THE FRONTAL ASLANT TRACT: A SWING BETWEEN INNER AND THE OUTER WORLDS

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Background/Rationale: Whenever we must move as fast as possible in response to an event, we face a choice: anticipate the event (risking a “false start”) or wait for it to occur. Consequently, our behavior toward the external world constantly oscillates between two mutually exclusive strategies: 1) predicting external events based on internal timing models, and 2) waiting for external events to happen and reacting to them. The predictive strategy acts as "high-gain" regarding response speed but entails a higher risk of error. Conversely, the reactive strategy is "low-gain" regarding speed but carries a much lower risk of anticipation errors. Current knowledge points to the inferior frontal gyrus (IFG) as the neural substrate of arbitrary visuomotor associations and the superior frontal gyrus (SFG) as the machinery for internally timed actions.

Research Questions: What neural structures generate these two strategies? More importantly, how does the brain orchestrate the choice between predictive and reactive behaviors so that they do not interfere at the time of action? We hypothesize that the Frontal Aslant Tract (FAT), a white matter bundle connecting the IFG and SFG, mediates these interactions.

Methods: To explore the role of the FAT, we applied online transcranial magnetic stimulation (TMS) to 19 healthy human volunteers. We targeted six sites along the medial and lateral terminations of the FAT during the fixed-duration “set” period of a delayed reaction task (“ready-set-go” scenario). We exploited the fact that this task can be solved using either predictive (internally driven/timed) or reactive (externally driven) strategies. Indeed, participants adopt one of the two strategies on a trial-by-trial basis, with an approximate 2:3 ratio of predictive to reactive trials. We administered event-related single-pulse TMS to three spots on the SFG and three spots on the IFG that were reciprocally connected by FAT fibers. Coil positioning was established using individual tractography-guided neuronavigation, performed on FAT bundles reconstructed from individual diffusion-weighted Magnetic Resonance Imaging (DW-MRI).

Results: ANOVA on the behavioral propensity to act with either strategy revealed a significant effect [$F(6,108)=5.61, p=0.004$; partial $\eta^2=0.238$; observed power ($\alpha=0.05$)=0.996]. Planned comparisons between each of the six active TMS sites and sham stimulation showed that TMS increased the propensity toward reactive behavior when applied to a specific portion of the IFG, whereas it increased predictive behavior when applied to a specific SFG spot. Notably, these two active spots in the SFG and IFG were directly connected by a specific sub-bundle of FAT fibers.

Discussion: These findings confirm our hypothesis that the SFG and IFG play opposing roles — with the SFG promoting internally generated (predictive) behavior and the IFG promoting externally cued (reactive) behavior — and that their interaction is mediated by the FAT. We propose that the propensity to choose one strategy over the other is mediated by a mechanism of reciprocal inhibition, supporting a "winner-takes-all" decision process facilitated by direct FAT connectivity. The results further indicate that up to the actual moment of movement onset (during the SET-period), both strategies remain available in parallel channels within the participant’s motor system.

Keywords: Executive control, Prefrontal

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