Syntactic complexity governs temporal processing of phonological structure

John R. Starr, Marten van Schijndel, Helena Aparicio, Draga Zec (Cornell University)

Previous psycholinguistic research on incremental processing primarily focuses on syntax and semantics [1, 2, 3], with some reporting phonological effects in *syntactically-identical* contexts [4, 5]. This study examines how incremental processing of *different* syntactic structures affects phonological processing. We find a trade-off between syntactic and phonological processing: simpler syntactic structures are processed before phonological distinctions surface, while complex syntactic structures are processed after phonological distinctions surface.

Method. Participants (N=40) completed a self-paced reading task where they read 27 English sentences with TARGETS (REAL WORDS, PHONOLOGICALLY VIABLE NONCE WORDS, PHONOLOGICALLY UNVIABLE NONCE WORDS) in certain STRUCTURES (MATRIX SUBJECT, EMBEDDED SUBJECT, CENTER-EMBEDDED SUBJECT) (Table 1). The TARGETS distinguish levels of phonological viability (REAL > VIABLE > UNVIABLE); the STRUCTURES reflect increasingly difficult syntax (MATRIX < EMBEDDED < CENTER) [3]. All TARGETS were the 4th word of the sentence; words 5 and 6 were identical across all conditions. We collect the reading times (RTs) for each word.

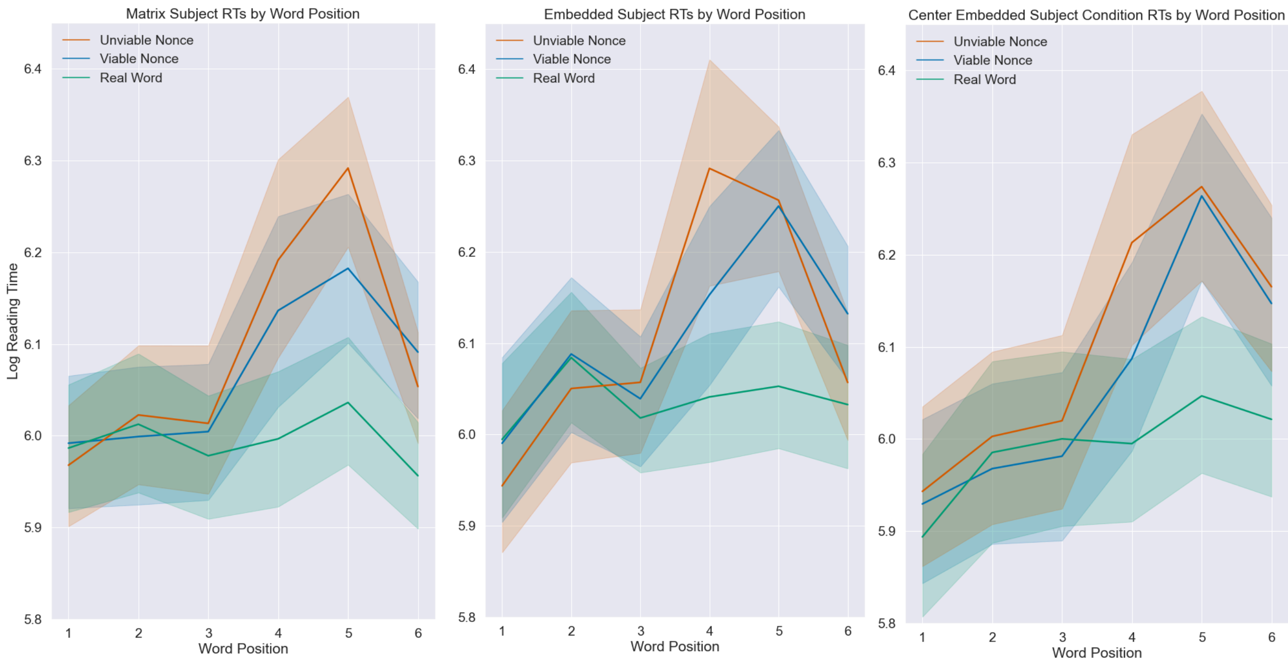
Results. Target Position. To compare the effects of phonological information on each syntactic structure, we subset our results into three partitions corresponding to each STRUCTURE condition (Fig 1a-c). For each partition, we fit a linear mixed-effects regression model to the log RTs of the target word of the experimental task (position 4), with TARGET factors as a fixed effect (baseline: VIABLE), and random intercepts for participants and items. In the EMBEDDED and CENTER partitions, we find the VIABLE RTs are significantly faster than the RTs for the UNVIABLE condition (β=0.14, $p<0.05$ (EMBEDDED); β=0.15, $p<0.05$ (CENTER)). In the MATRIX partition, we find no significant difference between the UNVIABLE and VIABLE conditions. All partitions show the VIABLE condition is significantly slower than the REAL condition. <u>Our results suggest that phonological distinctions surface in the TARGET position when processing embedded STRUCTURES, but such distinctions do not appear when processing non-embedded STRUCTURES.</u>

Post-target Position. Previous work has shown that spillover syntactic processing also occurs after the initial presentation of the target stimulus [3,4]; as such, we also analyze RTs at position 5, the verb immediately following the TARGET (Fig 1a-c). We fit an identically-structured linear mixed-effects regression model to each partition at position 5. We find the EMBEDDED and CENTER partitions pattern with one another again, but the pattern is different than at position 4: VIABLE RTs are not significantly different from the RTs for the UNVIABLE condition in both partitions. In the MATRIX partition, VIABLE RTs are significantly faster than UNVIABLE RTs (β=0.11, $p<0.01$). All partitions again show that the VIABLE condition is significantly slower than the REAL condition. In sum, we note that the effects of STRUCTURE on TARGETS in position 5 pattern oppositely to those found in position 4: <u>in the position following the TARGET, phonological distinctions surface when processing non-embedded STRUCTURES, but these distinctions do not surface when processing embedded STRUCTURES.</u>

Discussion. We find that the temporal processing of phonological distinctions varies according to syntactic structure, as demonstrated by differences in how phonological effects surface between non-embedded (Fig 2a) and embedded (Fig 2b,c) clauses. This trade-off supports a model of processing that is governed by syntactic complexity: more difficult syntactic structures are processed later and display early effects of phonology, whereas simpler syntactic structures are processed immediately and show late effects of phonology.

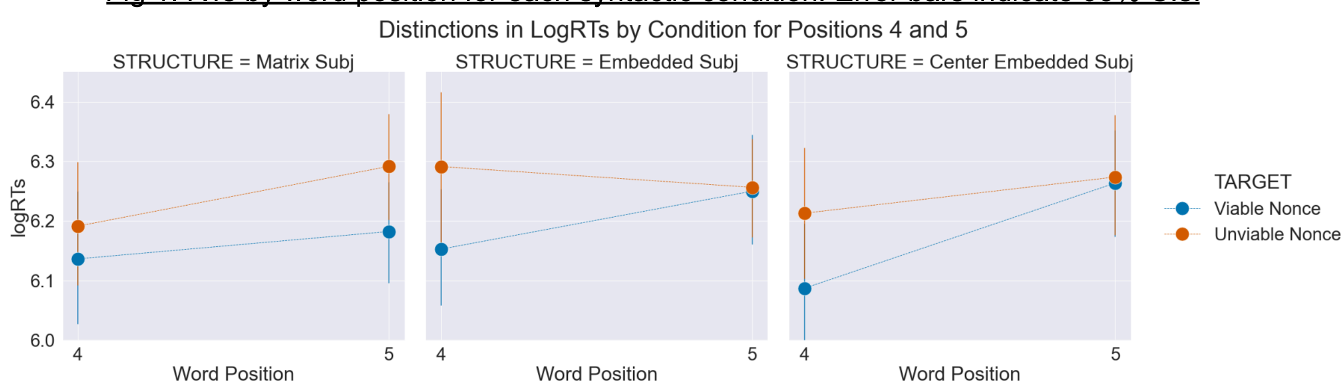
	Matrix Subject	Embedded Subject	Center-embedded Subject
Real Word	Last$_1$ night$_2$ the$_3$ brick$_4$ smashed$_5$ through$_6$ …	I$_1$ hoped$_2$ the$_3$ brick$_4$ smashed$_5$ through$_6$ …	The$_1$ window$_2$ the$_3$ brick$_4$ smashed$_5$ through$_6$ …
Viable Nonce	Last$_1$ night$_2$ the$_3$ blick$_4$ smashed$_5$ through$_6$ …	I$_1$ hoped$_2$ the$_3$ blick$_4$ smashed$_5$ through$_6$ …	The$_1$ window$_2$ the$_3$ blick$_4$ smashed$_5$ through$_6$ …
Unviable Nonce	Last$_1$ night$_2$ the$_3$ bnick$_4$ smashed$_5$ through$_6$ …	I$_1$ hoped$_2$ the$_3$ bnick$_4$ smashed$_5$ through$_6$ …	The$_1$ window$_2$ the$_3$ bnick$_4$ smashed$_5$ through$_6$ …

Table 1: Experimental Conditions. Numbers indicate word position.



(a) (b) (c)

Fig 1. RTs by word position for each syntactic condition. Error bars indicate 95% CIs.



(a) (b) (c)

Fig 2. RT distinctions between positions 4 and 5 by condition. Error bars indicate 95% CIs.

References [1] Ferreira & Henderson (1990). *Journal of Experimental Psychology.* [2] Dember & Keller (2008). *Cognition*. [3] van Gompel & Pickering (2007). *The Oxford Handbook of Psycholinguistics*. [4] Rayner et al. (1992). *Cognition.* [5] Plummer & Rayner (2012). *Attention, Perception, and Psychophysics*