

Investigating Executive Control Networks with a Stimulus Onset Asynchrony Manipulation in the Stroop Task

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INTRODUCTION

Executive Control

• Domain-general and domain-specific recruitment of prefrontal cortex, parietal lobes (angular gyrus), and subcortical areas (caudate, putamen, thalamus) based on task, type of conflict, and mechanism of conflict processing (Niendam et al., 2012).

- 1) Anterior cingulate cortex (ACC): Implicated in conflict detection (Botvinick et al., 2001) or regulation and selection for action (Roelofs et al., 2006). Sensitive to the amount and nature of conflict (MacDonald et al., 2000; Barch et al., 2001).
- 2) Dorsolateral prefrontal cortex (DLPFC)/middle frontal gyrus (MFG): Involved in cognitive control/conflict resolution (Botvinick et al., 2001).
- 3) Left inferior frontal gyrus (LIFG): Involved in suppression of irrelevant information (Ye & Zhou, 2009).

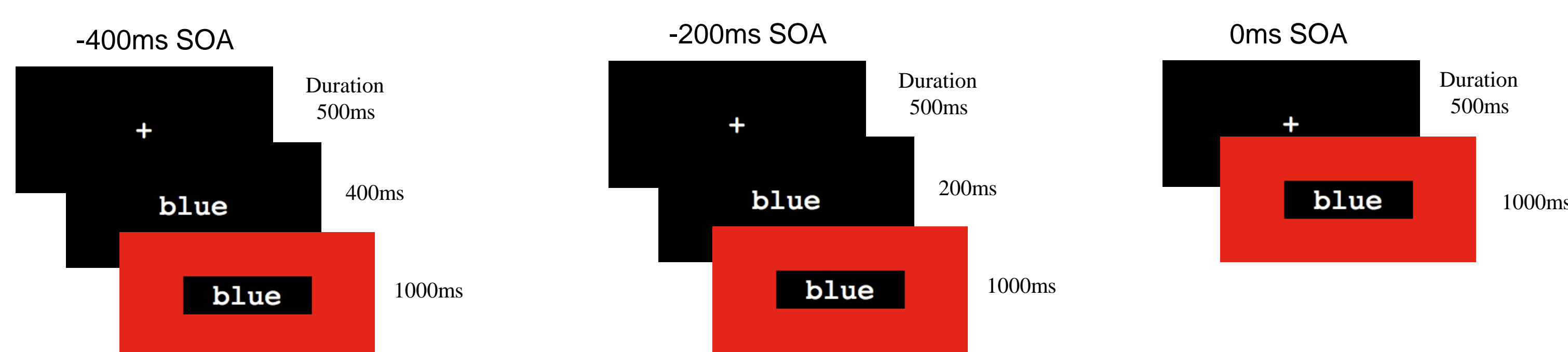
SOA manipulation in the Stroop task

- Pre-exposing distractors (e.g. the word, in a color-naming Stroop task) modulates the amount of conflict (Coderre et al., under review; Appelbaum et al., 2009).
- Strongest interference at -200 ms SOA (word pre-exposed 200 ms before color), strongest facilitation at -400 ms SOA.

Question: How does SOA manipulation in the Stroop task modulate the recruitment of the executive control network?

METHODS

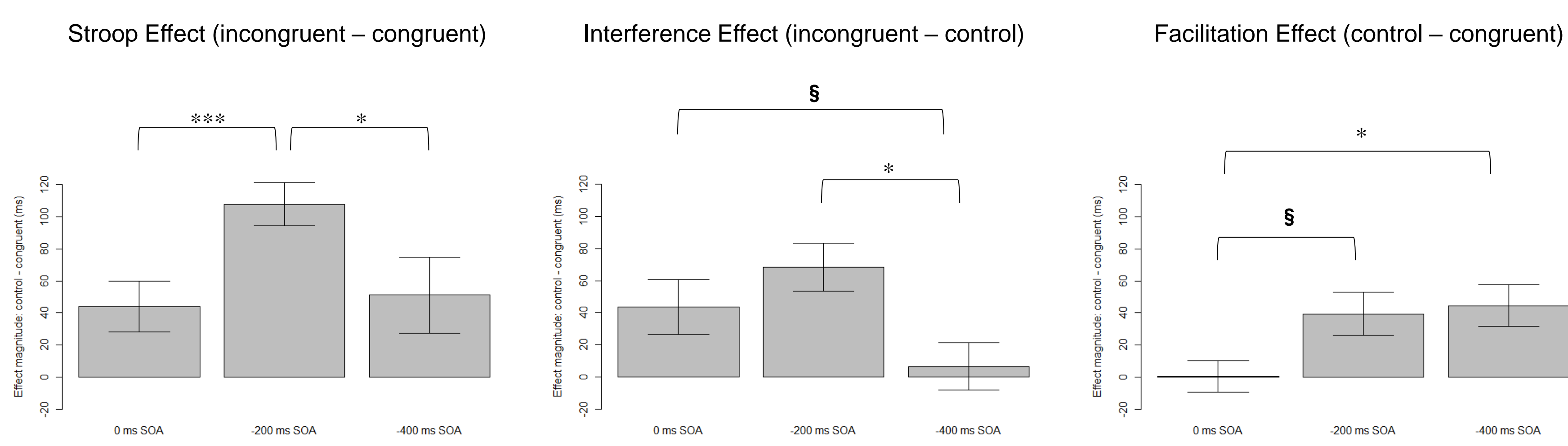
- 14 native English speakers (7 females), mean age 25.4 (4.4)
- Color-naming Stroop task
- Three SOAs: -400, -200, 0 ms
- 120 trials total: 30 incongruent, 30 congruent, 30 control (%%%)
- Philips Achieva 3T, TR 2500, TE 40 ms, voxel size 3x3x3, 38 slices, no gap, FOV 240mm, matrix size 80x80.
- SPM8, Marsbar, WFU Pickatlas
- All analyses at $p < 0.001$ uncorrected, cluster threshold 20 voxels.



BEHAVIORAL RESULTS

Behavioral Results

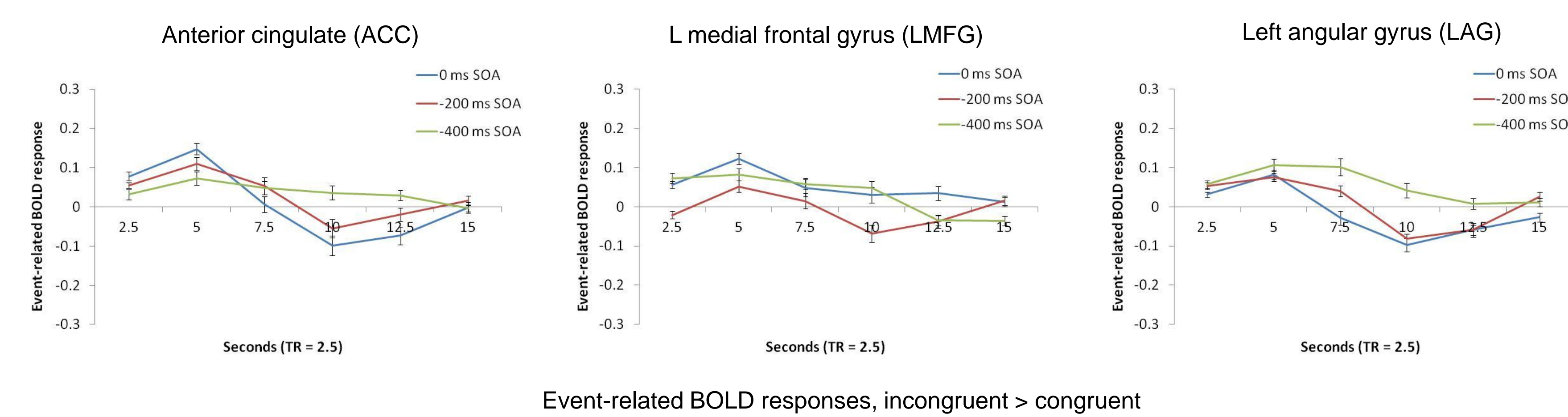
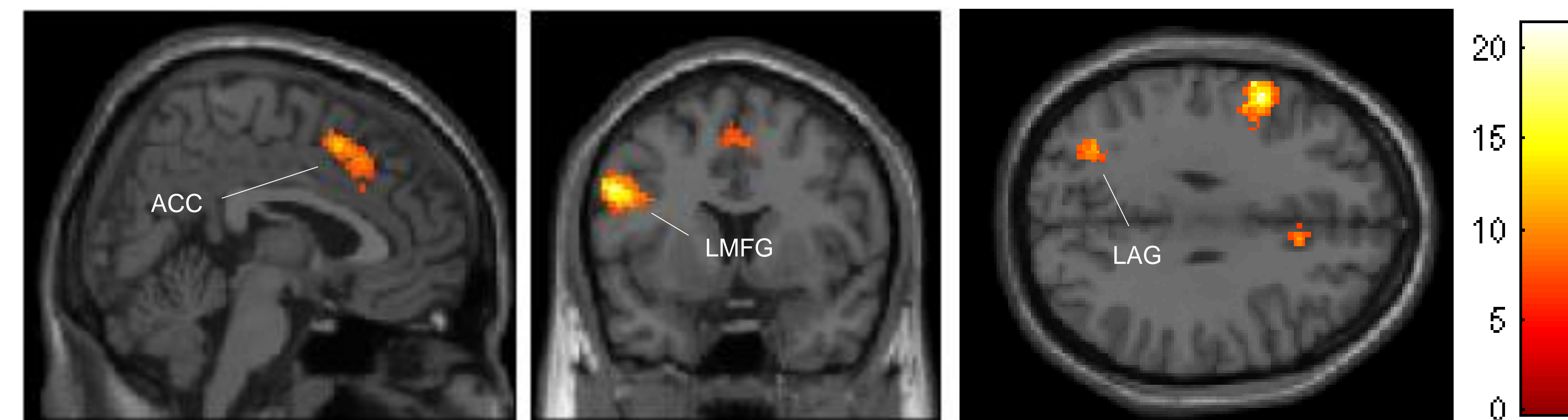
- Largest interference effects in the -200 ms SOA
- Largest facilitation effects in the -400 ms SOA



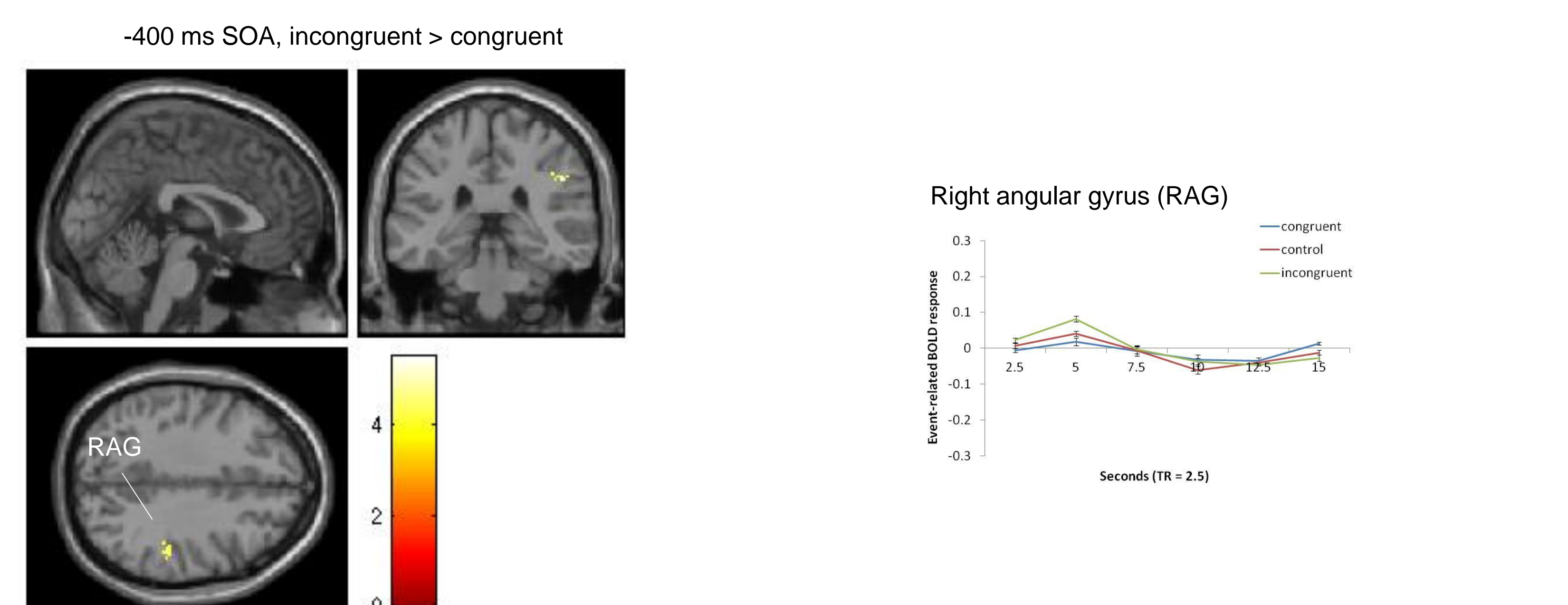
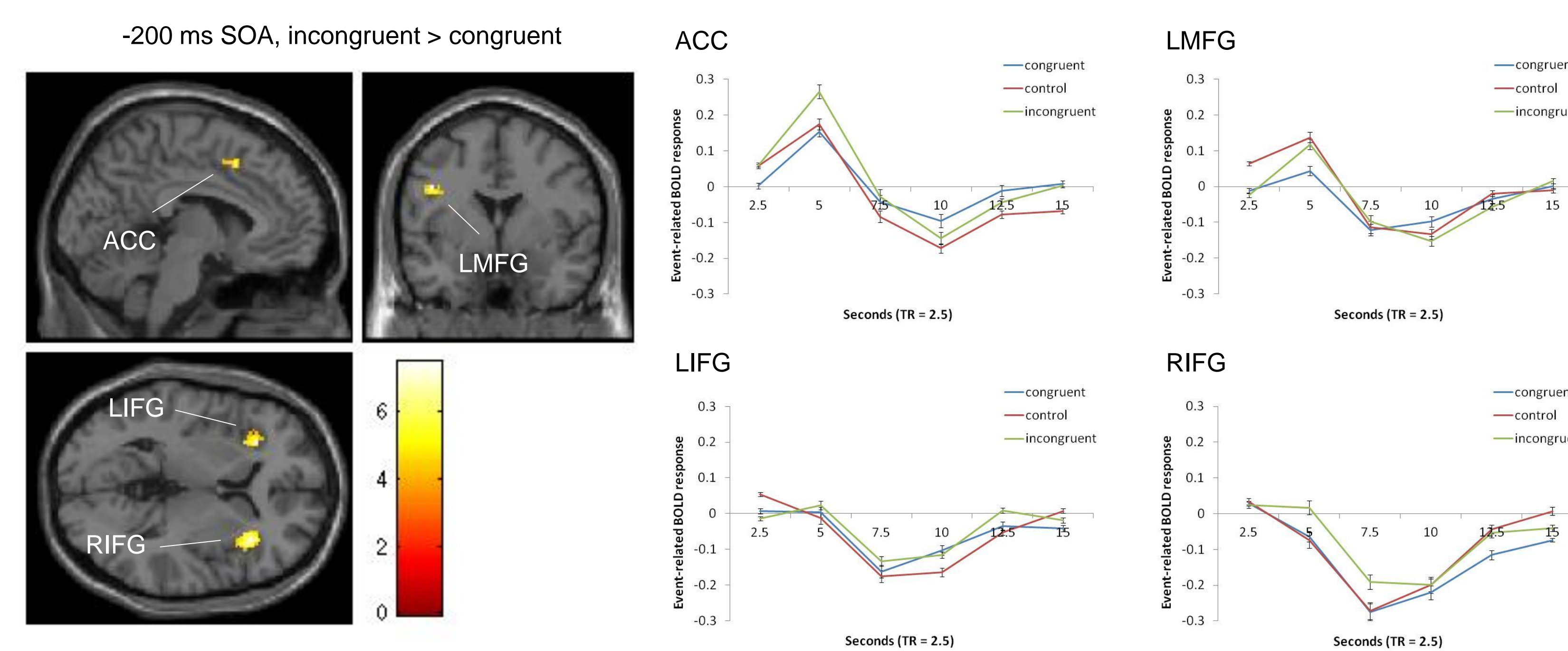
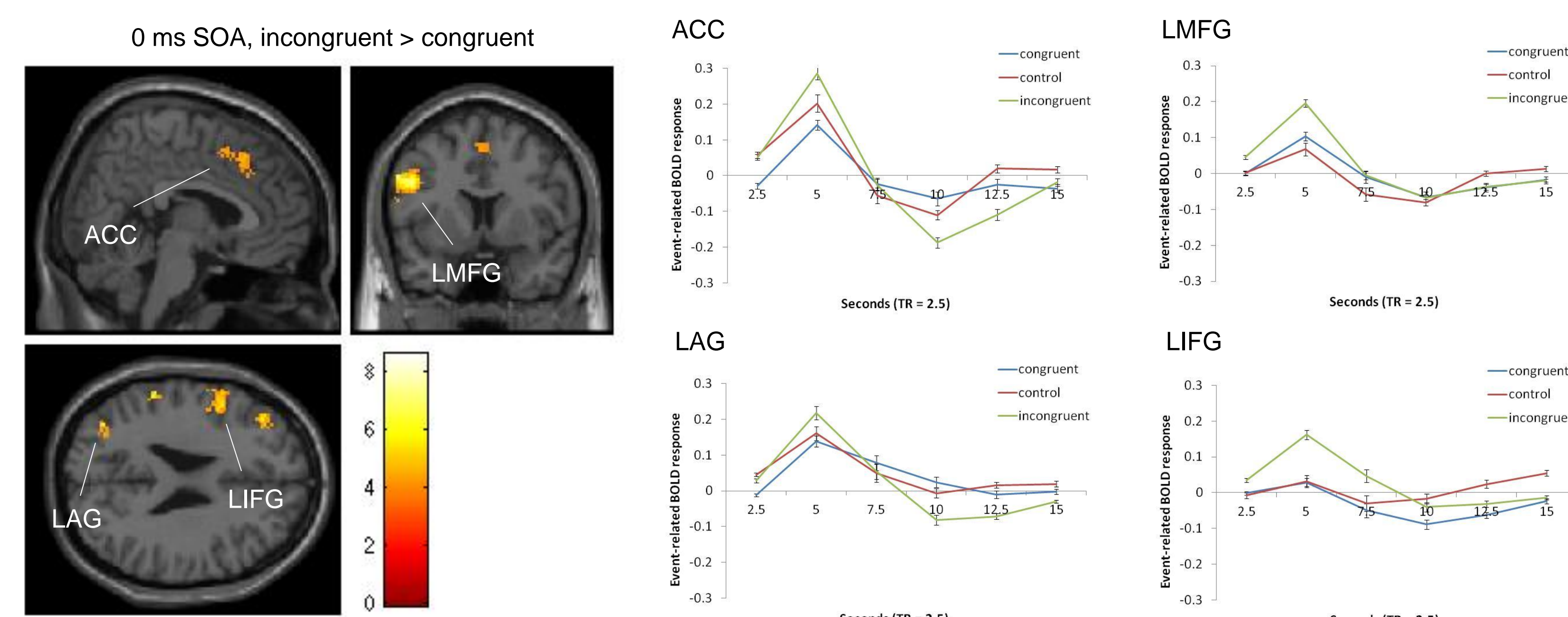
fMRI RESULTS

Main effects of conflict

- Incongruent > congruent (data collapsed across SOA)



SOA-specific conflict processing (incongruent > congruent)



DISCUSSION

SOA-general conflict processing in the ACC and LMFG

- More activation for 0 ms SOA than -200 ms SOA in both areas
- Negative correlation with BOLD activity and behavioral interference
 - 0 ms SOA: increased response in ACC and LMFG → decreased behavioral interference
 - -200 ms SOA: short pre-exposure of the word disrupts conflict processing → less recruitment of ACC and LMFG → increased behavioral interference

SOA-specific recruitment of additional areas

- Left inferior frontal gyrus (LIFG):
 - Active in both 0 ms and -200 ms SOAs
 - Slightly different distributions across SOA
 - Larger extent of activation in 0 ms SOA suggests greater conflict resolution by suppression of word information (Ye & Zhou, 2009).
- Right inferior frontal gyrus (RIFG):
 - Active in -200 ms SOA only
 - Involved in inhibitory control and response inhibition (Aron et al., 2004)
 - Suggests that pre-exposure of the word primes semantic activation/response selection, which must then be inhibited (Appelbaum et al., 2009).

- Left angular gyrus (LAG):
 - Active in 0 ms SOA only
 - Involved in 'sustained activation of competing responses' during response selection (Bunge et al., 2002).
 - In high-conflict conditions (i.e. 0 ms SOA), LAG keeps competing responses active while conflict resolution processes select the appropriate response.
- Right angular gyrus (RAG):
 - Active in -400 ms SOA only
 - Involved in visuospatial attention and orienting (Rushworth et al, 2001; Corbetta et al., 1993)
 - Greater attention to color target stimulus in incongruent condition?

CONCLUSIONS

Overall, similar brain areas are recruited to deal with conflict (ACC and LMFG), but the extent of activation is modulated by SOA.

Conflict processing in the 0 ms SOA relies more on suppressing the distracting information (more LIFG activity). In the -200 ms SOA, pre-exposure of the word primes semantic activation and response preparation, which must then be inhibited (more RIFG activity).

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