



## Research paper

# Morphological knowledge affects processing of L2 derivational morphology: An event-related potential study



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## ABSTRACT

This study used event-related potentials (ERPs) to investigate the effect of morphological knowledge on L2 derivational processing in a sentence reading task with Chinese-English bilinguals. Correctly derived words and pseudo-derived words were embedded in a semantically plausible sentence. Compared with the correctly derived words, a significant P600 to pseudo-derived words was elicited in the group with high morphological knowledge, indicating their sensitivity to rule violations and application of rule-based decomposition. For the group with low morphological knowledge, a significant N400 was observed, suggesting that participants in this group depend more on a whole-word processing mechanism. These results suggest that morphological knowledge plays an important role in L2 processing of derivational morphology.

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## 1. Introduction

Recently, many researchers have shown great interest in second language (L2) morphological processing (Diependaele, Duñabeitia, Morris, & Keuleers, 2011; Gor & Cook, 2010; Lehtonen, Niska, Wande, Niemi, & Laine, 2006; NeubKauer & Clahsen, 2009; Pliatsikas & Marinis, 2013; Silva & Clahsen, 2008). Much of this work has investigated whether second language (L2) learners, especially late learners who learned the L2 after puberty, can apply rule-based decompositions to process morphologically complex words. Following a dual-mechanism model, researchers have investigated whether morphologically complex words are stored in memory as whole-word units to be directly accessed from the separate lexical entries during processing, or whether these words are processed via some rule-governed decomposition (Pinker, 1999; Pinker & Ullman, 2002). However, there have been a limited number of studies, especially with online processing measures, and findings have been inconsistent (Clahsen, Felser, Neubauer, Sato, & Silva, 2010). Thus, the details of how late L2 learners process morphologically complex words remain largely unknown.

Much research concerning L2 complex words has mainly focused on inflectional morphology, particularly for the past tense (De Diego Balaguer, Sebastián-Gallés, Diaz, & Rodriguez-Fornells, 2005; Gor & Cook, 2010; Lehtonen et al., 2006; NeubKauer & Clahsen, 2009; Pliatsikas & Marinis, 2013; Silva & Clahsen, 2008). For instance, Silva and Clahsen (2008) adopted a masked priming paradigm to investigate regularly inflected words by groups of Chinese and German L2

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learners of English. Three types of prime–target pairs, including identity (e.g. pray–pray), test (e.g. prayed–pray), and unrelated (e.g. bake–pray), were presented to the participants. The native speakers showed full priming effects as evidenced by the amount of priming in the test condition being equivalent to the amount of priming in the identity condition. The results of the L2 learners showed no priming effect: The regular past-tense primes yielded the same target reaction times as unrelated primes, indicating that the L2 learners relied on the whole-word processing. In the masked visual priming experiment of NeubKauer and Clahsen (2009), the German regular past participles that are suffixed with -t were processed by highly proficient adult Polish (L1)–German (L2) learners. The three types of prime–target pairs as in Silva and Clahsen (2008) were also included. The L1 group showed a full priming effect for the regular participles, suggesting that they rely on morphological parsing. The L2 learners, showed no prime effect, indicating that they rely more on lexical storage than morphological parsing. However, Pliatsikas and Marinis (2013) tested highly proficient Greek–English learners with naturalistic or classroom L2 exposure in a self-paced reading task focusing on past tenses forms. The inflected and pseudo-inflected verbs were embedded in the semantically plausible and syntactically simple sentences. The time that the participants spent on the segment that includes the verb was analyzed as the critical indicator. Reading times for the regularly inflected forms were significantly longer than those for the pseudo-inflected verbs, indicating that L2 learners rely on rule-based decomposition for regular forms. In brief, as concerns L2 inflectional processing, whether L2 learners can apply rule-based decompositions remains equivocal.

As for L2 derivational morphology, another type of morphologically complex words, the number of studies is rather scarce, and the results are also inconsistent (Diependaele et al., 2011; Silva & Clahsen, 2008). For example, Silva and Clahsen (2008) observed a reduced priming effect for L2 learners when processing derived words, suggesting that the L2 learners applied the rule-based decompositions in a less automatic way compared with native speakers. However, Diependaele et al. (2011) investigated the performance of Spanish–English and Dutch–English bilinguals on a masked morphological priming lexical decision task. Three types of derivational words were selected, including transparent suffixed primes, opaque suffixed primes, and form control primes. The results indicated a graded facilitation pattern in both groups of L2 learners, with the largest priming effect in the transparent condition, intermediate in the opaque condition, and smallest in the form condition. The data suggested that L2 learners, similar to native speakers, can engage in the decomposing process of the derivational words. Based on the limited number of derivational studies and inconsistent results, it is difficult to draw any conclusions of whether L2 learners engage in decomposition of derived words.

The declarative/procedural model posed by Ullman posited that late L2 learners may lack automated procedural memory for L2, leaving them to depend largely on declarative memory. Therefore, their abilities to compute aspects of morphologically complex words may be reduced. To be more specific, these morphologically complex words would be stored as whole-word units and could be directly accessed. However, with an increase in proficiency or exposure, L2 learners can begin to apply rule-governed decomposition during online processing. This theory is also open in principle to the possibility that other factors besides proficiency might affect the attainment of rule-based decomposition (Ullman, 2005, 2012). Thus, the present study aims to explore other possible factors.

Moreover, the studies reviewed above were all conducted using behavioral methods. As claimed by Morris and Holcomb (2005), it is difficult to test the representation and processing of morphologically complex words by behavioral methods based only on the reaction time data. The event related potentials (ERPs) technique, owing to its high temporal resolution, has been widely used to investigate the neural mechanisms of online language processing. In this study, we made use of this technique to further investigate how later L2 learners process derivational words.

ERP studies on L1 derivational morphology have been conducted at the single word level and at the sentence level. At the single-word level, the priming paradigm is mostly employed (Kielar & Joanisse, 2011; McKinnon, Allen, & Osterhout, 2003). The N400, a negative going waveform that peaks around 400 ms after stimulus onset, is consistently elicited, and the reduction of this component is taken as an indication of semantic integration, possibly aided by morphemic segmentation (Kielar & Joanisse, 2011; Lavric, Clapp, & Rastle, 2007). At the sentence level, the violation paradigm is often used, and two ERP components are often focused on: N400 and P600. In sentence processing, the N400 has been related to lexical processing and semantic integration processes (Friederici & Weissenborn, 2007; Kutas & Federmeier, 2011). In derivational violations, the N400 has been interpreted to reflect the possibility that the pseudo-derived words are processed as whole units (Lück, Hahne, & Clahsen, 2006) or as pseudo-words (Janssen, Wiese, & Schlesewsky, 2006). Also in sentence contexts, the N400 has been thought to reflect a failed attempt to semantically integrate incorrectly derived words (Leinonen, Brattico, Järvenpää, & Krausea, 2008). The P600, a late positive component for morphological violations, has been observed at sentence level processing involving affixes (Leinonen, Brattico, et al., 2008). This late positivity may reflect the repair process where the incorrectly combined stem and suffix is placed with a compatible suffix (Leinonen, Brattico, et al., 2008). Also, this positive component can be taken as indicative of combinatorial linguistic processes, specifically with respect to morphological violations (Havas, Rodrí guez-Fornells, & Clahsen, 2012). In summary, studies on L1 ERP derivational processing produce a relatively consistent pattern. Especially at the sentence level, the N400 component can be interpreted as the word-level lexical-semantic processing, and the P600 can be taken as an indication of combinatorial processes.

In contrast to the relatively extensive ERP studies on L1 morphologically complex words, the ERP research on these words in L2 is less prevalent. In L2 inflectional processing, for instance, Hahne, Mueller, and Clahsen (2006) have investigated the processing of German inflected words by German learners with Russian as their native language. Two different types of German inflection were studied: participial inflection and noun plurals inflection. The inflected words were embedded in sentence contexts. ERP results showed that in L2 learners, processing regular violations elicited an anterior negativity and/or

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