

A slow time constant in the neurophysiology of language processing

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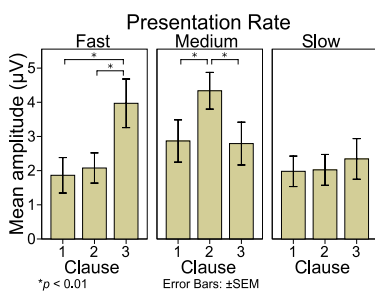
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Introduction

- The phonological trace of perceived words starts fading away in short-term memory after 2–3 s (Baddeley, et al., 1975).
- Spoken utterances are usually 2–3 s long (Horne et al., 2006; Vollrath et al. 1992). This allows the listener to form coherent prosodic phrases while the words still have clear traces in short-term memory.
- We tested whether readers also process texts in 2–3 s long prosodic phrases (Roll et al., in press).

Pretest

- Three Swedish speakers read 30 of the test sentences using phrases containing either one, two, or three clauses (see example in Material section). The speakers spontaneously increased their speech rate for the three-clause prosodic phrases, keeping them at a mean of 2.7 s.



Figures

Left: Average potentials 500–700 ms after final words in clauses 1–3 at a centroparietal RoI.
Right: Test sentence example (A) and brain potentials at electrode PZ in proportion to presentation rates (B). Potentials for clause-final words in test sentences and for average pre-final words in control sentences (C). Average potentials for clause-final words in 2.7 s and 3.4 s long clauses at slow rate for the two working memory span groups (D).

Method

Material

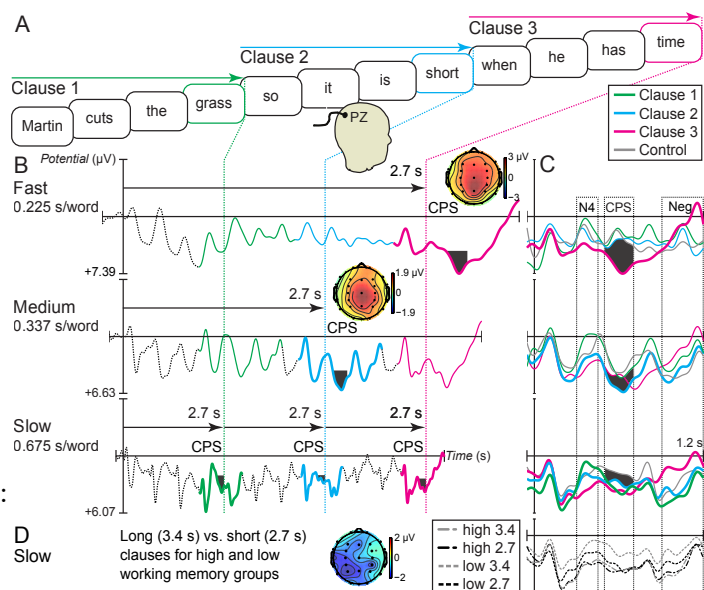
- Sentences consisting of 4-word clauses were presented word by word at three different speeds:
Fast [Clause] [Clause] [Clause] ||_{2.7 s}
Medium [Clause] [Clause] ||_{2.7 s} [Clause]
Slow [Clause] ||_{2.7 s} [Clause] ||_{2.7 s} [Clause] ||_{2.7 s}
- Control sentences with 5-word clauses, i.e. 4th word appearing at 2.7 s was penultimate, e.g.:
Slow [Clause] ||_{3.4 s} [Clause] ||_{3.4 s} [Clause] ||_{3.4 s}
- 40 sentences presented randomly at all speeds
- 32-channel EEG was recorded using Synamps 2.

Participants

- 26 participants, mean age 24.5 years, 18 women
- 2 working memory span groups: Low, $M = 23.4$, $SD = 8.0$, and high, $M = 53.8$, $SD = 10.0$, based on automated operation span results.

Results

- Positivity 500–700 ms after every clause ending a 2.7-s unit (Closure Positive Shift, CPS):
Fast Final word in clause 3 > clause 1 and 2
Medium Final word in clause 2 > clause 1 and 3
Slow Final word in clause 1, 2, 3 > control
- Low working memory span group had increased negativity in 3.4-s clauses (slow control).
- N400 reduction over sentence and sentence-final negativity were invariable for all speeds.



Discussion

Results showed a late centroparietal positivity every 2.7 s during reading where a prosodic boundary was possible. The positivity was interpreted as a Closure Positive Shift (CPS) (Steinhauer et al., 1999), showing that the silent readers made 2.7 s long prosodic phrases. Participants with low working memory span showed signs of increased phonological working memory load in clauses that were “too long” (3.4 s).

References

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