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Literature Review: ERP Evidence on the Factors Affecting L2 Syntactic Processing

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Abstract

This paper provides a literature review of the new findings of ERP evidence on the factors affecting L2 syntactic processing. Four affecting factors have been primarily identified and discussed in the paper, i.e. proficiency, AoA (Age of Acquisition), L1-L2 syntactic similarity and immersion. Therefore, researchers must consider multiple factors in order to obtain a nuanced understanding of L2 neurocognitive processing.

Keywords

ERP; L2; Syntactic processing.

1. Introduction

In linguistic research, syntactic processing has always been an important research direction. For second language (L2) learners, how to understand and process the syntactic structure of sentences has always been a concern.

In the past few decades, researchers have proposed a series of hypotheses about syntactic processing mechanisms and tested these hypotheses through behavioral experiments and other methods. Especially in recent years, event-related potential (ERP), as a neurophysical technique, has been widely used in the study of syntactic processing. At present, ERP technology has been widely used in the study of second language learners' syntactic processing. ERPs have provided information that complements findings obtained with other methodologies regarding L2 processing. One of the central questions still being addressed in L2 ERP research is whether second language learners can show neurocognitive processing signatures that are similar to those of native speakers.

Notably, syntactic processing in L1 and L2 has been claimed to differ in L1 and L2 at least as revealed by the processing of violations. On the one hand, a P600 effect similar to that found in native speakers has been revealed in L2 learners for syntactic anomalies (Weber-Fox & Neville, 1996), suggesting that native-like syntactic processing can be achieved in L2. On the other hand, this effect was not found for all L2 learners (Hahne, 2001). Early negativities had not been reported in L2 (Hahne, 2001) until 2006 (Hahne et al., 2006). Note, nonetheless, that these negativities have not been consistently reported in monolinguals and their interpretation is still in question (Müller & Hagoort, 2006). Moreover, recent ERP studies have put forward the hypothesis that differences between native and L2 syntactic processing are attributable to proficiency, AoA as well as to L1/L2 similarity. However, even with additional research on this issue, the question of whether second language learners can show neurocognitive processing signatures that are similar to those of native speakers remains open as conflicting results have continued to emerge.

This paper aims to sort out and summarize the existing literature that uses ERP to explore the factors affecting second language learners' syntactic processing, and finally analyze the main problems and challenges of current research. This literature review may be helpful for those

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who want to have a deeper understanding of the mechanism of L2 learners' syntactic processing and provide reference and direction for subsequent research.

2. ERP Evidence on The Factors Affecting L2 Syntactic Processing

This section provides a review of ERP evidence on the four factors affecting L2 syntactic processing respectively, i.e. proficiency, AoA, L1-L2 syntactic similarity and immersion.

2.1. Proficiency

Some ERP studies have revealed that native-like syntactic processing can be observed in the L2 provided a high level of proficiency as well as sufficient regularity of the grammatical rule in question. Rossi et al. (2006) presented sentences containing word category violations, morphosyntactic agreement violations or both types of violations to high- and low-proficiency German and Italian L2 learners of Italian and German, respectively. The results for high-proficiency learners were similar to those found for native speakers (albeit with some differences in amplitude): an ELAN (early left anterior negativity) and a P600 effect for word category violations and a LAN and a P600 effect for morphosyntactic violations. In contrast, low-proficiency learners did not show any LAN effect and displayed a delayed P600 effect. The authors concluded that late L2 learners who achieve high proficiency can process language similarly to native speakers given sufficient exposure to the L2, and they suggested that Friederici's (2002) three-phase model could be applied to L2 language processing.

In similar manner, Bowden, Steinhauer, Sanz, and Ullman (2013) examined syntactic processing in two groups of English native-speakers who were studying L2 Spanish at the university level. One group of Spanish L2 learners began to acquire Spanish at an average age of 14.1 years, had completed an average of 2.0 semesters of university-level Spanish classes, had never lived in a Spanish-speaking environment, and were classified at a low-intermediate level of proficiency based on a standard speaking test. The second group of Spanish L2 learners began to acquire Spanish at an average age of 12.4 years, had completed an average of 6.9 semesters of university- level Spanish classes, had lived in a Spanish-speaking environment for at least one semester, and were classified at an advanced level of proficiency based on a standard speaking test. In regard to processing Spanish phrase structure violations, native Spanish speakers evidenced a LAN, a P600, and a late AN. The low-intermediate proficiency L2 speakers did not evidence any significant ERP effect. However, the advanced proficiency L2 group evidenced statistically equivalent LAN and P600 effects as compared to native speakers, suggesting that L2 speakers can rely on processing mechanisms that are indistinguishable from native speakers. In all, the results of this study suggest that proficiency and experience may affect L2 processing to a great extent.

2.2. AoA

A number of studies have also used the ERP method to study syntactic processing in the bilingual or second language context for subjects of various ages. A wide variety of experiential and biological factors have been proposed to account for these age effects. One of the most famous and debated theory that has been proposed on this issue is the critical period hypothesis (Johnson and Newport, 1989; Lenneberg, 1967; Newport et al., 2001), which generally states that there is a time window early in life when the brain exhibits a special sensitivity to certain types of environmental stimuli. This early experience can be considered crucial (critical period) or just facilitatory (sensitive period) for the successful attainment of a specific function.

Weber-Fox and Neville (1996) asked different AoA groups Chinese-English bilinguals to read sentences that contained three different types of syntactic violations (phrase structure, specificity constraint, and subjacency constraint) as well as semantic violations. In their ERP

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study, they observed that ERP correlates of English (L2) phrase structure violations differed from those of English (monolingual) natives, especially when the L2 was acquired after age 11. While, in monolingual natives, word category violations initially elicited greater left negativities followed by a P600 effect; L2 speakers with a late AoA (above 11 years old) showed anterior negativities without a clear left lateralization, and no P600 effect was observed when the L2 acquisition started after 16 years old. On the basis of these results the authors claimed that, as AoA increases, neural correlates of early syntactic processes would show a reduced left hemispheric specialization and ERP effects underlying late processes of revision would be delayed or even not available (Weber-Fox and Neville, 1996; see also Pakulak and Neville, 2011). This is thought to be due to biological and/or experiential changes that happened after puberty.

Pakulak and Neville (2011) also found processing differences between L1 and L2 for native speakers of German learning L2 English who had an average age of acquisition of 11.05 years, who lived in an English-speaking environment, and who were matched in proficiency to native English speakers on a standard speaking and grammar test. English phrase structure violations yielded an extended AN and a P600 in native speakers but only a P600 in the L2 group. Because proficiency was matched between the groups, the researchers concluded that the neural organization of syntactic processing is sensitive to age of acquisition effects and that more automatic processes, as reflected by the AN, are particularly susceptible to age of acquisition effects.

2.3. L1-L2 syntactic similarity

Other ERP studies have underlined the role of the syntactic similarity of the L1 and the L2 (Osterhout et al., 2006; Tokowicz & MacWhinney, 2005). These research has shown that L2 learners can evidence native-like ERP effects for L2 grammatical features that are present in their first language (L1).

Sabourin and Stowe (2008) compared the performance of Romance and German learners for the definite determiner condition in Dutch (e.g. Hetneu /∗ Decom kleine kindcom “the small child”). They observed a P600 effect for the German group and an uncharted frontal negativity in the group of Romance learners. The authors concluded that automatic gender processing in L2 not only depends on the presence of a grammatical gender system in the L1 but also requires overlapping of lexical gender. Here the rules were either the same or differed across the L1 and L2. For German participants, agreement rules within the DP were the same in their L1 and L2, whereas for Romance speakers this was not the case, as not only the determiner but adjective as well must agree in gender with the noun in Romance languages (e.g., la petite table vs. le petit enfant “the small table” vs. “the small child”). Hence, differences in performance between the German and the Romance group may also have been due to cross-linguistic differences in agreement rules. Furthermore, conclusions from the results should be drawn with caution because of the variability between the groups of learners regarding N size (N = 8 Romance vs. 14 German learners).

Foucart and Frenck-mestre (2011) examined the effect of proficiency and similarity at the same time between the first and the second language on grammatical gender processing in L2. In three experiments, they manipulated gender agreement violations within the determiner phrase (DP), between the determiner and the noun (Experiment 1), the postposed adjective and the noun (Experiment 2) and the preposed adjective and the noun (Experiment 3). They compared the performance of German advanced learners of French to that of French native controls. The results showed a similar P600 effect for native and non-native speakers for agreement violations when agreement rules where similar in L1 and L2 (Experiment 1, depending on proficiency), whereas no effect was found for L2 learners when agreement rules

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varied across languages. These results suggest that syntactic processing in L2 is affected by the similarity of syntactic rules in L1 and L2.

However, contrary to some claims regarding the potential for nonnative processing, there are also research suggesting that L1 and L2 speakers show similar ERP responses when processing agreement, even when the L1 lacks the relevant distinction. Cheng et al. (2022) use ERPs to examine nonlocal agreement processing between native (L1) English speakers and Chinese–English second language (L2) learners, whose L1 lacks number agreement. They manipulated number marking with determiners (the vs. that/these) to see how determiner-specification influences both native and nonnative processing downstream for verbal number agreement. Behavioral and ERP results suggest both groups detected nonlocal agreement violations, indexed by a P600 effect. Moreover, the manipulation of determiner-number specification revealed a facilitation effect across the board in both grammaticality judgment and ERP responses for both groups: increased judgment accuracy and a larger P600 effect amplitude for sentences containing violations with demonstratives rather than bare determiners.

2.4. Immersion

The quantity and the type of the L2 input (formal education vs. immersion) can influence how language is acquired and computed (Mun˜oz, 2008, 2010). While during formal education, L2 input is restricted to an educational environment and L2 speakers are usually exposed to the target language in a structured and discontinuous way; with immersion, L2 input is massive and provided in a variety of sources, speech acts and social settings. University students often report making significant advances in their L2 ability after immersion in a nonnative language through study abroad. The degree to which late L2 learners can become native-like in terms of L2 performance and brain processing is unclear in second language acquisition research. The link between L2 proficiency and learning context has been characterized in previous research, yet the role of learning experience in attaining native-like brain processing of L2 remains to be elucidated.

Brito (2017) contrasted learners with advanced French proficiency who had attained this level with no, little, or more immersion experience through study abroad. By using empirical neurolinguistic techniques, he investigated the impact of immersion versus classroom experience on second language processing. Participants were advanced learners of French who were separated into groups based on amount of immersion experience. Participants read sentences in French, which were either correct or contained a subject-verb agreement error. These errors were of two types: either silent (written but not pronounced) or phonologically realized (written and pronounced). Using electroencephalography (EEG), he monitored the brain's electrical activity during the sentence-reading task. The subsequent ERPs provided insight into how French morpho-syntax is being processed in the brain. By comparing these ERP signatures among the three groups and to those of native speakers, he examined and interpreted any differences in L2 processing. The results of this experiment replicated the finding that phonologically realized errors elicit more robust ERP signatures as compared to silent errors. Further, he observed a difference in L2 processing among the three groups: participants with more immersion showed more native-like ERP signatures as compared to equally proficient participants without such experience.

There is another research that proves that prolonged immersion will lead to changes in the processing of morphosyntactic violations. Bilinguals do not process language the way monolinguals do, presumably due to constant parallel activation of both languages. Bergmann et al. (2015) tried to isolate the effects of parallel activation in a group of German first-language (L1) attriters, who have grown up as monolingual natives before emigrating to an L2 environment. Two types of constructions were presented as stimuli in an ERP experiment: (1) verb form combinations (auxiliaries + past participles and modals + infinitives) and (2)

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determiner-noun combinations marked for grammatical gender. L1 attriters showed the same response to violations of gender agreement as monolingual controls (i.e. a significant P600 effect strongest over posterior electrodes). Incorrect verb form combinations also elicited a significant posterior P600 effect in both groups. In attriters, however, there was an additional posterior N400 effect for this type of violation. Such biphasic patterns have been found before in L1 and L2 speakers of English and might reflect the influence of this language. Generally, their results can interpreted as evidence for the stability of the deeply entrenched L1 system, even in the face of L2 interference.

3. Conclusion

This article reviewed ERP evidence on the factors affecting L2 syntactic processing. Four influential factors in the research have been identified and discussed. Firstly, native-like syntactic processing can be observed in the L2 provided a high level of proficiency of the grammatical rule in L2. Secondly, the neural organization of syntactic processing is sensitive to age of acquisition effects. Thirdly, L2 learners can evidence native-like ERP effects for L2 grammatical features that are present in their L1. Lastly, participants with more immersion showed more native-like ERP signatures as compared to equally proficient participants without such experience.

These results can only lead us to conclude that a host of factors may be at play in regard to whether L2 learners are able to rely on similar neurocognitive processes as native speakers for (morpho)syntactic processing. Therefore, research must consider multiple factors in order to obtain a nuanced understanding of L2 neurocognitive processing. Indeed, this is the direction that L2 ERP research has taken in many years.

However, most previous L2 studies have focused on natural languages. In L2 learners of natural languages, significant increases in proficiency towards native-like levels often take months or years, are difficult to predict, and are thus difficult to study within the same participants. This is where miniature languages such as those used by Friederici et al. (2002), Mueller et al. (2005; 2007) and Morgan-Short et al. (2007), have significant advantages, since they allow the study of progress from novice to native-like proficiency within a feasible time frame (usually a few weeks). Miniature versions of natural languages (e.g. Mueller et al., 2005; 2007) have the additional advantage that real native speakers are available who can serve as controls. However, even in these approaches, it is difficult to avoid confounds of phonology and morphosyntax (as shown and discussed in Mueller et al., 2005; 2007; for discussion relevant to this issue, see also Goad and White, 2004; 2006). In contrast, artificial miniature languages, if modelled after natural languages, can avoid or minimize such confounds. Specifically, the study of artificial languages allow us to control for problematic confounds arising in natural language studies, and even in miniature versions of them.

All in all, these patterns of findings have significantly moved forward our understanding of the neurocognitive processing on L2, in part because they have been informed both by research in cognitive neuroscience as well as by research in the field of second language acquisition. With continued interdisciplinary approaches and sophisticated research designs, L2 ERP research is only beginning to reach its potential and promises to uniquely inform central questions of second language acquisition.

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