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Shared cognitive processes underlying performance on the Wisconsin Card Sorting Test and the Stroop Test in patients with schizophrenia: A measurement artifact?

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Abstract

We explored the hypothesis that, while sensitive to different aspects of executive functioning in patients with schizophrenia, the Wisconsin Card Sorting Test (WCST) and the Stroop Test also measure the same construct, namely, inhibitory control. Specifically, our goal was to confirm and extend previous findings [A. Rossi, E. Daneluzzo, P. Mattei, M. Bustini, M. Cassachia, P. Stratta, Wisconsin Card Sorting Test and Stroop performance in schizophrenia: a shared construct, Neurosci. Lett. 226 (1997) 87–90] by demonstrating the independence of this construct from other abilities necessary to successfully perform the tasks. More importantly, we sought to improve on this previous study by eliminating the influence of the variance of speed of responding. We examined 55 patients with schizophrenia and initially found that performance on the Stroop Color-Word condition could, indeed, be predicted only by the percentage of perseverative errors on the WCST, and not variables reflective of other cognitive skills, thus replicating and extending previous findings. Once we removed the influence of speed of responding from our measure, however, thus isolating the inhibitory process, this finding disappeared. Therefore, our findings highlight the importance of isolating the individual components of interest from complex measures before drawing conclusions regarding the cognitive processes underlying particular test performance.
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Keywords: Wisconsin Card Sorting Test; Stroop; Executive functioning; Inhibition; Schizophrenia

Impairment in executive functioning is frequently reported in patients with schizophrenia [27] and has received considerable research attention [10]. The term executive functioning, however, is imbued with a multitude of definitions [27]. As such, it is used to refer to a variety of cognitive skills [12], including cognitive flexibility, establishing, maintaining and shifting cognitive sets as a response to changing environmental demands, hypothesis formation and testing, self-monitoring, goal-directed behavior, and the ability to suppress an automatic reaction in favor of a more adaptive one [10,27,32]. Consequently, tests that are considered to be sensitive to deficits in executive functioning may, in fact, be measuring different aspects of this broad skill.

Two widely used tests of executive functioning in schizophrenia are the Wisconsin Card Sorting Test (WCST) [11,13] and the Stroop Color-Word Test [31]. While often used to measure executive functioning in a broad sense, in fact, both of the aforementioned tests are also sensitive to different aspects of this skill. Even within each test, however, different processes may be necessary for successful performance.

Various cognitive processes have been implicated in WCST performance. Traditionally, this test has been used to evaluate cognitive flexibility [34] and is considered to require the contribution of processes such as conceptualizing, creating and testing hypotheses, as well as shifting cognitive set [15]. Since the first publication that investigated the performance of patients with schizophrenia on the WCST [9], a plethora of subsequent studies have confirmed that patients with schizophrenia perform worse on the task than healthy controls overall [8,15,16,18,22,29]. In a factor analytical study [33] of the conventionally used WCST variables [13], the investigators sought to reduce potential redundancy in the variables, while assessing three groups

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(patients with schizophrenia, patients with chronic alcoholism, and healthy controls). Three factors emerged from this analysis: perseveration, inefficient sorting, and non perseverative errors [33], suggesting that WCST performance indeed reflects dissociable cognitive processes. This study also confirmed the test's construct validity in schizophrenia, supporting the hypothesis that WCST performance is selectively sensitive to frontal impairment. More specifically, poor performance of patients with schizophrenia was greatest on the perseveration factor (reflecting difficulty inhibiting inaccurate responding and shifting to the correct mode of responding). Given the richness of information it can provide regarding cognitive processes, it is not surprising that the WCST is perhaps the most widely used test of executive functioning in schizophrenia research [10].

The Stroop Color-Word Test [31] is a classic measure of selective attention [2]. Various formats of this test have been described in the literature. Regardless of the variant that each study adopts, Stroop-type Tests can also be considered interference tasks, since they require the selective processing of incongruent stimuli in the presence of distracters [3] through the active inhibition of automatic responses [27]. In a review of the first 50 years of studies reporting variants of the test, the author evaluated the most prevalent theoretical models purporting to explain the Stroop effect [20]. Whereas the results of several studies conflicted with the most traditional interpretations, namely, models emphasizing the speed of information processing and the continuum of automaticity, he rejected these as inadequate. Instead, he concluded that the parallel distributed processing model [7] accounts best for all the findings in the literature. This model integrates speed of information processing and automaticity theories and expands on them. More specifically, in this model, processing occurs along pathways of varying strength; the strength of the connections is modulated by attention, which is based on task instructions and the nature of the required response. Consequently, successful performance on the Stroop Test requires active selection, and, therefore, in some instances, inhibition, of the features requiring attention in order to produce the appropriate response.

As many studies have demonstrated, patients with schizophrenia generally perform more poorly than healthy individuals on various versions of the Stroop Test [14,16,21,24,23]. A number of studies, however, have reported no difference between patients with schizophrenia and healthy controls with respect to the interference effect [3,5]. Interference refers to the ability to inhibit the tendency to read a word – a presumably automatic response – and, instead, to name the incongruent color in which it is printed. This inconsistency raises questions about the Stroop task versions that are employed, as the results that they generate appear to depend on the particular form of the task rather than a generalizable cognitive process [3].

Given the inferential nature of neuropsychological studies, it is important to tease apart the constituent elements of the cognitive processes under investigation as much as possible in order to more closely approximate the actual point of breakdown. This is particularly critical when investigating broad-based terms and categories of functions, such as executive functioning or even one of its components, namely, inhibitory control. In fact, patients with schizophrenia are known to be impaired in a broad range of functions [4]; this knowledge, however, does little to further our understanding of the actual mechanisms of their dysfunction, not only in various cognitive domains, but, even more critically, in the social and interpersonal arena. Differentiating the various components of the cognitive function under investigation can help to delineate the actual dysfunctional mechanisms that occur in a particular disorder, as well as what they might mean for understanding the pathophysiology of the disorder and may be used with functional neuroimaging studies in the attempt to associate these dysfunctional components/processes with particular neural activity.

In an investigation of the constructs shared by the WCST and the Stroop Test [28], the authors investigated the parameter of inhibitory control in a group of patients with schizophrenia. They reported a significant relationship between the percentage of perseverative errors on the WCST and both the time to completion of the Color-Word condition of the Stroop, as well as the Stroop Interference score. The investigators also reported a relationship between the number of unique errors on the WCST and the number of errors on two conditions of the Stroop (Word and Color-Word). Based on these findings, they concluded that the two tests shared sensitivity to the construct of set shifting and maintenance, which they described as being homogeneous, and which they speculated is independent of the other abilities necessary for successful WCST performance, such as concept formation, planning, and sequencing. They did not, however, demonstrate this differentiation among the various skills needed to perform the tasks, as they did not include variables in their analyses, which reflected these abilities. An additional limitation of this study was related to the nature of the measure of inhibitory control in the Stroop Test, which may be influenced by potential variance in participants' speed of responding.

We undertook the present study in order to replicate and extend the findings reported by Rossi et al. [28]. More specifically, we sought to confirm that the WCST and the Stroop Test measure similar cognitive processes in patients with schizophrenia, as suggested previously, and to identify these processes. In doing so, we first developed a 'cleaner' measure of inhibitory control in the Stroop task by removing the factor of speed of responding from the variable. In addition, we intended to demonstrate that these common processes do not reflect a generalized performance impairment, but that they are, in fact, independent from the other abilities necessary to successfully perform the tasks. We expected that the shared construct in these two tests would be related specifically to inhibitory control, but that performance on the Stroop Test could not be predicted by other aspects of WCST performance, namely, efficiency in learning the WCST, conceptualization or insight into the correct sorting principles, or overall level of performance.

The patients who participated in this study were recruited from the acute ward (all current) and the outpatient service (consecutive admissions) of a university psychiatric clinic. Patients were included if they fulfilled the following criteria: informed consent to participate, Greek as a native language, a diagnosis of schizophrenia according to DSM-IV criteria [1], no comorbid psychiatric disorder, no current or past history of neurological

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