

Psychology Bachelor of Science Thesis -

“Neural Mechanisms of Flanker and Stimulus-Response-Congruency Interference”

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There is an ongoing controversy concerning the interaction, or lack thereof, of stimulus-stimulus (S-S) and stimulus-response (S-R) interference, which extends into a discussion whether conflict based cognitive control is domain-specific. Based on one account, put forward by Egner (Egner, 2008; Egner et al., 2007) and Kornblum (Kornblum, 1994; Kornblum et al., 1990; Kornblum et al., 1999; Zhang et al., 1999) S-S incongruency, eg. the Flanker task (Eriksen and Eriksen, 1974), interferes on the stimulus-processing stage, while S-R incompatibility, like the Simon task (Lu and Proctor, 1995; Simon, 1969; Simon and Berbaum, 1990), interferes the response-selection stage. This is due to the nature of dimensional overlap of the interference: the Flanker and Simon task consist of the irrelevant stimulus dimension overlapping with the relevant stimulus dimension or the response dimension, respectively.

This implies different and independent resolution and predicts additive behavioural effects in response times and error rates. Furthermore it would predict differing blood-oxygen-level dependent (BOLD) responses and the possibility to specifically affect the resolution of a single conflict by transcranial magnetic stimulation (TMS) perturbation.

Behaviourally, these predictions have been confirmed by employing a Type 7 Ensemble as per Kornblum taxonomy (Kornblum and Lee, 1995), combining a Stroop-like task and a Simon task (Hommel, 1997, Experiment 1; Kornblum, 1994; Simon and Berbaum, 1990). The neural response of Flanker and Simon task variations has been assessed for the conflicts presented independently (not in combination), revealing diverse activation patterns (Fan et al., 2003; Liu et al., 2004; Nee et al., 2007). Egner et al (2007) used a factorial combination of Stroop and Simon interference, and also identified independent BOLD response.

However, there have been accounts of interacting S-S incongruency and S-R compatibility (Hommel, 1997, Experiment 2 and 3). Most recently Treccani et al. (2009) argued that the flanker task, as instance of and S-S conflict, and an accessory-Simon task, as instance of S-R

conflict, subadditively interact on the response selection stage, if combined in a factorial design.

Additionally, studies employing TMS suggested the Flanker task interfering on the response selection stage (Soto et al., 2009; Taylor et al., 2007; Verleger et al., 2009).

A factor complicating the issue, is that it has been shown that even conceptually similar derivations of the same task (e.g. motion and location-based Simon tasks) result in diverse neural responses (Galashan et al., 2008; Wittfoth et al., 2006). This leads us to conclude that comparisons of independent studies employing different, single implementations of specific tasks are limited in giving insight in similarity among neural responses of tasks of similar or different nature.

Thus, we attempt to address this problem by establishing a fully factorial paradigm, as suggested by Egner (Egner, 2008), combining a Flanker (Type 4 Ensemble) and an accessory-Simon task (Type 3 Ensemble), which forms a Type 7 Ensemble (Kornblum and Lee, 1995) in combination. Using event-related functional magnetic resonance imaging (fMRI) areas of the brain associated with a conflict's resolution are localized and those areas will be perturbed via TMS to investigate if the conflict resolution can be specifically manipulated, without influencing the resolution of the other conflict. Both experiments will be conducted with the same participants.

Additionally, the TMS will scrutinize the assumption, that an additive behavioural effect (no interaction) is indicative of processing on different, independent stages (Egner, 2008; Sternberg, 1969). Non-interacting behavioural data, but a three-way interaction of the interference factors with the TMS treatment, would reveal an interactive process, that merely appears additive on the behavioural level.

Based on the existing literature we expect increased neural activation in the right dorsolateral prefrontal cortex (dlPFC) and the anterior cingulate cortex (ACC) for the Flanker task (Botvinick et al., 1999; Casey et al., 2000) and the posterior parietal cortex (PPC) (Nee et al., 2007) and Pre-SMA (Liu et al., 2004; Wittfoth et al., 2006) for the Simon-like task. Additionally, Friedmann-Hill et al. (2003) have suggested a more general role of filtering distractions for the PPC which would also be relevant to the Flanker task.

The dlPFC/BA 9 also will be of special interest in resolving the high conflict trials (Botvinick et al., 2001; Egner, 2008; Fan et al., 2003; Nee et al., 2007; Wittfoth et al., 2009).

Also TMS has been shown to influence the Flanker task (not in combination) if applied to the primary motor cortex (Soto et al., 2009; Verleger et al., 2009) and the dorsomedial prefrontal cortex (Taylor et al., 2007).

If a conflict can be independently observed and specifically manipulated, this would firmly support the theory of parallel, domain-specific resolution of conflict.

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