Validation of a Modified Stroop Task for fMRI Studies in Patients With Schizophrenia

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Abstract ~ Numerous studies have reported associations between poor performance on neuropsychological measures of executive functions and antisocial behavior. These findings are supported by neuroimaging studies that report prefrontal cortical abnormalities in aggressive subjects. Epidemiological studies indicate that patients diagnosed with schizophrenia perform poorly on executive tasks and are at higher risk for violent behavior than those without mental illness. These data suggest that aggression in schizophrenia may be the result of prefrontal abnormalities, and consequent executive dysfunction. A widely used measure of executive functioning is the Stroop paradigm, which requires frontally-mediated cognitive processes such as response inhibition, interference resolution and behavioral conflict resolution. However, imple-

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mentation of the task, in its traditional form, is problematic for fMRI research. Verbal responses can introduce movement artifacts and the use of covert responses limits evaluation of subjects' performance. In this ongoing study the investigators are validating a modified version of the Stroop task for use in fMRI experiments with violent and non-violent schizophrenic patients and healthy controls. The modified task requires subjects to respond to directional stimuli by means of a 2-choice button press. Verbal and nonverbal stimuli are presented either alone (neutral condition) or together (congruent and incongruent conditions). Preliminary results from 9 patients indicated robust interference effects in terms of both accuracy and reaction time. Final results from patients and controls are presented and their implication for the use of this new test in future fMRI research is discussed. *Schizophrenia Research*, 60 (supl), 122.

Introduction

The Stroop paradigm has been widely used as measure of executive function. Typically, this task requires subjects to name the color of the ink a word is printed in, ignoring the word itself. The task elicits a reliable and robust interference effect: Responses to incongruent stimuli (e.g., "green" printed in red) are longer than those to congruent or neutral stimuli. The interference has been attributed to response competition. Performance on this test has been related to activation in prefrontal cortical regions and in anterior cingulate cortex in healthy subjects (Leung, Skudlarski, Gatenby, Peterson, & Gore, 2000; Peterson et al., 1999; Carter, Mintun, &

Cohen, 1995; Carter et al., 1998). However, for functional neuroimaging studies, the verbal responses required in the traditional Stroop paradigm can introduce movement artifacts. Some researchers have used covert responding to circumvent this problem, but in the absence of objective behavioral measures, it is unclear how activations should be interpreted.

Prefrontal network dysfunction may be specifically associated with a recurrent, impulsive subtype of aggression (Kuruoglu et al., 1996; Volkow et al., 1995; Goyer et al., 1994; Raine, Buchsbaum, & LaCasse, 1997). We were interested in studying prefrontal network function in schizophrenic patients with a history of aggressive behavior and therefore set out to develop a modified Stroop task that would elicit response competition and provide objective measures of task performance without requiring verbal responses.

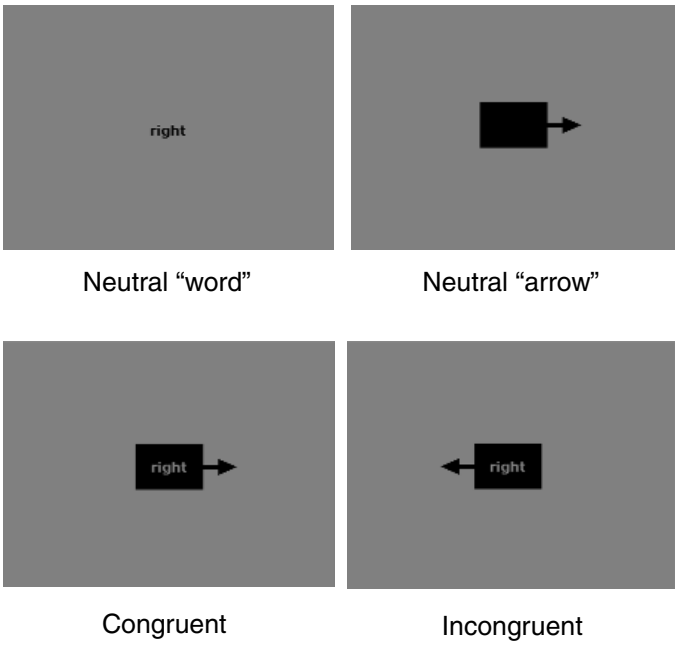
Methods

Task description:

Stimuli consisted of either an arrow (pointing left or right) or the word "left" or "right", either alone (neutral) or in combination. The combined stimuli can be either congruent (word and arrow indicate the same direction) or incongruent (word and arrow indicate different directions). The task was run on a laptop computer. Subjects responded by pressing the left or right button of a two-button mouse. Each test session consisted of 240 trials. (At the beginning of each block of (120) trials, the subject was instructed to respond either to the meaning of the

word or to the direction of the arrow. Within each block, the first 40 trials were "neutral" (word or arrow alone) followed by 64 congruent and 16 incongruent trials (the latter conditions were randomly presented). Order of presentation of arrow and word blocks was randomized.

Figure 1: Illustration of stimuli



Neutral “word” Neutral “arrow”

Congruent Incongruent

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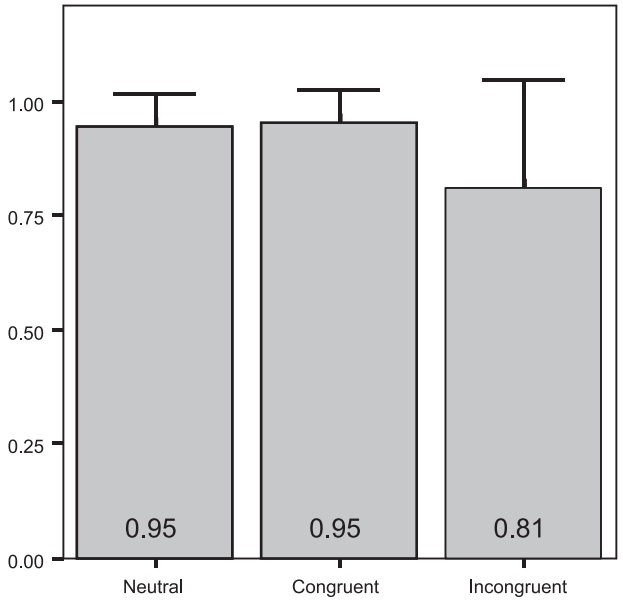
Subjects:
Data were obtained from 43 subjects, 27 patients and 16 controls. Four patients who scored less than 60% correct on either neutral or congruent trials for at least one of the task conditions were eliminated from the analysis. Thus, the analyses below are based on 16 controls and 23 patients (18 schizophrenia; 5 schizoaffective disorder). Patient and control groups did not differ significantly in terms of either sex (5f/18m vs. 8f/8m, chi square=3.39, p=.066) or age (mean age 36.0 vs. 37.3, F=.101, p=.753). All patients were inpatients at the time of their participation and all were medicated. Total PANSS scores at the time of testing ranged from 51 to 112, with a mean of 83.8.

Results

Overall accuracy was good (95% correct overall; 95% neutral, 96% congruent and 81% incongruent trials). Patients performed less accurately than controls (means .87 and .95, respectively; F=16.35, df 1,222 p<.001). Subjects responded more accurately to the direction of arrows than to the meaning of words (mean accuracy .93 for arrows, .89 for words; F=4.57, df 1,222, p=.034). There was a significant effect of condition on accuracy (overall F=20.71, df=2,222, p<.001). Accuracy was lower for incongruent trials than for either congruent or neutral trials (Figure 1). There were no significant interactions between group and task and/or trial type.

Figure 2: Mean accuracy as a function of condition*



* Error bars show Mean +/-1.0 SD
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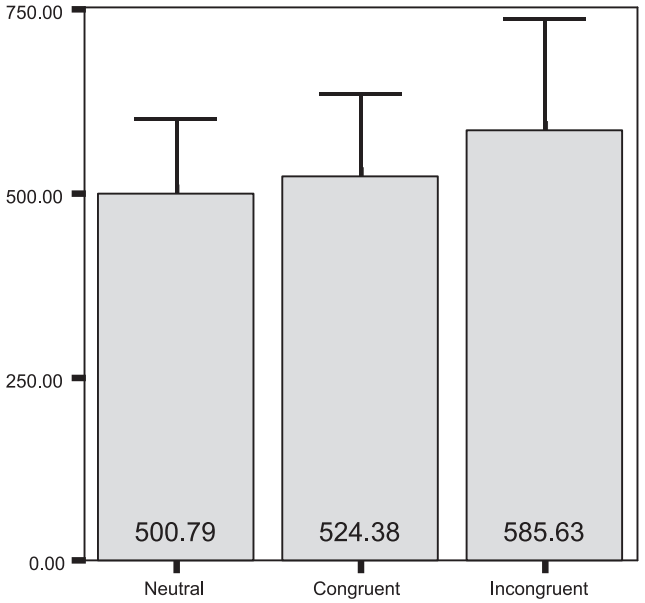
Controls responded more quickly than patients (mean RT 480.34 and 555.63, respectively; F=47.555, df=1,221, p<.001). Responses to arrows were faster than responses to words (mean RT =471.82 and 580.41, respectively; F=66.897, df=1,221, p<.001). There was a significant effect of

Figure 3: Mean RT as a function of condition*



* Error bars show Mean +/-1.0 SD
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condition on reaction time (overall F=14.13, df=2,221, p<.001). Responses to incongruent stimuli were slower than those to either neutral or congruent stimuli (Figure 2). There were no significant second or third order interactions.

Conclusions

The results presented here indicate that this task may be used to induce response conflict similar to that elicited in the traditional Stroop paradigm. It is simple, yet challenging enough to be useful in both schizophrenic and healthy control populations. Although schizophrenic subjects responded more slowly and less accurately than control subjects, there were no interactions between either task or condition and subject group. This indicates that the experimental manipulations affected performance in both groups comparably.

Because this task involves visual stimuli and manual responses, it is well-suited for use in neuroimaging studies. This approach provides objective measures of subjects' performance while reducing the likelihood of movement artifacts. Future studies will employ this task to examine frontal activation in relation to propensity for aggressive behavior.

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