Processing Mechanisms of Morphologically Complex Words in Second Language Learners

Authors: Cong Fengjiao, Chen Baoguo, Chen Baoguo

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Abstract

In most languages, morphologically complex words constitute a substantial proportion. The regularity of form-meaning mapping in morphologically complex words enables readers not only to directly retrieve whole-word semantics from the mental lexicon, but also to utilize morphological rules to construct word meanings. Research has demonstrated that native speakers can exploit morphological rules to process complex words; however, studies on second language (L2) learners have yielded considerable divergence and displayed patterns distinct from those of native speakers. Grounded in Complementary Learning Systems theory and the Episodic L2 Hypothesis, we propose a perspective on the processing mechanism of L2 morphologically complex words, thereby accounting for the divergence in research findings. Future research should investigate the influence of factors such as morphological family size on L2 morphologically complex word processing, and elucidate the neural mechanisms underlying such processing.

Full Text

The Processing Mechanism of Morphologically Complex Words in Second Language Learners

Cong Fengjiao, Chen Baoguo
(Department of Psychology, Beijing Normal University, Beijing 100875, China)

Abstract

Morphologically complex words constitute a high proportion in most languages of the world. The regularity of form-meaning mapping in these words allows readers to extract whole-word semantics directly from the mental lexicon or to construct word meaning using morphological rules. Research has demonstrated that native speakers can utilize morphological rules to process complex words, yet studies on second language (L2) learners have yielded highly divergent results that differ from native speaker patterns. Based on the Complementary Learning Systems account and the Episodic L2 Hypothesis, we propose a theoretical perspective on the processing mechanisms of L2 morphologically complex words to account for these discrepancies. Future research should investigate how factors such as morphological family size influence L2 morphological processing and elucidate the neural mechanisms underlying L2 morphologically complex word processing.

Keywords: second language learners, morphologically complex words, processing mechanism, morphological rules

Introduction

Morphologically complex words are composed of two or more morphemes [**?**, **?**]. For example, the English word "builder" consists of two morphemes: "build" and "er" . Unlike monomorphemic words, morphologically complex words exhibit regularity in the mapping between form and meaning. The same root (e.g., "build") can appear repeatedly in different words (e.g., builder, building, rebuild) expressing similar semantics, while the same affix (e.g., "er") can appear in different words (e.g., teacher, builder, banker) and change word meaning in predictable ways [**?**, **?**]. This regularity indicates that words in the mental lexicon are interconnected, with morphologically complex words sharing the same root belonging to the same morphological family, and those sharing the same affix belonging to the same morphological series [**?**, **?**].

The investigation of morphologically complex word processing mechanisms has long been a central focus of research. First, morphologically complex words account for a very high proportion in most languages worldwide [**?**, **?**]. For instance, approximately 85% of English vocabulary consists of morphologically complex words [**?**, **?**]. Second, the regularity of form-meaning mapping plays a crucial role in reading: readers can utilize morphological rules to access word meaning. When encountering "builder" , readers can attach the affix "er" to the root "build" and construct its meaning ("someone who builds") in real time to achieve whole-word semantic access. Because of the existence of morphological rules, readers have two options when accessing the semantics of morphologically complex words: they can either extract whole-word meaning directly from the mental lexicon, as with monomorphemic words, or use morphological rules to achieve whole-word semantic access through morpheme decomposition and construction. Therefore, whether readers can utilize morphological rules when processing morphologically complex words is the central concern of morphological processing theories. The whole-word access theory proposes that semantic access to morphologically complex words can only be achieved through direct extraction of whole-word representations [**?**, **?**], while the morphological decomposition view argues that morphological parsing is mandatory—that is, only the morphological parsing route can achieve whole-word semantic access [**?**, **?**]. The dual-route theory adopts a compromise position, suggesting that both whole-word and morphological parsing routes can achieve semantic access to morphologically complex words [?, ?].

Investigating morphologically complex word processing mechanisms not only advances our understanding of language processing but also illuminates the nature of human cognitive abilities. In the human brain, domain-specific knowledge involves two aspects: how knowledge is stored and how new knowledge is constructed. The trade-off between whole-word access and morphological parsing routes concerns the balance between storage and construction of domain-specific knowledge in the human brain [?, ?]. If the brain seeks optimal storage—that is, accessing semantics through minimal stored representations—then whole-word representations of morphologically complex words would not be stored in the mental lexicon, and semantic extraction would rely entirely on morphological parsing. Conversely, if the brain seeks optimal construction—that is, extracting semantics in the shortest time possible—then semantic extraction of morphologically complex words should rely entirely on whole-word access. Therefore, investigating morphologically complex word processing mechanisms helps us understand whether the brain seeks optimal storage or optimal construction, thereby enhancing our understanding of the nature of human cognitive abilities. Moreover, such investigations also help us understand generalization mechanisms in language learning—how general morphological rule knowledge is extracted from individual words. Thus, morphological processing serves as a window into the human brain [?, ?].

Over the past decades, researchers have extensively investigated the processing mechanisms of morphologically complex words in native (L1) speakers using behavioral and cognitive neuroscience methods, finding that native speakers can utilize morphological parsing routes to access complex word semantics [?, ?], and that this process occurs very rapidly [?, ?]. Building on these findings, researchers have further explored the processing mechanisms behind morphological rules (how), the timing of morphological rule activation (when), and their corresponding brain locations (where).

In today' s world, the number of second language (L2) learners is substantial, raising the question: Can L2 learners acquire morphological rules in non-native languages and utilize these rules in real-time language processing? Answering this question not only helps us understand how L2 speakers represent and process morphologically complex words but also addresses whether native and non-native speakers share the same language processing mechanisms. However, L2 research findings remain highly divergent. If we cannot clarify the reasons for these discrepancies, discussions of L2 morphologically complex word processing mechanisms will remain at the basic question of whether readers can use morphological rules, hindering deeper advancement. Therefore, we argue that clarifying the sources of divergence and differences is particularly urgent. This paper centers on the question of whether L2 speakers can utilize morphological rules, first reviewing relevant L2 empirical research, summarizing the divergences and differences between native and L2 speakers in processing morphologically complex words. We then propose a theoretical perspective on L2 morphologically complex word processing mechanisms to explain these divergences and differences, and finally offer suggestions for future research.

2.1 Research Paradigms and "Morphological" Manipulation Methods

Over the past 30 years, researchers have widely adopted the masked priming paradigm to study morphologically complex word processing [**?**, **?**]. In this paradigm, primes are typically masked by stimuli such as shapes or symbols (pre-mask when presented before the prime; post-mask when presented after). To prevent strategic factors, the interval between prime and target presentation is very brief (usually <60 ms). Masking stimuli reduce conscious processing of the prime, making the masked priming paradigm suitable for investigating early automatic decomposition in morphologically complex word processing [**?**, **?**]. In masked priming studies, participants typically complete a lexical decision task, judging whether the target is a word.

Studies using this paradigm manipulate the key independent variable "morphology" in three main ways. The first method establishes three priming conditions: (1) identity priming (e.g., walk → WALK), (2) morphological priming (e.g., walked → WALK), and (3) unrelated control (e.g., look → WALK). The difference between identity and unrelated control conditions is called the identity priming effect or repetition priming effect, representing the maximum priming magnitude. The difference between morphological and unrelated control conditions is called the morphological priming effect. The logic is that if readers can use morphological rules to process morphologically complex words, then when the prime is a morphologically complex word (walked) that can be decomposed into morphemes (walk+ed), it should facilitate target word (WALK) recognition, resulting in better performance in the morphological condition than the unrelated control. However, compared to the unrelated control, morphological primes also share orthographic and semantic information with targets, so significant morphological priming effects are not entirely due to morphology. Therefore, researchers also compare the magnitude of identity and morphological priming effects: if they do not differ significantly (full priming), it indicates the morphological condition produces maximal priming, suggesting readers can fully utilize morphological information. If identity priming exceeds morphological priming (partial priming), it indicates that while the morphological condition shows facilitation over the unrelated control, it does not match identity priming, suggesting readers have some morphological knowledge but are not highly efficient at using morphological rules.

The second method also establishes three priming types: (1) morphological priming (e.g., billed → BILL), (2) orthographic priming (e.g., billion → BILL), and (3) semantic priming (e.g., tip → BILL). All three conditions use the same target (BILL). In morphological priming, the prime is a morphologically complex word (billed) that is highly related to the target morphologically, orthographically, and semantically. In orthographic priming, the prime is a monomorphemic word containing the target (billion), highly related orthographically but sharing no morpheme. In semantic priming, the prime is a monomorphemic word semantically related to the target (tip) but without orthographic overlap. These three conditions are collectively called related priming conditions, each paired with a corresponding unrelated control. The difference between morphological and control conditions is the morphological priming effect, indicating morphological rule use. Correspondingly, differences between orthographic and semantic conditions and their controls are orthographic and semantic priming effects. Since morphological priming may also involve orthographic and semantic facilitation, researchers typically compare morphological priming against orthographic and semantic priming to isolate the pure morphological contribution.

The third method manipulates semantic transparency to investigate morphologically complex word processing. Semantic transparency measures the degree of semantic relatedness between whole-word and constituent meanings [?, ?]. Based on transparency, words are classified as semantically transparent (e.g., reader) or opaque (e.g., corner). For transparent words, morpheme and whole-word meanings are highly related; for opaque words, they are unrelated or weakly related. Researchers typically establish three priming conditions: (1) semantically transparent priming (e.g., employer → EMPLOY), (2) semantically opaque priming (e.g., corner → CORN), and (3) orthographic priming (e.g., brothel → BROTH), each paired with unrelated controls. By comparing opaque priming effects (opaque minus control) and orthographic priming effects (orthographic minus control), researchers can determine whether morphological decomposition occurs in early morphological processing. If opaque priming exceeds orthographic priming, morphological decomposition exists in early processing. Comparing transparent and opaque priming effects reveals whether semantic information influences early morphological decomposition.

2.2 Processing of L2 Inflectional Words

Morphologically complex words can be divided into three types based on formation: inflectional, derivational, and compound words. Inflectional words primarily express grammatical features such as tense and number and cannot create new words. They can be further divided into regular inflections (e.g., look-looked) and irregular inflections (run-ran). Unlike inflectional words, both derivational and compound words can create new words expressing new meanings, though they differ in structure. Derivational words combine roots and affixes (e.g., reader = read + er), while compound words combine roots with roots (e.g., bookstore = book + store). Whether different types of morphologically complex words have distinct processing mechanisms remains debated, and given that L2 studies on the same word type show divergent results, we separately discuss these three types to explain why differences emerge within the same word type.

Given that most studies have used the masked priming paradigm, Table 1 summarizes recent L2 inflectional word studies using this paradigm, while Table 2 summarizes recent L2 derivational word studies. L2 compound word studies are few and not tabulated.

Table 1 shows that regular inflection studies are numerous while irregular inflection studies are scarce. Irregular inflection findings are consistent: both high- and low-proficiency L2 readers use whole-word processing [?, ?, ?].

Regular inflection processing results are highly inconsistent. Using the first manipulation method with identity, morphological, and unrelated control conditions, [?, ?] investigated morphologically complex word processing in English natives and high-proficiency English L2 speakers. Native speakers showed full priming, while high-proficiency L2 speakers (Chinese-English, German-English, and Japanese-English bilinguals) showed significant identity priming but no morphological priming, with identical results across groups. This suggests L2 readers cannot use morphological rules for regular inflections, regardless of L1 type. Similar results were found when L2 was other languages (L2 German, [?, ?]; L2 Turkish, [?, ?]). However, [?, ?] using identical materials found that high-proficiency Greek-English bilinguals showed full priming, indicating L2 speakers can process inflections like natives. Notably, these studies differed in L2 age of acquisition (AoA): Chinese-English participants in [?, ?] averaged 14.6 years, German-English 13.1 years, while Greek-English participants in [?, ?] averaged 8.5 years. Research shows AoA affects inflection processing: [?, ?] found that for Turkish-German bilinguals acquiring L2 after age 5, inflectional priming effects decreased with increasing AoA. Thus, AoA differences may contribute to inconsistent inflection findings.

Recently, more studies have used the second manipulation method or combined both methods. [?, ?] established morphological, orthographic, and unrelated control conditions with high- and low-proficiency L2 groups. High-proficiency Serbian-English bilinguals responded faster in morphological than orthographic priming, while low-proficiency L2 readers showed no difference between conditions. The authors proposed that L2 regular inflection processing is modulated by L2 proficiency: high-proficiency L2 readers can use morphological information like natives, while low-proficiency readers cannot. This conclusion is supported by [?, ?], who used ERPs to investigate Chinese-English bilinguals' regular inflection processing and confirmed that L2 proficiency affects processing: high-proficiency L2 readers showed morphological priming between 350-550 ms (reduced N400 amplitude), while low-proficiency readers showed no effect. However, not all studies find proficiency effects: some show that moderate- or even low-proficiency L2 learners can use morphological rules [?, ?, ?]. For instance, [?, ?] used ERPs to examine French learners with different L1 backgrounds processing regular inflections. Reaction time data showed full priming regardless of proficiency. ERP data showed priming effects for both identity and morphological conditions (reduced N400) with no difference in magnitude. Conversely, some studies found that even high-proficiency L2 speakers cannot use morphological rules for regular inflections [?, ?, ?].

No satisfactory explanation currently exists for inconsistent L2 regular inflection findings. Recent L1 research shows morphological priming is modulated by other factors. [?, ?] found morphological family size affects priming: larger families produce greater effects. [?, ?] showed that prime-target frequency and target pseudo-morphological family size (sum of all orthographic neighbors containing the word) jointly affect priming: for high-frequency targets, significant morphological priming occurs only with high-frequency primes, regardless of pseudo-family size; for low-frequency targets, significant priming also requires high-frequency primes, but only when targets belong to small families. Thus, morphologically complex word processing is influenced not only by word structure but also by lexical activation states (prime-target relative frequency) and lexical families (morphological, pseudo-morphological). However, L2 research has not examined these factors.

In summary, whether L2 speakers can use morphological rules to process regular inflections remains a research focus, with one set of findings showing they can and another showing they cannot. Overall, L2 morphological priming effects are unstable, constrained by factors like AoA and proficiency, while researchers have not considered influences such as prime-target relative frequency, morphological family, and pseudo-morphological family.

2.3 Processing of L2 Derivational Words

Table 2 summarizes recent L2 derivational word studies. In studies using the first two manipulation methods or their combination, participants were all high-proficiency L2 speakers. Most research focused on suffixation, with few examining prefixation.

In prefixation studies, [?, ?] found high-proficiency Polish-German bilinguals relied more on whole-word processing. In suffixation studies, high-proficiency L2 speakers generally could use morphological information. [?, ?] examined derivational processing in English L2 speakers with different L1 backgrounds. Experiment 3 used highly productive suffixes (ness) and Experiment 4 used less productive ones (ity). High-proficiency L2 speakers showed significant partial priming (though not full priming like natives), a pattern unaffected by L1 background or suffix productivity. The authors concluded that high-proficiency L2 speakers can use morphological rules for derivational processing, albeit less efficiently than natives. [?, ?] found that morphological knowledge level affected high-proficiency Chinese-English bilinguals' derivational processing: high-knowledge L2 speakers showed full priming, while low-knowledge speakers showed none. Three recent studies found significant morphological priming in high-proficiency L2 speakers with different L1 backgrounds (Russian-German bilinguals, [?, ?]; [?, ?]; [?, ?]), suggesting high-proficiency L2 speakers can process derivations through morpheme decomposition.

However, studies using the third manipulation method found opposite results: no significant morphological priming in L2, with no difference between opaque and orthographic priming effects, suggesting L2 speakers cannot use morphological parsing. [?, ?] examined Spanish-English and Dutch-English bilinguals processing derived suffixes. Both high-proficiency groups showed no difference between opaque and orthographic control conditions, indicating L2 speakers cannot use morphological rules like natives. Similarly, [?, ?, ?, ?] found no significant morphological priming in Chinese-English bilinguals regardless of proficiency. Two recent studies also found no morphological priming for prefixed and suffixed words [?, ?, ?].

Thus, an interesting phenomenon emerges: "morphological" manipulation methods affect results. Studies using the first two methods found high-proficiency L2 speakers can use morphological information for suffixation, while four studies using the third method found no significant differences between opaque and orthographic priming regardless of proficiency. To our knowledge, no research has examined how manipulation methods affect results. We propose that in the third method, transparent, opaque, and orthographic conditions all share the root, increasing the proportion of orthographic overlap between primes and targets across the experiment. Since masked priming is sensitive to visual similarity between primes and targets [?, ?], L2 speakers may rely more on orthographic information for lexical decisions, obscuring differences between morphological and orthographic priming. Overall, high-proficiency L2 readers can use morphological information for derivational processing, but the third method fails to reveal pure morphological priming because orthographic information masks it. This has two implications: manipulation methods can affect results, and L2 speakers may rely more heavily on orthographic information.

2.4 Processing of L2 Compound Words

[?, ?] first used masked priming to examine Korean-English bilinguals' compound processing, finding morpheme-based decomposition. This was supported by [?, ?]. However, these studies used morphemes as primes and compounds as targets, raising the possibility that participants might process targets based solely on orthographic information, meaning observed priming effects might reflect orthographic rather than automatic morphological decomposition.

To overcome this limitation, [?, ?, ?, ?] used compounds as primes and morphemes as targets, establishing three conditions: semantically transparent (e.g., toothbrush → TOOTH/BRUSH), semantically opaque (e.g., honeymoon → HONEY/MOON), and orthographic (e.g., restaurant → REST; tomorrow → ROW), each with unrelated controls. When repeating the final morpheme, high-proficiency Chinese-English bilinguals showed significant morphological priming (opaque > orthographic), but when repeating the initial morpheme, morphological priming disappeared (opaque = orthographic). The authors attributed this to presentation format: targets were approximately four letters shorter than primes, and uppercase targets (e.g., TOOTH) did not fully mask lowercase primes (e.g., toothbrush), with unmasked initial letters potentially facilitating L2 recognition. Despite non-significant priming for initial morphemes, significant effects for final morphemes led the authors to conclude that L2 readers can use morphological decomposition for compounds.

In summary, across three morphologically complex word types, L2 readers possess some morphological knowledge but apply rules less efficiently than natives. Moreover, L2 speakers tend to rely more on orthographic information. Below, we detail L1-L2 differences and propose a theoretical perspective on L2 morphologically complex word processing to explain these differences.

3.1 Manifestations of L1-L2 Differences in Morphologically Complex Word Processing

Current findings show L1-L2 differences in two main aspects. First, all L1 studies find significant morphological priming across word types, indicating native speakers can use morphological rules. In contrast, L2 morphological priming is unstable, suggesting L2 rule use may depend on many factors. For example, not all L2 regular inflection studies show morphological rule use, and in derivational processing, manipulation methods affect strategy: when prime-target pairs have high orthographic overlap, morphological priming disappears (opaque = orthographic), whereas native speakers show significant morphological priming with the same manipulation. Second, L1 studies consistently show non-significant orthographic priming, explained by lexical competition between orthographically similar primes and targets canceling out orthographic facilitation [?, ?]. However, many L2 studies find significant orthographic priming [?, ?, ?, ?, ?, ?, ?]. Additionally, in L2 studies reporting non-significant orthographic priming, the difference between orthographic and control conditions, while not significant, is still large compared to L1 results [?, ?, ?]. This suggests that when primes and targets share orthographic overlap, L2 speakers do not show lexical competition that cancels orthographic facilitation, unlike natives.

Some studies have attempted to explain these L1-L2 differences. [?, ?] proposed that L2 processing differences stem from proficiency differences. Low-proficiency L2 speakers have developing lexical systems with more incompletely consolidated words that are essentially similar to non-words in L1. Therefore, no lexical competition occurs between primes and targets, allowing orthographic overlap facilitation to remain unopposed, resulting in significant orthographic priming. As L2 proficiency increases, the L2 lexical network matures, and orthographic overlap facilitation becomes canceled by lexical competition, making orthographic priming smaller until it disappears. Their results indeed showed that as L2 proficiency increased, orthographic priming patterns became more native-like. However, if high-proficiency L2 speakers become more native-like, they should also show significant morphological priming like natives. Contrary to this prediction, their study found high-proficiency L2 speakers showed non-significant morphological priming. Furthermore, this explanation contradicts other findings: some studies show significant orthographic priming even in high-proficiency L2 speakers [?, ?, ?], and [?, ?] found low-proficiency L2 readers showed significant orthographic priming but non-significant opaque priming. If low-proficiency L2 speakers rely mainly on orthographic information, opaque conditions should also show priming. Therefore, while L2 proficiency affects morphologically complex word processing, L1-L2 differences cannot be explained by proficiency alone. To our knowledge, current theories cannot adequately explain both the instability of L2 morphological priming and the absence of lexical competition for orthographically similar words (significant orthographic priming). [?, ?] noted that theories from non-linguistic domains can expand our understanding of human language processing, so in Section 3.2 we introduce memory-related theories to explain these phenomena.

3.2 Reasons for L1-L2 Differences in Morphologically Complex Word Processing

The Complementary Learning Systems account posits that learning and memory are based on two distinct systems: the hippocampal system, which rapidly encodes individual events, and the neocortical system, which integrates new memories with existing knowledge to encode structures shared across events [?, ?]. Building on this, [?, ?] proposed that native speakers can activate morphological rules through two mechanisms: neocortical and hippocampal. The neocortical mechanism stores abstract morphological rule representations (e.g., reader, banker, builder → V+er, meaning "person who does V"), while the hippocampus lacks such abstract rules. When using the neocortical mechanism, readers can directly extract morphological rule information. When using the hippocampal mechanism, they must create a temporary rule through real-time construction, requiring additional processing time. Why have two mechanisms rather than directly extracting abstract rules from the neocortex? [?, ?] found that forming abstract rule representations in the neocortex requires certain conditions. For instance, learning new irregular words (e.g., corner) could catastrophically interfere with existing knowledge (e.g., reader, banker, builder → V+er). Therefore, neocortical learning must proceed slowly and gradually to avoid interference. However, learning in natural contexts often occurs rapidly, requiring the hippocampal system to encode new items as distinct, unrelated representations that allow fast encoding without massive interference with existing knowledge. [?, ?] noted that L1 is typically acquired implicitly, while L2 acquired after the critical period (age 5) is mainly explicit. In the L2 morphological processing studies reviewed here, reported AoA was after the critical period. [?, ?] found that only implicitly acquired syntactic rules produce native-like processing in L2. Since morphology, like syntax, reflects linguistic regularity [?, ?], we propose that for L2 speakers, morphological rule acquisition may be similar to syntactic rule acquisition and affected by acquisition mode. For post-critical period L2 learners, explicit L2 acquisition makes it difficult to store abstract morphological rule representations in the neocortex like natives. Therefore, L2 speakers can only activate morphological rule information through the hippocampal mechanism. Because extracting morphological rules via hippocampus requires reconstruction and real-time rule construction takes time, L2 speakers cannot use morphological rules as efficiently as natives in real time, leading to unstable morphological priming.

The Episodic L2 Hypothesis posits that AoA affects L2 lexical memory storage. For simultaneous bilinguals, L2 and L1 are stored in the same lexical memory system, while for late L2 learners, regardless of proficiency, L2 words may be stored in episodic memory [?, ?, ?]. This hypothesis is supported by recent findings. [?, ?] found that the prime lexicality effect stable in L1 [?, ?] is absent in L2. The prime lexicality effect refers to greater priming when the prime is a non-word (e.g., contrapt → CONTRAST) than a real word (e.g., contract → CONTRAST) when primes and targets are orthographic neighbors. This occurs because real-word primes compete with targets, canceling orthographic facilitation. [?, ?] proposed that the absence of this effect in L2 occurs because L2 words are stored in the episodic memory system, where stored words do not compete, preventing the prime lexicality effect. However, they did not explain why episodically stored words do not compete. Given the Complementary Learning Systems account' s proposal that the hippocampus encodes episodic memories as unrelated representations, we propose that words stored in episodic memory do not compete because hippocampal storage creates unrelated representations, preventing competition between orthographically similar primes and targets.

In summary, for late L2 learners, L2 morphological rule processing mechanisms differ substantially from natives. Due to factors like L2 acquisition mode, late L2 learners may not form abstract morphological rule representations in the neocortex. Therefore, when processing morphologically complex words, they cannot activate abstract morphological rules via neocortical mechanisms but must create temporary rules via hippocampal mechanisms. This requires additional processing time and is vulnerable to factors like manipulation methods, making rule use inefficient. Additionally, late L2 learners store vocabulary in episodic memory, where hippocampal representations are unrelated, so orthographically similar primes and targets do not compete semantically, leaving only orthographic facilitation. This explains why most L2 morphological studies find significant orthographic priming. However, L2 lexical storage and morphological rule processing mechanisms need not be causally related: using hippocampal mechanisms for morphological rules does not necessarily mean L2 words are stored in hippocampal episodic memory.

Compared to natives, late L2 learners show lower efficiency in constructing morphological rules across all word types (inflectional, derivational, compound). Based on this, we propose that word type does not affect hippocampal morphological rule construction—all are processed via hippocampal mechanisms. However, research shows that unlike regular inflections processed primarily through decomposition, natives processing derivations and compounds use both morphological parsing and whole-word access [?, ?], with interactive activation between routes [?, ?, ?, ?]. This suggests native processing mechanisms differ between word types: both morpheme and whole-word information are activated and facilitate each other in derivations and compounds, while regular inflections rely more on morphological parsing. Additionally, L2 studies show more stable morphological priming for derivations than regular inflections. These findings suggest word type may modulate hippocampal construction difficulty. Inflections mainly add affixes to express grammatical information without creating independent meanings. [?, ?] argued that inflectional changes are grammatical changes representing grammatical forms. Derivations and compounds create new words expressing new meanings through root+affix or root+root combinations. Extensive research shows L2 speakers have substantial difficulty processing grammatical information [?, ?]. Based on these findings, we propose that although late L2 learners can process inflections, derivations, and compounds via hippocampal mechanisms, hippocampal construction of morphological rules for inflections may be relatively more difficult.

4 Future Research Directions

Despite growing attention to L2 morphologically complex word processing mechanisms, many questions require further investigation.

First, based on Complementary Learning Systems theory and the Episodic L2 Hypothesis, we have proposed that late L2 learners may rely on hippocampal mechanisms for morphological rule processing. However, this remains a theoretical hypothesis requiring cognitive neuroscience evidence. Additionally, our hypothesis targets late L2 learners; the processing mechanisms of early L2 learners also need investigation—whether they can process morphologically complex words like natives.

Second, future research should use eye-tracking to examine L2 morphologically complex word processing in natural reading for greater ecological validity. Most current studies use lexical decision tasks with single words, whereas real-world processing occurs in sentences providing contextual information. Whether sentence-context processing differs from single-word processing remains unclear. Very few studies have examined L2 complex word processing in sentences, mostly using ERPs. For example, [?, ?, ?, ?, ?] used ERPs to investigate morphologically complex word processing in sentences, embedding correctly spelled derived words and pseudo-derived words in semantically plausible sentences. High morphological knowledge L2 readers showed larger P600 for pseudo-derived words, while low-knowledge readers showed larger N400, suggesting high-knowledge readers rely more on decomposition and low-knowledge readers on whole-word access. However, ERPs present words sequentially, unlike natural reading. Eye-tracking allows simultaneous presentation of sentences or paragraphs, offering high ecological validity, high temporal resolution, multiple measures, and sensitivity to morphological processing timecourse [?, ?]. Future studies should use eye-tracking to investigate L2 morphologically complex word processing in sentence reading to examine processing mechanisms in more ecological contexts.

Third, research should examine how morphological family size affects processing. That morphological and pseudo-morphological families influence native processing suggests that viewing morphological parsing as a simple bottom-up process (morpheme decomposition and construction) is incomplete. [?, ?] found that when affixes belong to small families, natives cannot form abstract morphological rule representations in the neocortex but can create temporary rules via hippocampal mechanisms. Based on our hypothesis, if L2 speakers can only activate morphological rules via hippocampus, then differences between native and L2 rule activation efficiency should be modulated by family size: differences should be larger for large families than small families. This is because both natives and L2 speakers must use hippocampal mechanisms for small families, but natives can directly extract abstract rules from the neocortex for large families. Investigating morphological family effects can further reveal L2 morphologically complex word processing mechanisms.

Finally, research should explore the neural mechanisms of L2 morphologically complex word processing. Previous research shows that for natives, written word semantic access can be achieved through two pathways: dorsal (form-phonology-meaning) and ventral (form-meaning), with morphological parsing associated with the ventral pathway [**?**, **?**]. With increasing reading experience, natives shift from dorsal to ventral pathway dependence [**?**, **?**]. [**?**, **?**] proposed that morphological rule acquisition plays a crucial role in this shift, with increased reading experience enabling rapid morphological decomposition. However, few studies have examined L2 neural mechanisms, with highly divergent results [**?**, **?**, **?**]. Future research should address this issue, which will deepen our understanding of L2 morphologically complex word processing and answer the fundamental question of whether natives and L2 speakers share the same language processing mechanisms.

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Note: Figure translations are in progress. See original paper for figures.