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Pediatric Listening Effort Pilot: Gaze vs Dilation

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Introduction

Listening effort (LE) is a critical element of communication and quality of life. An objective way to measure LE is through pupil dilation, or pupillometry, via an eye tracker. As cognitive demands increase, the nervous system responds by increasing pupil dilation. In the case of a listening task, pupil dilation changes can be used to infer LE (Zekveld, et al., 2010). While many studies test this methodology in adults, few studies have been done in children. This may be due to the increased activity/movement of children, as accurate pupil dilation measures are dependent on limited subject movement. Another eye tracking measure used to quantify cognitive effort is gaze duration (Pavlovic & Jensen, 2006; Meghanathan, van Leeuwen, & Nikolaev, 2015). Gaze duration relies less on limited subject movement and may provide a more efficient method for measuring LE in children. Another study consideration is the participant's subjective perception of LE. Some studies report correlations between objective and subjective measures of LE, although other investigations failed to find a relationship (Picou et al., 2011). It is hypothesized that gaze duration will be more effective than pupil dilation for measuring LE when keeping the head restrained is a challenge, and that subjective effort will positively correlate with duration of fixation as well as negatively correlate with accuracy (i.e., harder conditions will increase gaze duration and subjective ratings of effort but decrease accuracy).

Objectives

The objective of this study was to evaluate the relationships amongst two objective, pupillometry and gaze duration, and two subjective, NASA Task Load Index and Visual Analog Scale of Fatigue Severity, measures of listening effort. We hypothesized that gaze duration and pupil dilation would increase with greater listening effort and that the subjective measures would positively correlate with the objective measures. If the results indicate that gaze duration is an accurate way to measure listening effort in adults, this study will be replicated with adolescents.

Materials

- Az Bios sentence lists one through three from the Minimum Speech Test Battery were combined with three SNRs (3, +9, and +15) for each list. Sentences were set at 50 dBA and the babble was adjusted accordingly
- A RedCap survey was created to combine the NASA Task Load Index and the Visual Analog Scale of Fatigue Severity.

Methods

Participants were required to complete a vision and hearing screening. They must have hearing thresholds 25 dB HL or better from 250-8000 Hz and vision corrected or uncorrected to 20/20 to participate in the study. They must be English speaking and not have a diagnosis of ADHD. The participants filled out a survey about to determine caffeine intake and sleep patterns.

The experiment began with the participant sitting in the audiometric booth with the eye tracker and lighting levels of 30 lux. A target sticker was placed on their forehead for calibration, and their eye movements and pupil size were tracked at a sampling rate of 500 Hz. For all three conditions, AzBio list and SNR were randomly assigned to each participant. They were instructed to gaze at a target, listen to the sentence, and repeat it back after the noise ended. This was done for 20 sentences. After each list, the participant would complete the subjective RedCap survey.

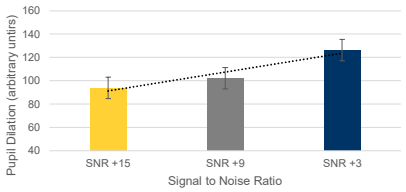
Data Analysis

- The number of gaze fixations and their durations were taken from an area of interest that began at the sentence onset and ended at its offset.
- The average number of fixations and gaze durations were calculated for each SNR.
- Pupil dilation was recorded during the first five seconds of each sentence, which ensured that only speech processing-related changes (and not motor planning or behavioral response artifacts) were included in the analysis.
- Pupil data was downsampled to 50 Hz then common artifact rejection and data smoothing techniques were applied (Winn et al., 2018).
- The peak dilation was recorded for each sentence and averaged for each condition for each participant.
- The RedCap survey collected responses for both subjective measures.

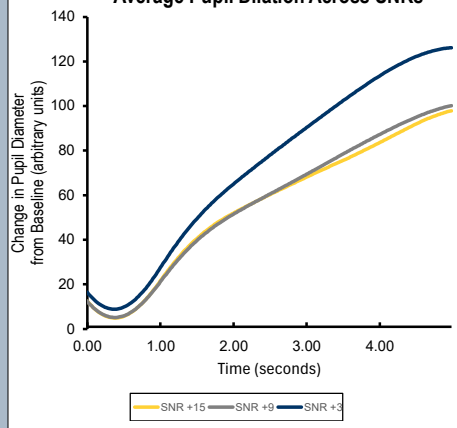
Results

Overall, the results revealed that pupil dilation was a more sensitive measure to listening effort than gaze duration in the given tasks. An order effect was seen for peak pupil dilation and subjective ratings.

Peak Pupil Dilation

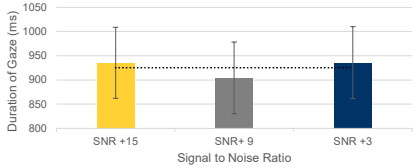


Average Pupil Dilation Across SNRs



There was a significant difference between the +3 and +15 SNRs (p= <0.001) and between the +3 and +9 SNRs (p= <0.001.) There was no significant difference between the +15 and +9 SNRs (p= 0.21). There was no significant effect of gaze duration across any of the SNRs (p =0.663)

Gaze Duration

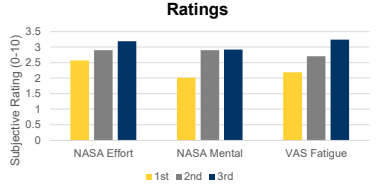


While there was no significant difference observed for subjective ratings across the differing SNRs, there was an order effect. NASA Mental showed a significant difference between 1st and 3rd (p= 0.016) and 1st and 2nd (p= 0.016). NASA Effort showed a significant difference between 1st and 3rd (p= 0.025). NASA Performance showed no significant difference between the presentations. VAS Fatigue showed a significant difference between 1st and 2nd (p= 0.026) 1st and 3rd (p= <0.001) and 2nd and 3rd (p= 0.020)

Subjective Ratings

Rating Scale	Presentation Order	Mean	Std. Error
NASA Mental	1	2.015	0.379
	2	2.900	0.377
	3	2.918	0.379
NASA Effort	1	2.571	0.410
	2	2.900	0.405
	3	3.188	0.409
VAS Fatigue	1	2.192	0.376
	2	2.707	0.376
	3	3.326	0.376

Presentation Order and Subjective Ratings



Peak Pupil Dilation

Presentation Order	Mean	Std. Error
1	116.098	9.246
2	104.874	9.203
3	101.562	9.211

Conclusions

The results revealed that pupil dilation was sensitive to changes in listening effort, but our implementation of gaze duration was not. The SNRs also exhibited less significant differences than anticipated, perhaps due to a ceiling effect, at +9 and +15 dB SNR.

There were also order effects observed that were not anticipated. This likely shows that the participants began to experience fatigue simply from doing the task for a sustained period, rather than the task itself.

Further Research

In the future, we anticipate including more challenging conditions, thus allowing for increased listening effort and elimination of the ceiling effect. We also plan to modify the gaze duration task by implementing a visual word paradigm in which a word is presented, and the participant gazes at the picture that visually represents the target word.

References

Meghanathan, R. N., van Leeuwen, C., & Nikolaev, A. R. (2015). Fixation duration surpasses pupil size as a measure of memory load in free viewing. Frontiers in Human Neuroscience, 8, p 1-9. DOI: 10.3389/fnhum.2014.01063

Pavlovic, N., & Jensen, K. T. (2009). Eye tracking translation directionality [Scholarly project]. In Translation Research Projects. Retrieved from http://isg.urv.es/publicity/isg/publications/trp_2_2009/index.htm

Picou, E. M., Ricketts, T. A., & Hornsby, B. W. Y. (2011). Visual cues and listening effort: Individual variability. Journal of Speech,Language, and Hearing Research, 54, 1416-1430.

Winn, M. B., Wendt, D., Koelewijn, T., & Kuchinsky, S. E. (2018). Best Practices and Advice for Using Pupillometry to Measure Listening Effort: An Introduction for Those Who Want to Get Started. *Trends in Hearing*, 22, 2331216518800869. https://doi.org/10.1177/2331216518800869

Zekveld, A. A., Kramer, S. E., & Festen, J. M. (2010). Pupil response as an indication of effortful listening: The influence of sentence intelligibility. Ear & Hearing, 31(4), 480-490.