Serial dependence in perception: decision making, metacognition, and awareness

Marta Suárez-Pinilla[1,2], Anil K. Seth[1,2], Warrick Roseboom[1,2]

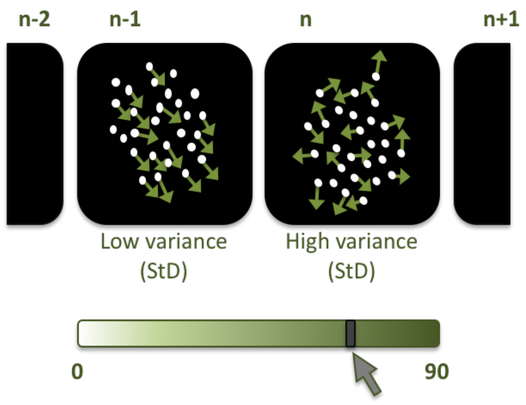
1. Sackler Centre for Consciousness Science 2. Dept. of Informatics, University of Sussex, UK

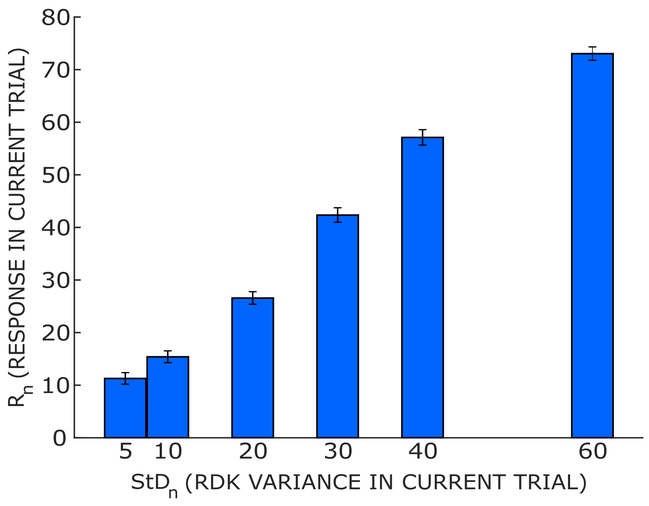
Introduction

Serial dependence (SD) describes a phenomenon whereby perceptual judgments are attracted towards recent, briefly presented stimuli[1,2]. SD exists for both low and high-level perceptual dimensions, suggesting a central role in shaping visual experience[3].

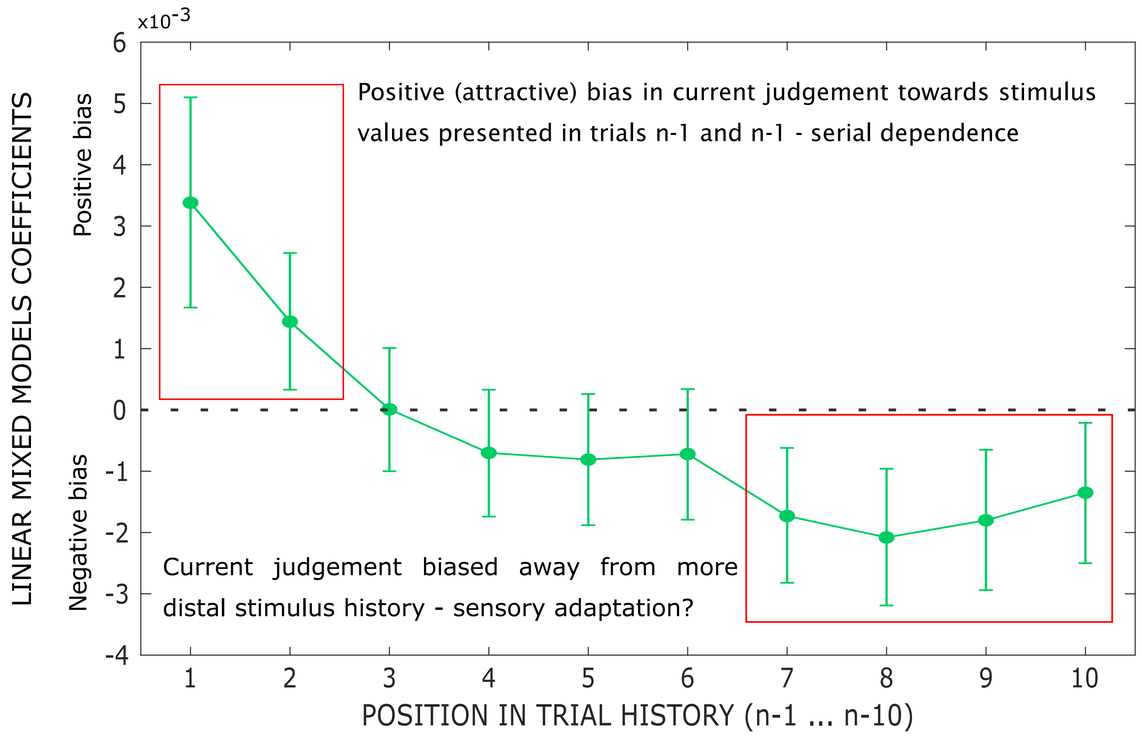
There is debate about whether SD arises in low-level perceptual and/or higher level decision processing, such as working memory[4]. Furthermore, the relationship of SD to metacognitive processes and perceptual awareness remains unclear.

We explored how decision making, confidence, and perceptual awareness constrain SD in visual variance and orientation.

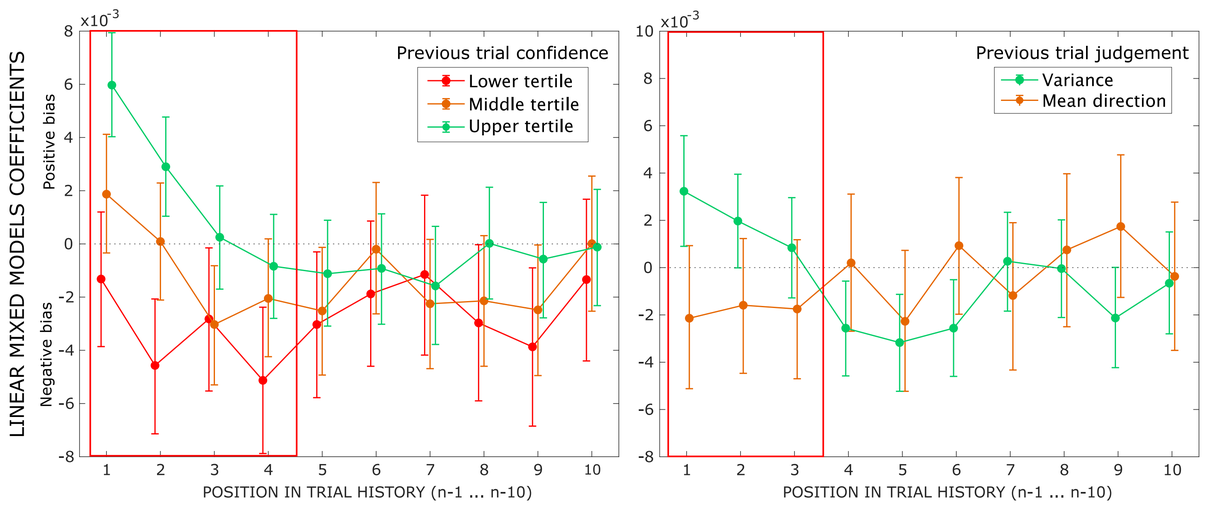




Serial dependence in visual variance



Serial dependence, confidence, and decision making



Confidence (left panel):
SD arises only when participants' previous decisions were reported as high confidence. Lowest confidence decisions induce no positive SD bias.

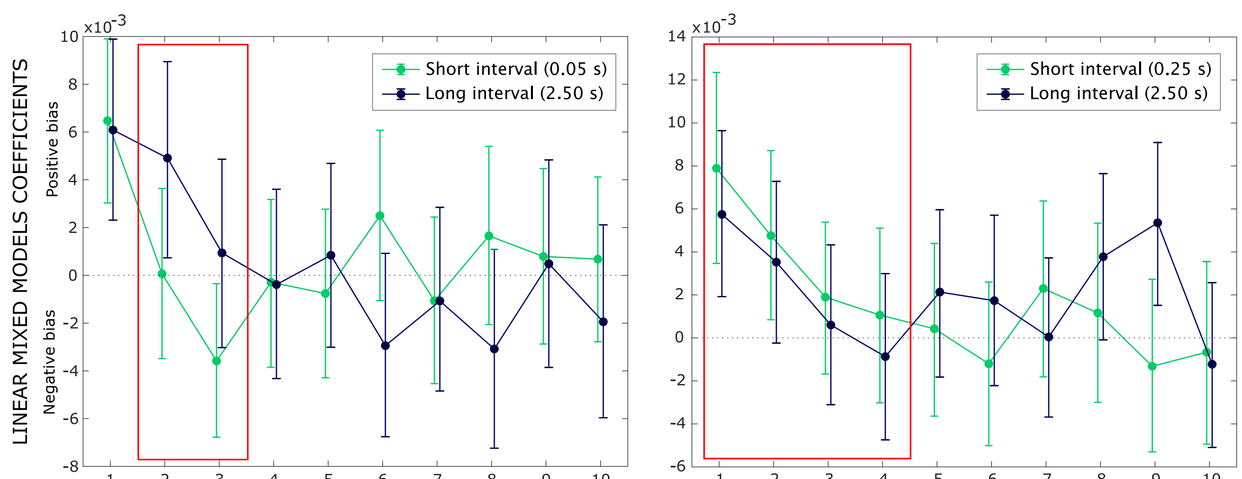
Decision making (right panel):
Positive SD abolished when participants switch between making judgements about the stimulus variance and mean stimulus direction. This is true regardless of whether the required judgement was pre- (shown) or post-cued - ruling out 'attention' related explanations.

Contact: ms822@sussex.ac.uk www.sussex.ac.uk/sackler

Serial dependence of decisions over time

Stimulus-response interval - wait after stimulus presentation to provide response

Inter-trial interval - passive waiting between successive presentations



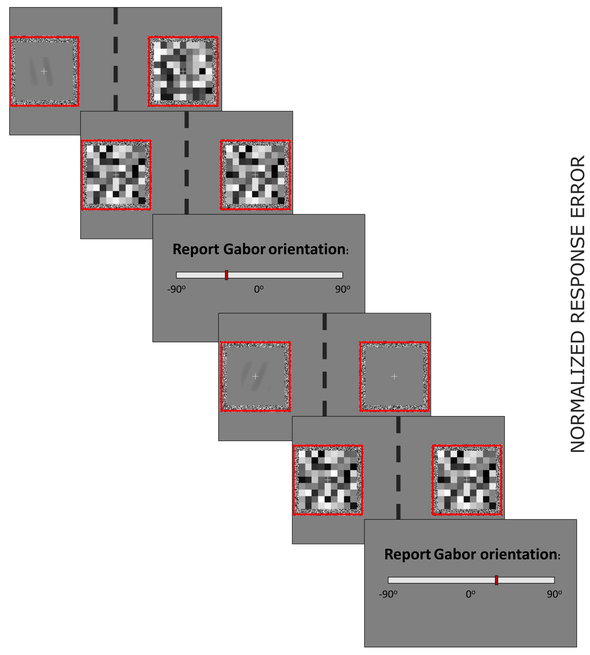
Active maintenance of decision enhances SD (left panel):

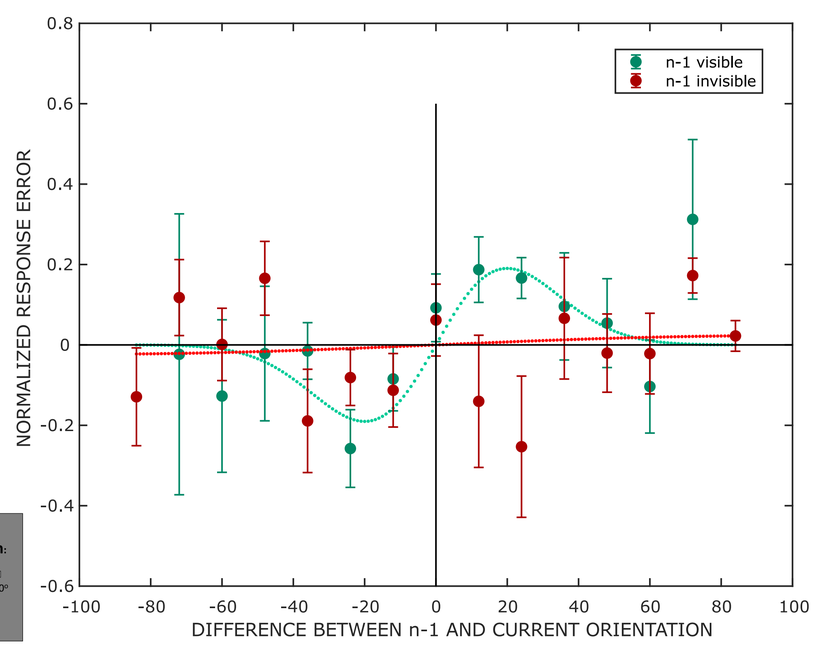
When waiting to provide response following stimulus presentation (on the current trial), there is an increased bias towards less recent (n-2 and n-3) presentations[4].

SD decays with time (right panel):
Passively waiting between successive trial presentations (not required to maintain response, etc) reduces the bias towards previous trials.

Serial dependence requires visual awareness

We explored SD in the orientation of a sequence of Gabor patches using a continuous flash suppression paradigm where 50% of presentations were masked.





Characteristic derivative of Gaussian tuning of SD in orientation[4] only arises when n-1 trial was visible. Counter to previous claims[1] and unlike the sensory adaptation seen in illusions like the tilt after effect, SD in orientation is not the result of low level visual processing.

Conclusions

Generation of SD: past stimuli exert SD on subsequent presentations in presence of:
a. High decisional confidence for past decision.
b. Contiguity of feature dimension about which decision is made.
c. Perceptual awareness of past stimulus.

Maintenance of SD: duration of influence of a past stimuli is affected by:
a. Time-related (passive) decline.
b. Active maintenance of current representation in working memory. Longer maintenance of a decision before report increases bias toward past presentations[4].

Serial dependence is consistent with high-level process of iterative (Bayesian-like) biases in decision rather than perception and only occurs in the presence of high decisional confidence and perceptual awareness.

References

1. Fischer J, Whitney D. (2014) .Serial dependence in visual perception. Nature Neuroscience, 17:738-43.
2. Suárez-Pinilla, M., Seth, A.K. & Roseboom, W. (in press). Serial dependence in the perception of visual variance. Journal of vision.
3. Kiyonaga, A., Scimeca, J.M., Bliss, D.P., Whitney, D. (2017). Serial Dependence across Perception, Attention, and Memory.Trends in Cognitive Sciences. 21(7):493-7.
4. Bliss, D.P., Sun, J.J., D'Esposito, M. (2017). Serial dependence is absent at the time of perception but increases in visual working memory. Scientific Reports. 7, 14739.

Acknowledgements

This work was supported by a donation from the Dr Mortimer and Theresa Sackler Foundation and the H2020 FET grant TIMESTORM (641100).