ABSTRACT

To allow goal-directed behavior, individuals depend on cognitive control processes (i.e., executive functions) to monitor and regulate their thoughts, emotions, and hence actions. Conceptually, action control is driven by two core processes, namely feature binding and retrieval (Frings et al., 2020; Kiesel et al., 2023), which enables the integration of several sensory, mental, and motor features in so-called event-files (Hommel, 2004; Hommel et al., 2001). The management of binding and retrieval is thereby modulated by the (re-)configuration and inhibition of task-sets, which are cognitive representations of rules, goals, and stimulus-response mappings (Monsell, 2003; Monsell & Driver, 2000). The present work employed three elaborated tasks to investigate processes of action control and their neural basis. Based on neurophysiological EEG data, the underlying network architectures and dynamics were investigated. For this, beamforming analyses and a sophisticated artificial neural network approach were used to shed light on the directed information transfer during action control.

The behavioral results were in line with previous research showing that cognitive conflict (such as switching, updating, or incongruency) leads to performance decrements, which are likely caused by (re-) configuration processes of task-sets. Beyond that, the current findings suggest that, at the neural level, these configuration processes are likely modulated by the interplay of a brain-wide information transfer in distinct frequency bands (i.e., theta, alpha, and beta), particularly within the fronto-parietal control network, with additional contributions from temporal regions such as the anterior temporal lobe and integrative hubs like the insula. Thereby, directed connectivity results showed predominantly symmetric information transfer in all networks and highlighted the role of nonlinear models. Specifically, only nonlinear connectivity patterns were associated with computational and behavioral measures of performance, and neural integrity, thus providing better insights into brain functioning than linear models. Future research might use these findings for clinical practice (e.g., the treatment of neurodegenerative disorders) and/or tailored treatments of cognitive decline in general.