Poster 97

Pupil dilation, as a continuous measure of listening effort, during sustained attention to competing talkers

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Intro

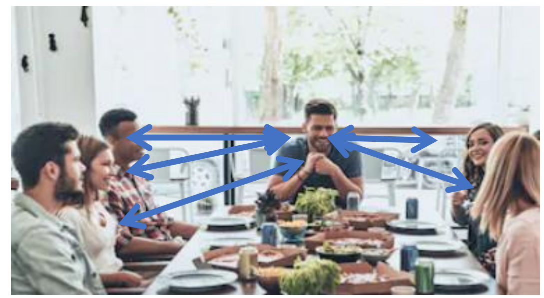
Communicating in realistic listening environments often requires people to continuously attend to different talkers. When acoustic demands increase (crowded bar), listeners must exhibit greater effort to track the different talkers *(Zekveld et al. 2018)*. Listening effort may furthermore be exacerbated in persons that experience declines in auditory and cognitive function, such as older adults *(Zekveld et al. 2011).*

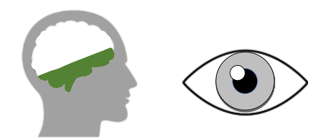
Research aims and hypothesis

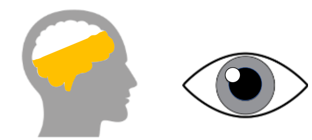
We aim to measure the pupil dilation, which has been used as a physiological measure of effort *(Winn et al. 2018),* to quantify listening effort during naturalistic speech processing in varying signal-to-noise ratios (SNR).

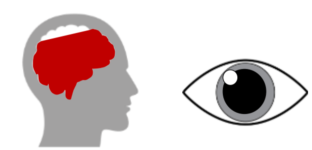
- Pupil size ↓ when listening repeatedly to the same speech stimulus
- Pupil size ↑ when task difficulty ↑
- Pupil size ↑ for older versus younger people

People communicating in noisy environments









Methods

Research design

<u>Participants</u>

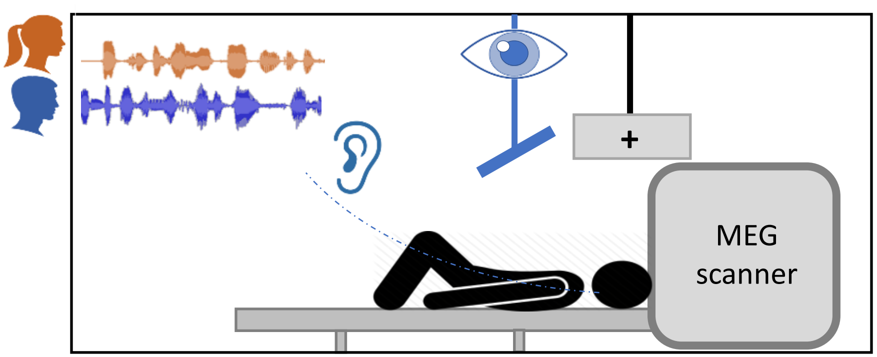
- 19 younger adults (17-26 years)
- 16 older adults (65-78 years)
- Both groups have normal hearing
  (125-4000 Hz thresholds ≤ 25 dB HL)

<u>Task:</u>

- Repeated listening of 60-s audiobook segments (trials)
- Attend to male/female speaker (ignore the other one)
- Clean speech (1 trial)
- Mixed speech (3 trials, at each of two SNRs)
  (male vs female speaker: 0 dB, -6 dB)
- Randomized block design across participants

<u>Set-up:</u>

Pupillometry (EyeLink; 1000 Hz sampling) and MEG
(visit poster 71 of I.M Dushyanthi Karunathilake for MEG results)

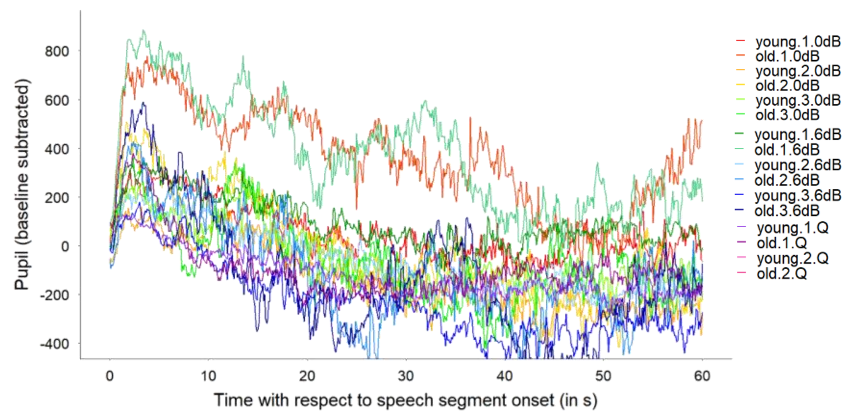


Analysis

<u>Preprocessing</u>

- Removal of eyeblinks, downsample to 10 Hz
- Remove trials if
  - > 60% of baseline data missing
  - > 45% of task data is missing
- Baseline subtraction (median of 1 s before onset)

Raw pupil dilation curves for all conditions across time



<u>General additive mixed models (GAMMs)</u>

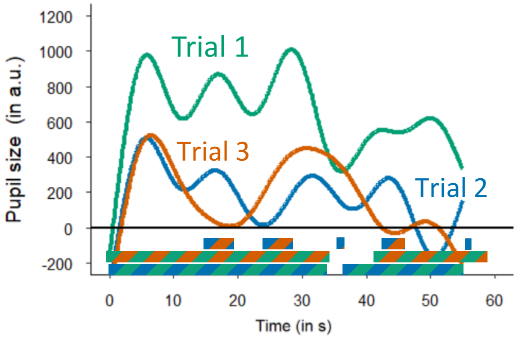
Several advantages over linear mixed-effect models *(Soskuthy, 2017; van Rij et al., 2019; Wieling, 2018)*:

- model non-linear patterns without predefining the number of polynomials
- when adding an AR1 model, you can correct for the autocorrelation in the data

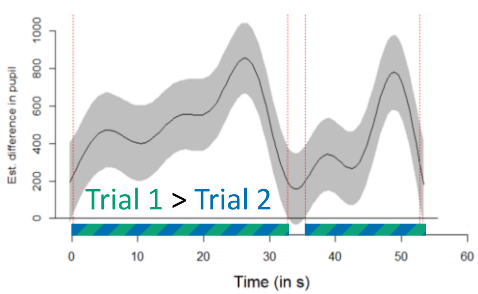
Results: Hypothesis 1: **Repeated listening** (trial effect): pupil size ↓

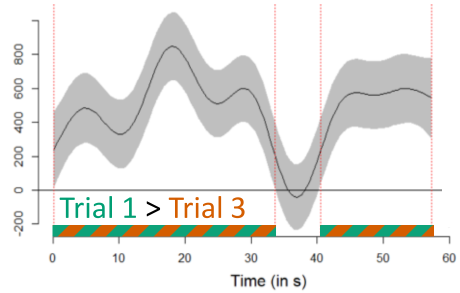
Pupil dilation for **younger** adults across time (-6 dB)

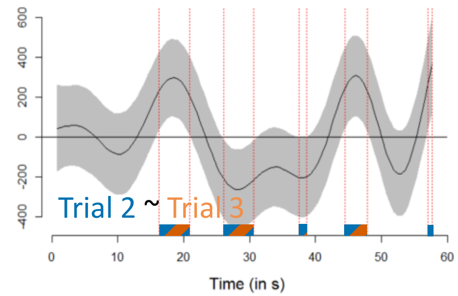
GAMMs curves



Difference curves

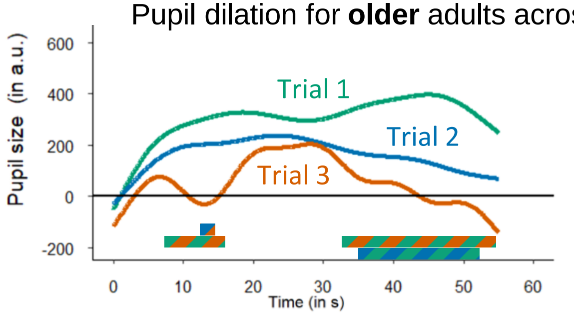




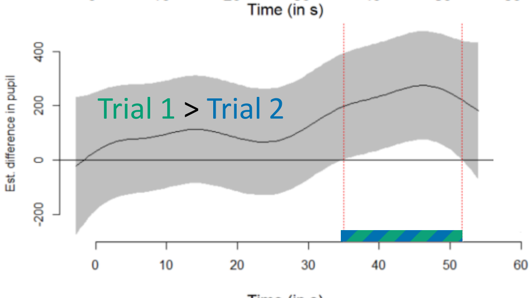


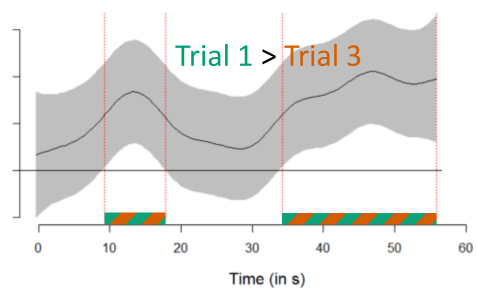
Pupil dilation for **older** adults across time (-6 dB; trial effect is diminished for older adults)

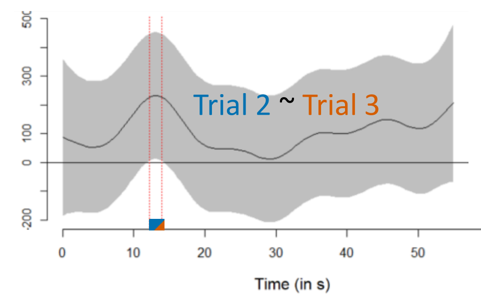
GAMMs curves



Difference curves



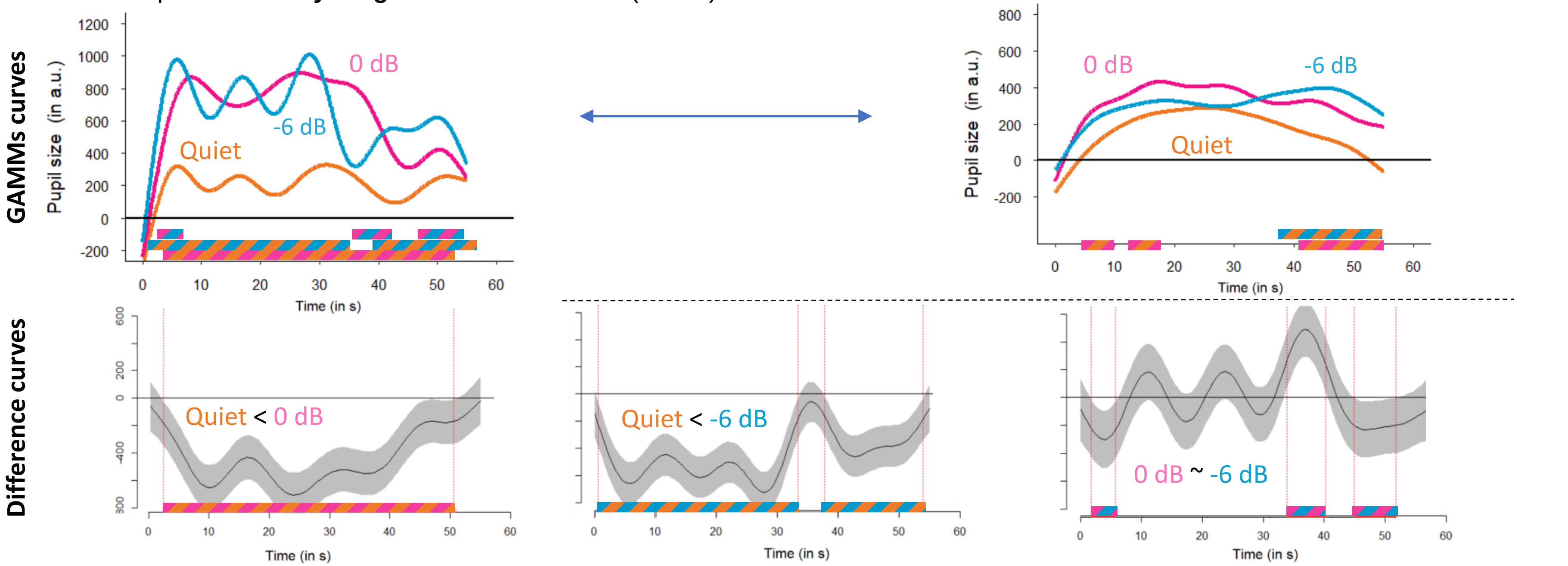




Results: Hypothesis 2: **Task difficulty**: pupil size ↑

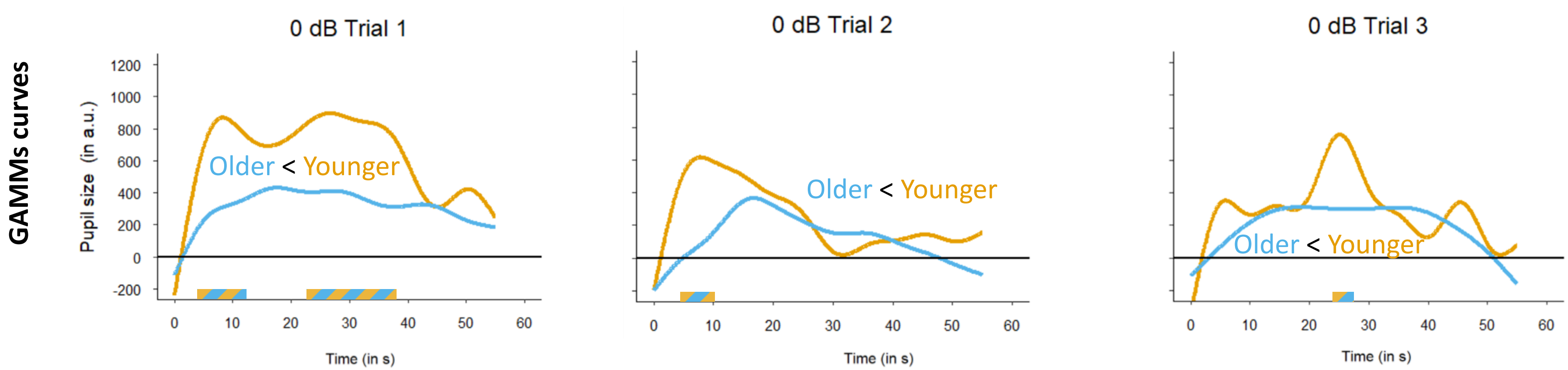
Pupil dilation for **younger** adults across time (Trial 1)

Pupil dilation for **older** adults across time (Trial 1; task difficulty effect is diminished for older adults)



Results: Hypothesis 3: Pupil size ↑ for **older vs younger** adults (more effort)

Pupil dilation for **older vs younger** adults (age effect diminishes with advancing trial)

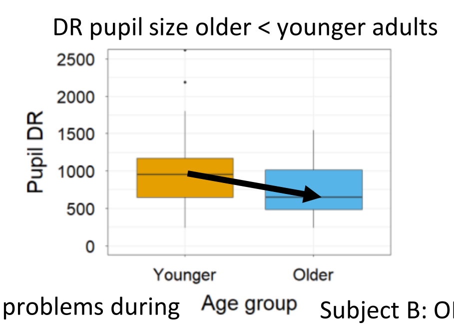


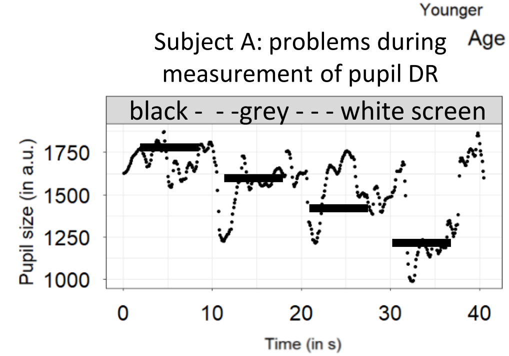
Summary

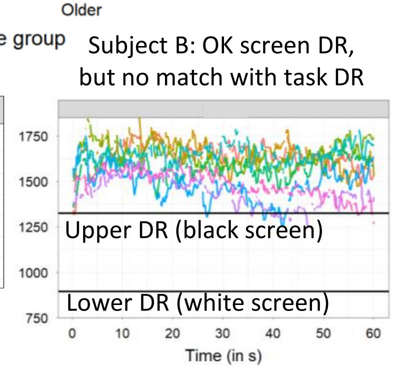
- Measuring pupil size during long-duration speech segments is feasible in younger and older normal-hearing adults
- Pupil initially increases, then decreases over a long-duration time course (~ pupil response for short sentences)
- Pupil results demonstrate that:
  - ○ repeated listening leads to reduced effort or giving up? (trial 1 > 2 and 3)
    (will investigate this using simultaneously collected behavioral speech-in-noise and MEG data)
  - ○ task difficulty leads to increased effort (0 and -6 dB > quiet)
  - ○ no consistent effects of age (older < younger: opposite to effort hypothesis*)
- Long time course (60s) pupil size is best analyzed using general additive mixed models (GAMMs):
  - can model non-linear patterns
  - can correct for autocorrelation in data
  - allow a study of the significant time windows

Outstanding questions*

- *Listening effort hypothesis:* Effort older > younger adults during speech processing, thus pupil size older > younger adults?
- Current *results* show the *opposite (older < younger).* This can be due to not taking the age-related changes in the dynamic range of the pupil response into account (*Piquado et al. 2010*).
- We used a *black-to-white screen* to measure a person's pupil dynamic range (DR), but observed two problems:
  - non-reliable screen DR measurement (subj A)
  - mismatch between screen DR and task DR (subj B)
- *Solution*? Find a better way to disentangle age-related pupil deterioration versus effort-related pupil increase for older adults.







Thank you for your interest in our poster!

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