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# Temperament moderates the association between sleep duration and cognitive performance in children



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## ABSTRACT

The importance of sufficient sleep for cognitive performance has been increasingly recognized. Individual differences in susceptibility to effects of sleep restriction have hardly been investigated in children. We investigated whether individual differences in temperament moderate the association of sleep duration with sustained attention, inhibition, and working memory in 123 children (42% boys) aged 9 to 11 years. Sleep duration was assessed using parental diaries, and temperament traits of extraversion and negative affectivity were assessed by child self-report (Early Adolescent Temperament Questionnaire–Revised). Computerized assessment of sustained attention (short-form Psychomotor Vigilance Task, PVT), inhibition (PVT Go/No-Go adaptation), and working memory (visual Digit Span) were performed at school. Our findings

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demonstrate that long-sleeping introverted and negatively affective children show worse sustained attention and working memory than short-sleeping children with these temperaments.

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## Introduction

An adequate amount of sleep is important for children's development. Habitual sleep duration has shown to be highly variable among children (Jenni & Carskadon, 2012; Jenni, Molinari, Caflisch, & Largo, 2007) and is dependent on multiple factors such as age, sleep problems, and temperament (El-Sheikh & Buckhalt, 2005; Gau, 2000; Moore, Slane, Mindell, Burt, & Klump, 2011). Total sleep duration (hours per night) declines with age; for children aged 9 to 11 years, habitual sleep duration is on average approximately 10 h (Iglowstein, Jenni, Molinari, & Largo, 2003; Laberge et al., 2001; Szymczak, Jasinska, Pawlak, & Zwierzykowska, 1993). Studies showed that inadequate sleep in school-age children has a negative impact on multiple domains, including more internalizing and externalizing behavioral problems (Astill, Van der Heijden, Van Ijzendoorn, & Van Someren, 2012; Sadeh, Gruber, & Raviv, 2002), an increased risk of obesity (Cappuccio et al., 2008), and poorer cognitive and academic performance (Astill et al., 2012; Buckhalt, El-Sheikh, Keller, & Kelly, 2009; Dewald, Meijer, Oort, Kerkhof, & Bogels, 2010). Studying the association between sleep duration and cognitive performance is highly relevant given that (a) approximately one out of three children suffers from sleep problems (Fricke-Oerkermann et al., 2007; Mindell & Meltzer, 2008), (b) a considerable decline in children's sleep duration has been found over the last decennia (Matricciani, Olds, & Petkov, 2012), and (c) there is an increase in the use of electronic devices (e.g., computers, mobile phones) that compromise sleep when used in the evening (Cain & Gradisar, 2010).

Studies employing experimental curtailment of sleep in children aged 9 to 14 years (Carskadon, Harvey, & Dement, 1981; Sadeh, Gruber, & Raviv, 2003) indicate that task performance is affected by sleep deprivation as well as by multiple nights of sleep restriction. Even a single night of restricted sleep to 5 h resulted in performance decrements in verbal creativity and cognitive flexibility in children aged 10 to 14 years (Randazzo, Muehlbach, Schweitzer, & Walsh, 1998) but did not impair performance of response inhibition and sustained attention tasks in children aged 8 to 15 years (Fallone, Acebo, Arnedt, Seifer, & Carskadon, 2001). Furthermore, children aged 10 to 12 years who started school earlier than usual, and consequently slept 24 min less than their counterparts with regular school start times, complained significantly more of daytime fatigue, sleepiness, and concentration difficulties (Epstein, Chillag, & Lavie, 1998). Detrimental effects are not only found in studies on short-term sleep restriction. A longitudinal study showed that a period of relatively short sleep (<10 h) during early childhood related to worse performance on tasks several years later in development, even when sleep had normalized during the last years before cognitive assessment (Touchette et al., 2007).

Although the association between sleep and cognitive performance was frequently studied during the past decades, more research is needed to describe factors that can moderate this association. Individual differences in the sensitivity to sleep restriction on cognitive performance have been demonstrated in adults (Van Dongen, Baynard, Maislin, & Dinges, 2004) but have remained elusive in children. It is important to identify children who are sensitive to sleep restriction because the extensive and long-term consequences might be preventable with appropriate sleep interventions. Previous research in adults (Killgore, Richards, Killgore, Kamimori, & Balkin, 2007; Rupp, Killgore, & Balkin, 2010; Taylor & McFatter, 2003) suggests that temperament could moderate the effect of sleep restriction on cognitive performance. Temperament is the innate inclination to behave in particular ways such as extraversion (i.e., the ease of a child to approach novel stimuli or situations) and negative affectivity/neuroticism (i.e., the proneness to experience feelings of fear, anger, and sadness). Temperament has shown to be relatively stable across various kinds of situations and over the course of time (Zentner & Bates, 2008).

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