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# Further analysis of the effects of positive reinforcement on working memory in children with autism

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ABSTRACT

Individuals with autism spectrum disorders (ASD) often exhibit impaired executive function (EF) performance, including difficulty with working memory (WM), in particular. While research has documented the existence of these deficits, surprisingly little research exists that evaluates potential treatment strategies for improving EF or WM. One exception is a study that used positive reinforcement to improve performance on a classical WM task, the counting span, resulting in both maintenance and generalization (Baltruschat et al., 2011). The current study is the second in a programmatic line of research on behavioral intervention for improving WM in children with autism. This study extended the use of the same procedure (positive reinforcement) to another task which is said to measure WM, a Complex Span, and included three additional children with autism. Results demonstrated significant improvements in performance for each participant, including maintenance and generalization to untrained stimuli and untrained responses. These results provide further evidence that behavioral intervention procedures may be useful for improving skills labeled as EF or WM in children with ASD.



Individuals with autism spectrum disorders (ASD) suffer from impairment in communication and social interaction as well as demonstrate restricted, repetitive and stereotypical patterns of behavior and interests (American Psychiatric Association; APA, 1994). Delays in areas such as cognition, play, daily living skills, and motor development are also common (Tervo, 2003). Impairment in executive function is an additional area of concern with many children with ASD (Hughes, 2001; Ozonoff, 1995; Ozonoff & Jensen, 1999). The term executive function (EF) generally refers to a collection of presumably cognitive processes involved in such things as planning, goal persistency, cognitive flexibility, abstract thinking, rule acquisition, initiating appropriate actions, inhibiting inappropriate actions, and selecting relevant sensory information (Hill, 2004). Given the broad and complex abilities to which the term EF refers, it is not surprising that it is somewhat ill-defined, with no broad-based consensus regarding a definition or model of EF between as well as within various scientific disciplines (Ruble & Scott, 2002).

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Working memory (WM) is a commonly researched component of EF and is said to refer to one's ability to "keep information online" while simultaneously processing it. Most agree that the WM construct consists of several different components, however, there is little agreement on the exact nature and composition of the components (Alloway, Gathercole, & Pickering, 2006). A detailed model of WM describing separate memory systems responsible for the temporary storage of visuospatial and phonological representations was postulated in 1974 by Baddeley and Hitch (Baddeley, 2000). The visuospatial sketchpad, the phonological loop, and the central executive are described as the three main WM components of their system. According to Baddeley, visual information is processed in the visuospatial sketchpad, the phonological loop is responsible for auditory information, and the central executive represents a supervisory system, controlling the flow of information from the other two systems. In 2000, a fourth system, the "episodic buffer," was added, which is said to link visual and auditory information within the correct chronological sequence.

Research on WM in children with ASD has documented deficits across a range of ages and functioning levels (Geurts, Verté, Oosterlaan, Roeyers, & Sergeant, 2004; Ozonoff, 1997; Verté, Geurts, Roeyers, Oosterlaan, & Sergeant, 2006; see Hill, 2004 for a recent review). The central executive component of WM in particular has been shown to be impaired in children with ASD (Ozonoff, Pennington & Rogers, 1991; Prior & Hoffman, 1990; Rumsey & Hamburger, 1988). Shifting between tasks, retrieving new strategies, inhibiting inappropriate reactions, and strengthening selective attention are all included as tasks of the central executive.

Like most cognitive constructs, the presence of WM (and of the central executive in particular) is inferred by measuring performance on tasks that involve overtly observable behavior. One such set of tasks is referred to as "complex span tasks" (Andersson, 2008). Complex span tasks are based on a "dual-task paradigm," combining a memory span measure with a concurrent processing task. They are said to measure a participant's ability to simultaneously store and process information and were developed to prevent the participant from rehearsing the stimuli in order to memorize it (Bull, Johnson, & Roy, 1999; Fournet, Moreand, Roulin, Naegele, & Pellat, 1996). An early complex span task is the so called "reading span," first invented by Daneman and Carpenter in 1980. In reading span tasks, a number of sentences are presented to the participant while the participant is required to memorize the last word of the sentence. The words have to be recalled in the correct order as soon as the last sentence was presented. Each time a sentence is presented, the participant must simultaneously remember the last word of the previous sentence and identify and remember the last word of the current sentence, therefore uninterrupted rehearsal is difficult or impossible (Swanson & Ashbaker, 2000). Another variation of the complex span task, including classification responses as the distracter task, was first developed and experimentally tested by Zoelch, Seitz, and Schumann-Hengsteler (2005). This task involves the presentation of a sequence of visual stimuli and for each stimulus, the participant is asked to emit a classification response according to the function of the object (e.g., "Can you eat it?"). At the end of the sequence of the stimuli, the participant is asked to state the names of the stimuli in the order they had been presented.

While a significant amount of research has documented the presence of EF and WM impairment in individuals with ASD, surprisingly little research has been done on methods for improving it. The small amount of treatment research that exists generally focuses on children with attention deficit hyperactivity disorder (ADHD), fetal alcohol spectrum disorder, or Down syndrome. An early study from 1978 showed that a rehearsal training program effectively improved the mnemonic performance of a child with Down syndrome (Farb & Throne, 1978). Another utilizing rehearsal increased WM span scores in typically developing children (Turley-Ames & Whitfield, 2003). A recent study showed that the performance on neuropsychological tests in EF areas, including WM, increased in children with ADHD by training their selective, alternating, and divided attention (Tamm et al., 2010).

Cognitive constructs in general, and EF and WM in particular, tend to receive little attention in behavior analytic research. Basic researchers conducted a limited number of studies demonstrating that positive reinforcement can affect performance on short-term memory tests with typically developing adults in the 1970's (e.g., Cuvo, 1974; Loftus, 1972) but little work has been published since. Further, little behavioral research has addressed WM, and virtually no research is being done on the application of behavioral principles to WM in clinical populations. It seems likely that this dearth of behavioral research on cognition is partially responsible for the common but false belief that cognitive events cannot (or should not) be studied by behavior analysts. Although this belief remains a common one, it is misguided. Starting in 1945, Skinner described the basic assumptions which forged the philosophical foundation for contemporary behavior analytic psychology, that is, Radical Behaviorism (Skinner, 1945). The core of Radical Behaviorism is the assumption that anything anyone does in interacting with their environment is to be considered behavior, be it overt or covert. Furthermore, all behavior is assumed to be subject to the same basic principles of learning and motivation (i.e., reinforcement, extinction, stimulus control, punishment), regardless of whether it is covert or overt. Thus, mental or cognitive events, insofar as they refer to something a person is actually doing, are not mental or cognitive at all, but are rather "private" behaviors. The only defining difference between public and private events is that public events are amenable to observation by more than one person simultaneously, whereas private events are not (Skinner, 1974).

Approaching WM from a radical behavioral perspective is inherently practical because decades of research on the principles of behavior are already available, all of which is assumed to apply equally to private behavior. This literature should be a rich source of ideas for how research and practical work in the area of WM may proceed. For example, if working memory performance involves behavior, then one should be able to improve working memory performance through the most foundational of behavioral processes: positive reinforcement. Furthermore, it might be pointed out that individuals responding to tests of WM are almost always doing something in addition to merely providing the correct or incorrect answer. That is, there are other behaviors occurring which may affect the probability of the correct response occurring. If