UKE Paper of the Month Juni 2017
eLife, 2017; 10.7554/eLife.23232

Dynamic modulation of decision biases by brainstem arousal systems

Jan Willem de Gee, Olympia Colizoli, Niels A. Kloosterman, Tomas Knapen, Sander Nieuwenhuis, Tobias H. Donner

ABSTRACT: Decision-makers often arrive at different choices when faced with repeated presentations of the same evidence. Variability of behavior is commonly attributed to noise in the brain's decision-making machinery. We hypothesized that phasic responses of brainstem arousal systems are a significant source of this variability. We tracked pupil responses (a proxy of phasic arousal) during sensory-motor decisions in humans, across different sensory modalities and task protocols. Large pupil responses generally predicted a reduction in decision bias. Using fMRI, we showed that the pupil-linked bias reduction was (i) accompanied by a modulation of choice-encoding pattern signals in parietal and prefrontal cortex and (ii) predicted by phasic, pupil-linked responses of a number of neuromodulatory brainstem centers involved in the control of cortical arousal state, including the noradrenergic locus coeruleus. We conclude that phasic arousal suppresses decision bias on a trial-by-trial basis, thus accounting for a significant component of the variability of choice behavior.

STATEMENT:
We believe our paper should be considered as paper of the month because:
(i) The paper constitutes a significant advancement in the fundamental understanding of decision-making and variability therein. Overcoming the numerous challenges associated with brainstem fMRI, the authors were able to track varying levels of locus coeruleus activity, a small nucleus in the brainstem that shapes arousal levels by releasing noradrenaline. The data suggest that the locus coeruleus reduces existing biases in our decision-making. Varying levels of locus coeruleus activity may thus explain why we can reach different conclusions when considering the same information on multiple occasions.
(ii) The paper is a showcase for modern neuroscience that is changing its ways in response to the replication crisis. Supporting this cause, we made all the data we collected for this study publically available on Figshare, and all analysis scripts on Github. First author Jan Willem de Gee was quoted in a recent eLife editorial blog post on forking custom software to the eLife GitHub account

BACKGROUND:
This project was part of the PhD thesis of Jan Willem de Gee, MSc. The work was performed at the Department of Neurophysiology and Pathophysiology in the group of Tobias H Donner, PhD, who holds a Heisenberg professorship at the UKE since 2015. The research was supported by the German Research Foundation (DFG, SFB 936/Z1 and DO 1240/3-1) and the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement no. 604102 (Human Brain Project). Both authors have strong research interests in the field of decision-making, with a special focus on how decision computations are shaped by neuromodulatory signals.