A comparison of temporal binding across different tasks

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Introduction

- Haggard et al. first reported the *temporal binding effect* (TB) in 2002.
- Several studies have already used *different methodologies* to assess this effect.
- No study investigated how *reliable* the effect is using various tasks and whether there were consistent correlations across them.
- An effect that is reliable from the experimental point of view may not be so from the correlational point of view (Hedge et al., 2018; Parsons et al., 2019).
- $t = \frac{m-\mu}{\frac{s}{\sqrt{n}}}$
- $ICC = \frac{var_{between-subjects}}{var_{between-subjects}+var_{between-sessions}+var_{\epsilon}}$

Objectives

We developed a battery of *4 tasks*, evaluating the *same participants* in *several sessions* to estimate the *reliability* of the effect and used it as a probe for temporal perception.

Methods

Participants completed 4 tasks containing causal and non-causal conditions: Temporal Anticipation, Libet Clock, Temporal Estimation and Temporal Reproduction. In our 1st experiment, *57 participants* completed *2* experimental sessions; in our 2nd experiment, *46 participants* completed *6* experimental sessions.

Results

A Repeated-Measures ANOVA revealed a significant difference between causal and non-causal conditions in the direction of the TB in Estimation, Libet and Reproduction, both in our 1st experiment ($F(1, 56)=12.90$, $p<.001$, $\eta_p^2=.19$; $F(1, 56)=4.10$, $p<.05$, $\eta_p^2=.07$; $F(1, 56)=26.66$, $p<.001$, $\eta_p^2=.32$) and in our 2nd experiment ($F(1, 45)=5.11$, $p<.05$, $\eta_p^2=.10$; $F(1, 45)=21.30$, $p<.001$, $\eta_p^2=.32$; $F(1, 45)=26.43$, $p<.001$, $\eta_p^2=.37$).

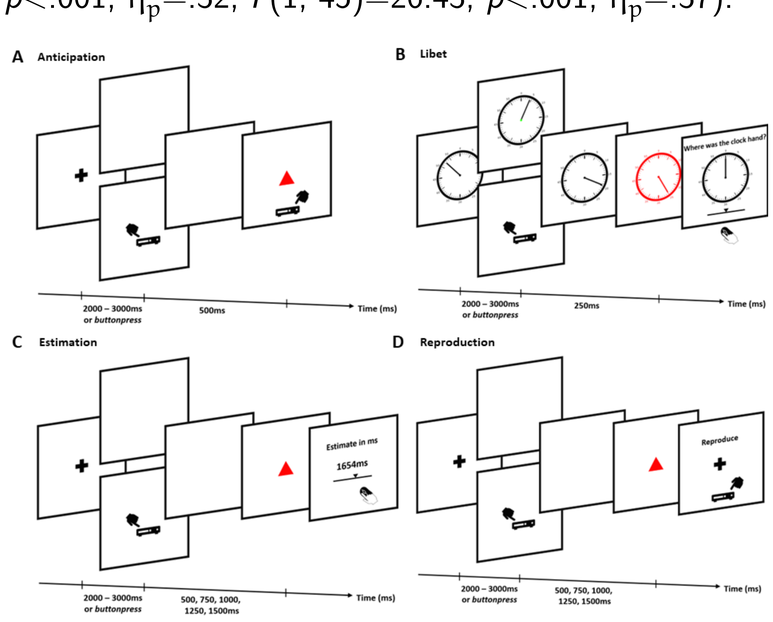

Figure 1: **Experimental trial scheme for all tasks. (A)** Participants had to anticipate a red target stimulus (caused by their action or after an external event). **(B)** Participants indicated where the clock hand was when a target event (red flash) happened. **(C)** Participants estimated how long a target interval lasted (500, 750, 1000, 1250, 1500ms). **(D)** Participants reproduced the duration of a target interval by pressing a button on the keyboard/response pad.

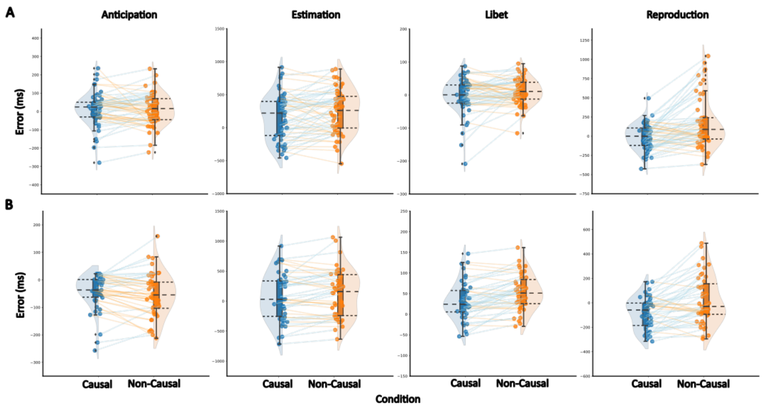

Figure 2: **Paired distribution of median errors. (A)** and **(B)** refer to Experiments 1 and 2, respectively. **Blue lines** represent the presence of the TB, while **orange lines** its absence.

- *Within-tasks reliability*: all estimates yielded a strong correlation degree ($>.6$) for all tasks and sessions in both experiments.
- *Between-tasks correlation*: the only significant correlation was between the Estimation and Reproduction tasks ($r(57)=.53$, $p<.001$; $r(46)=.68$, $p<.001$).
- *Between-sessions reliability*: all tasks showed poor reliability, the highest being that of Libet in our 1st experiment ($ICC(3, 1)=.54$, $CI=[.33, .70]$). In our 2nd experiment, we combined data from 6 experimental sessions into sets of triplets, mitigating variations across sessions. The resulting estimates for $ICC(2,1)$ revealed consistently high values ($>.7$) for all measures.
- *Within-sessions correlation*: we performed a Repeated-Measures Correlation for each pair of tasks to estimate the reliability; none of the correlations yielded significant results.

Conclusions

- We successfully replicated the TB effect in 3 out of 4 tasks across both experiments.
- We observed stable effects within the same task throughout the experimental session, supported by high correlation coefficients.
- Initial between-session reliability had lower values but notably improved when we aggregated data from sets of 3 sessions. This consistent pattern implies trait-related influences rather than state-related ones.
- We found a significant correlation between the Estimation and Reproduction tasks, possibly indicating a shared cognitive mechanism.
- Within-session assessment revealed varying binding effects for different tasks within the same experimental session.

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