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Sleep problems and recall memory in children with Down syndrome and typically developing controls



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ABSTRACT

Background: Research conducted with typically developing (TD) infants and children generally indicates that better habitual sleep and sleep after learning are related to enhanced memory. Less is known, however, about associations between sleep and recall memory in children with Down syndrome (DS).

Aims: The present study was conducted to determine whether parent-reported sleep problems were differentially associated with encoding, 1-month delayed recall memory, and forgetting over time in children with DS and those who were TD.

Methods and procedures: Ten children with DS (mean age = 33 months, 5 days) and 10 TD children (mean age = 21 months, 6 days) participated in a two-session study. At each session, recall memory was assessed using an elicited imitation paradigm. Immediate imitation was permitted at the first session as an index of encoding, and delayed recall was assessed 1 month later. In addition, parents provided demographic information and reported on child sleep problems.

Outcomes and results: Although parents did not report more frequent sleep problems for children with DS relative to TD children, regression-based moderation analyses revealed that more frequent sleep problems were associated with increased forgetting of individual target actions and their order by children with DS. Evidence of moderation was not found when examining encoding or delayed recall.

Conclusions and Implications: Although group differences were not found when considering parent-reported sleep problems, more frequent sleep problems were positively associated with increased forgetting by children with DS relative to those who were TD. Although future experimental work is needed to determine causality, these results suggest that improved sleep in children with DS might reduce forgetting, ultimately improving long-term recall memory.

What this paper adds

Relative to typically developing (TD) children, children with Down syndrome (DS) more commonly experience sleep problems (Ashworth, Hill, & Karmiloff-Smith, 2013; Austeng et al., 2014; Breslin, Edgin, Bootzin, Goodwin, & Nadel, 2011; Churchill, Kieckhefer, Landis, & Ward, 2012; Cotton & Richdale, 2006; Levanon, Tarasiuk, & Tal, 1999; Maris, Verhulst, Wojciechowski, Van De Heyning, & Boudewyns, 2016) and have difficulty recalling temporal order information over the long term (Blinded for Review, 2016). Despite these findings, minimal research has been conducted documenting associations between sleep and recall memory in

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children with DS. The present research examines associations between parent-reported sleep problems in children with DS and TD children matched on developmental age. The results revealed that sleep problems are preferentially associated with the forgetting of information by children with DS. That is, at higher levels of parent-reported sleep problems, children with DS demonstrated increased forgetting relative to TD children. These findings highlight the need for additional experimental work demonstrating causality, with the long-term goal of developing and implementing interventions that improve sleep and cognitive functioning in children with DS.

1. Introduction

The importance of obtaining adequate sleep for optimal daytime functioning is not contested: in typically developing (TD) samples, sleep problems have been associated with poorer mental and physical health (Stein, Belik, Jacobi, & Sareen, 2008) as well as with impaired cognitive functioning (Beebe, 2011; Curcio, Ferrara, & De Gennaro, 2006). When considering associations between sleep and cognitive functioning in particular, the conducted research has revealed significant associations between sleep and recall memory from infancy to adulthood (for a review, see Kopasz et al., 2010). The work conducted with TD infants and children has indicated that better habitual sleep (Lukowski & Milojevich, 2013) and sleep immediately after learning (Kurdziel, Duclos, & Spencer, 2013; Seehagen, Konrad, Herbert, & Schneider, 2015) is associated with enhanced performance. Less is known, however, about relations between sleep and recall memory in children with Down syndrome (DS). This limited literature is surprising when considering the widespread documentation of sleep problems in children with DS (Ashworth et al., 2013; Austeng et al., 2014; Breslin et al., 2011; Churchill et al., 2012; Cotton & Richdale, 2006; Levanon et al., 1999; Maris et al., 2016) and recent findings indicating that children with DS experience difficulty recalling temporal order information over the long term (Blinded for Review, 2016). The present study was conducted to determine (1) whether parents reported greater sleep problems for children with DS relative to those who were TD and (2) whether parent-reported sleep problems were differentially related to recall performance in TD children and children with DS when considering the encoding, delayed recall, and forgetting of individual elements of events and their temporal order.

Examining associations between sleep and recall memory is particularly important, as the processes associated with encoding and remembering information over the long term are used not only in everyday life but are also required for successful performance in intervention and educational settings. One in every 1000 to 1100 infants born around the world has DS (World Health Organization, 2018), a genetic mutation that results from extra genetic material on the 21st chromosomes. DS is most commonly due to errors in cell division that occur around the time of conception (Antonarakis, Avramopoulos, Blouin, Talbot, & Schinzel, 1993; Sherman et al., 1994; Yoon et al., 1996; for a review, see Sherman, Allen, Bean, & Freeman, 2007) and is the most common genetic cause of intellectual impairment. DS has also been associated with reduced intelligence or IQ, issues with receptive and expressive language, and challenges with particular aspects of executive functioning (see Lukowski, Milojevich, & Eales, 2019). In addition, DS has been associated with specific physical characteristics, including reduced muscle tone and restricted upper airways, that may contribute to the sleep disturbances and problems commonly observed within this population (Charleton, Dennis, & Marder, 2014).

Parent-report measures suggest that up to 85% of children with DS experience clinically concerning sleep problems (Breslin et al., 2011; Hoffmire, Magyar, Connolly, Fernandez, & Van Wijngaarden, 2014). Studies conducted using polysomnography provide corroborating evidence, with indications of sleep-disordered breathing or obstructive sleep apnea (OSA) in 55% (de Miguel-Díez, Villa-Asensi, & Álvarez-Sala, 2003; see also Shott et al., 2006) to 79% of children tested (Dyken, Lin-Dyken, Poulton, Zimmerman, & Sedars, 2003). Although there are no studies to our knowledge documenting associations between sleep problems or OSA and recall memory in individuals with DS, an extensive body of work has examined relations between OSA and executive functioning in this population given the proposed impact of OSA on prefrontal functioning in particular (see Beebe & Gozal, 2002). Results indicate that children with DS who also experienced OSA performed less well on measures of verbal IQ and measures of cognitive flexibility relative to children with DS who did not have OSA (Breslin et al., 2014). Other research has revealed that adolescents and young adults with DS experienced deficits in verbal fluency and inhibition in relation to parent-reported symptoms of OSA (Chen, Spanò, & Edgin, 2013). A recent review on this topic suggests that the increased cognitive impairments associated with OSA in individuals with DS may significantly impact their daily functioning and independent living (Lal, White, Joseph, Van Bakergem, & LaRosa, 2015), indicating that the impact of sleep problems on functional outcomes in this population is significant.

Despite findings documenting associations between sleep problems and executive functioning in elementary school aged children and adolescents, there is limited research examining relations between sleep problems and recall memory in younger children with DS. One relevant study indicated that TD children recalled more animal-name pairs after a period of overnight sleep relative to baseline, but overnight improvements in performance were not observed for children with DS. However, time of day was associated with recall by children with DS, such that children tested in the morning showed improved performance over time (Ashworth, Hill, Karmiloff-Smith, & Dimitriou, 2017). More recent work similarly suggests that the timing of sleep differentially impacts memory in TD children and children with DS. Using a word learning paradigm, Spanò et al. (2018) found that TD children who napped after learning recognized a greater proportion of objects correctly relative to children with DS. Conversely, the children with DS who remained awake after learning demonstrated better memory relative to TD children. These two studies provide converging evidence to indicate that TD children experience cognitive benefits from sleep after learning, whereas children with DS experience benefits from remaining awake – a pattern that was maintained after a 24-h delay in Spanò et al. (2018). These findings suggest that sleep may not serve to consolidate memories in children with DS as has been observed in TD samples.

Whereas previous research has examined sleep-cognition associations in preschoolers and school-aged children with DS, part of the challenge in assessing recall memory in younger samples is methodological. Because children with DS may experience challenges with productive language (e.g., Miller, 1999), developmentally appropriate behavioral measures may be best suited to assess

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