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Anterior Cingulate Cortex and Response Conflict: Effects of Response Modality and Processing Domain

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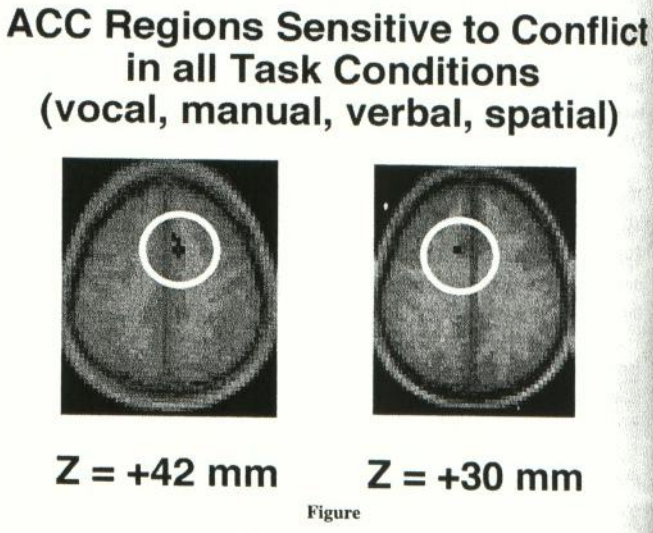
Introduction:

Studies of a variety of higher cognitive functions consistently activate a region of anterior cingulate cortex (ACC), situated posterior to the genu and superior to the corpus collosum. We recently proposed that this region of ACC is active under a range of task conditions because it evaluates the demand for cognitive control by monitoring for the occurrence of response conflict or crosstalk in information processing [1] . A number of studies provide support for this hypothesis [2, 3] . However, an additional question is whether the same ACC region responds to conflict in all response modalities (e.g., both verbal and motor) and/or all processing domains (e.g., verbal and spatial). In previous work, Paus found that inhibition tasks using oculomotor, manual, and speech responses activated slightly different ACC regions [4] . However, this study did not statistically compare activation in the different ACC regions across output modalities. In the current study, we explored this question using fMRI and tasks designed to elicit response conflict (e.g., Stroop), as well as novel methods that allowed us to acquire the content and *reaction times* of both manual and *verbal* responses.

Methods:

Thirteen subjects performed tasks using a factorial design, with two Spatial Stroop tasks (Attend to Location, Attend to Word) fully crossed with two response types (manual, verbal). We used a rapid event related design, with four trial types (fixation, congruent, neutral, incongruent) pseudorandomly interleaved. In all conditions, subjects were presented with a word either to the right or left of a central fixation point. In the location task, subjects were told to respond to the location of the word, and ignore its content. In the word task, subjects were told to respond to the content of the word and ignore its location. A fiberoptic button box was used to record accuracy and reaction time (RT) for manual responses. Verbal responses were acquired through the use of an elastic tube, and a condensor microphone. The signal from the microphone was then split, going both into a taperecorder (to record content) and into a voice-activated response key that recorded the RT. Normally, the noise generated by fast changing echoplanar gradients preclude accurate acquisition of verbal responses. Thus, a quiet interval of 800 ms was interleaved with each frame acquisition. Images were acquired on a Siemens 1.5 Tesla with a standard head coil. Structural images were acquired using a high resolution (1.25 x 1 x 1 mm) sagittal 3-D MP-RAGE T1-weighted sequence. Functional images were acquired using an asymmetric spin-echo echo-planar sequence (TR=2400 ms, Quiet Period=800 msec, TE= 50 ms, flip = 90°). During each run 128 sets of 16 contiguous, 8 mm thick axial images were acquired parallel to the AC-PC plane (3.75x3.75 mm in-plane). The functional imaging data were movement corrected, co-registered, smoothed, and pooled across subjects. Magnitude estimates for each condition were obtained using a General Linear Model, and these magnitude estimates were analyzed using ANOVAs treating subjects as a random effect.



Figure

Results:

We began by looking for ACC regions that displayed significant effects of response conflict (incongruent versus neutral trials) in all four task conditions (vocal and manual responses, location and word tasks). As shown in the Figure, this analysis identified two regions of ACC that demonstrated significant response conflict effects with both vocal and manual responses and with both spatial and verbal processing. One of these regions was centered in BA 32 (X = 7.5 , Y = 9, Z = 42), and the other in BA 24 (X= -10.5; Y= 9, Z= 33). There were no ACC regions that showed a response modality (vocal versus manual) X response conflict interaction, a task (location versus word) X response conflict interaction, or a response modality X task X response conflict interaction. Thus, the results of our study suggest that the same regions of ACC are responsive to conflict arising with both manual and verbal output and with both spatial and verbal processing.

References

1. Botvinick, M.M., T.S. Braver, C.S. Carter, D.M. Barch, and J.D. Cohen, submitted.
2. Barch, D.M., F.W. Sabb, and D.C. Noll, Journal of Cognitive Neuroscience, in press.
3. Carter, C.S., T.S. Braver, D.M. Barch, M.M. Botvinick, D.C. Noll, and J.D. Cohen, Science, 1998. 280: p. 747-749.
4. Paus, T., M. Petrides, A.C. Evans, and E. Meyer, Journal of Neurophysiology, 1993. 70(2): p. 453-469.