

# TIME COURSE OF MONITORING AND RESOLVING CONFLICT

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## Abstract

The role of prefrontal cortex and the anterior cingulate in resolving conflict has been a topic of great current interest. In order to understand the time course of these activations we used a version of the flanker task in a high density ERP study. We found that activity of a generator in the medial frontal (ACC) areas, which was active in our previous fMRI study, responded differently to incongruent compared to congruent trials at about 250-400 ms after input. Analysis of differences between correct and error trials suggest that there is an error-related negativity which peaks very close to the response in the midline electrodes. There was only very weak evidence for a generator in the lateral frontal cortex. Our previous fMRI result suggested that lateral and medial areas worked together to monitor conflict.

## Introduction

According to one view, the anterior cingulate is mainly involved in monitoring conflict while lateral prefrontal areas might act to resolve the conflict perhaps by inhibiting posterior brain areas carrying the conflicting information (Botvinick et al. 2001). We recently reported an event related fMRI study showing that three different conflict tasks activated a common prefrontal and anterior cingulate network (Fan et al. submitted) (See Figure 1).

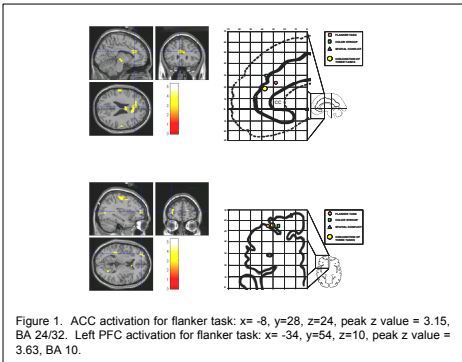


Figure 1. ACC activation for flanker task:  $x = -8, y = 28, z = 24$ , peak  $z$  value = 3.15, BA 24/32. Left PFC activation for flanker task:  $x = -34, y = 54, z = 10$ , peak  $z$  value = 3.63, BA 10.

In order to understand the time course of these activations we have now run some of the same subjects previously studied in fMRI while recording EEG from 128 scalp electrodes. We used one of the three conflict tasks used in the fMRI study that involved a version of flanker task in which a response was required to the direction of a central arrow surrounded by flankers that were either congruent or incongruent.

## Participants

Eight right-handed normal adults (mean age = 30.3 years, SD = 6.7, range:20-36 years; 5 female, 3 male) participated in this study. They were scanned in either a 1.5T or a 3.0T MRI scanner in a previous study while they carried out the flanker task.

## Flanker task

Stimuli consisted of a row of 5 visually presented horizontal black lines, with arrowheads pointing leftward or rightward, against a gray background. The target was a leftward or rightward arrowhead at the center. This target was flanked on either side by two arrows in the same direction (congruent condition), or in the opposite direction (incongruent condition). Participants were instructed to respond with the left button if the central arrow pointed left and the right button if the central arrow pointed right.

## Acquisition of EEG data

The EEG was recorded from 128 scalp sites using the 128 channel Geodesic Sensor Net (Tucker, 1993). All recordings were referenced to Cz. EEG was recorded using a 0.1 – 100 Hz band-pass. The data were re-referenced to an average of all channels and grand average ERP for all 8 subjects was computed.

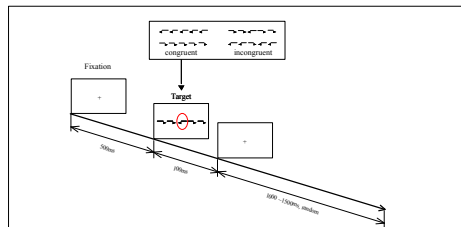


Figure 2. The procedure of the experiment. In each trial, a fixation cross first appears in the center of the screen for 500 msec. Then the target and flankers appeared for 100 msec. Then a post-target fixation cross appeared for a variable duration. The duration between the offset of the target and the start time of the next trial was a random duration (1000 to 1500 msec). The time window for subjects' response was 1000 msec starting from the offset of the target.

## Behavioral Results

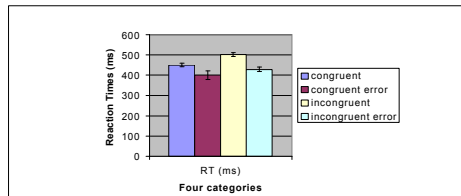


Figure 3. The behavioral results. The mean RT for correct congruent trials was 450 ms and for incorrect congruent trials was 401. The mean RT for correct incongruent trials was 502 ms and for incorrect incongruent trials was 429.

## Methods

## ERP Results

Figure 4-5 show the stimulus-locked ERP for the four categories: congruent, congruent error, incongruent, incongruent error, and the difference between correct incongruent and congruent. Figure 6-7 show the response-locked ERP and ERN.

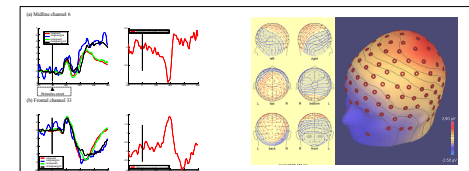


Figure 4 (left). The ERPs from midline channel 6 and frontal channel 33 demonstrating the onset of the difference between incongruent and congruent conditions. The departure starts at about 300ms after the onset of the target and peaks at 372 ms. Figure 5 (right). Spine (0.2 mV/line) and voltage maps at 372 msec after onset of target for the difference ERPs between correct incongruent and correct congruent.

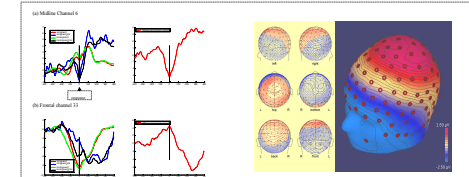


Figure 6 (left). The ERNs from midline channel 6 and frontal channel 33 demonstrating the onset of the difference between incorrect and correct responses. The peak is at about the onset of the response. Figure 7 (right). Spine (0.2  $\mu$ V/line) and voltage maps of ERN at response time point.

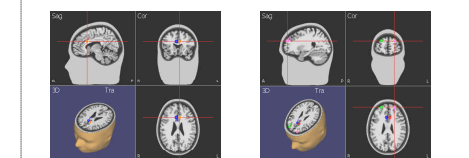


Figure 8 (left). ACC Modeling results for the difference between ERPs of incongruent and congruent conditions (-30 to 30 ms around 372 ms after the onset of target). Two symmetric dipoles were seeded at the ACC. R.V. = 14.215% Best = 11.921%. Figure 9 (right). Two more symmetric dipoles were added at the PFC. R.V. = 10.671% Best = 8.662%. For the ERN (difference between ERPs of incorrect and correct responses, response locked) the model of Figure 8 was tested and it resulted in the best solution (R.V. = 9.219, Best = 6.569, -90 to 90 ms around response). Adding two PFC dipoles, the same as in Figure 9, did not improve the model much, R.V. = 7.767, Best = 5.28.

## Discussion

We examined midline electrode to determine the earliest time when the cingulate area responds differently to the incongruent and congruent trials. We found that the cingulate responded differently to incongruent compared to congruent trials at about 250-400 ms after input and showed a peak difference at about 380 ms or about 70-120 ms prior to the response. Dipole analysis was consistent with the cingulate activation found in the fMRI study.

In a recent article Van Veen and Carter (in press) used a different flanker task to examine ACC activation during conflict and the error related negativity. They also found that incongruent and congruent trials diverged over midline electrode sites at about 380 ms. In their experiment this was during a negative wave (N2). Our localization and time course is similar but in our results the departure comes during a positive deflection.

In our data analysis of differences between correct and error trials suggest that there is an error related negativity which peaks very close to the response in the midline electrodes. Dipole analysis suggested that the generator was similar to that found active in comparison of incongruent and congruent trials. These effects were also quite similar to those reported by Van Veen & Carter.

Overall our results show a likely generator in the ACC but provide only weak support for any independent generator in the lateral frontal cortex. If there is a generator in the lateral frontal cortex, as was found in our previous fMRI result, we cannot reject the hypothesis that its time course is the same as in the ACC

In our previous work (Fan, submitted) we reasoned that if the two brain areas found active in relation to conflict were involved in suppressing conflict we would expect that the need to suppress two different sources of conflict in the same task would cause considerable interference. However, based on previous results in perceptual studies (Duncan, 1980) we reasoned that if the areas were only monitoring conflict there would be little specific interference between different computations performed by this network, and thus we tentatively suggested that the network as a whole (both lateral and medial areas) serves to monitor conflict. The inhibitory operations that suppress conflict may then be in a different area specific for each conflict task.

## References

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