

Comments

- I thought this was a perspective that would significantly change the conventional view of child development. It can be said that conventional developmental theories have basically examined mechanisms based on the assumption that children are awake and active. It is an extremely important perspective to consider how the seemingly restful hours of sleep affect development. In particular, given that approximately one-third of the day is spent sleeping, it made me think that it is necessary to approach development from the perspective of both waking activities and sleeping/resting time.

- It made me think again about the many different types of sleep. It was also very interesting to discuss that the mechanism also differs depending on age and developmental characteristics. I thought that the method of closely following what kind of sleep appears at what time of day and to what extent is important as a research method, and I thought it would be very helpful.

- This finding seemed a bit dangerous if used incorrectly. I fear that if sleep is reported to have a positive or negative impact on development, the will (desire) to control into uncontrolled areas may become stronger. Without attention, this information makes parents anxious and to think "Don't let children have this kind of sleep!".

- The question is whether the effects of sleep can be viewed as a sleep stand-alone process. There are issues of the environment in the home, such as whether parents sleep together or how much storybooks are read to them before bed, or the environment where they live, such as the noise outside when they are sleeping. Of course, this presentation also suggests a relationship between socioeconomic variables and sleep. However, I think it is important to have a perspective on the process leading up to sleep that goes beyond the indicators that appear in numerical values.

- In clinical practice, it is recognized that child development and sleep are quite related. In particular, children with developmental disorders do not sleep well. It is said that their brain structure does not allow for good brain switching to get a good night's sleep. Sleep hygiene instruction can lead to better switching, which can decrease the tendency for hyperactivity if the child has ADHD.

- I have read a paper on how facial expression recognition in ADHD is related to sleep. The results showed that when the effects of sleep were controlled for, there was no difference in facial expression recognition, but when the experiment was conducted under sleep deprived

conditions, it affected facial expression recognition in ADHD. I wondered if not controlling for differences in sleep would lead to erroneous interpretations.

- Some people do not sleep much during the week and sleep a lot on weekends, which can disrupt the rhythm of sleep. This also affects various activities.

Questions

Thank you so much for these highly valuable and interest comments and reflections! Please find my responses to the specific questions below.

- The perspective of the connection between sleep and language development was new to me. Why did you decide to make that connection?

Thank you so much for this question! My PhD and postdoctoral research was primarily focused on understanding mechanisms of language learning – how do we lay down new memories for new words and how can we use this understanding to optimize language learning over the lifespan? We took a domain general approach to addressing these questions, taking the stance that language learning draws on general cognitive learning systems. Simultaneously, there was growing interest in the view that sleep plays an active role in consolidating newly formed memories, transferring them to long term memory stores. We thus began investigating whether the same is true for memories of newly learned language and indeed we observed the same effects in adults at first. Of course, we know that sleep changes radically over development, so I then became fascinated with understanding how these changes in sleep architecture might support language development. We also know that sleep is often disrupted in children with neurodevelopmental disorders where language development is often hampered.

- I am a literacy researcher, but I have never thought of relationship between sleep and literacy. Besides language development, are there any other studies on literacy as affected by sleep?

Yes! There are studies (carried out by my group and numerous others) that have examined the effects of sleep on orthographic word learning, revealing similar sleep benefits (i.e., new written words are recalled better if a period of sleep follows learning relative to a period of wake in both [children](#) and [adults](#), see [here](#) for a recent review). There are also [studies](#) that have shown that the critical language skills that underpin literacy (i.e., the fine tuning of

phonological representations) are also sleep-dependent. Thus, taking a domain general approach to language and literacy, and the assumption that general cognitive memory mechanisms underpin these aspects of development, there's good reason to assume that literacy development would be influenced by sleep in similar ways to vocabulary development.

• Japanese children sleep very little and stay up late at night. In the UK, I think children go to bed earlier. I think there are cultural differences in what time of day they go to bed. Do you have any thoughts on such cultural differences?

This is an interesting and important question. There are certainly cultural differences in sleeping habits and sleep hygiene. Whilst there is some research that aims to characterize these fascinating differences, there's much to be done to understand the impact that such differences have on different aspects of development, including language development. One relevant and important area where research has been carried out is the impact of the timing of the school day on sleep and the influence of this on key aspects of development (including performance at school, but also daily cognition and mood), with this being one example of how cultural differences might influence development.

• What are your thoughts on continuity from fetal life? The language area on brain is quite well formed at birth. I think that "children who get enough sleep" are "children with a well-developed language area". Is the influence of language area maturation a controlled study design?

Thank you for raising this important point. So, as I hinted at in the presentation, it could just be that individuals who sleep well are also individuals who have more mature brain development, globally speaking. This may at least partly account for the associations that we see. However, environmental influences on sleep (e.g., tech use at bedtime, poor diet, noise pollution, over-crowding) still have an impact on sleep, and intervention studies show that improving these aspects can have positive effects on cognitive and social skills as well as health and wellbeing. Thus, it's not the case that the sleep of sleep on development is fixed from the fetal stage and amenable to change.

• ASD and TD differed in sleep; do these differences in language learning between ASD and TD control for sleep quality?

Another important point! It is the case that children with ASD wake up more frequently and

sleep for shorter durations, as well as spending less time in non-rapid eye movement (NREM) sleep. These differences in sleep quality may well go some way to accounting for the differences in sleep architecture that we observed (e.g., lower proportion of slow waves and sleep spindles).

• I think that the amount of sufficient sleep varies from person to person. Can such individual differences be measured? Also, was such an individual difference taken into account in your studies?

I completely agree with this assumption. The amount of sleep varies across and within individuals. Our studies (both in the lab and in the longitudinal cohort datasets) aim to understand how these individual differences relate to different aspects of development.

• I have heard that narcolepsy is genetically difficult for people to cure. Is sleep a matter of habit or physical constitution?

This is another really interesting and important question! Research tells us that whilst sleep is strongly genetically influenced it also has a strong environmental contribution, and hence it IS amenable to improvement, despite myths.