

## Media, Sleep and Memory in Children and Adolescents

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### Abstract

Media usage across children and adolescents is steadily increasing and captures a significant amount of their usual waking time. Excessive media use affects sleep quality and quantity including increased sleep onset latency, night awakenings and overall reduced sleep duration. Healthy sleep is important for overall health, as well as physical and mental performance and disrupted sleep during early childhood and adolescent results in emotional and behavioral consequences including impaired school performance, attention problems and a higher risk for ADHD and obesity. The present review summarizes recent findings related to the effects of media on sleep and memory in children and adolescent and provides practical recommendations for children's' and adolescent's media and sleep behavior.

**Keywords:** Sleep; Memory; Adolescents; REM sleep

### Introduction

Media are one of the most powerful forces in young people's lives today. In western society average media consumption in children and adolescents is steadily increasing and accounts for over 7.5 hours a day, seven days a week [1]. Within the last decade the impact of media on children's health and wellbeing is increasingly recognized and considered as a serious problem in modern society. Excessive television and videogame usage has been associated with somatic problems, obesity and multiple psychiatric symptoms such as aggressive behavior, attention problems and hyperactivity [2-7]. Within the last years there is also accumulating evidence that excessive media consumption can significantly impair sleep behavior and memory performance [8,9]. This topical review gives an overview of the recent key findings that addressed the relationship between media, sleep and memory in children and adolescents.

### Media Exposure and Sleep Behavior in Children and Adolescents

Clinical experience with adults and children with sleep problems strongly implicates television-viewing habits as a potentially significant influence on sleep behavior [8]. Media exposure is associated with sleeping difficulties, bedtime resistance, sleep-onset delay, sleep anxiety, night awakenings, and shortened sleep duration [8-10]. A study by Johnson et al. showed that watching television three or more hours per day during adolescence elevated significantly the risk for frequent sleep problems by early adulthood [10,11]. The reasons how media exposure affects sleep behavior seems to be multiple: Especially late evening television viewing can contribute to heightened alertness and increased physiological arousal, which are associated with difficulty falling asleep [8,12,13]. Second, extended exposure to the bright light of a television screen may contribute to delayed or reduced melatonin secretion, adversely affecting the sleep-waking cycle [12-14]. Third, both news media and entertainment fiction may lead to short-term and enduring fright reactions. Even TV programs, movies and news made for children may trigger fear [15] therefore selectively supporting to the development of sleep problems [16-18]. Also, physical inactivity, which seems to be associated with extensive television viewing, may contribute to increased restlessness and difficulty falling or staying asleep [5,19]. Indeed, an inverse relationship between time spent using video games and daily physical activity has been observed [20-22]. Positive effects of

physical activity on children's overall health, sleep quality, sleep latency and deep NREM sleep have been observed in different studies [19-24]. Beside the reduced physical activity, excessive media use appears to be clearly associated with elements of a less healthy diet including lower fruit and vegetable consumption; higher consumption of energy-dense snacks, drinks, and fast foods; and higher total energy intake [25-27], therefore increasing the risk for overweight and obesity. Indeed, recent results from a 30-year study indicate that increased daily hours of TV consumption on weekends predicted a higher BMI at the age of 30 and that each additional hour of TV watched on weekends at age 5, increased the risk of adult obesity by 7% [28].

But what is the most powerful predictor for sleep problems among children and adolescent? Multiple independent studies identified the occurrence of a TV in children's bedroom as major predictor for sleep problems [29]. A bedroom television increases the opportunity for young children to watch frightening or violent content as well as adult-targeted television content which has been linked to an increased for sleep problems [30]. In general, regular bedroom television usage was associated with delayed bedtimes, difficulty falling asleep, and less overall sleep, and thus seems to be the most powerful predictor of overall sleep disturbance and bedtime resistance [9,29]. These data are supported by recent observations from real life daily practice whereby 20% to 43% of US preschool-aged children have a television in their bedroom, and increasing numbers of families report sleep problems as one of the primary reasons [29]. Since sleep problems itself can clearly influence daytime physical and mental performance, special care is needed to prevent potential negative effects of poor sleep on children's health and cognitive development.

### Sleep and Memory in Children and Adolescents

It is widely known that the newborn brain continues to develop

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rapidly through the first few years of life and that considerable plasticity exists during this time period [31,32]. In the last decades, extensive research has been accumulated demonstrating that sleep is essential for important processes of brain development, neuronal plasticity and memory consolidation in children and adolescents [33-37].

Sleep seems to be particularly important during early brain development up to the age of two years when a child still spends more time asleep than awake. Even when starting school, sleep accounts for up to 50 percent of the 24-h day. Often, total sleep duration in children and adolescents is also below general recommendations and despite cultural differences, many studies have shown that adolescents world-wide sleep significantly less than the recommended 9-10 h [38]. Compared to adulthood, childhood is characterized by longer sleep duration and higher amounts of deep and restorative non-rapid-eye-movement (NREM) sleep and active (rapid-eye-movement) REM sleep which is characterized by a high-frequent brain activity as measured in the electroencephalogram (EEG) [38,39]. Results from longitudinal EEG sleep studies suggest that sleep regulation undergoes a period of maturation during infancy and a lower frontal predominance of NREM slow wave activity has been observed in children and adolescents compared to adults, possibly reflecting the late maturation of the frontal cortex [40].

Presumably, both REM and NREM sleep are involved in the consolidation process, in which NREM sleep is particularly favorable to explicit memory, whereas REM sleep favors implicit memory processes [41,42].

Various studies have investigated the impact of sleep on learning and memory in children and adolescents and evidence is condensing that disrupted sleep negatively affects these processes. Steenari et al. showed that longer sleep latency and lower sleep efficiency were associated with poorer auditory and visual working memory, whereas shorter sleep duration was associated with lower working memory performance. The authors concluded that sleep quality rather than sleep duration appeared to be strongly associated with working memory performance [42]. Sadeh et al. examined the association between sleep and neurobehavioral functioning, including the encoding of declarative memory content in school-age children. "Good" and "Poor" sleepers were identified and the "Poor" sleepers showed more fragmented sleep and reduced sleep efficiency. Overall, good sleepers showed better results learning digits compared to the poor sleepers. Interestingly, this difference only showed up in a morning but not in the noon hours. The authors hypothesized that the findings are in line with theories of general cognitive performance emphasizing the contribution of both chronobiological and homeostatic factors on cognitive performance [43,44].

One night of total sleep deprivation in young adolescents (12-15 years) resulted in a significant decline of correctly recalled words in the Williams Word Memory Test. In a further study, Sadeh et al. [43] examined the effects of prolonged modest sleep restriction or extension in children. After two regular nights with normal sleep duration, children (9-12 year old) were asked to extend or restrict their sleep time by 1 h for three consecutive nights. Children, who extended their sleep time, improved their memory task performance significantly compared to baseline and compared to the sleep-restriction group. Other studies compared the effects of nocturnal sleep versus daytime wakefulness on declarative memory consolidation and procedural memory consolidation in 6-8 year old children and adults [33,42]. Declarative memory performance was enhanced when sleep followed learning. Interestingly, in contrast to the hypothesis and to findings in

adults, in children procedural performance was impaired after periods of nocturnal sleep in comparison to periods of daytime wakefulness. The authors concluded that the sleep-related consolidation process of distinct memory systems might depend on developmental stage. Together these and other studies provide evidence that sleep is critically involved in memory encoding and working memory in children and adolescents.

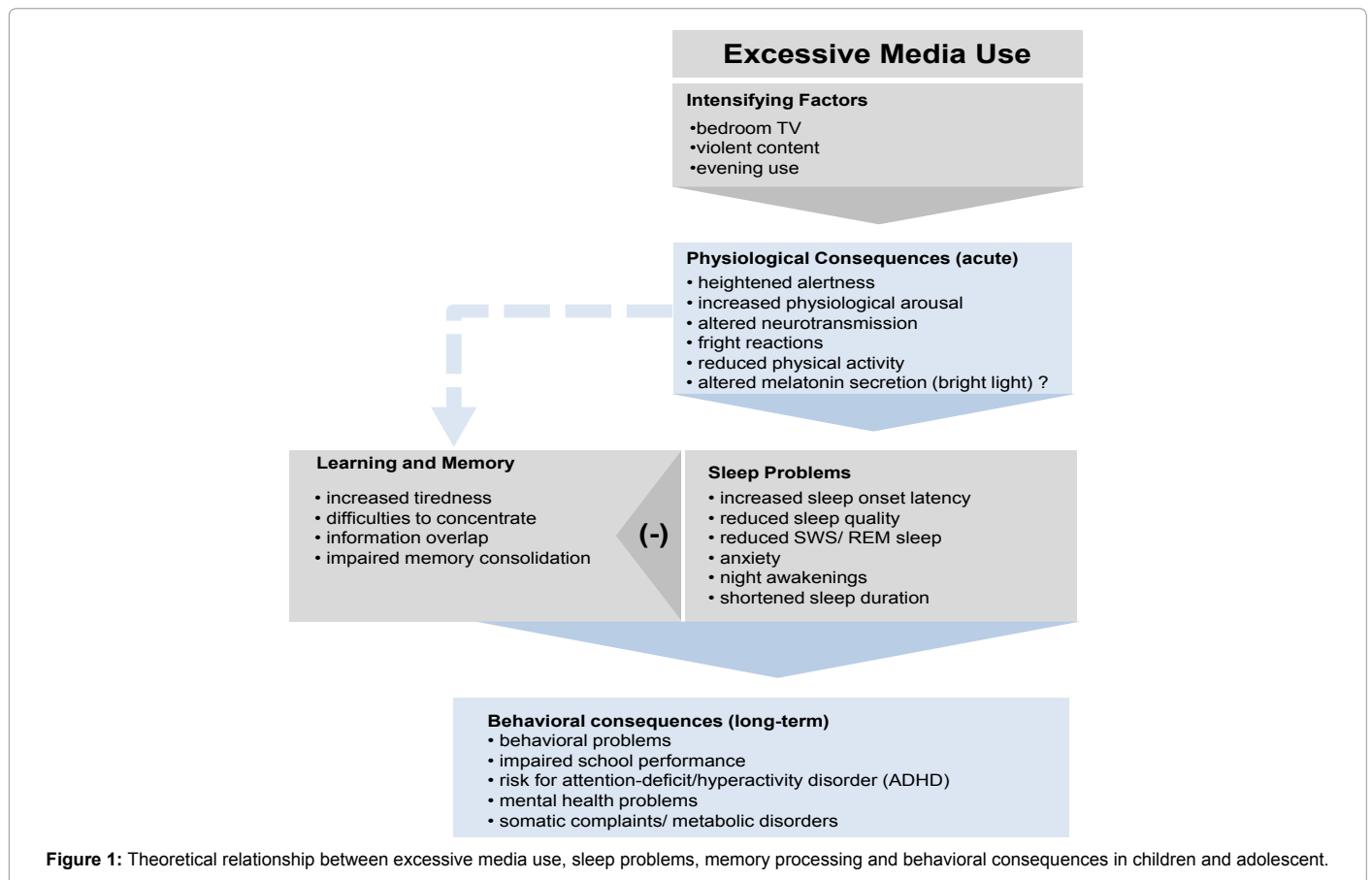
### Effects of Excessive Media Consumption on Sleep-Dependent Memory Performance

Poor sleep quality may result in mental health problems, impaired school performance, and somatic complaints. Sleep difficulties are significantly associated with both behavioral problems, such as school attendance problems, and higher levels of tiredness [9]. Most studies examined long-term effects of media exposure on sleep timing, whereas only a few studied the effects of television and computer exposure on children's and adolescence sleep quality and associated health problems.

In one of our previous studies, we examined the effects of intense media use on sleep and cognitive performance in school-aged children. Children were exposed to voluntary television use (TV-movie for 90 minutes) and video game consumption for 90 minutes or no media at all a few hours before their usual bedtime. Sleep behavior was measured in all participants in the following night by using polysomnographic measurements to determine sleep-architecture and sleep-continuity parameters. Furthermore, a visual and verbal memory test was used before media stimulation and on the following day after one night of sleep to determine visuo spatial and verbal memory performance [45]. Playing an exciting video prolonged sleep-onset latency and increased the percentage of stage 2 sleep, which reflects a lighter and more interference-prone sleep stage, whereas NREM slow-wave sleep (stage 3 and 4) was significantly reduced. Playing the video game was also associated with a decline in verbal memory performance in the participating children. Television viewing reduced sleep efficiency but did not affect sleep patterns. Overall, no effects on REM-sleep were observed.

Previous studies showed different effects of television viewing and video game playing on several physiologic parameters [46]. Unlike television viewing, which expends the same energy as sitting quietly, interactive video game consumption resulted in significant increases in various physiologic and metabolic variables in young children, including heart rate, blood pressure, respiratory rate, energy expenditure, and ventilation, and thus a higher arousal state of the central nervous system [46]. The magnitude of these changes was below standard physical exercise and national health recommendations and did not affect metabolic, cardiovascular, pulmonary, hemodynamic, and endocrine systems in the whole body and the brain as physical activity does [47]. A higher arousal state within the hours before sleeping might be a strong factor that influences subsequent sleep. Further different effects of television viewing and video game playing could influence emotional factors. TV viewers are in a receptive state, whereas video game users are playing an interactive role. Children might identify themselves with the role they take within the game and aggressive or violent contents could be encoded [48].

The observation that playing a heart-pounding video game can impair verbal memory performance is in line with several studies showing that strong emotional experiences, such as computer games and thrilling films, could influence learning processes decisively. Since recently acquired knowledge is very sensitive in the following



consolidation period, emotional experiences within the hours after learning could strongly influence processes related to memory consolidation [49-51]. Often, interactive video games are challenging, sometimes frustrating, exciting, and often surprising for children and adolescents, and during playing, individuals may experience a range of emotions accompanied by neurophysiological changes.

Exposure to adult media potentially has a stronger impact than media exposure time [52,53]. Especially adult (violent/sexual) media content and associated individual excitement can affect sleep and learning in children [54], but only 13% have parental control with rules about the content of their consumed media [1].

Movie, television, and video game use during the middle school years was uniformly associated with a negative impact on school performance [53]. Children with lowest grades spend more time playing video games and less time reading than those with the best grades [1]. Limiting young children's exposure to television as a medium during formative years of brain development may reduce children's subsequent risk for developing ADHD and social and scholastic problems [53-55].

## Conclusion and Recommendations

Media use is steadily increasing and captures a significant amount of children's and adolescents waking time. Excessive media use can affect sleep quality and quantity including increased sleep onset latency, night awakenings and shortened sleep duration. Healthy sleep is important for overall health and development and disrupted sleep during early childhood and adolescent can result in neuro-developmental implications and emotional and behavioral consequences including

impaired school performance, attention problems and a higher risk for ADHD and obesity (Figure 1).

Parents and educator should be aware of their children's media use. Children's and adolescents bedroom is no place for a TV. Parents and teachers should provide directions about total media use including the time spent with television and computer as well as the contents of TV and video games. Restriction of media time should be associated with alternative challenging activities. Insofar, physical activity and team sport can absolutely be recommended. Physical activity is an important component in the development of self-esteem in children. It has a preventive function concerning obesity and an improving influence on sleep quality. However, further research is needed to examine the long-term consequences of excessive media use in children and adolescents on overall health and behavior.

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