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Joint modeling confirms pupil dilation as neurophysiological marker of Bayesian spatial inference in dynamic auditory environments

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Bayesian inference has been used successfully to explain how listeners integrate prior information with auditory signals to stabilize perception in dynamic and noisy environments. Recently, it was suggested that the arousal system plays a notable role by modulating the relevance and reliability of priors (Krishnamurthy, Nassar, et al., 2017, Nat Hum Behav). This suggestion was based on observed correlations between pupil dilation measures and latent variables of an ideal observer model in an auditory localization task with audiovisual priors. However, it is unclear how the sequential fitting to behavioral and then physiological data may have compromised the results. Here, we propose a refined Bayesian observer model that simultaneously predicts behavioral responses and pupil size measures by explicitly defining an interpretable linking function between model variables and physiological outcomes. In a re-analysis of the original data, we jointly fitted various versions of the model to each individual's data. We thus tested a variety of hypothesized 'linking functions'and selected the most parsimonious model. Our results not only indicated improved behavioral fits but, more importantly, the joint modeling approach was able to confirm and quantify the relationship between Bayesian perceptual processes and the arousal system as reflected by pupillometry. In general, our findings aim to demonstrate how integrating behavioral data and neurophysiological measurements in a single-model approach can aid our understanding of auditory perception.

Primary author: MEIJER, David (Acoustics Research Institute, Austrian Academy of Sciences)

Co-authors: BARUMERLI, Roberto (Acoustics Research Institute, Austrian Academy of Sciences); BAUMGARTNER, Robert (Acoustics Research Institute, Austrian Academy of Sciences)

Presenter: MEIJER, David (Acoustics Research Institute, Austrian Academy of Sciences)

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