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Cognitive flexibility in autism spectrum disorder: Explaining the inconsistencies?

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ABSTRACT

The Wisconsin Card Sorting Task (WCST) is the only cognitive flexibility task that has consistently shown deficits in individuals with an autism spectrum disorder (ASD). As this is the only task characterized by limited explicit task instructions and a high degree of disengagement required to perform the switch, we hypothesized that cognitive flexibility deficits of individuals with ASD might only become apparent in situations fulfilling these requirements. However, the WCST involves various additional cognitive processes besides switching, making it uncertain whether difficulties are indeed due to cognitive flexibility impairments. The aim of this study was to investigate whether individuals with ASD show cognitive flexibility impairments on a more controlled task-switching variant of the WCST, still fulfilling both requirements. We therefore developed such a task and administered it to 40 high-functioning children with ASD and 40 age- and IQ- matched typically developing controls. As predicted, individuals with ASD made more perseveration errors and had a significantly higher switch cost than typically developing controls, but they performed equally well on the control measures.

1. Introduction

Autism spectrum disorders (ASDs) are early onset neurodevelopmental disorders characterized by a co-occurrence of impairments in social reciprocity and communication, combined with restricted and repetitive patterns of interests and activities (American Psychiatric Association [APA], 2000). These restricted and repetitive behaviors and interests have been proposed to be associated with executive dysfunctions in individuals with ASD (Boyd, McBee, Holtzclaw, Baranek, & Bodfish, 2009; Happé & Ronald, 2008; Hill, 2004; Turner, 1997). Executive functioning (EF) involves goal-oriented planning and regulation of thoughts and actions (Denckla, 1996). It is an umbrella term for several higher-order cognitive functions (Hill, 2004). Pennington and Ozonoff (1996) have outlined six EF domains: inhibition, working memory, contextual memory, planning, fluency (or generativity), and cognitive flexibility (or set-shifting). Of all these EF domains, cognitive flexibility has been most clearly related to repetitive behaviors in ASD (Lopez, Lincoln, Ozonoff, & Lai, 2005).

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Cognitive flexibility refers to "the ability to shift to different thoughts or actions depending on situational demands" (Geurts, Corbett, & Solomon, 2009, p. 74). Although it has been shown that flexibility deficits in ASD do occur and that they are related to repetitive behaviors in ASD (South, Ozonoff, & McMahon, 2007; Yerys et al., 2009), there are many inconsistent findings. Studies investigating cognitive flexibility in natural settings by means of the Behavior Rating Inventory of Executive Function (BRIEF) have shown that people with ASD have problems with flexibility in daily life (Gioia, Isquith, Kenworthy, & Barton, 2002; Mackinlay, Charman, & Karmiloff-Smith, 2006). These flexibility deficits have also been related to the repetitive behaviors typical for ASD (Boyd et al., 2009). However, studies measuring cognitive flexibility in a clinical or research setting have yielded more inconsistent findings.

Table 1 provides an overview of the most commonly used cognitive flexibility tasks in autism research, indicating the number of studies showing deficient versus intact performance in ASD. In a recent review, Geurts et al. (2009) make a distinction between three types of cognitive flexibility tasks: (a) traditional clinical neuropsychological measures, (b) a hybrid neuropsychological/experimental paradigm (i.e., the intra-dimensional/extra-dimensional shift task [ID/ED] of the Cambridge Automated Neuropsychological Test and Battery – CANTAB), and (c) experimental task-switching paradigms. Firstly, the clinical neuropsychological measures are mostly paper-and-pencil tasks, without control stages measuring possible confounding variables. Concerning these measures, all studies using the Wisconsin Card Sorting Task (WCST) have consistently reported deficits in individuals with ASD, whereas the majority of studies using other neuropsychological measures (e.g., the trail making test) reported intact performance. Secondly, the ID/ED shift task is a computerized task that contains several stages measuring possible confounds. Studies using this task also yielded inconsistent findings, with the majority of studies showing intact performance in individuals with ASD (as measured by the number of errors on the ED-shift trials). Thirdly, the experimental task-switching paradigms provide a more controlled measure of cognitive flexibility by allowing the calculation of a switch cost, that is the difference in response time between maintain trials (the sorting rule stays the same) and switch trials (the sorting rule changes) (Geurts et al., 2009). So far, only two behavioral studies have applied such a switch cost paradigm to investigate cognitive flexibility in ASD and both of them reported intact performance in individuals with ASD.

Taken together, the literature on cognitive flexibility in ASD shows two types of inconsistencies. First, there are inconsistencies within a certain measure: studies using the same task can yield different findings. These inconsistencies might be due to differences in participant characteristics like age, IQ, and co-occurring disorders (Geurts et al., 2009; Happé, Booth, Charlton, & Hughes, 2006; Hill, 2004; Russo et al., 2007). Second, there are inconsistencies between measures. Briefly stated, based on measures of everyday behavior and findings from the WCST, there is clear evidence for impairments in cognitive flexibility in individuals with ASD, whereas studies using other cognitive flexibility tasks generally fail to reveal these impairments. This apparent discrepancy between the obvious inflexibility in natural settings and the inconsistent findings on tasks used in clinical or research settings has been referred to as "the paradox of cognitive flexibility in ASD" (Geurts et al., 2009).

In this article, we propose and test an explanation for the inconsistent findings in the ASD literature on the WCST and the other cognitive flexibility tasks used in clinical or research settings.

One explanation entails that deficits on the WCST are not inherently due to cognitive inflexibility, but result from problems with other aspects of the task (like the high social demands, high working memory and generativity load), that are controlled for in other cognitive flexibility measures. This might indeed explain why individuals with ASD show deficits on the WCST and intact performance on more controlled experimental task switching paradigms. However, it does not explain the intact performance on the other clinical cognitive flexibility tasks that also impose high social demands, and/or high working memory and generativity loads (e.g., the modified WCST and the Playing Cards Test from the Behavioral Assessment of the Dysexecutive Syndrome [BADS]; see Table 1). Furthermore, postulating that individuals with ASD have no cognitive flexibility deficits clearly contradicts with the obvious inflexibility they show in daily life.

Given this clear daily life inflexibility of individuals with ASD, we suggest that they do have problems with cognitive flexibility, but that these deficits only become apparent under specific conditions. When closely comparing the WCST with the other cognitive flexibility tasks, it appears that this task differs from the others in at least one of two factors that might be crucial to elicit the cognitive flexibility deficits in individuals with ASD: (a) the degree of explicitly provided task instructions and (b) the amount of disengagement required to perform the switch.

Cognitive flexibility tasks can be categorized according to *the degree of explicitly provided task instructions* by applying a five level taxonomy (see Table 1). At the lowest level (0), no indications are given about the rules that should be applied, nor that a rule switch will occur. At level 1, participants are instructed before the task that a rule switch will occur. At level 2, participants are instructed that a rule switch will occur and they get an explicit warning during the task indicating when they have to switch. At level 3, participants are instructed before the task what rules should be applied and when to switch to another rule. At the highest level (4), a cue is shown on each trial, explicitly indicating which rule should be applied. Based on this classification, the WCST appears to be the only task with the lowest degree of explicitly provided task instructions. On the contrary, the experimental task-switching paradigms are situated on the highest degree, and all other cognitive flexibility tasks somewhere in between. Our concept of 'degree of explicitly provided task instructions' is comparable with that of 'degree of rule constraints' (Ciesielski & Harris, 1997) and 'degree of open-endedness' (White, Burgess, & Hill, 2009). Although these other concepts are broader, we could say that higher degrees of explicitly provided task instructions correspond with higher degrees of rule constraints and lower degrees of open-endedness. Ciesielski and Harris (1997) have already shown that the lower the degree of rule constraints in flexibility tasks, the higher the impairments for individuals