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Neural processing of morphosyntactic tonal cues in second-language learners

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ABSTRACT

The morphosyntactic nature of word accents in Swedish makes them a perfect candidate for the study of predictive processing in language. The association of word stem accents with upcoming suffixes allows native listeners to pre-activate a word's potential ending and thereby facilitate speech processing. Unlike native speakers, second language learners are known to be less able to use prediction in their L2s. This is presumably due in particular to competing information from the learners' L1 and a poorer exposure to the relevant L2 information. Swedish word accents, however, are abundant in the input and rare cross-linguistically, making them ideal for studying the implicit acquisition of linguistic prediction in beginner L2 learners. We therefore recorded learners' electrophysiological brain responses to Swedish word accents and compared them to those of native speakers. In the native speaker group, a pronounced suffix-related PrAN (pre-activation negativity), N400 and a P600-like late positivity indicate predictive processing. The learners, however, only produced a late (400–600 ms) centrally distributed negativity for word accent processing, remarkably similar to the deflection for pure pitch height differences found in the same subject group. Crucially, correlation analysis indicated that this negativity increased (at right-lateral electrode sites) for learners with increased level of Swedish proficiency. We conclude that, to allow L2 tone-suffix association and to enable its predictive capacity, the acquisition of Swedish word accents and their predictive properties might first involve dissociation of word tones from the default L1 tonal patterns as well as sensitisation to pitch height differences.

1. Introduction

Understanding spoken language is a complex and resource-demanding task. The work-load is even higher if the language to be processed is non-native to the listener (Hasegawa, Carpenter, & Just, 2002). The present study set out to investigate whether beginner learners of a language can implicitly learn and make use of predictive prosodic cues that do not exist in their native language in order to facilitate the processing of upcoming morphological information.

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1.1. Prediction in language processing

The idea that listeners use predictability in constrained contexts to facilitate the processing of upcoming information has influenced language research since the 1970s (e.g. DeJong, 1979; Fischler & Bloom, 1979). Accelerated lexical decision times for correctly pre-activated information in constrained sentences has been seen as proof thereof (Fischler & Bloom, 1979). However, it has remained difficult to show that these accelerated lexical decision times result from a word's higher contextual predictability rather than eased integration of the word into the sentential context as traditional bottom-up language processing theories would claim (e.g. Jackendoff, 2002; Norris, 1994). More recently, however, the use of event-related potentials (ERPs) to directly sample the brain's activity dynamics during language tasks has produced a growing body of evidence for the psychological reality of prediction in language comprehension and production.

1.1.1. Benefits and consequences of predictive processing

In a study on compound nouns, Koester, Gunter, Wagner, and Friederici (2004) observed a left anterior negativity (LAN) for both the first and the second constituent in the compound if they were mismatched in gender with a preceding determiner. The LAN for the first noun in compounds - where a match in gender is irrelevant - suggests that listeners automatically make predictions about the gender of the upcoming noun when encountering a gender-specific determiner. Placing noun phrases into sentential contexts, other studies have looked at the processing of articles which by themselves carry little differential semantic weight. By investigating articles, influences of integration could be minimalised and effects of prediction could more easily be factored out. It has been shown that listeners produce a higher N400 when encountering an article of an unexpected gender (Wicha, Moreno, & Kutas, 2003) or with an unexpected phonological form (DeLong, Urbach, & Kutas, 2005) in contextually constrained sentences. Both the unexpected article and the following unexpected noun have been seen to elicit a greater N400, which, furthermore, is observed to correlate with the noun's offline cloze probability (DeLong et al., 2005). In contextually constrained contexts, a reduced N400 to correctly predicted words can thus be said to function as an index of the processing benefits of prediction.

The reason why these studies found differences in the N400 while Koester et al. (2004) found a LAN presumably lies in the fact that the latter looked at noun phrases in isolation and hence had a more morphosyntactic focus, while Wicha et al. (2003) and DeLong et al. (2005) placed nouns into sentential contexts and tasked participants with comprehension or memory tasks which focus more on the lexical-semantic content. The LAN and the N400 have been argued to be very similar effects that are slightly more influenced by morphosyntax and semantics, respectively (Molinaro, Barber, Caffarra, & Carreiras, 2014). This is corroborated by studies on predictive tones (i.e. word accents, see section 1.1.2) in Swedish, which have found a LAN for failed predictions in the absence of semantic information, i.e. using pseudowords (Söderström, Horne, & Roll, 2016b). Unpredicted suffixes in real words have rather produced an N400-like increased negativity (Roll, 2015).

Akin to the early negativities, a late positivity or P600 has frequently been found to follow the LAN or N400 in predictive contexts (e.g. Federmeier, Wlotko, De Ochoa-Dewald, & Kutas, 2007; Hahne & Friederici, 1999; Koester et al., 2004). The P600 has been argued to show consequences of failed prediction (Federmeier et al., 2007; Kutas, DeLong, & Smith, 2011) i.e. the need of repair or update of a context model originating from the unexpected resolution of a wrongly predicted sentence continuation. The anterior-posterior distribution of the late positivity in this context varies between studies; while explanations for this variability diverge somewhat, researchers seem to agree that the frontal effect stems from the resolution of ambiguity for unexpected words in contextually constrained sentences (e.g. Kaan & Swaab, 2003; Kuperberg & Jaeger, 2016; Kuperberg, 2013; van Pretten & Luka, 2012). This effect would be evoked for instance when ending the sentence “His skin was red from spending the day at the” with the unexpected, but plausible ending “farm” rather than the contextually expected “beach” (cf. Federmeier et al., 2007). An unexpected but fully plausible ending does not as such call for repair. The frontal component thus rather signals an ambiguity resolution (Kaan & Swaab, 2003). The posterior distribution of the positivity, on the other hand, is argued to stem from an implausible/incongruent or morphosyntactically erroneous continuation. This is seen for instance in verbs or adjectives that mismatch the obligatory number agreement prediction generated by preceding noun phrases (Kaan & Swaab, 2003; Roll, Gosselke, Lindgren, & Horne, 2013), suffixes that mismatch the number prediction generated by prosodic cues (Roll, 2015; Söderström et al., 2016b) or verbs that mismatch the event structure prediction generated by thematic roles (Kaan & Swaab, 2003; Kuperberg, 2013), i.e. incongruent sentence completions (van Pretten & Luka, 2012). The ERP response in this context indicates the need for revision or repair.

1.1.2. Online predictive processing: Swedish word accents and pre-activated endings

By highlighting the connection between ERP events and related preceding conditioning contexts, the above studies have provided strong evidence for the existence of predictive strategies in language processing. However, they do not tap into the pre-activation process itself. Predictions are most often gradually built up throughout sentence processing and there is not usually a clear cut-off point at which a prediction is formed. There are, however, exceptions. The Swedish language has a prosodic system at the word-level which modulates the predictability of an immediately upcoming suffix and thus pinpoints a precise moment in speech processing where predictions can be made. This allows for the study of ongoing pre-activation. Previous research in this area has shown that native listeners, upon hearing prosodic cues on word stems, are able to pre-