**Editorial: Sleep problems in children with dyslexia: understanding the role of sleep in neurocognitive development through the lens of developmental disorders**

Faye R H Smitha

&

Lisa M Hendersonb

a Institute of Neuroscience, Medical School, Newcastle University, Newcastle-upon-Tyne, UK, NE2 4HH; faye.smith@ncl.ac.uk

b Department of Psychology, University of York, York, UK, YO10 5DD; lisa-marie.henderson@york.ac.uk

Word count = 1349

**Sleep problems in children with dyslexia: understanding the role of sleep in neurocognitive development through the lens of developmental disorders**

It has long been recognized that sleep is more than a passive recovery state or mere inconvenience. Sleep plays an active role in maintaining a healthy body, brain and mind, and numerous studies suggest that sleep is integral to learning and memory. The importance of sleep for cognition is clear in studies of those experiencing sleep deprivation, who show consistent deficits across cognitive domains in relation to non-sleep deprived controls, particularly in tasks that tax attention or executive functions1. Poor sleep has been associated with poor grades, and academic performance suffers when sleep is sacrificed for extra study.2 Thus, it is perhaps unsurprising that children with developmental disorders of learning and cognition often suffer from sleep disturbances. These have been well-documented in children with autism and attention-deficit-hyperactivity-disorder (ADHD), where sleep problems can be particularly severe. However, a growing body of evidence suggests that sleep can be atypical across a spectrum of learning disorders. Understanding the ways in which sleep is affected in different developmental disorders can not only support the design and implementation of effective assessment and remediation programs, but can also inform theories of how sleep supports cognition in typical development. The study by Carotenuto et al.3 in this issue makes a valuable contribution to this literature by looking at sleep disturbances in children with developmental dyslexia.

 Dyslexia is the most common specific learning disorder, affecting around 1 in 10 children in our classrooms. It is characterized by difficulties with reading and spelling, and is primarily caused by a deficit in phonological processing. However, dyslexia often co-occurs with other developmental disorders, such as ADHD and specific language impairment, and there can be striking heterogeneity between children. This has led to the suggestion that dyslexia can result from complex combinations of multiple risk factors and impairments.4 Consequently, research attention is turning towards the wider constellation of sub-clinical difficulties often experienced by children with dyslexia, including potential sleep problems.

Two preliminary studies have found differences in the sleep architecture of children with dyslexia in comparison to typical peers, using overnight sleep EEG recordings (polysomnography).5,6  Notably, children with dyslexia showed unusually long periods of slow wave sleep and an increased number of sleep spindles. Slow wave sleep and spindles are related to language learning, most notably through promoting the consolidation of new vocabulary.7 Children with dyslexia have pronounced deficits in learning new oral vocabulary, providing a plausible theoretical link between sleep disturbances and language difficulties. If sleep problems do in fact exacerbate the learning difficulties associated with dyslexia, as well as impacting on daily cognitive function, this could have important implications for intervention and support programs.

However, an important first step is to establish the nature and extent of sleep disturbances in dyslexia. Previous studies5,6 have used small samples (N=<30) and examined a large array of sleep parameters on a small number of unusual nights (where children were wearing sleep recording equipment), as opposed to looking at global patterns over time. As such, how representative these findings are is questionable, and consequently these studies should be viewed as hypothesis-generating rather than hypothesis-testing.

Carotenuto et al.3 addresses some of these concerns, administering questionnaire measures of sleep habits to parents of 147 children with dyslexia and 766 children without dyslexia, aged 8-12 years. A sample of this size allows for a robust analysis of sleep characteristics. Therefore, their findings that children with dyslexia showed higher rates of several markers of sleep disorders lend significant weight to suggestions that dyslexia might be associated with an increased risk for sleep problems.

Importantly, the sleep questionnaire used by Carotenuto et al.3 allows for a breakdown of sleep disturbances. It is interesting to note that they found the greatest difficulties in initiating and maintaining sleep, sleep breathing disorders and disorders of arousal. This closely mirrors the types of sleep problem documented in children with ADHD.8 While Carotenuto et al.3 took care to exclude children with co-morbid diagnoses, many children with dyslexia show subtle features of attention disorders that do not reach clinical thresholds. Future studies that can establish whether sleep disturbances are associated with sub-clinical attention problems or dyslexia *per se*, will be particularly informative for understanding which cognitive skills most critically relate to sleep. This is also vital information for establishing whether information about sleep habits could have clinical relevance in the assessment and management of children with dyslexia.

There are a number of ways in which Carotenuto et al’s findings could be taken forward in future studies. Not least, the findings need to be replicated using more objective measures of sleep, including polysomnography and/or actigraphy, both of which can be administered in the home environment. It is notable that neither of the two polysomgraphy studies to date observed differences in sleep onset time or nighttime awakenings in children with dyslexia compared to typical peers. Although this could be a result of a lack of statistical power due to the very small samples in these studies, the discrepancy could also be due to the subjective nature of the questionnaires used.

Future studies must also take care to recruit samples that are free of referral bias. Carotenuto et al. recruited their sample via referrals to a hospital clinic; hence it is possible that such children may be more likely to present with multiple issues (including sleep problems), rather than reading difficulty alone. Thus, it will be important to examine the prevalence of sleep difficulties in referred and non-referred samples.

 Although Carotenuto et al. makes substantial progress in establishing the frequency of sleep disorders in dyslexia, the study design cannot test causal hypotheses or establish whether there was a link between sleep difficulties and severity of reading impairment. Indeed, a great challenge in the field of sleep and developmental disorders is establishing the extent to which sleep is causally related to cognitive difficulties. It is possible that brain abnormalities associated with disorders can cause both cognitive and sleep differences without them being directly linked to each other. Moreover, sleep difficulties may simply be a consequence of increased anxiety associated with having a developmental disorder.

Randomised controlled trials are often viewed as the gold standard means of establishing causality. For example, a recent study has shown that a sleep intervention for children with ADHD led to significant improvements in ADHD symptomatology and working memory.9 Given that the type of sleep problems encountered by children with dyslexia are similar to those in ADHD, it is tempting to propose that such an intervention may prove useful for children with dyslexia. However, it is important to be cautious: Only 42% of the children with dyslexia in the Carotenuto et al. study suffered sleep difficulties. This indicates that while having dyslexia seems to greatly increase a child’s risk of sleep problems, sleep disturbances are unlikely to represent a causal pathway to reading difficulties. Therefore, it is unlikely that a sleep intervention would be useful for all individuals with dyslexia. Nonetheless, it remains plausible that sleep difficulties could exacerbate cognitive and literacy difficulties in some children, who might then benefit from clinical intervention. If this is the case, then such interventions should be seen as complementary to literacy-targeted interventions that tackle the reading difficulty itself. Further research is needed to ascertain if and how sleep difficulties contribute to the difficulties experienced by children with dyslexia, and to establish which children with dyslexia are at the greatest risk of sleep disturbances.

Understanding the role of sleep in developmental disorders is vital, not only to improve assessment and treatment for affected children and families, but also to advance theoretical models of sleep and neurocognitive development. While sleep problems are common in several neurodevelopmental disorders, these problems are likely to differ qualitatively and quantitatively across children with different difficulties. Therefore, it is important to study sleep problems within each learning disorder as well as looking at the heterogeneity across the spectrum of learning difficulties. Studies like the one by Carotenuto et al., which looks specifically at sleep in dyslexia are crucial in this regard; raising awareness of the possible role of sleep difficulties, and opening up a plethora of potential lines of future research in this area.

1. Lim, J. & Dinges, D.F. (2010). A meta-analysis of the impact of short-term sleep deprivation on cognitive variables. *Psychological Bulletin*, 136, 375-389.

2. Gillen-O’Neel, C., Huynh, V.W. & Fuligni, A.J. (2013). To study or to sleep? The academic costs of extra studying at the expense of sleep. *Child Development*, 84, 133-142.

3. Carotenuto, M., Esposito, M., Cortese, S., Laino, D. & Verrotti, A. (2016). Children with developmental dyslexia showed greater sleep disturbances than controls including problems initiating and maintaining sleep. *Acta Paediatrica*

4. Pennington, B.F. (2006). From single to multiple deficit models of developmental disorders. *Cognition*, 101, 385-413.

5. Bruni, O., Ferri, R., Novelli, L., Terribili, M., Torianiello, M., Finoti, E. et al. (2009). Sleep spindle activity is correlated with reading abilities in developmental dyslexia. *Sleep*, 32, 1333-1340.

6. Mercier, L., Pivik, R.T. & Busby, K. (1993). Sleep patterns in reading disabled children. *Sleep*, 16, 207-215.

7. Henderson, L.M., Weighall, A.R., Brown, H. & Gaskell, M.G. (2012). Consolidation of vocabulary is associated with sleep in children. *Developmental Science*, 15, 674-687.

8. Cortese, S., Faraone, S.V., Konofal, E. & Lecendreux, M. (2009). Sleep in children with attention-deficit/hyperactivity disorder: meta-analysis of subjective and objective studies. *J Am Acad Child Adolesc Psychiatry*, 48, 894-908.

9. Hiscock, H., Sciberras, E., Menash, F., Gerner, B., Efron, D., Khano, S. et al. (2015). Impact of a behavioural sleep intervention on symptoms and sleep in children with attention deficit hyperactivity disorder, and parental mental health: randomized controlled trial. *British Medical Journal*, 350, h68.