Using eye movements for analyzing the influence of linguistic complexity, noise, and hearing loss on sentence processing time

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Using eye movements for analyzing the influence of linguistic complexity, noise, and hearing loss on sentence processing time (A3.2)

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Introduction

High linguistic complexity can reduce speech intelligibility and can increase cognitive effort. A method for detecting the latter was presented by Wendt et al. (2014) using an eye-tracking (ET) paradigm measuring increased processing time for complex sentences. This study evaluates this method and compares the ET method to electrooculography (EOG). The processing time of sentences with different linguistic complexity was measured in quiet and in modulated noise using ET and EOG simultaneously. Eleven participants with hearing impairment and five participants with normal hearing participated in the study. Processing times measured using ET and using EOG showed a correlation of 94%. Furthermore, our results confirm the findings of Wendt and colleagues, that more complex sentences show increased processing time. This study evaluated that sentence processing time can be analyzed equally well using ET and EOG. The method reveals characteristic consequences of linguistic complexity and noise on sentence processing time which can be used as an indicator of the cognitive effort during sentence comprehension.

Audio-visual Paradigm

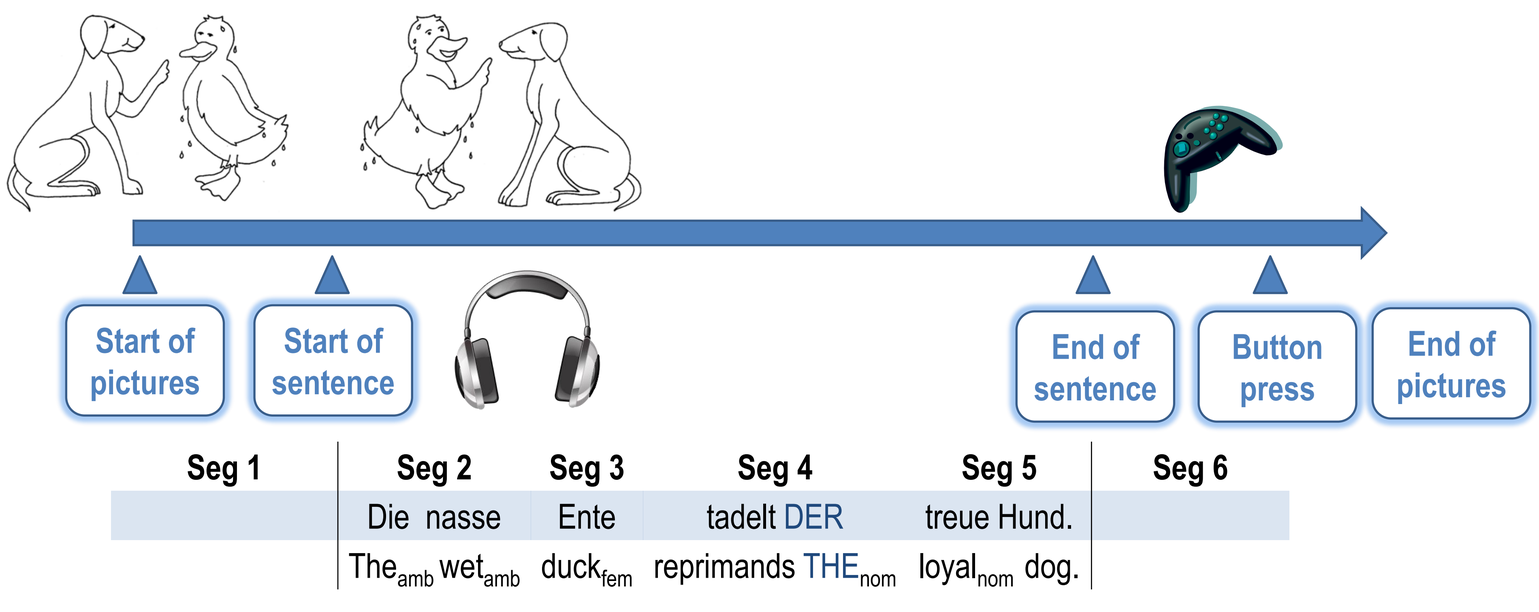

Figure 1: *Schematic illustration of the audio-visual paradigm.*

Task: Find the picture that matched the acoustic stimulus (target – here the left picture) by pressing a button as soon as possible after the acoustic presentation.

EOG and ET:
Simultaneous recording of eye-fixations with eye-tracking (ET) and electrooculography (EOG)

11 hearing-impaired (HI) and 5 normal-hearing (NH) participants

OLACS sentence corpus [2]:
SVO: "DER kleine Junge grüßt den lieben Vater."
"THE$_{nom}$ little$_{nom}$ boy greets the$_{acc}$ nice$_{acc}$ father."

OVS: "DEN lieben Vater grüßt der kleine Junge."
"THE$_{acc}$ nice$_{acc}$ father greets the$_{nom}$ little$_{nom}$ boy."

ambOVS: see table in Figure 1.

Results

The recorded data were transformed into a *single Target Detection Amplitude* (s*TDA*) which quantifies the fixations of the participants towards the visual stimuli as a function of time.

Important definitions:
- Decision moment (DM) – Point in time when sTDA first exceeds a relative threshold of 42 % of the maximum of the individual sTDA.
- Point of target disambiguation (PTD) – Point in time at which the participant could identify the target picture.
- Measure for processing speed – Disambiguation to decision delay (DDD). Time between DM and PTD.

Cross correlations between sTDAs calculated from EOG and ET data**: r = 0.97**
Correlations between DDDs calculated from EOG and ET data**: r = 0.94**
no significant differences between DDDs calculated from EOG and ET data

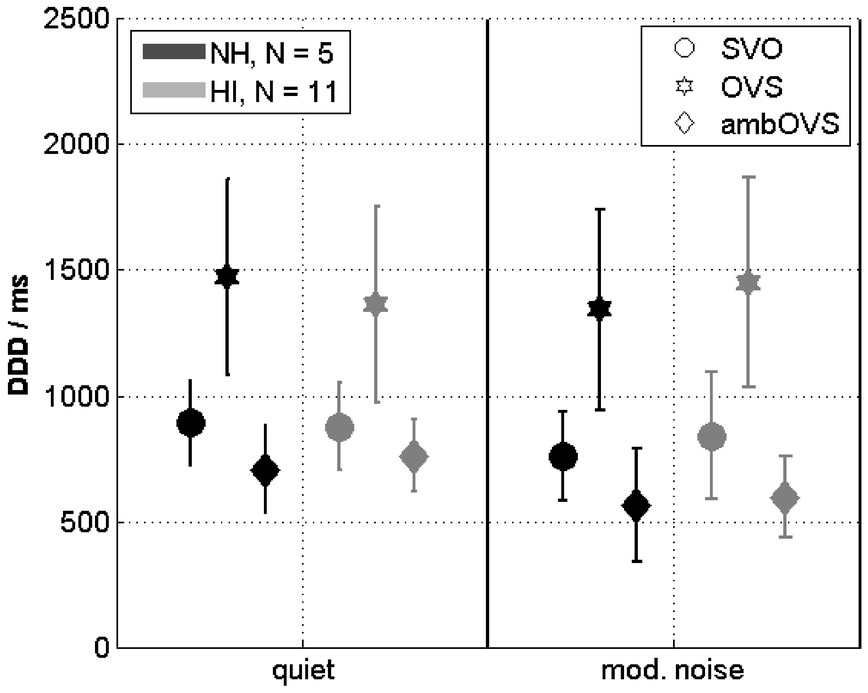

Figure 2: *Mean DDDs with standard errors for normal-hearing and hearing-impaired participants in quiet and in modulated noise recorded with EOG.*

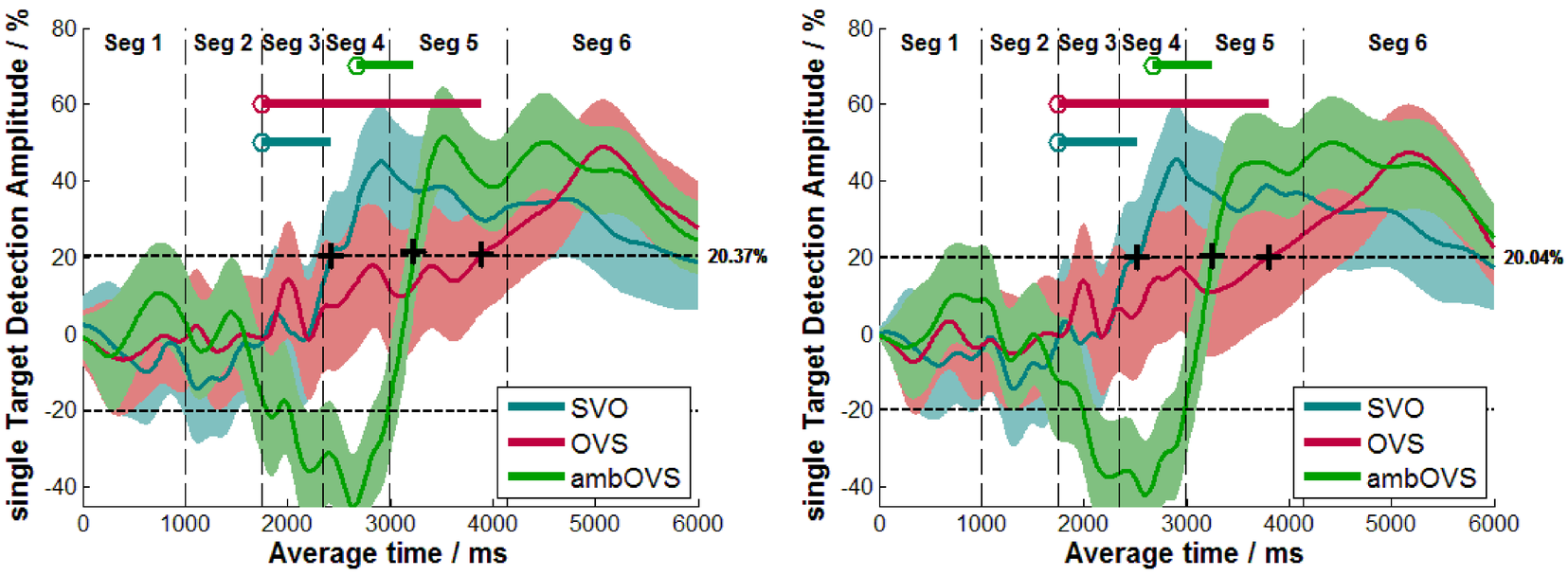

Figure 3 : *Single Target Detection Amplitude (sTDA) for the three sentences types of OLACS. The shaded areas illustrate the 95% confidence intervals. The plus signs in the graphs denote the decision moment (DM). The disambiguation to decision delay (DDD, lines above the sTDA) between DM and PTD were calculated.*

Conclusion

- The EOG recording method for eye fixations was successfully evaluated as an alternative to the ET recording method used in the paradigm proposed by Wendt et al. (2014).
- Our collective of listeners did not show differences in DDD between quiet and modulated noise and between NH and HI.
- The audio-visual paradigm developed and evaluated by Wendt and colleagues enables the investigation of processing time during sentence comprehension.

References

[1] Wendt, D., Brand, T., & Kollmeier, B. (2014). An Eye-Tracking Paradigm for Analyzing the Processing Time of Sentences with Different Linguistic Complexities. *PloS One*, *9*(6), 1–13.

[2] Verena N. Uslar, Rebecca Carroll, Mirko Hanke, Cornelia Hamann, Esther Ruigendijk, Thomas Brand, and Birger Kollmeier (2013). Development and evaluation of a linguistically and audiologically controlled sentence intelligibility test. J. Acoust. Soc. Am., 134, 4, 3039-3056.

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