 3). Additionally, only correct responses in the lexical decision task were included, and responses whose reaction time was (a) either below 10 ms or above 2,000 ms, and (b) beyond 95% confidence interval were excluded for the final analyses.

Linear multiple regression models (Baayen, Davidson, & Bates, 2008) were applied for the analyses, and an *lme4* package for R (Bates, Mäechler, Bolker, & Walker, 2014) was used. The factors in the prime condition were manually effect-coded by forward difference coding. Forward difference coding enabled us to contrast the first two levels ('Identical'-'Related' prime condition), and the last two levels ('Related'-'Unrelated' prime condition). For the following analyses, we used forward difference coding for prime condition and dummy coding for the subgroup condition. Based on multiple regression models, we compared responses of the native group, the L1-I group, and the L2-H group (see Figure 4 for a visual summary).

For the multiple regression model, we selected the prime condition ('Identical', 'Related', 'Unrelated') and the subgroup condition (L1, L2-I, and L2-H) as fixed effects, and subject and item as random effects. There was a main

Table 2. Mean Accuracy and SDs (in parentheses) of raw data

	L1	L2 - I	L2 - H
Identity	1 (0.12)	1 (0)	1 (0)
Related	1 (0.08)	0.99 (0.12)	0.98 (0.14)
Unrelated	1 (0.12)	1 (0)	0.98 (0.14)

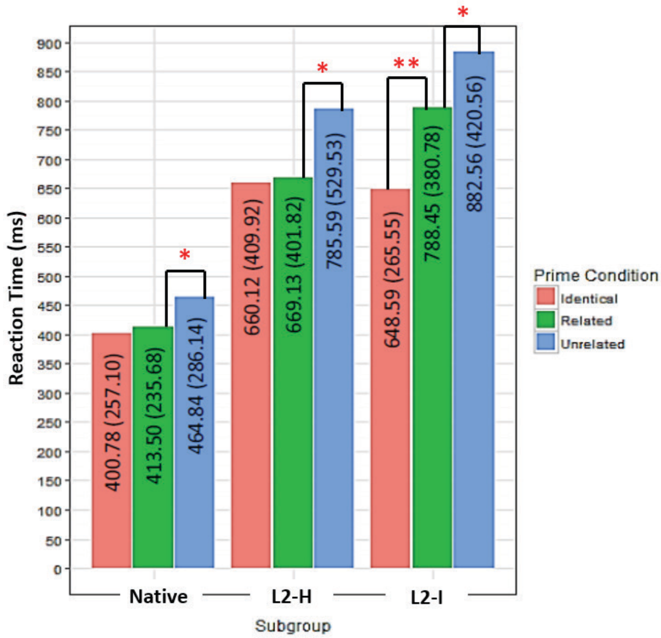

Figure 4. Comparison of RTs of critical items by Subgroup. (Mean RTs (in ms) and SDs (in parentheses))

effect of prime condition, between 'Related' and 'Unrelated', β= –39.54 (*SE* = 20.96), z = –1.89, p = .06). There was also a main effect of subgroup, both in the L2-I group (β= 358.308 (*SE* = 117.93), z = 3.04, p = .007), and the L2-H group (β= 299.790 (*SE* = 128.08), z = 2.34, p = .03).[2)] The result indicates that both fixed effects, prime condition and subgroup, were influential.

3.3. Analyses within the L1 group

The data from the L1 group served as the baseline. A multiple linear regression model was used for the analysis, where the prime condition was selected as a fixed effect, and subject and item as random effects. While the contrast between 'Identical' and 'Related' did not show statistical difference

2) Note that the value of the grand mean is inherited in the intercept coefficient in effect coding (Wendorf, 2004).

(β= –26.03 (SE = 17.37), z = –1.50, p = .14), the 'Related' and 'Unrelated' prime conditions were significantly different (β= –38.60 (SE = 17.64), z = –2.19, p = .03). Accordingly, the model demonstrated a significant effect of prime condition on natives' reaction time.

Furthermore, we extracted trials where irregular verbs were presented as the prime. A multiple regression model that included prime condition as a fixed effect and subject and item as random effects showed a statistical difference in 'Identical' and 'Related' conditions (β= –52.03 (SE = 27.03), z = –1.93, p = .06), and in 'Related' and 'Unrelated' conditions (β= –47.42 (SE = 26.35), z = –1.80, p = .08). Yet, there was no significant difference of reaction time for regular verbs.

3.4. Analyses within the L2 group

We initially considered the possibility of the difference between the two L2 subgroups: L2-H (highly proficiency L2 group), and L2-I (intermediate L2 group). Separate multiple linear regression models for each proficiency group in L2 participants were used. First, for the L2-I group, a multiple regression model run with prime condition as a fixed effect, and subject and item as random effects showed that difference in both levels of prime condition comparison reached significance in the model: 'Identical' and 'Related' (β = –121.59 (SE = 39.94), z = –3.04, p = .003), and 'Related' and 'Unrelated' prime condition (β = –105.16 (SE = 39.05), z = –2.70, p = .08). Secondly, the same type of regression model was used for L2-H group data analysis. The model showed that the 'Identical' and 'Related' conditions did not show significant difference (β = –28.48 (SE = 42.66), z = –0.67, p = .50) while responses from each 'Related' and 'Unrelated' condition statistically differed (β = –80.15 (SE = 42.18), z = –1.90, p = .06).

In addition, we observed the influence of verb types on reaction time within two L2 subgroups. A multiple regression model with prime condition and verb type as fixed effects, and subject and item as random effects was implemented using full data from all L2 participants. There was an interaction between prime condition—'Related' and 'Unrelated' in particular—and verb type—regular verbs in particular—reached statistical difference (β =

–101.72 (SE = 58.36), z = –1.74, p = .08). No meaningful difference in reaction time was found in irregular verbs.

We further analyzed trials that had regular verbs as the prime. First, a multiple linear regression model with prime condition as a fixed effect and subject and item as random effects was used to analyze data from L2-I. The model showed that both levels of contrast reached significance: 'Identitcal' and 'Related' (β = –151.03 (SE = 57.05), z = -2.64, p = .01), and 'Related' and 'Identical' (β = –114.49 (SE = 56.16), z = –2.04, p = .05). Secondly, the results from L2-H were also analyzed by the same type of model used for the L2-I group. The model revealed a significant difference between 'Related' and 'Unrelated' prime conditions (β= –80.15 (SE = 42.18), z = –1.90, p = .06), but not between 'Identical' and 'Related' conditions (β = –28.48 (SE = 42.66), z = –0.67, p = .50).

Moreover, no statistically meaningful correlation was found between word frequency and morphology processability. This was to both L2-I group (r = –.08) and L2-H group (r = .04) regarding the correlation between word frequency and reaction time.

4. Discussion

A significant influence of main effects in the model from both L1 and L2 results indicates that participants were likely to respond differently depending on what type of prime condition they were presented with. The first model suggests that prime words of three conditions were processed and computed differently by participants. Furthermore, the subgroup difference reached stastical significance, indicating that the reaction time measured from L1, L2-I, and L2-H quantitatively differd from one another. This shows that language processing by L2 learners is comparatively slower than the control native group.

The data from the native group was analyzed. In accordance with previous studies on morphology processing with masked priming paradigm, 'Identical' and 'Related' prime condition showed significant difference while 'Related' and 'Unrelated' did not. Such full priming effect can be interpreted that L1 participants were sensitive to a word's internal morphological structure, and decomposed the root and the inflection. A statistical difference in the magnitude of priming effect between 'Related' and 'Unrelated' reveals that there was language processing related to morphology analysis. Moreover, the regression model demonstrated that partial priming was observed where irregular verbs were presented as the prime. It is noteworthy that a different type of priming effect was reported for irregular verbs because it indicates that irregular past tense verbs are stored as a whole word chunk or a single lexicon unit. The results thus support a dual-mechanism model, which predicts regular and irregular past tense verbs to be stored and processed in a separate mechanism.

We then exmained how morphological processing by the L2 learner group differs from that of the native control group. The tendency in the L2-H group was comparable to what was shown in the native group. Concerning the effect of the type of prime condition, the L2-I group showed partial priming effect while the L2-H showed full priming effect. In short, while the L2-I group showed a different pattern of priming effect from the native group, the L2-H group demonstrated a tendency parallel to the L1 group. This differs from the data reported in Silva & Clahsen (2008), where even highly proficient learners of English performed differently from the native control group.

Furthermore, for regular past tense verbs, the L2-I group showed parital priming effect whereas the L2-H group showed full priming effect. The result partly resembles the results from Feldman et al. (2010) in that regular past verbs were fully primed. The result confirms that the L2-H group was fully aware of the morphological structure within the presentened form. Participants in the L2-I group were successfully primed by the prime word, but it is unlikely that they employed the same type of language processing mechanism used by the native group or the L2-H group. In brief, the results from the L2 group advocates that morphology processing mechanism employed by native speakers and L2 learners is not fundamentally different as the tendency by L2 learners with high proficiency resembles natives'.

For some, whether L1 and L2 processing mechanisms are fundamentally the same may still remain questionable, nevertheless. They may counterargue that even though L2 learners showed a smiliar or the same tendency as the native group did, longer reaction time by the L2 learner group indicates different mechanism was being employed. It should be noted, however, that automaticity and processing speed do not directly relate to the issue that asks the fundamental difference between L1 and L2 processing mechanism. L2 learners are reportedly given more taxing cognitive works to deal with (e.g., Sagarra & Herschensohn, 2010; Service, Simola, Metsänheimo, & Maury, 2002). McDonald (2006) demonstrated that L2 learners show less efficient performance in decoding ability and speed of processing than native speaker, which makes L2 learners' language processing less automatic. Results from McDonald's (2006) experiments showed that L2 learners performed similar to natives when the natives were distracted by noise.

Accordingly, a slower reaction time does not disprove the idea that L1 and L2 morphology processing is different. Instead, the similar reaction pattern is a more crucial factor for supporting for a fundamentally same L1-L2 procesing mechanism. In other words, it is a matter of automaticity and cognitive limitations that costed the L2-H group additional processing time and not because a different mechanism was employed by the L2 learners. Therefore, based on the similar tendency observed from the native group and the L2-H groups, we suggest that L1 and L2 share fundamentally the same mechanism during past tense morphology processing.

5. Conclusion

The two research questions are revisited. First, we asked whether regular and irregular verbs are processed in the same way. The issue relates to the issue whether morphology processing can be explained by a single-mechanism model or a dual-mechanism model. The data from the native group showed that with regard to processing inflections that are suffixed to regular and irregular verbs, morphology is processed through a dual-mechanism. Secondly, how native and L2 learners compute inflectional morphology in past tense verbs was examined. The pattern observed in the L2-H group was similar to that of the native group. Such parallel tendency demonstrated that the morphology processing is computed under the same mechanism by the two groups.

In short, the present paper suggests that (i) inflectional morphology in past tense verbs is processed in a dual-mechanism, and that (ii) native speakers and L2 learners of English share fundamentally the same mechanism to process inflections of past tense verbs. Compared to previous studies, the current paper particularly focused on the effect of level of proficiency of L2 learners, word type, and word frequency. The influence of the first two conditions was detected while word frequency was not. Although word frequency was controlled by reflecting frequency information extracted from text books, it may not fully reflect the extent to which each individual is familiar with the given word. We thus hope that future studies that aim to measure the influence of word frequency on morphology processing would reflect more factors that can affect word frequency effect.

References

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.

Basnight-Brown, D. M., Chen, L., Hua, S., Kostić, A., & Feldman, L. B. (2007). Monolingual and bilingual recognition of regular and irregular English verbs: Sensitivity to form similarity varies with first language experience. *Journal of Memory and Language, 57*(1), 65-80.

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2014). Fitting linear mixed-effects models using lme4. *arXiv preprint arXiv:1406.5823.*

Clahsen, H., Balkhair, L., Schutter, J. S., & Cunnings, I. (2013). The time course of morphological processing in a second language. *Second Language Research, 29*(1), 7-31.

Clahsen, H., & Felser, C. (2006). Grammatical processing in language learners. *Applied Psycholinguistics, 27*(1), 3-42.

Coughlin, C. E., & Tremblay, A. (2013). Proficiency and working memory based explanations for nonnative speakers' sensitivity to agreement in sentence processing. *Applied Psycholinguistics, 34*(3), 615-646.

Cunnings, I. (2016). Parsing and working memory in bilingual sentence processing. *Bilingualism: Language and Cognition*, 1-20.

DeKeyser, R. M. (2000). The robustness of critical period effects in second language acquisition. *Studies in second language acquisition, 22*(4), 499-533.

Drummond, A. (2013). Ibex farm. *Online server: http://spellout. net/ibexfarm.*

Eckerth, J., & Tavakoli, P. (2012). The effects of word exposure frequency and elaboration of word processing on incidental L2 vocabulary acquisition through reading. *Language Teaching Research, 16*(2), 227-252.

Feldman, L. B., Kostić, A., Basnight-Brown, D. M., Djurdjević, D. F., & Pastizzo, M. J. (2010). Morphological facilitation for regular and irregular verb formations in native and non-native speakers: Little evidence for two distinct mechanisms. *Bilingualism: Language and Cognition, 13*(2), 119-135.

Felser, C., Cunnings, I., Batterham, C., & Clahsen, H. (2012). The timing of island effects in nonnative sentence processing. *Studies in Second Language Acquisition, 34*(1), 67-98.

Festman, J., & Clahsen, H. (2016). How Germans prepare for the English past tense: Silent production of inflected words during EEG. *Applied Psycholinguistics, 37*(2), 487-506.

Forster, K. I., & Davis, C. (1984). Repetition priming and frequency attenuation in lexical access. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 10*(4), 680.

Franceschina, F. (2001). Morphological or syntactic deficits in near-native speakers? An assessment of some current proposals. *Second Language Research, 17*(3), 213-247.

Friederici, A. (2002). Towards a neural basis of auditory sentence processing. *Trends in Cognitive Sciences, 6*(2), 78-84.

Frost, R., Deutsch, A., Gilboa, O., Tannenbaum, M., & Marslen-Wilson, W. (2000). Morphological priming: Dissociation of phonological, semantic, and morphological factors. *Memory & Cognition, 28*(8), 1277-1288.

Gor, K., & Cook, S. (2010). Nonnative processing of verbal morphology: In search of regularity. *Language Learning, 60*(1), 88-126.

Hawkins, R., & Chan, C. Y. H. (1997). The partial availability of Universal Grammar in second language acquisition: The 'failed functional features hypothesis'. *Second Language Research, 13*(3), 187-226.

Hopp, H. (2010). Ultimate attainment in L2 inflection: Performance similarities between non-native and native speakers. *Lingua, 120*(4), 901-931.

Jegerski, J. (2016). Number attraction effects in near-native spanish sentence comprehension. *Studies in Second Language Acquisition, 38*(1), 5-33.

Jiang, N. (2004). Morphological insensitivity in second language processing. *Applied Psycholinguistics, 25*(4), 603-634.

Jiang, N. (2007). Selective integration of linguistic knowledge in adult second language learning. *Language learning, 57*(1), 1-33.

Johnson, J. S., & Newport, E. L. (1989). Critical period effects in second language learning: The influence of maturational state on the acquisition of English as a second language. *Cognitive psychology, 21*(1), 60-99.

Keating, G. D. (2009). Sensitivity to Violations of Gender Agreement in Native and Nonnative Spanish: An Eye-Movement Investigation. *Language Learning, 59*(3), 503-535.

Lim, J. H., & Christianson, K. (2015). Second language sensitivity to agreement errors: Evidence from eye movements during comprehension and translation. *Applied Psycholinguistics, 36*(6), 1283-1315.

McClelland, J. L., & Patterson, K. (2002). Rules or connections in past-tense inflections: What does the evidence rule out? *Trends in Cognitive Sciences, 6*(11), 465-472.

McDonald, J. L. (2006). Beyond the critical period: Processing-based explanations for poor grammaticality judgment performance by late second language learners. *Journal of Memory and Language, 55*(3), 381-401.

Mueller, J. L. (2005). Electrophysiological correlates of second language processing. *Second Language Research*, *21*(2), 152-174.

Neubauer, K., & Clahsen, H. (2009). Decomposition of inflected words in a second language. *Studies in Second Language Acquisition, 31*(3), 403-435.

Pinker, S., & Ullman, M. T. (2002). The past and future of the past tense.

Trends in Cognitive Sciences, 6(11), 456-463.

Romanova, N., & Gor, K. (2016). Processing of gender and number agreement in Russian as a second language. *Studies in Second Language Acquisition*, 1-32.

Sabourin, L., & Stowe, L. A. (2008). Second language processing: when are first and second languages processed similarly?. *Second Language Research, 24*(3), 397-430.

Sagarra, N., & Herschensohn, J. (2010). The role of proficiency and working memory in gender and number agreement processing in L1 and L2 Spanish. *Lingua, 120*(8), 2022-2039.

Scherag, A., Demuth, L., Rösler, F., Neville, H. J., & Röder, B. (2004). The effects of late acquisition of L2 and the consequences of immigration on L1 for semantic and morpho-syntactic language aspects. *Cognition, 93*(3), B97-B108.

Schwartz, B. D., & Sprouse, R. A. (1996). L2 cognitive states and the full transfer/full access model. *Second language research, 12*(1), 40-72.

Service, E., Simola, M., Metsänheimo, O., & Maury, S. (2002). Bilingual working memory span is affected by language skill. *European Journal of Cognitive Psychology*, *14*(3), 383-408.

Silva, R., & Clahsen, H. (2008). Morphologically complex words in L1 and L2 processing: Evidence from masked priming experiments in English. *Bilingualism: Language and Cognition, 11*(2), 245-260.

Song, Y. (2015). L2 processing of plural inflection in English. *Language Learning, 65*(2), 233-267.

Tanaka-Ishii, K., & Terada, H. (2011). Word familiarity and frequency. *Studia Linguistica, 65*(1), 96-116.

Tsimpli, I. M., & Dimitrakopoulou, M. (2007). The interpretability hypothesis: Evidence from wh-interrogatives in second language acquisition. *Second Language Research, 23*(2), 215-242.

Wendorf, C. A. (2004). Primer on multiple regression coding: Common forms and the additional case of repeated contrasts. *Understanding Statistics, 3*(1), 47-57.

White, L. (2003). Fossilization in steady state L2 grammars: persistent problems with inflectional morphology. *Bilingualism: Language and Cognition, 6*(2), 128-141.

Appendix

Verb Type	Prime			Target
	Identity	Related	Unrelated	
Regular	ask	asked	protect	ASK
	call	called	enter	CALL
	enjoy	enjoyed	pull	ENJOY
	form	formed	pay	FORM
	join	joined	begin	JOIN
	learn	learned	expect	LEARN
	look	looked	cover	LOOK
	pass	passed	watch	PASS
	pick	picked	visit	PICK
	play	played	open	PLAY
	seat	seated	laugh	SEAT
	sign	signed	stand	SIGN
	wait	waited	grow	WAIT
	walk	walked	fill	WALK
	work	worked	count	WORK
Irregular	come	came	buy	COME
	fall	fell	push	FALL
	feel	felt	stay	FELL
	give	gave	walk	GIVE
	hear	heard	need	HEAR
	hold	held	wash	HOLD
	keep	kept	show	KEEP
	know	knew	mean	KNOW
	lose	lost	sleep	LOSE
	meet	met	turn	MEET
	ride	rode	leave	RIDE
	sing	sang	cook	SING
	take	took	speak	TAKE
	tell	told	eat	TELL
	write	wrote	clean	WRITE

ABSTRACT

Past Tense Verb Processing by Native Speakers and L2 Learners of English: Evidence from Masked Priming Experiment

Sanghee Kim

The current study investigated (i) how past tense verb morphology is processed online, and (ii) whether mechanism employed during morphology processing is fundamentally the same between native speakers and L2 learners. Twelve native speakers of English and 12 Korean learners of English (6 intermediate (L2-I); 6 highly proficient (L2-H)) were recruited for the experiment. An adapted version of masked priming paradigm was used, and thirty regular/irregular past tense verb pairs served as critical items (15 regular; 15 irregular). The prime words were presented in three conditions: (a) 'Identical', (b) 'Related', (c) 'Unrelated'. Measured RTs were analyzed by using multiple linear regression models. There was full priming effect (a=b<c) in the native control group, supporting a dual-mechanism model for morphology processing. While the L2-I showed partial priming effect (a<b<c), L2-H demonstrated full priming effect, the same tendency observed in the L1 group, substantiating the argument that native speakers and L2 learners have the same language processing mechanism with regard to morphology in past tense verbs.

Key Words morphology processing, inflectional morphology, past tense verbs, L1/L2 processing mechanism