

# Influences of the Immediate Past: Recurring Brain States and Their Relation to Action Control

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The ability to exert goal-directed behavior is crucial for everyday life. Research on action control has focussed on this through the investigation of perception-action links. A recent account of how perception-action integration influences goal-directed behavior is the Binding and Retrieval in Action Control (BRAC) framework. Building on ideomotor theory, the framework suggests that the features of the stimulus, the response and its effect are bound together in so-called event file. Upon the repetition of any feature, the event file is retrieved. The framework stresses the importance of the *immediate past*, as previous perception-action links have an impact on current action control when the previous event file is retrieved but has to be reconfigured. Importantly, the *immediate past* therefore also refers to the time frames intermittent to an experiment and the activity preceding the individual trials. The aim of this dissertation was to simultaneously investigate the neurophysiological processes underlying binding and retrieval and the influence of preceding brain states.

To this end, four studies were conducted that analyzed the role of neurophysiological processes preceding binding and retrieval. Two classic binding paradigms and two paradigms showing behavioral effects that can be explained by the BRAC framework were investigated: I) a stimulus-response binding task, II) a response-response binding task, III) a Go/Nogo paradigm with overlapping stimulus features, and IV) a working memory-based task switching paradigm. The behavioral results show significant binding effects across the different paradigms, highlighting the universal applicability of the BRAC framework. The EEG data were source-reconstructed in a multi-step procedure in order to identify task-relevant regions of interest in the alpha-, theta-, and beta-frequency bands during the trial and in recurring brain states preceding the individual trials. It was hypothesized that within-trial activity would show an interplay of these oscillations according to a recent addition of the BRAC framework. Across all four studies, these assumptions could be validated. Binding and retrieval of event files are realized through theta activity while alpha-band oscillations exert top-down and bottom up control on these processes. Beta-band activity corresponds to the latent (re-)activation of the event files.

Brain states in preceding time frames were analyzed in their relation to binding and retrieval processes. Based on limited previous literature, it was hypothesized that previous brain states – as characterized by ongoing oscillations – would interact with binding and retrieval processes through both a modulation of attentional preparation and through pre-allocation of cognitive resources. Across all studies, it could be shown that intermittent brain states significantly interact with processes during action control. This indicates that

brain states provide a 'linking hub' between past and future behavior. The findings show the preceding brain states are involved in maintaining and shielding the current event file from interfering information. Additionally, it was shown that attentional control toward upcoming stimuli can bias the brain toward retrieval. Simultaneously, a preparation of subsequent retrieval and reconfiguration efforts can be prepared through a preallocation of cognitive resources.

The results of the four studies are integrated with previous literature and implications on both the BRAC framework and brain states are discussed. The presented studies highlight that event file binding and retrieval are not isolated processes, but are shaped by oscillatory dynamics of recurring brain states. While binding and retrieval processes seem to be universal across different paradigms, previous brain states may depend on the current task demands. Intermittent brain states therefore seem to implement a weighting of different preparatory processes for event file maintenance, retrieval and reconfiguration. A new analysis framework is discussed that allows to further disentangle intermittent brain states as well as binding and retrieval processes in action control. Overall, the presented findings suggest new perspectives on goal-directed behavior and highlight the importance of previous experiences as manifested in intermittent brain states.