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Distinguishing between autism spectrum disorder and attention deficit hyperactivity disorder by using behavioral checklists, cognitive assessments, and neuropsychological test battery

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ABSTRACT

Children with attention deficit hyperactivity disorder (ADHD) and autism spectrum disorder (ASD) share many common symptoms, including attention deficit, behavioral problems, and difficulties with social skills. The aim of this study was to distinguish between ASD and ADHD by identifying the characteristic features of both the disorders, by using multidimensional assessments, including screening behavioral checklists, cognitive assessments, and comprehensive neurological battery. After screening for comorbid disorders, we carefully selected age-, sex-, IQ-, and socio-economic status-matched children with typical development (TD). In the Wechsler Intelligence Scale for children, a lower score was observed for the ASD group than for the TD group in Picture concept, which is a subscale of perceptual reasoning. A lower score was shown by the ADHD group than by the TD group in the spatial working memory test in the Cambridge Neuropsychological Test Automated Battery (CANTAB®). Although ASD and ADHD have many similar symptoms, they can be differentiated by focusing on the behavioral and cognitive characteristics of executive function.

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1. Introduction

Children with attention deficit hyperactivity disorder (ADHD) and autism spectrum disorder (ASD) have many common symptoms (Matson and Nebel-Schwalm, 2007), including attention deficit, behavioral problems, and difficulties with social skills. These various overlapping symptoms often complicate a differential diagnosis. Moreover, children diagnosed with ADHD likely show some autistic symptoms and vice versa, which presents a major problem when treating children and adolescents with developmental disorders. Because misdiagnosis leads to misunderstanding of patient symptoms and inadequate or inappropriate treatment; hence, it is important to understand the common and unique symptoms of these disorders, and the assessments that are the most useful in allowing clinicians to distinguish between two disorders.

Executive function (EF) is an overarching term when referring to mental control processes that enable physical, cognitive, and emotional self-control, which are necessary to maintain effective goal-directed behavior. EF generally includes response inhibition, working memory, cognitive flexibility, planning, and fluency. Moreover, they involve multiple distributed neural networks in the thalamus, basal ganglia, and prefrontal cortex. In particular, the prefrontal areas of the frontal lobe are important regions for performing EFs and complex cognitive processes (Alvarez and Emory, 2006). Many studies have suggested that the brain regions that are important for EF are those affected by ASD (Ozonoff et al., 2004; Lopez et al., 2005; Goldberg et al., 2005) and ADHD

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(South et al., 2007; Smith et al., 2013), and this is supported by the fact that deficits in EF are very often seen in patients with neurodevelopmental disorders, including ASD and ADHD. Several studies have proposed that the symptoms of ADHD mainly arise from a primary deficit in a specific EF domain such as response inhibition (Corbett et al., 2009) or working memory (Willcutt et al., 2005), while the symptoms of ASD arise from a primary deficit in planning and flexibility (Sinzig et al., 2008). Therefore, a specific deficit in EF might lead to a characteristic pattern of behavioral symptoms and cognitive features in individuals with both disorders, although we have to consider any shared neurological basis between ASD and ADHD.

To identify distinct domains of EF that underlie the specific deficits seen in ASD and ADHD, several comparative studies have been conducted using EF tests such as the Wisconsin Card Sort Test (WCST) for flexibility, the Tower of Hanoi (ToH) for planning, and the Stroop color-word test for inhibition. However, these studies have focused on only a few specific EF domains (inhibition, planning, set-shifting, and working memory) and have used diversified subjects (e.g., a wide ranging age group, high functioning autism [HFA] vs. Asperger disorder, ADHD vs. typical development [TD]). Because of these limitations, previous findings have yielded inconsistent results. The EF tests used in previous studies might provide inadequate information to conclude which domains of EF are specifically impaired in each disorder. Therefore, it is necessary to examine cognitive function of subjects using a comprehensive neuropsychological battery that can evaluate each EF domain in detail.

The developed computerized EF battery of the Cambridge Neuropsychological Test Automated Battery (CANTAB®) is another method of assessing EF in pediatric clinical populations. Researchers have used the CANTAB® specifically to evaluate EF (Goldberg et al., 2005; Rhodes et al., 2005; Coghill et al., 2007; Gau and Shang, 2010b). The CANTAB® has a number of advantages over other measures of EF as it provides a standard computerized-administration (controlling for variations across examiners), has more than 20 subtests to evaluate EF, is nonverbal, uses a touch-screen response, and provides empirical evidence for the role of prefrontal and medial temporal brain regions in the implementation of the CANTAB® tasks (Luciana and Nelson, 2002). Therefore, it is a suitable test battery for children with developmental disorders.

Recently, Goldberg et al. (2005) examined inhibition, planning, set-shifting, and working memory functions in a sample of children aged 8–12 years with HFA, ADHD, and TD by using the CANTAB®. In the study, the subjects were carefully assessed to screen for comorbid impulsivity or hyperactivity in autism. The study concluded that response inhibition, planning, and set-shifting were similar across the three groups of ASD, ADHD, and TD subjects, and only impaired spatial working memory (SWM) in the ADHD and HFA groups were reported (Goldberg et al., 2005). On the other hand, because rigorous case control studies by using the CANTAB® are rare, confounding evidence has been suggested (Hughes et al., 1994; Kempton et al., 1999).

Few studies have directly compared behavioral symptoms, cognitive features, and EF across ASD and ADHD groups in addition to the age-, sex-, and IQ-matched controls. To the best of our knowledge, this is the first CANTAB® study implemented using multidimensional assessments with vigilant case control. The aim of this study was to distinguish between ASD and ADHD by identifying characteristic features of children with these disorders, by using multidimensional assessments: various screening behavioral checklists, cognitive assessments, and comprehensive neurological test battery. We carefully assessed potential participants to screen out comorbid ADHD symptoms in ASD and comorbid ASD symptoms in ADHD. Additionally, we selected normally developing children as a control group to avoid the effects of sample bias. To measure children's cognitive abilities, we chose four tasks from the CANTAB® that, according to previous research, showed promise for distinguishing between ASD and ADHD: rapid visual information processing, spatial working memory, delayed matching to sample, and spatial span. The results obtained in this experiment were interpreted in detail based on the framework of cognitive psychology.

2. Methods

2.1. Participants

Participants in this study included 11 children with high functioning (IQ > 75) ASD, 15children with ADHD, and 19 children with TD. The demographic information for the groups is provided in Table 2. All children with ASD and ADHD were treated as outpatients at the Hiratani Pediatric Clinic (HPC), which is one of the largest clinics for children with developmental disorders in Japan. In the HPC, in addition to medical treatment, individual educational classes and group psychotherapy are provided by speech therapists and clinical psychologists. The participants were required to be free of any medications resulting in active central nervous system except for methylphenidate. All patients were required to be off medication for at least 24 h prior to the administration of the experimental tasks. This period is considered sufficient to ensure full washout. Furthermore all participants were required to have an IQ of 75 or more. Participants with known medical causes of autism, including fragile X syndrome and tuberous sclerosis, and those with other neurological disorders, including epilepsy, were excluded from the study.

Age and sex matched TD compared children who had received treatment for allergy and common cold as outpatients were also recruited from the HPC. Children were not included if they had any psychiatric diagnosis or family history of social or attention related problems. To exclude any psychiatric diagnosis including suspected ADHD or ASD, all TD subjects underwent an extensive child psychiatric examination, conducted by an experienced child and adolescent psychiatrist according to DSM-IV-TR criteria.

The ASD group comprised 11 boys with a formal diagnosis of either high-functioning Autistic disorder or Asperger's disorder. In each case, the diagnosis had been made by more than two expert child psychiatrists and pediatricians according to established criteria (DSM-IV-TR) (American Psychiatric Association, 2000). Children were excluded if they had been diagnosed with either ADHD or Hyperkinetic Disorder. Furthermore, all subjects in the ASD group met the full DSM-IV-TR criteria of high-functioning autistic disorder or Asperger's disorder, and were excluded if they had even sub-threshold ADHD characteristics. To make a definitive diagnosis, other psychiatrists or pediatricians and clinical psychologists who had handled their therapy confirmed the diagnosis based on clinical observation.

The ADHD group comprised 13 boys and 2 girls with a formal diagnosis of ADHD. The diagnosis was based on (DSM-IV-TR) (American Psychiatric Association, 2000) criteria. Children were excluded if they had additional disorders such as pervasive developmental disorder, Tourette syndrome, obsessive-compulsive disorder, or conduct disorder. Moreover, subjects with any ADHD symptoms were excluded from this group. As previously mentioned, psychiatrists, pediatricians, and technical professionals involved in the care of the subjects made the final diagnosis.

All participants lived near the HPC and did not receive any public assistance. Additionally, none of the children had experienced parental divorce or any form of maltreatment, suggesting that they shared common socio-economic status.

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