Choices Change the Temporal Weighting of Decision Evidence

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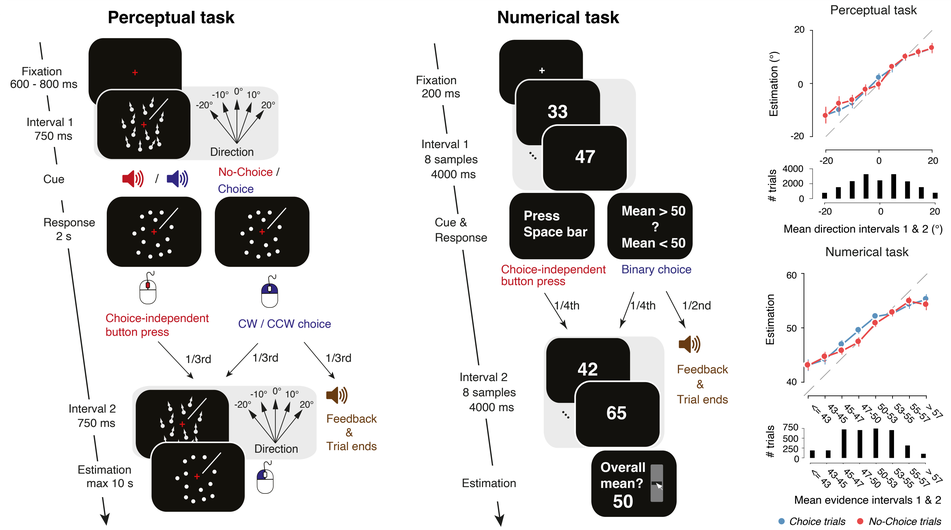
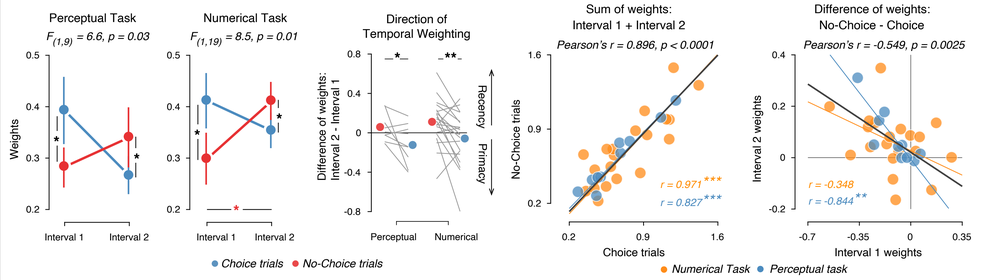
Background

- Real-life decisions are embedded in sequence of judgments based on continuous streams of information.
- Decisions result from the accumulation of decision-relevant information ("evidence") over time[1].
- Committing to a categorical hypothesis or to a course of action biases subsequent decision-making[2,3,4,5,6] and gives rise to confirmation bias[7].
- Little is known about the effect of categorical choices on the processing of decision-relevant information.
- We investigated if and how intermittent choices affect the temporal weighting of decision-relevant evidence.

2 interval continuous estimation task

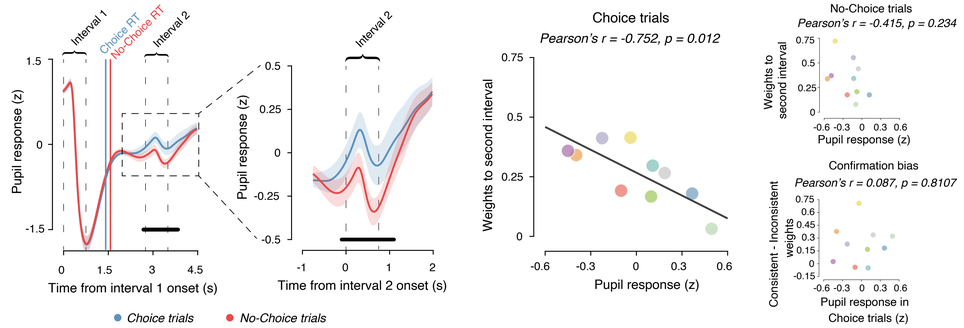


Intermittent choice alters temporal weighting



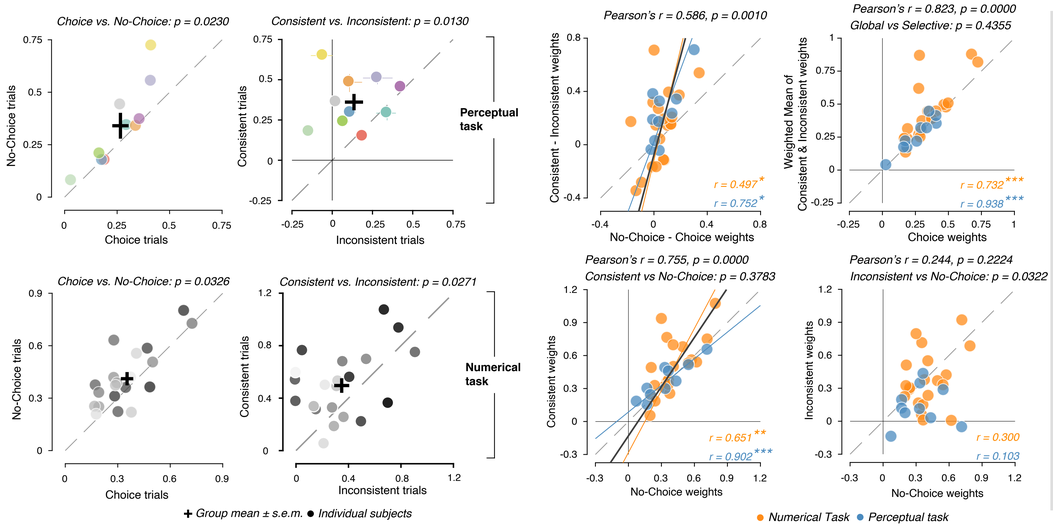
- Choice-commitment after the initial evidence boosted sensitivity to that early evidence, but at the cost of reducing sensitivity to subsequent evidence, and flipped the temporal weighting of evidence across the two intervals from recency to primacy.

Pupil response is modulated by choice commitment



- Pupil dilation was larger for Choice than No-Choice trials, likely reflecting the selection process associated with the decision[8,9,10].
- Subjects with larger choice-induced pupil dilation exhibited lower weights to the evidence from the second interval.

Choice-induced non-selective bias is coupled to selective confirmation bias



Computing sensitivity to evidence

Objective stimulus → Subjective evidence

$$X_i = \phi_i + \mathcal{N}(\delta, \sigma) \quad i = 1, 2$$

ϕ_i = *Physical stimulus*
δ = *Subjective bias*
$1/\sigma$ = *Subjective sensitivity*

Global gain Model

$$Estimation = w_{1c}\ X_{1c}\ + w_{2c}\ X_{2c}\ + \mathcal{N}(0, \xi_c)$$
$$Estimation = w_{1nc}X_{1nc} + w_{2nc}X_{2nc} + \mathcal{N}(0, \xi_{nc})$$

c = Choice trials; *nc = No-Choice trials*

Selective gain Model

$$Estimation = w_{1cc}X_{1cc} + w_{2cc}X_{2cc} + \mathcal{N}(0, \xi_{cc}) \qquad sign(\phi_{2cc}) = C$$
$$Estimation = w_{1ic}X_{1ic} + w_{2ic}X_{2ic} + \mathcal{N}(0, \xi_{ic}) \qquad sign(\phi_{2ic}) \neq C$$

$C = \pm 1$ *cc = Consistent trials* *ic = Inconsistent trials*

- Overt choices reduce the sensitivity to subsequent evidence in a non-selective fashion for numerical[6], and also for perceptual decisions.
- Sensitivity is selectively enhanced for information consistent with the intermittent choice, yielding a confirmation bias[7].
- Participants with a stronger global gain reduction also showed a stronger selective gain modulation, in line with a common underlying mechanism.

Conclusions

- Choices reduce the sensitivity to subsequent information for decisions based on both, perceptual and symbolic information.
- Choice-commitment elicited dilations of the pupil, a marker of central arousal, which predicted the sensitivity to subsequent information.
- Categorical choices dynamically alter the temporal weighting of decision evidence, potentially via pupil-linked arousal mechanisms.
- **Categorical choices might trigger a central arousal boost that changes the state of the neural circuits processing decision-relevant information.**

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References

[1]Gold, J. I., Shadlen, M. N. (2007); [2]Jazayeri, M., Movshon, A. J. (2007);[3]Stocker, A. A., Simoncelli, E. P. (2008); [4]Luu, L., Stocker, A.A. (2018); [5]Braun, A., et al. (2018); [6]Bronfman, Z. et al. (2015); [7]Talluri, B.C. et al.(2018); [8]de Gee, J.W. et al.(2014); [9]de Gee, J.W. et al.(2017); [10]de Gee, J.W. et al.(2020).

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