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Review

Working memory and autism: A review of literature

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ABSTRACT

Research studies that evaluated working memory with students with autism and other disorders were reviewed and summarized. Results suggest that persons with autism score lower on measures of working memory than do typical controls especially on tasks that require cognitive flexibility, planning, greater working memory load, and spatial working memory, and with increasing task complexity and in dual task conditions. Lower scores in verbal working memory were associated with greater problems in adaptive behavior and more restrictive and repetitive behavior. Children with autism were as likely as typical children to employ articulatory rehearsal (verbal WM). The format of WM tasks may determine whether or not performance is impaired. Implications for educational practice and future research are discussed.

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1. Introduction

Current definitions of Autism Spectrum Disorders (ASD), as those first described by Kanner (1943), include students who Exhibit (1) social/communication deficits, and (2) fixated interests and repetitive behaviors (American Psychiatric Association, 2013). Additionally, in their textbook description of children with Autism, Scott, Clark, and Brady (2000) included challenges in cognitive and executive abilities. Numerous investigations have focused on social, language, and behavioral characteristics of children with autism. Fewer studies have explored the cognitive functions and executive

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abilities of this group. Working memory is a cognitive function/executive ability that has implications for social, behavioral, and academic performance; it is an important component of numerous educational tasks.

Working memory (WM) has been defined as the process by which information is stored and processed mentally (Baddeley, 1986). The most frequently used model of WM was presented by Baddeley who stated that WM consists of multiple components: (a) the *phonological loop*, which is responsible for maintaining speech-based information; (b) the *visuo-spatial sketchpad*, that functions in storing material by its visual or spatial features (Gathercole, Pickering, Ambridge, & Wearing, 2004); and (c) the *attention component*, that allows maintenance of task relevant focus, processing capabilities, and self regulation in the presence of external or internal distractions (Wolf & Bell, 2007). These components of WM that provide the ability to mentally hold and process information have been considered essential for daily activities such as planning, organization, cognitive flexibility (for reviews see Baddeley, 1986, 1992), and the learning of skills such as reading (Bayliss, Jarrold, Gunn, & Baddeley, 2003), comprehension (Friedman & Miyake, 2004), arithmetic (DeStefano & LeFevre, 2004), and problem solving (Beilock & DeCaro, 2007).

A recent review of the implications of WM deficits stated that the majority of children with poor WM are slow to learn in the areas of reading, math, and science, across both primary and secondary school years. These students have difficulties in following instructions, with learning activities that require both storage and processing, with place-keeping, and appear to be inattentive, to have short attention spans, and to be distractible (Gathercole, 2008). Thus, deficits in WM are closely associated with learning deficits observed in daily classroom activities. To this end, researchers have suggested that without early intervention, these deficits cannot be overcome and will continue to reduce the likelihood of academic success (Alloway & Gathercole, 2006).

WM deficits in individuals with Autism Spectrum Disorder (ASD) appear to result in numerous problems associated with behavior regulation, cognitive flexibility, abstract thinking, and focusing and sustaining attention (Hughes, Russell, & Robbins, 1994; Ozonoff & McEvoy, 1994; Ozonoff, Pennington, & Rogers, 1991). However, previous research has been inconsistent and inconclusive on identifying the factors that influence WM performance or its academic implications for individuals with ASD. This is possibly due to the large variation in the characteristics of individuals with ASD and the implications of these characteristics on the WM assessment procedures.

Primarily, there are two subgroups of individuals with ASD, those that coexist with intellectual disability, and those with average or above average intellectual functioning. Individuals with ASD with average or above average functioning include those who are diagnosed with High Functioning Autism (HFA) or those with Asperger's (ASP), and their characteristics vary in terms of social, linguistic, and cognitive abilities from individuals with ASD who have intellectual disability. Koyama, Tachimori, Osada, Takeda, and Kurita (2007) compared the performances of individuals with ASP with higher (mean full-scale IQ, 98.3) and participants with HFA with lower (mean full-scale IQ, 94.6) intellectual functioning on the Wechsler Intelligence Scales and autism rating scales, and found that, consistent with previous studies, their participants with ASP had higher verbal IQ and scored significantly higher than participants with HFA on verbal subtests of Vocabulary and Comprehension, although neither group of participants in this study had below average IQ.

Although we have glimpses of the cognitive performances of children with ASD from these intelligence tests, many questions remain unanswered. Without fully understanding the cognitive challenges faced by individuals with Autism Spectrum Disorders (ASD) we are challenged in developing educational interventions. How do students with ASD perform on WM? How does their performance compare to children with other disabilities that also show difficulties in WM, such as those with ADHD, Tourette Syndrome, and intellectual disability? The information about WM is important for researchers to develop interventions that can better target the challenges for this population. Therefore, the purpose of this review is to evaluate existing WM research on individuals with ASD within the context of individual existing characteristics with linguistic and cognitive challenges.

2. Method

To search for articles for this review, we accessed the databases Academic Search Premier, ERIC, and Psych Info. We utilized the search words "Autism," "Asperger's," "Pervasive Developmental Disorders," "High Functioning Autism," "Working memory," "spatial working memory," and "auditory working memory." Research studies were included in this review if they were (a) published in peer-reviewed journals in English, (b) included individuals with ASD, Asperger's Syndrome, or High Functioning Autism, and (c) included experimental or quasi experimental methodologies that evaluated WM. We also included articles that had test results from the working memory subtests from the Wechsler Intelligence Scale for Children (WISC-III and IV). Both computer and hand searches were conducted to locate articles that met these criteria. We excluded studies that exclusively evaluated working memory using medical procedures, such as fMRI scans.

This search produced 24 studies that evaluated WM performance for individuals with ASD. The articles were obtained from 11 different journals and were published between 1996 and 2013. Twenty of the studies assessed child and teenaged populations. Four studies assessed adult populations and one study assessed both child and adult populations.

2.1. Participants and setting

The 24 studies that evaluated WM with individuals with ASD classified their participants into three main categories – HFA, ASP, and autism. The participants were diagnosed based on their ratings on one of the following instruments: the