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The readiness potential is associated with temporal attraction in intentional binding

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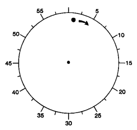
Introduction

When a voluntary action is causally linked with a sensory outcome, actions and their consequent effects are perceived as being closer together in time than they really are. This effect is called intentional binding. In this study we performed the intentional binding paradigm with twenty experienced meditators (mindfulness meditation: average experience of 10.1 years; in the last 8 weeks meditated on average for 7.6 hours a week) and compared the results with matched controls regarding the question of the underlying neural mechanism of the temporal binding effect. Brain dynamics as recorded with EEG and analyzed in single-trials was performed to estimate whether intentional binding is correlated with early neural processes (readiness potential, RP).

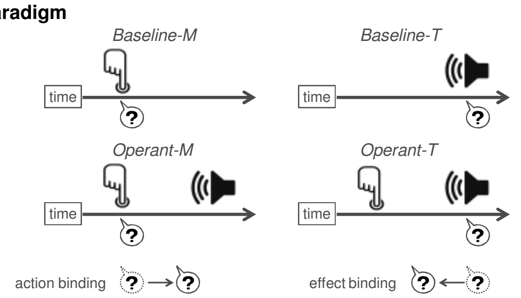
Methods

Intentional Binding paradigm

- We performed two **Baseline tasks** and two **Operant tasks** in pseudo-random order
- Two Operant tasks contain self-generated tone 250 ms after a voluntary movement
- Participants **report** either the **finger movement** or the **tone onset times** on a clock
- Electroencephalogram (EEG) was recorded simultaneously
- Twenty meditators were compared with 20 matched controls
- Reported-times and EEG recordings were examined
  between groups (the effects of mindfulness meditation)
  and between Baseline and Operant tasks (the effects of human agency)

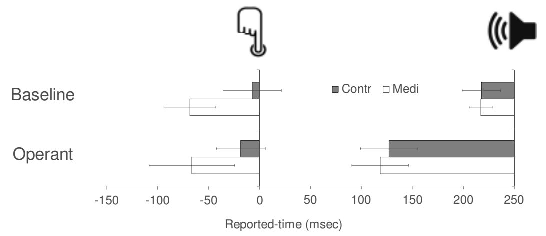


Libet's Clock



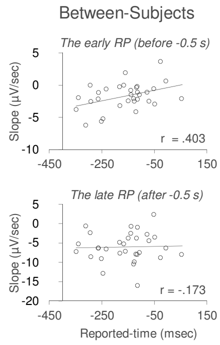
Results

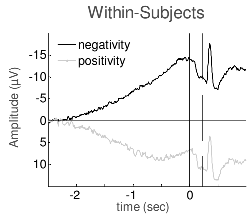
A Temporal binding effects



- We found <u>**no group effects**</u> neither in behavioral data (all p > .198) nor on EEG recordings (all p > .371).
- Overall, the binding effect is mainly driven by **effect binding** (tone-time as shifted towards action) rather than by **action binding** (movement-time as shifted towards tone), i.e., mainly by the shift of the tone time during the **Operant-T** task.

B The relation between the RP and effect binding during the **Operant-T** task





- The larger the shift of the tone-time towards the action (i.e., effect binding), the steeper the early RP slopes (p=.022).
- A larger shift of the tone-time towards the action (i.e., effect binding) occurred during negative rather than during positive potentials (p=.023).

Conclusion

Our results do not support the hypothesis that mindfulness meditators would display different performance in the intentional binding paradigm as compared to controls. However, the present findings of the early RP correlates to the temporal attraction shed light on the underlying neural mechanism of human agency. Our results suggest that the early neural activity within the range of spontaneous ongoing potential shifts affects the perceived time of the sensory outcome that is caused by intentional action.

Jo H-G, Hinterberger T, Wittmann M, Borghardt TL, Schmidt S (2013). Spontaneous EEG fluctuations determine the readiness potential: Is preconscious brain activation a preparation process to move? Experimental Brain Research 231, 495–500.
Jo H-G, Wittmann M, Borghardt TL, Hinterberger T, Schmidt S (2014). First-person approaches in neuroscience of consciousness: brain dynamics correlate with the intention to act. Consciousness and Cognition, in press.

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