Morphology aids syntax in noisy sentence processing

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Noisy-channel models of sentence processing suggest input uncertainty is maintained and subsequently resolved using prior grammatical information (Levy, 2008, 2011). Arguably, the first step in sentence processing is determining the syntactic categories of words. We explored the extent to which syntactic and morphological information are used in sentence processing to determine the syntactic categories of unknown words (pseudowords).

Experiment 1. Thirty-six native, monolingual English speakers read 60 target sentences (subject and object-extracted center embedded relative clauses) and 120 filler sentences in a non-cumulative word-by-word format. In half the sentences, a single lexical word at position 2, 3, or 4 was replaced with an orthographically and phonologically plausible pseudoverb with an *-ed* suffix (*scoaned*) or a morphologically unmarked pseudonoun (*threak*).

[1] **S**ubject **RC**: *The actor$_1$ who impressed$_2$ the critic$_3$ humiliated$_4$ the director$_5$.*

[2] **O**bject **RC**: *The actor$_1$ who the critic$_2$ impressed$_3$ humiliated$_4$ the director$_5$.*

Results. Per-word analyses were performed on residual RTs (RT - word length) using mixed-effects models with random intercepts for Subject and Item. Consistent with earlier work (Grodner & Gibson, 2005), for non-pseudoword sentences, participants were slower overall for ORCs, with the RC verb being the point of major difficulty (p<.05). Analyses comparing pseudoword vs. non-pseudoword sentences revealed that reading pseudowords did not always incur a penalty. For SRCs, only a pseudoword at position 2 caused a significant slowdown, which persisted through the end of the RC clause (p's < .05). For ORCs, pseudowords at both positions 2 and 3 caused a significant slowdown, but the slowdown did not persist (p's < .05).

The lack of a consistent pseudoword processing penalty suggests, at the very least, that determining the syntactic category of unknown words is seamless, and possibly reliant on the syntactic context. Next, we investigated whether morphological information plays a role as well.

Experiment 2. Thirty-two native, monolingual English speakers participated. The experiment was the same as in Experiment 1 with the following exceptions. First, we only substituted pseudowords at positions 2 and 3. Second, pseudowords were morphologically "congruent" with their syntactic position half the time, and "incongruent" in the other half. Congruent pseudonouns had a nominal derivational suffix (*-or, -ist, -ician*) and a plural suffix (*-s*), and congruent pseudoverbs had a verbal derivational suffix (*-ify,-ize, -ate*) and a past-tense inflectional suffix (*-ed*). Verbal and nominal suffixes were interchanged in non-congruent words.

Results. As in Experiment 1, subjects were slower overall for ORCs, with the point of major difficulty being the RC verb (p<.05). Unlike in Experiment 1, for both SRCs and ORCs, participants slowed down at both pseudoword positions (p's <.05). At the actual pseudoword positions, no significant differences were found between morphologically congruent vs. incongruent pseudowords. However, difficulty in processing incongruent morphology was observed in the form of longer RT "spillover" for morphologically incongruent pseudowords. For SRCs, slowdown persisted for two words after incongruent pseudowords, but only one word for congruent pseudowords. In addition, for pseudowords at position 2 of SRCs (the only <u>syntactically</u> ambiguous position), participants were significantly slower at the following word when the pseudoword was morphologically incongruent than when it was congruent (p<.05).
For ORCs, the slowdown only persisted through the following word for incongruent pseudowords (p's<.05), and did not persist at all for congruent pseudowords.

Conclusion. Consistent with noisy channel models, our findings indicate an important role of syntactic context in determining syntactic categories of unknown words. Crucially, when syntactic information is inadequate (e.g., position 2 in [1]), morphological information seems to guide sentence processing. Overall, our findings highlight the robustness of sentence processing and the interplay of morphological and syntactic information in guiding it.