

Listening effort over time depends on attention mobilization in anticipation of difficult listening

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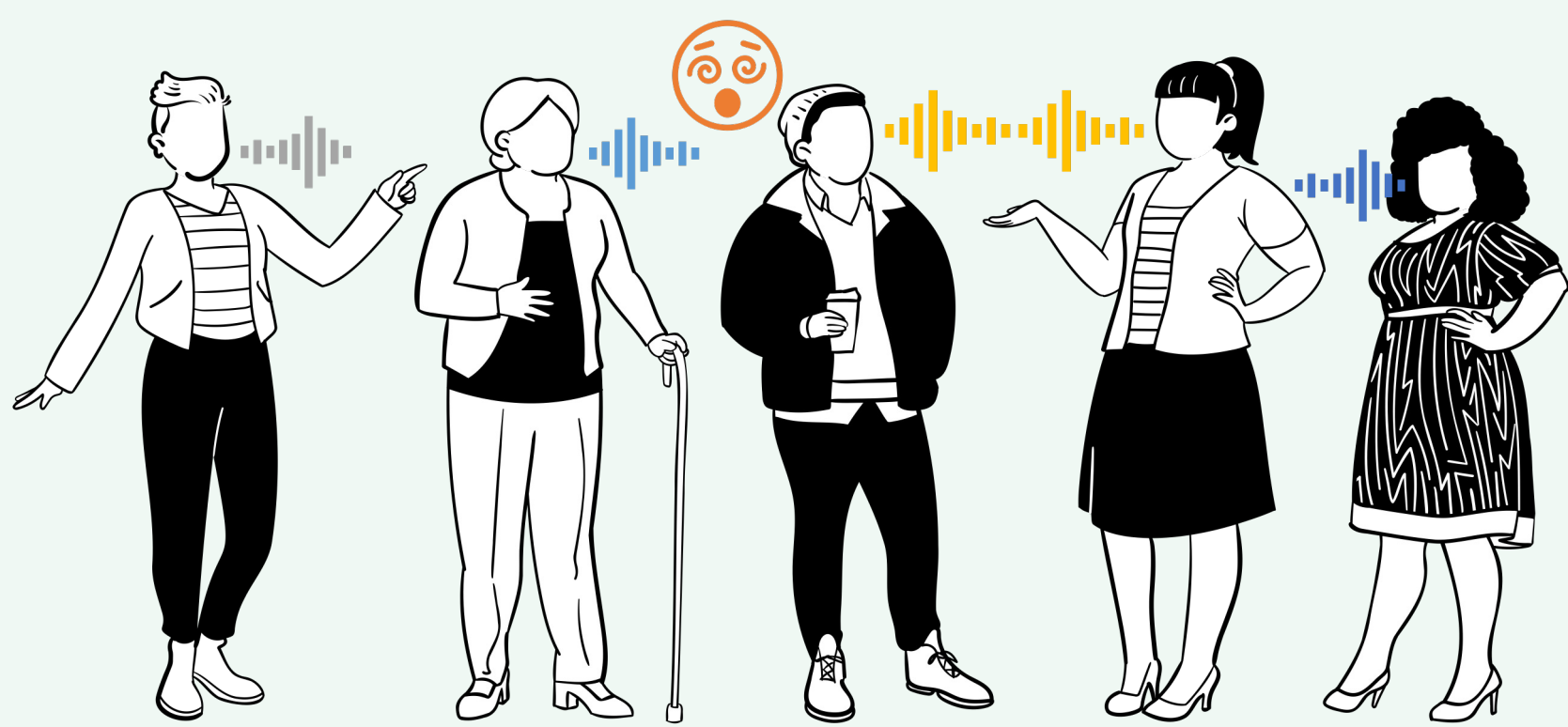
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Background

Understanding speech is **difficult**, especially in noisy contexts or environments.
Alain et al., 2018, Killion et al., 2004, Zekveld et al., 2010

Sustained listening compounds this difficulty.
McGarrigle et al., 2017

Listeners have **limited cognitive resources** to handle difficult listening situations.
Pichora-Fuller et al., 2016.



Listeners use **top-down mechanisms** to **proactively mobilize and allocate attention** based on what they know is coming next.

In anticipation of more optimal listening conditions, listeners may not mobilize (or prepare) their attention as greatly. As such, the amount of attention they allocate (or deploy) will likewise not be as great.

But, if listeners anticipate more difficult listening situations, they may need to both mobilize and allocate extra attention or—if overwhelmed—may ultimately under-allocate their attention.

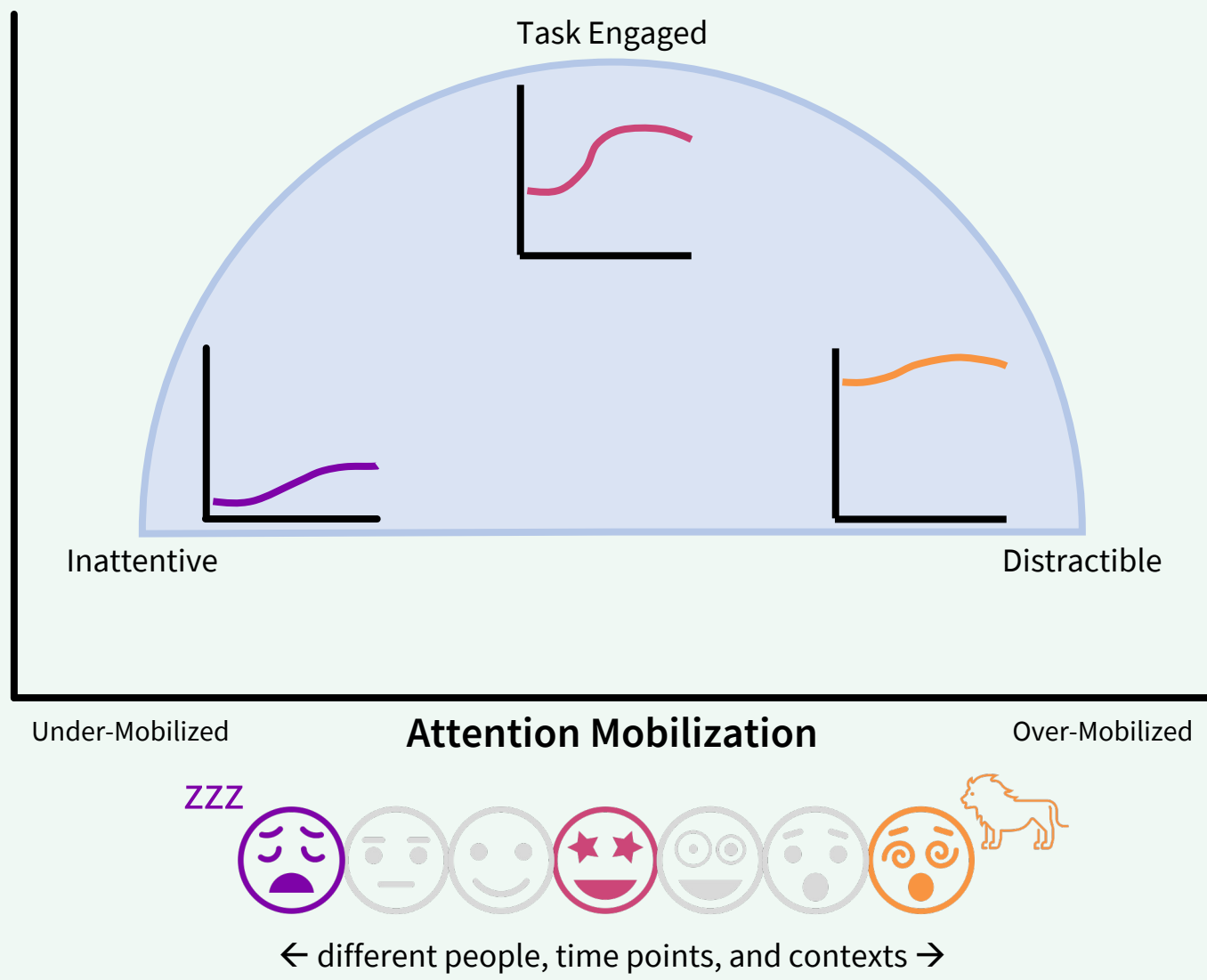
Attention Mobilization

- How an individual prepares their attention in anticipation of an upcoming task or stimulus.
Seropian et al., 2022
- Indexed by baseline pupil size (BPS).

Effort Allocation

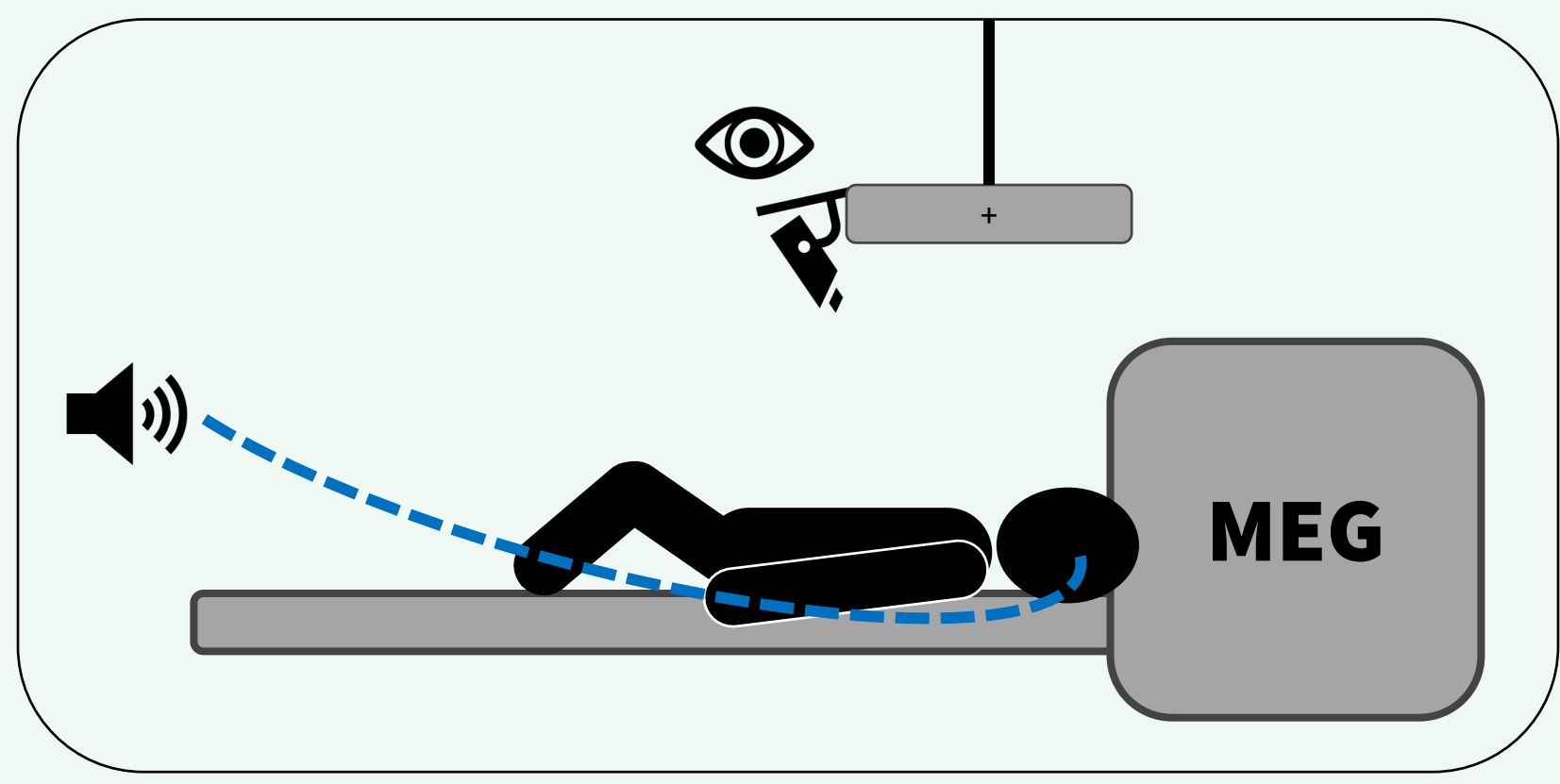
- How an individual deploys cognitive resources during the task or stimulus.
Pichora-Fuller et al., 2016
- Indexed by the task-evoked pupil response (TEPR).

Attention mobilization and effort allocation are not independent of one another and follow an “inverse U” relationship.
Aston-Jones & Cohen, 2005

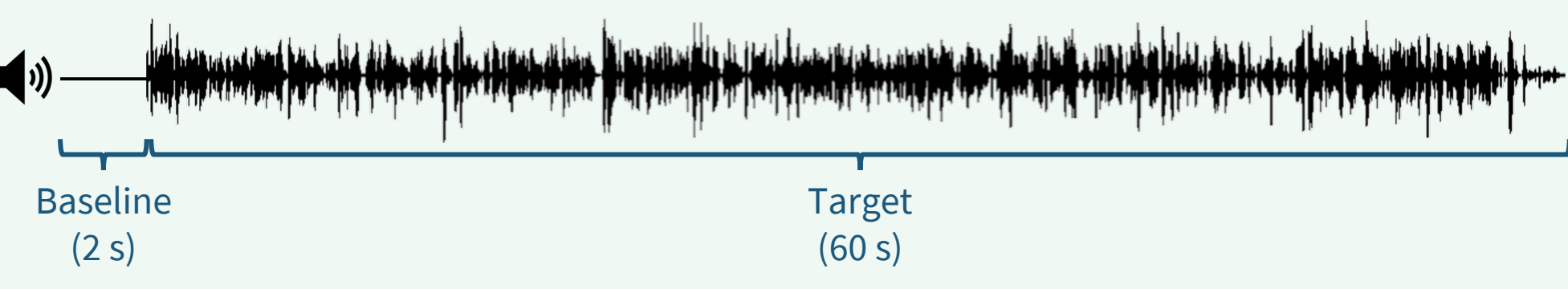


How does anticipated difficulty affect listening effort during a sustained listening task?

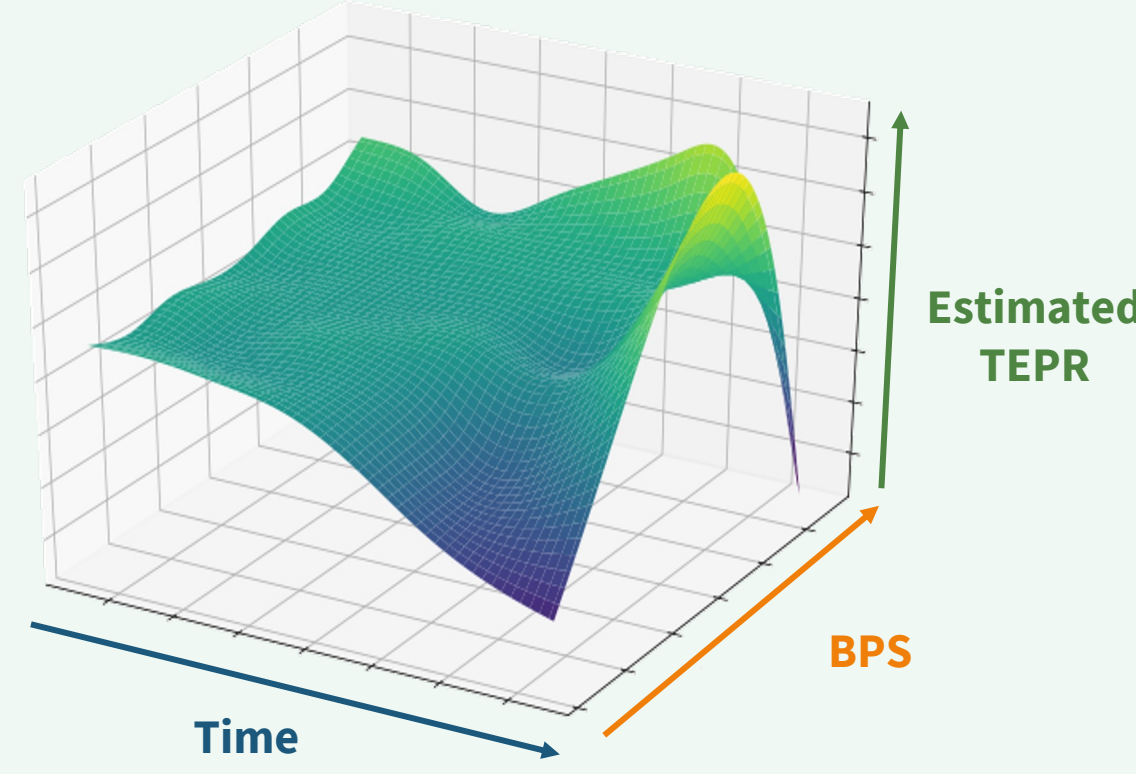
Methodology



19 young adults ($M_{\text{age}} = 21.1$ y) with normal hearing
Listened to 60-s long audiobook passages (*The Legend of Sleepy Hollow*)
0 dB SNR: two competing talkers presented at the same loudness
-6 dB SNR: target talker presented 6 dB softer than competing talker
Each passage was presented three times in a row
Magnetoencephalography (MEG) and eye-tracking data were recorded
See Karunathilake et al., 2023 for an analysis of the MEG data.



Generalized additive mixed models estimated the **task-evoked pupil response (TEPR)** as a non-linear function of **time** and **baseline pupil size (BPS)**.

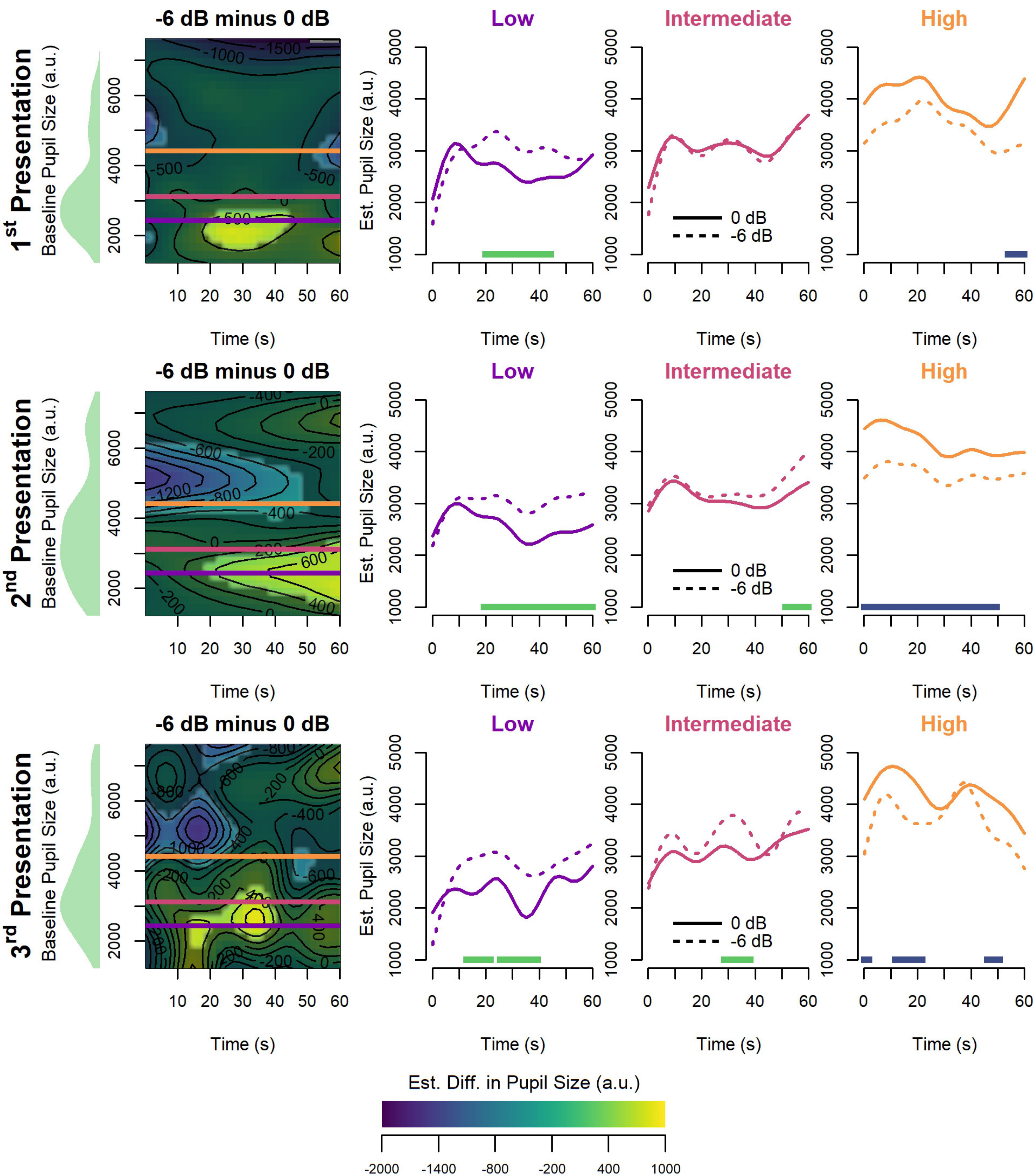
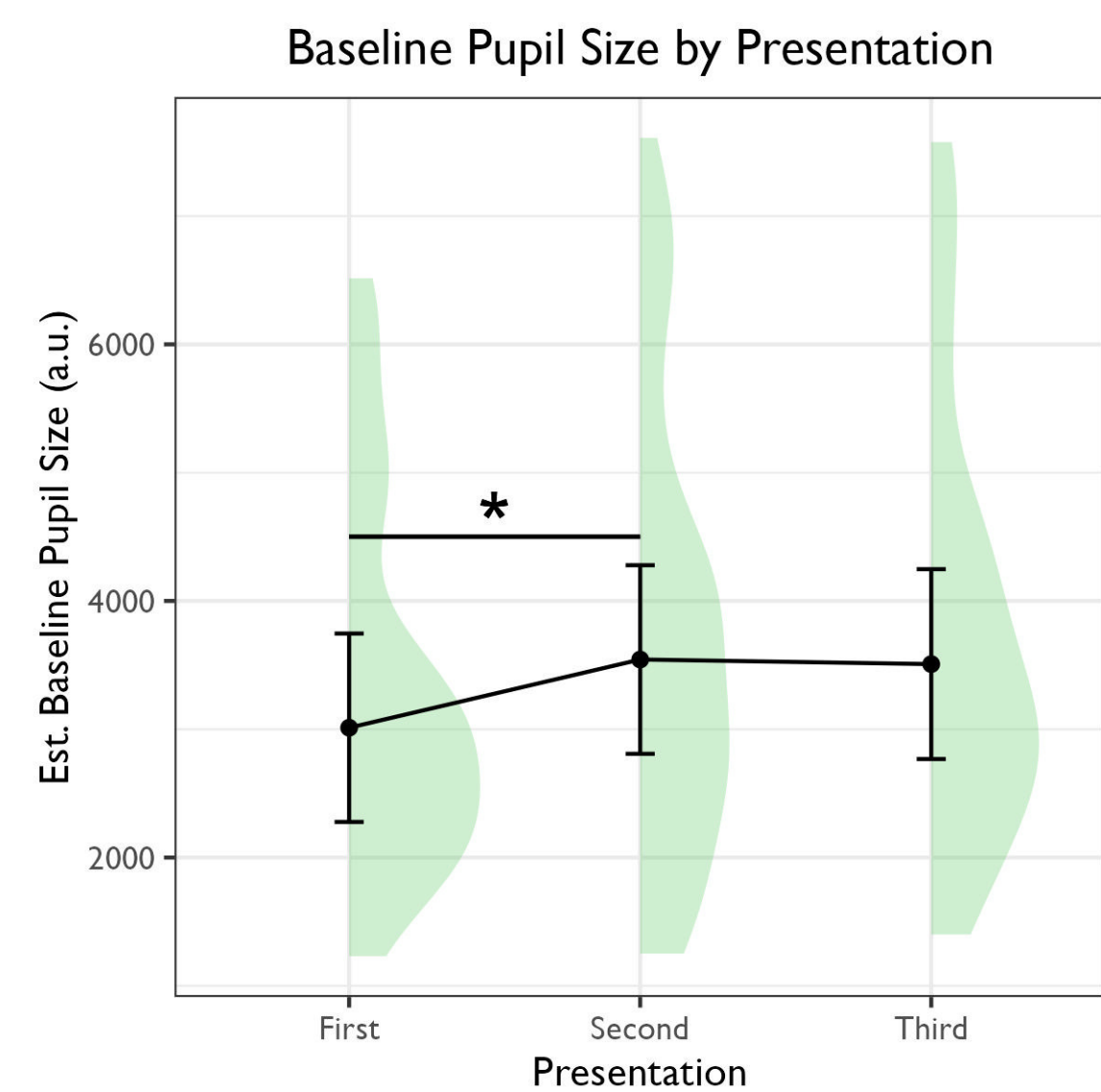


Results

No effect of SNR or presentation order on accuracy to comprehension questions following each passage.

Self-reported intelligibility was **significantly reduced** in the -6 dB SNR condition ($t = -4.40, p < .001$)

Baseline pupil size **increased** from the 1st to the 2nd presentation and **remained high** at the 3rd presentation.



At **low** baseline pupil sizes, listeners must **allocate extra effort** in the harder condition (-6 dB SNR) due to anticipatory attention being **under-mobilized**.

At **intermediate** baseline pupil sizes, there are **little-to-no differences** in the amount of effort listeners allocate between the two conditions, suggesting **optimal attention mobilization**.

At **high** baseline pupil sizes, listeners **initially do not differ** in how much effort is allocated in the two conditions.

By the second presentation, listeners appear to **“give up” or under-allocate effort** to the harder condition.

By the third presentation, listeners **under-allocate effort at first**, but eventually **recover**, benefitted by the additional repetition.



Scan here for an interactive, animated version of this figure!

Acknowledgements

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