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## Cognitive variability in adults with ADHD and AS: Disentangling the roles of executive functions and social cognition

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### ABSTRACT

Attention-deficit/hyperactivity disorder (ADHD) and Asperger's Syndrome (AS) share a heterogeneous cognitive profile. Studies assessing executive functions (EF) and social cognition in both groups have found preserved and impaired performances. These inconsistent findings would be partially explained by the cognitive variability reported in these disorders. First, the present study explored the inter-individual variability in EF and social cognition in both patient groups. Second, we compared differential characteristics and commonalities in the cognitive profiles of EF and social cognition between ADHD, AS and control adults. We assessed 22 patients with ADHD, 23 adults with AS and 21 matched typically developing subjects using different measures of EF (working memory, cognitive flexibility and multitasking) and social cognition (theory of mind and decision-making). Group comparisons and *multiple case series analyses* (MCSA) were conducted. The between-group comparisons showed an EF deficit in working memory in ADHD and a theory of mind (ToM) impairment in AS. The MCSA evidenced that, compared to controls, ADHD patients had a higher inter-individual variability in EF, while individuals with AS had a more heterogeneous profile in social cognition tasks compared to both groups. Finally, the AS and ADHD groups presented higher task-related variability compared to controls and shared a common heterogeneous profile in EF. This is the first study to compare variability in EF and social cognition profiles of ADHD and AS. We propose that heterogeneity in EF performance is a link between ADHD and AS which may explain the overlap of symptomatology between both diagnoses. In addition, patients with AS seem to show a unique heterogeneous profile in ToM which may explain the low probability of finding AS symptoms in patients with ADHD.

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## 1. Introduction

Attention-deficit/hyperactivity disorder (ADHD) and Asperger's Syndrome (AS) are neurodevelopmental disorders that persist into adulthood with a heterogeneous cognitive profile (Geurts et al., 2008; Happe, Ronald, & Plomin, 2006; Hill & Bird, 2006; Nigg, Willcutt, Doyle, & Sonuga-Barke, 2005; Sonuga-Barke, 2002). Although ADHD diagnosis in patients with AS are part of the exclusionary criteria for AS (American Psychiatric Association, 2000), an overlap of symptoms between both disorders has been extensively reported (Ames & White, 2011; Dickerson Mayes, Calhoun, Mayes, & Molitoris, 2012; Gillberg & Billstedt, 2000; Memari, Ziaee, Mirfazeli, & Kordi, 2012; Rommelse, Geurts, Franke, Buitelaar, & Hartman, 2011; Taurines et al., 2012).

The term executive functions (EF) refers to several higher-order cognitive functions required to goal-oriented behavior (Hill, 2004; Sonuga-Barke, Sergeant, Nigg, & Willcutt, 2008). From a neurocognitive perspective, ADHD and AS share a common executive dysfunction associated with deficits in fronto-striatal circuits (Castellanos & Proal, 2012; Corbett, Constantine, Hendren, Rocke, & Ozonoff, 2009; Cortese et al., 2012; Rommelse et al., 2011). However, studies exploring EF in each group separately have found inconsistent results. Although many reports suggest that ADHD is strongly associated with inhibitory problems, working memory, and planning difficulties (Alloway, 2011; Balint, Czobor, Meszaros, Simon, & Bitter, 2008; Desjardins, Scherzer, Braun, Godbout, & Poissant, 2010; Kofman, Larson, & Mostofsky, 2008; Martinussen, Hayden, Hogg-Johnson, & Tannock, 2005; Nigg, 2005) other studies failed to find deficits across these domains (Nigg, Blaskey, Huang-Pollock, & Rappley, 2002; Sonuga-Barke, 2002). Regarding patients with AS, recent reviews have also shown inconsistent findings on EF measures. Even though planning and cognitive flexibility have been the most robustly reported deficits, results have also been mixed, as some studies did not show any differences (Hill & Bird, 2006; Kaland, Smith, & Mortensen, 2008; Liss et al., 2001; Rajendran, Mitchell, & Rickards, 2005). In addition, recent studies have found that when patients are faced with more ecological tasks designed to evaluate EF (e.g., the Hotel task for multitasking assessment), adults with ADHD (Torralva, Gleichgerrcht, Lischinsky, Roca, & Manes, 2012) and patients with AS (Hill & Bird, 2006) who do not show impairments in traditional tests, do present deficits in this area.

Most studies with children have directly compared EF in ADHD and patients with AS, which indicate that both groups might have a different EF profile (Corbett et al., 2009; Ehlers et al., 1997; Goldberg et al., 2005; Semrud-Clikeman, Walkowiak, Wilkinson, & Butcher, 2010; Sergeant, Geurts, & Oosterlaan, 2002). Happe, Booth, Charlton, and Hughes (2006), reported that EF deficits in children with autism spectrum disorders (ASD), most of whom had an AS diagnosis, were less severe and more prone to improvement over time than in children with ADHD. However, the developmental progression of these neurocognitive abilities in adults remains unknown.

Another important area of study within ADHD and AS is social cognition. This construct refers to information processing related to inter-subjectivity and interactions between co-specifics, including theory of mind (ToM), decision-making, empathy, emotional processing, among others. Although deficits in social cognition were long believed to constitute a core deficit in individuals with AS (Happe, Booth, Charlton, & Hughes, 2006; Happe, Ronald, & et al., 2006), recent studies have also found impairments in ADHD patients (Ibanez et al., 2011; Uekermann et al., 2010). Theory of mind (ToM) is one of the most robustly proven social cognition deficits in patients with AS (Baron-Cohen, Jolliffe, Mortimore, & Robertson, 1997; Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001; Zalla, Sav, Stopin, Ahade, & Leboyer, 2009). However, the selection of a sensitive task to evaluate this function remains controversial. Several studies have reported ToM deficits in AS adults employing the Faux Pas test (FPT; Torralva, Gleichgerrcht, Roca, & et al., 2012; Zalla, Sav, Stopin, et al., 2009), but normal performance using the Reading the Mind in the Eyes test (RMET; Baron-Cohen et al., 1997, 2001; Torralva, Gleichgerrcht, Roca, & et al., 2012). Nonetheless, two studies found impaired performance using the latter (Ponnet, Roeyers, Buysse, De Clercq, & Van der Heyden, 2004; Spek, Scholte, & Van Berckelaer-Onnes, 2010). Regarding individuals with ADHD, prior research has focused mostly on children (Uekermann et al., 2010), finding that ToM deficits are not strongly present in these patients (Geurts, Broeders, & Nieuwland, 2010). To our knowledge, ToM abilities have not been compared between adults with ADHD and patients with a specific AS diagnosis. Nevertheless, there are some comparative studies between patients with ADHD and ASD where no differences between groups were detected (Buitelaar, Swaab, van der Wees, Wildschut, & van der Gaag, 1996; Nyden et al., 2010), and one study showed a selective ToM impairment in the ASD group (Dyck, Ferguson, & Shochet, 2001).

In addition, decision-making is a social cognition domain that is starting to be explored across the ADHD and AS literature. In patients with AS, no deficits in this process have been found (Johnson, Yechiam, Murphy, Queller, & Stout, 2006; Solomon, Smith, Frank, Ly, & Carter, 2011; Torralva, Gleichgerrcht, Roca, & et al., 2012), whereas in ADHD individuals, both impairment (Mantyla, Still, Gullberg, & Del Missier, 2012; Matthies, Philipsen, & Svaldi, 2012) and intact behavioral performance have been reported (Ibanez et al., 2012). Nonetheless, no previous decision-making studies comparing both disorders have been published.

In sum, both EF and social cognition domains have been considered preserved and impaired in individuals with ADHD and AS. One of the facts that could be associated with this inconsistent findings is the cognitive variability reported in both ADHD (Castellanos, Sonuga-Barke, Milham, & Tannock, 2006; Nigg, 2005; Sonuga-Barke, 2005) and AS (Baez et al., 2012; Happe, Ronald, & et al., 2006; Hill & Bird, 2006; Towgood, Meuwese, Gilbert, Turner, & Burgess, 2009). Braver (2012) states that cognitive variability can be differentiated between intra-individual (variability in performance in the same individual on a single test or on multiple tests) and inter-individual or trait-related variation (variability among individuals in the same

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