

Choice History Biases Depend on Environmental Stability and State Uncertainty

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Abstract

Perceptual decisions under uncertainty are often biased by the history of preceding events. For example, observers tend to repeat (or alternate) their judgments of the sensory environment more often than expected by chance (Braun, Urai, & Donner, 2018; Frund, Wichmann, & Macke, 2014). We test the idea that such choice history biases arise from the context-dependent accumulation of internal decision signals across trials (Glaze, Kable, & Gold, 2015). Observers performed a standard visual random dot motion discrimination task near psychophysical threshold in several different environments. Those were made up of different levels of auto-correlation between the stimulus categories in successive trials (Repetitive, Random, or Alternating), and the absence or presence of single-trial outcome feedback. Participants adjusted both the strength and the sign of their history biases to the environment. When no feedback was available this adjustment was driven by previous choices modulated by confidence. When feedback was provided the adjustment was predominantly based on previous stimuli.

Keywords: sequential effects; choice history bias; confidence; decision-making; environmental statistics

Results

Participants consistently adjusted their choice history biases to the statistical structure of the environment. In Repetitive or Alternating environments, the individual degree of this adjustment of history bias was about as good a predictor of performance as perceptual sensitivity. Biases were adjusted effectively to the environmental statistic, even when no trial-by-trial feedback was provided and subjects remained uncertain about the previous stimulus category. But critically, the form of the adjustment differed between environments with or without feedback. In the absence of feedback, history bias adjustment was largely governed by previous correct choices (i.e., dependent on the combination of previous choice and stimulus category) and scaled with another proxy of decision confidence about previous choices: reaction time (Sanders, Hangya, & Kepecs, 2016; Urai, Braun, & Donner, 2017). By contrast, when feedback was provided observers based their

bias adjustment predominantly on the preceding stimulus category. Preliminary MEG results show neural signatures of the bias adjustment during the inter-trial interval as well as during stimulus viewing. In the inter-trial interval low frequency (9–23 Hz) power in visual cortex was enhanced in accordance with the bias, possibly reflecting a top-down modulation. During stimulus viewing single trial bias-dependent activity built up in motor cortex. Evidence was accumulated into the direction of the bias independent of the upcoming choice.

Conclusions

Action-independent decision variables, which encode the choice modulated by confidence when performing under high uncertainty and are solely based on the stimulus when feedback is provided, are accumulated across choices in a flexible manner.

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References

- Braun, A., Urai, A. E., & Donner, T. H. (2018, jan). Adaptive history biases result from confidence-weighted accumulation of past choices. *The Journal of Neuroscience*, *38*(10), 2418–2429. doi: 10.1523/jneurosci.2189-17.2017
- Frund, I., Wichmann, F. A., & Macke, J. H. (2014, jun). Quantifying the effect of intertrial dependence on perceptual decisions. *Journal of Vision*, *14*(7), 9–9. doi: 10.1167/14.7.9
- Glaze, C. M., Kable, J. W., & Gold, J. I. (2015, aug). Normative evidence accumulation in unpredictable environments. *eLife*, *4*. doi: 10.7554/elife.08825
- Sanders, J. I., Hangya, B., & Kepecs, A. (2016, may). Signatures of a statistical computation in the human sense of confidence. *Neuron*, *90*(3), 499–506. doi: 10.1016/j.neuron.2016.03.025
- Urai, A. E., Braun, A., & Donner, T. H. (2017, mar). Pupil-linked arousal is driven by decision uncertainty and alters serial choice bias. *Nature Communications*, *8*(1). doi: 10.1038/ncomms14637

