A Distributed Network for Emotional and Non-Emotional Conflict Processing

Matthew Mian MD; Emad N. Eskandar MD
Department of Neurosurgery, Massachusetts General Hospital
Harvard Medical School, Boston, MA

CNS 2016 ANNUAL MEETING
San Diego CALIFORNIA
SEPTEMBER 24-28, 2016

Introduction

'Conflict' arises when incompatible response tendencies compete. Prior work has established roles for the anterior cingulate cortex (ACC) and dorsolateral prefrontal cortex (DLPFC) in detecting (1) and resolving conflict (2), respectively. Recent functional imaging studies have also posited a separate pathway involving the amygdala for processing conflict with emotional content (3), but an electrophysiologic account is lacking.

Methods

Human subjects (n=8) who underwent stereotactic depth electrode insertion for epilepsy performed a non-emotional and an emotional conflict task (Multi Source Interference Task and Emotional Conflict Resolution task, respectively) as we recorded local field potentials (LFPs) in the ACC, DLPFC, and amygdala. The tasks permitted the dissociation of neural selectivity for (1) conflict, (2) level of cognitive control, and (3) emotional valence.

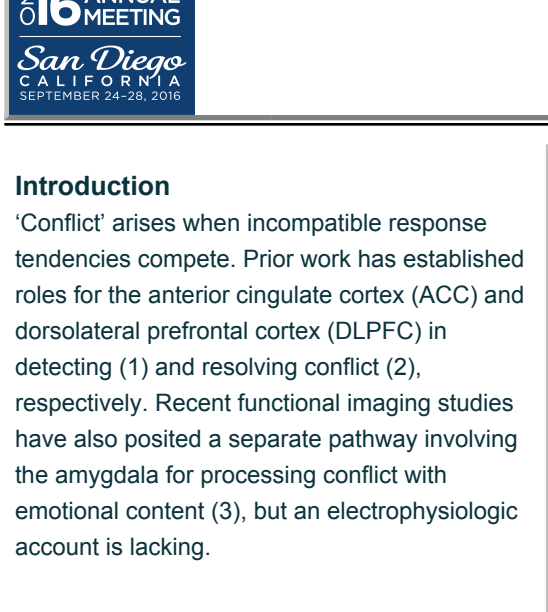


Fig 1. Behavioral tasks. In each trial (upper), subjects respond via button press to a stimulus either consisting of an array of three numbers (non-emotional task, 'MSIT') or a face with superimposed label (emotional task, 'ECR'). In each of the two tasks (lower panel) trials are either congruent (C) or incongruent (I).

Results

Subjects performed the non-emotional and emotional conflict tasks accurately (98% vs 97% of trials correct) and demonstrated expected conflict-induced response slowing ($p<1x10-20$ for each). LFPs across the three recording sites indicated robust task-related activity.

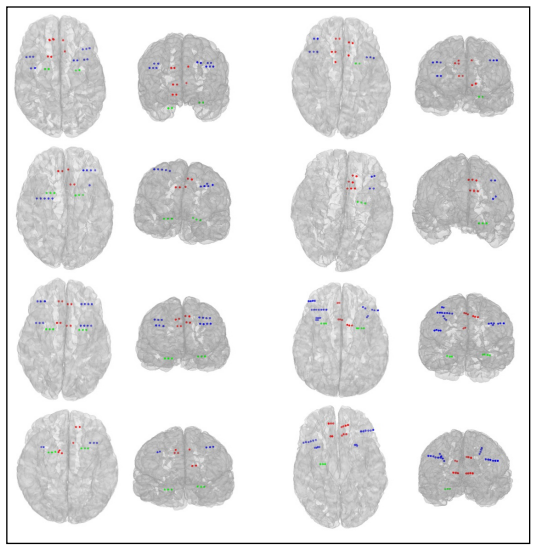


Fig 2. Subject recording locations. Red = ACC, green = amygdala, blue = DLPFC.

In the non-emotional task, most ACC and DLPFC sites were sensitive to both conflict and cognitive control during the stimulus epoch (ACC: 72% vs 51%, DLPFC: 66% vs 59%), with ACC selectivity arising preferentially in the left hemisphere ($p=0.007$). LFPs in the amygdala also registered both conflict and cognitive control (42% vs 46% of sites).

In the emotional conflict task, the ACC and DLPFC again signaled conflict and cognitive control (ACC: 50% vs 50%, DLPFC: 51% vs 39%). The amygdala was similarly active (41% of sites detecting conflict, 41% indicating level of control, the latter almost exclusively on the left; $p=0.001$). Of note, the amygdala was more sensitive to emotional valence than either conflict or cognitive control (74% of sites, $p=0.02$).

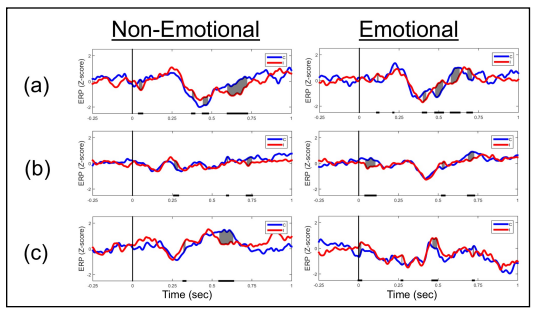
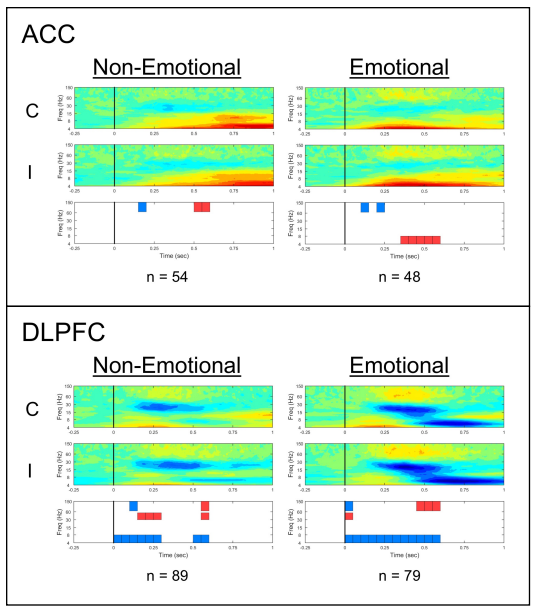


Fig 3. Averaged ERPs for (a) ACC, (b) DLPFC, and (c) amygdala for non-emotional (left) and emotional (right) tasks. Blue = congruent; red = incongruent. Shaded regions denote statistical significance between conditions.

We examined power spectra to further elucidate the dyanmics of conflict processing. Of particular interest were the theta, gamma, and high gamma bands. Composite spectrograms (**Fig 4**) demonstrate similar site-specific power profiles.

ACC sites tended to demonstrate prominent increases in theta power. DLPFC contacts consistently showed increase high gamma power. Most amygdalar contacts were quiet relative to baseline.



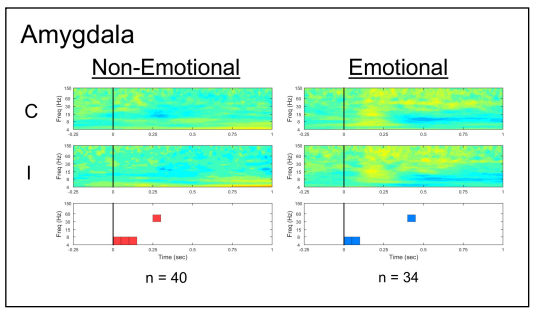


Fig 4. Spectrograms by site, task, and congruency. Scaled in dB relative to 0. Bottom panels denote time windows in the theta, gama, and high gamma bands where power spectra differed significantly between conditions, with red boxes indicating I > C power, and blue I < C.

Conclusions

Our findings support a distributed network for conflict detection and resolution that is less modular than suggested by existing models. Evoked potentials and power spectra reveal similar dynamics between the emotional and non-emotional contexts in the examined sites. As gauged by evoked potentials, the amygdala indeed registers emotional conflict, but it is at least as sensitive to non-emotional conflict and even more responsive to emotional valence.

Learning Objectives

By the conclusion of the session, participants should be able to: (1) define cognitive conflict and distinguish between emotional and non-emotional conflict, and (2) outline the circuit for conflict processing.

References

1. Sheth SA, Mian MK, et al. Human dorsal anterior cingulate cortex neurons mediate ongoing behavioural adaptation. *Nature.* 2012;488(7410):218-221.
2. MacDonald AW, Cohen JD, et al. Dissociating the role of the dorsolateral prefrontal and anterior cingulate cortex in cognitive control. *Science.* 2000;288(5472):1835-1838.
3. Etkin A, Egner T, et al. Resolving emotional conflict: a role for the rostral anterior cingulate cortex in modulating activity in the amygdala. *Neuron.* 2006;51(6):871-882.