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Research Report

Event-related potential (ERP) responses to violations of inflectional and derivational rules of Finnish

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ABSTRACT

Event-related potentials (ERP) were used to investigate the electrophysiological correlates of inflectional and derivational morphology. The participants were presented with visual sentences containing critical words in which either inflectional, derivational or both rules (combined violation) of Finnish were violated. Inflectional anomalies violated a number agreement of a noun with a previous auxiliary word. Derivational violations included a word-internal selectional restriction violation, i.e., a root and suffix category violation. Combined violations contained both a number and a category violation. The phonemic length of the critical words was controlled. Inflectional violations elicited a bilateral negative effect in the 450–550 ms time window, which was interpreted as an anterior negativity (AN) effect. Inflectional violations also elicited a late positivity (P600) effect. Derivational violations elicited an N400-like negativity effect, followed by the P600 effect. The P600 effects in the derivational and inflectional violation conditions summated linearly in the combined violation condition. The results are discussed with respect to the hypothesis that inflectional and derivational processes are independent and elicited in parallel in the online language comprehension.

1. Introduction

One of the most persistent undefinables in morphology has been the distinction between derivation and inflection (Bybee, 1985). It has been proposed that inflection and derivation represent functionally distinct processes (Anderson, 1982; Scalise, 1986). Several criteria have been presented to support this distinction (e.g., Anderson, 1982; Stump, 1998): a) inflectional morphemes, such as number ('banana–bananas') specify the grammatical functions of words in phrases, whereas derivational affixes are used to derive new words (lexeme formation), e.g., 'work–worker', b) derivational affixes usually change the syntactic category of the base word (happy–happiness, from adjective to noun), while inflectional affixes do not (boy–boys, from singular noun to plural noun); c) inflectional affixes are more productive than derivational suffixes, as the latter are constrained by more selectional restrictions; d) inflection is semantically more transparent than derivation, e) inflectional rules are applied only after the derivational suffixes has been applied.

All of these criteria, however, have been challenged (Stump, 1998). Some authors have proposed that there is no need for a distinction between inflection and derivation since they represent only different uses of morphology, not different kinds of morphology. Inflection is the morphological realization of syntax, while derivation is the morphological realization of

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lexeme formation (Aronoff, 1994). According to Bochner (1992), both inflection and derivation use the same formal operations, such as prefixation, suffixation and infixation and thus can be treated in a unified fashion. To date, the exact relationship between inflectional and derivational processing remains under debate.

This theoretical controversy arouses a question of whether derivational and inflectional morphological processes are separable and independent in the online language comprehension. On one hand, it is possible that the inflectional and derivational aspects of words are processed independently of each other and possibly in parallel. On the other hand, it is possible that they use the same neurocognitive processes (e.g., linguistic operations, morphological decomposition). Moreover, it is possible that while some aspects of inflectional and derivational morphological parsing processes are independent of each other, they might partially overlap. The question of distinctiveness, independence and/or interaction of derivational and inflectional processes is the scope of the present study.

1.1. *Priming studies*

Several morphological priming studies have specifically addressed the differences in the processing of derived and inflected words (e.g., Feldman, 1994; Laudanna et al., 1992; Schriefers et al., 1992; Stanners et al., 1979). Stanners et al. (1979) observed stronger priming effects for regular inflections than for irregular inflections and derived words. Laudanna et al. (1992) reported equal priming effects for inflected and derived words. On the other hand, Schriefers et al. (1992) and Feldman (1994) reported greater priming effects for inflected than derived words. Raveh (2002) observed equal priming for low-frequency derived and inflected words, but stronger priming for high-frequency inflected words than for derived words. Feldman (1994) has argued that lexical representation of inflected and derived words must differ since the linkage between whole word forms with a shared root is stronger for inflectionally-related forms than for derivationally-related forms. This might be due to greater semantic transparency of inflectional relationships as compared to derivational relationships (Feldman, 1994). In contrast, McQueen and Cutler (1998) have interpreted the results form Feldman's study in such a way that inflectional and derivational morphology could be processed similarly in the lexicon with factors such as semantic transparency being the main determinant of the strength and nature of connections between morphemes. According to McQueen and Cutler (1998, p. 413), there may be no need for a qualitative distinction between lexical representation of inflected and derived words. Overall, based on these priming studies it is unclear whether derivational and inflectional parsing processes interact in the online comprehension.

1.2. *Event-related potential (ERP) studies on morphology*

Hypotheses about the representation and processing of morphologically complex words have been difficult to test using only behavioral methods as it is difficult to separate the influence of semantic, phonological, orthographic and morphological properties on reaction time data (Morris and Holcomb, 2005). This has led to the extensive use of the event-related potential method in psycholinguistics over the last two decades. Event-related potentials are small changes in the electrical activity of the brain that are recorded from the scalp and that are brought about by some external or internal event (e.g., Otten and Rugg, 2005). This method has proven to be a powerful tool for studying language processing due to its good temporal resolution.

Event-related potential studies on morphological processing have mainly examined the distinction between regular and irregular inflection in various languages (e.g., English, German, Italian, Catalan and Spanish). Overall, it has been reported that regular and irregular inflectional patterns elicit distinct electrophysiological (ERP) responses (e.g., Allen et al., 2003; Linares et al., 2006; Lück et al., 2006; Morris and Holcomb, 2005; Newman et al., 2007; Penke et al., 1997; Rodriguez-Fornells et al., 2001; Weyerts et al., 1997). Most of these studies have used a violation paradigm in which subjects read or listened sentences, stories or single words containing inflectional violations (Allen et al., 2003; Gross et al., 1998; Linares et al., 2006; Lück et al., 2006; Morris and Holcomb, 2005; Newman et al., 2007; Penke et al., 1997; Rodriguez-Fornells et al., 2001; Weyerts et al., 1997). In contrast to studies on inflectional morphology, there are only few ERP studies on the processing of derived words (Janssen et al., 2006; McKinnon et al., 2003).

1.2.1. *The LAN effect*

Violations of regular inflectional rules such as adding a regular inflectional suffix to an irregular stem (such as **grewed* instead of *grew*) or violating stem formation rules have elicited a LAN-type negativity effect (e.g., Linares et al., 2006; Lück et al., 2006; Morris and Holcomb, 2005; Penke et al., 1997; Rodriguez-Fornells et al., 2001; Weyerts et al., 1997). The LAN effect elicited during inflectional violations has been interpreted to reflect processes involved in integrating a word into its syntactic context as well as morphological structure building (Morris and Holcomb, 2005; Penke et al., 1997; Rodriguez-Fornells et al., 2001).

1.2.2. *The N400 effect*

In addition to the LAN effect, several studies have reported an N400 effect elicited in violations of inflectional and derivational morphology (Janssen et al., 2006; Linares et al., 2006; Lück et al., 2006; Morris and Holcomb, 2005; Weyerts et al., 1997). In inflectional violations, the N400 effect has been reported in conditions where an irregular suffix was applied to a regular stem (Lück et al., 2006; Weyerts et al., 1997), as well as in stem violation conditions (Linares et al., 2006). The N400 has also been observed in a single-word paradigm for both regular and irregular inflectional violations (Morris and Holcomb, 2005). In derivation violations, the N400 has been elicited in relation to a category violation of a stem and productive derivational suffix (Janssen et al., 2006).

The N400 effect has been interpreted to reflect the possibility that these violation types are processed as whole units since there are no rules for building such forms (e.g. Lück et al., 2006) and they might be treated as pseudo-words (e.g., Janssen et al., 2006).

1.2.3. *The P600 effect*

Besides the LAN and N400 effects, several studies have observed a late positive component (P600) for morphological violations (Allen et al., 2003; Lück et al., 2006; Morris and Holcomb, 2005; Newman et al., 2007; Rodriguez-Fornells et al., 2001). The P600 effects have been observed both in sentence