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Auditory and visual sustained attention in Down syndrome

Gayle G. Faught *, Frances A. Conners, Zachary M. Himmelberger

Department of Psychology, University of Alabama, Box 870348, Tuscaloosa, AL 35487-0348, United States

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ABSTRACT

Background: Sustained attention (SA) is important to task performance and development of higher functions. It emerges as a separable component of attention during preschool and shows incremental improvements during this stage of development.
Aims: The current study investigated if auditory and visual SA match developmental level or are particular challenges for youth with DS. Further, we sought to determine if there were modality effects in SA that could predict those seen in short-term memory (STM).
Methods and procedures: We compared youth with DS to typically developing youth matched for nonverbal mental age and receptive vocabulary. Groups completed auditory and visual sustained attention to response tests (SARTs) and STM tasks.
Outcomes and results: Results indicated groups performed similarly on both SARTs, even over varying cognitive ability. Further, within groups participants performed similarly on auditory and visual SARTs, thus SA could not predict modality effects in STM. However, SA did generally predict a significant portion of unique variance in groups' STM.
Conclusions and implications: Ultimately, results suggested both auditory and visual SA match developmental level in DS. Further, SA generally predicts STM, though SA does not necessarily predict the pattern of poor auditory relative to visual STM characteristic of DS.

What this paper adds

This paper adds to the current literature on sustained attention (SA) in Down syndrome (DS) by using solid methodology to both confirm and expand upon past research. Considering methodology, this paper is perhaps among the first to explore SA in DS by comparing youth with DS to typically developing (TD) youth using the sustained attention to response test (SART) paradigm. Further, unlike in some past studies, we explored both auditory and visual SA in DS. This is a particularly important aspect given modality effects in cognitive processing in DS. We also matched groups for nonverbal mental age *and* receptive vocabulary rather than relying on a single matching variable. Considering our results in the context of the literature, the finding that youth with DS performed similarly to TD youth confirmed previous findings that SA is not a particular challenge in DS. This study also expanded upon past research in two ways: (1) by examining the development of SA in youth with DS relative to TD youth through use of cross-sectional trajectories, and (2) by considering how SA might predict short-term memory (STM) in DS. The former was crucial because many cognitive processes develop atypically in DS. The latter was also important, leading to the finding that SA did not predict modality effects in STM that are characteristic of DS but did account for more general variance in STM. This particular finding makes way for important follow-up studies.

* Corresponding author. Tel.: +1 2053485083.
E-mail addresses: eggraham@crimson.ua.edu (G.G. Faught), fconners@ua.edu (F.A. Conners), zhimmelberger@crimson.ua.edu (Z.M. Himmelberger).

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1. Introduction

Down syndrome (DS) is the most prevalent childhood genetic disorder and cause of intellectual disability, occurring in about one of every 691 births in the United States each year (Parker et al., 2010). DS nearly always results from an entire extra Chromosome 21 beyond the usual two in all bodily cells. The result is a variety of physical, health, and cognitive characteristics, many of which present challenges. Among the cognitive characteristics associated with DS are difficulties in language expression and syntax, with relatively better receptive language and vocabulary; limited short-term memory; and limited working memory (see Abbeduto, Warren, & Conners, 2007; Fidler, 2005; Silverman, 2007). In short-term memory (STM; simple short-term storage and retrieval), there is a very distinct discrepancy between the auditory-verbal and visuo-spatial modalities, with severe limitations in the auditory-verbal modality but few limitations beyond developmental level in the visuo-spatial modality. In working memory (storage and retrieval plus simultaneous processing), both modalities are similarly affected (see Conners, Moore, Loveall, & Merrill, 2011).

The current study examined sustained attention (SA) in DS, an aspect of cognition that is essential to higher cognitive functioning, yet has not been studied widely in DS. One goal of the current study was to determine whether SA is among the cognitive challenges or relative strengths associated with DS. Another goal was to determine whether modality affects SA in DS—that is, whether sustaining attention to auditory stimuli is especially challenging to young people with DS compared to sustaining attention to visual stimuli. If this was true, a third goal was to find out if the modality effect in SA explains the modality effect in STM.

2. Sustained attention

SA is the maintenance of cognitive focus on a task or task stimuli for an extended period of time. It underlies nearly all aspects of information processing and thus is a basic requirement for cognitive development. Specifically, auditory SA is the maintenance of attention for information heard (e.g., speech sounds), while visual SA is the maintenance of attention for information seen (e.g., writing on a board). In typically developing (TD) populations, there is high agreement across modalities in SA tasks, suggesting SA is a central construct with the same mechanisms underlying both auditory and visual SA (Seli, Cheyne, Barton, & Smilek, 2012).

SA is measured using a variety of paradigms, including the continuous performance task (CPT) paradigm and sustained attention to response test (SART) paradigm. In the CPT paradigm, participants respond to an infrequently presented target over long periods of time. In the SART paradigm, participants respond to frequently presented *non-targets* over relatively short periods of time (Robertson, Manly, Andrade, Baddeley, & Yiend, 1997). SA tasks generally result in performance declines over time, indicating the duration of SA is limited (see See, Howe, Warm, & Dember, 1995).

Currently, there are two theories that attempt to explain performance lapses in SA tasks: the mindlessness model and resource depletion model. Briefly, the mindlessness model theorizes SA lapses are due to task monotony and lack of exogenous attention support, causing automatic responding and task disengagement (e.g., see Manly, Robertson, Galloway, & Hawkins, 1999). The resource depletion model theorizes SA lapses are due to declines in attentional resources essential to task performance. Specifically, the intensity of SA tasks does not allow for replenishment of cognitive resources, causing fatigue and again task disengagement (e.g., see Warm, Parasuraman, & Matthews, 2008).

Some individuals have more difficulty sustaining attention than others, possibly because of a lack of attentional resources. For instance, individuals with low intelligence tend to show shorter response decrements compared to those with typical intelligence of the same age (Tomporowski & Simpson, 1990). Individuals who have SA difficulties may be inefficient at processing information in their environment. For example, as students they may have difficulty processing information presented in school by their teachers. Given the importance of SA in daily functioning, it is imperative to understand how well SA functions in DS. Better understanding of SA in DS could potentially lead to early intervention and improved functioning.

3. Development of sustained attention

Based on theoretical accounts and factor analytic studies of adults, SA is considered one of three main types of attention, along with selective attention and attentional control (e.g., Mirsky, 1987; Mirsky, Anthony, Duncan, Ahearn, & Kellam, 1991; Posner & Petersen, 1990; Robertson, Ward, Ridgeway, & Nimmo-Smith, 1996). Studies with school-age children have also supported SA as a primary separable component of attention (Kelly, 2000; Manly et al., 2001; Mirsky et al., 1991; but see Wilding, Munir, & Cornish, 2001). Quite possibly, separable attentional components emerge during the preschool period. In two studies of preschoolers, only two attentional factors were found rather than the usual three or four (Breckenridge, Braddick, & Atkinson, 2013b; Steele, Karmiloff-Smith, Cornish, & Scerif, 2012). Breckenridge and colleagues split their preschool sample into younger children (age 3 to 4.5 years) and older children (age 4.5 to 6 years) and found that only younger children showed the two-factor solution, while older children showed a three-factor solution similar to that of school-age children and adults. Interestingly, in this study SA was a separable component even for children age 3 to 4.5 years, reinforcing the notion that it is a fundamental individual difference throughout development. Further, Breckenridge and colleagues reported incremental improvements in SA from age 3 to 4 years and from age 4 to 5 years, though improvements in other attentional measures had different developmental trajectories.