A Time to Learn, a Time to Teach

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Six years ago we were invited as editors of a special issue of *Mind, Brain, and Education* devoted to the role of sleep and circadian rhythms on teaching and learning activities (Golombek & Cardinali, 2008). Several authors showed how mental performance varied significantly throughout the day, correlating with fatigue and alertness scales (Valdez, Reilly, & Waterhouse, 2008). Moreover, the extra burden of work affected not only fatigue but also academic performance in students (Fischer et al., 2008). School itself is also partially responsible for changes in academic performance; indeed educational schedules do not usually take into account the physiological needs of the students (Azevedo et al., 2008; Menna-Barreto & Wey, 2008; Miller, Shattuck, Matsangas, & Dyche, 2008). We finished our introduction to the issue by stating that "The concepts of time and timing—deeply controlled by the brain—need to be incorporated into any general view of educational processes."

Six year later the prediction is still unfulfilled. This occurs despite the fact that chronobiology has certainly advanced our understanding of the strong influence of timing on education and academic performance, as well as on the quality of life of not only students but also teachers and parents. Indeed, the scientific study of biological rhythms and clocks can be considered part of the necessary bridge between neuroscience and education, which was originally defined as "too far" (Bruer, 1997) but has only recently been considered to be possible, because "current work on the construction of direct links between brain data and pedagogical interventions promises to be a particularly important field of research for future neuroscience" (Sigman, Peña, Goldin, & Ribeiro, 2014). In the review by Sigman et al., the authors propose four domains of neuroscience research that have a profound effect on education, the first of which is none other than looking at the role of sleep and health and academic performance. It is well known that sleep results in memory consolidation and, moreover, diverse types of sleep disruption interfere with learning processes (Huber, Ghilardi, Massimini, & Tononi, 2004; Wagner, Gais, Haider, Verleger, & Born, 2004). An extreme case of sleep deprivation resulting in poor performance is found in adolescents, whose circadian clock appears to be phase-delayed and, therefore, inappropriate for the usually very early timing of high school start time of classes (Carskadon, 2011; Hansen, Janssen, Schiff, Zee, & Dubocovich, 2005). An obvious remedy would be to delay the start of classes and, indeed, diverse studies show the beneficial effect of such intervention (Owens, Belon, & Moss, 2010).

As already stated, our knowledge of the basic mechanisms, physiology and molecular biology of circadian rhythms, including the deleterious effects of circadian disruption has significantly expanded in recent years (Golombek et al., 2013; Golombek & Rosenstein, 2010). Specific polymorphisms that affect the timing of sleep have been identified (von Schantz, 2008) and, in addition, the idea of "social jetlag" (i.e., the situation in which external—environmental, work, and school-related—timing is separated from, and sometimes opposed to, endogenous circadian timing) has gained a significant momentum, with data suggesting this situation is a clear symptom of contemporary society.

As the seven articles in this special issue of *Mind, Brain, and Education* suggest, the time is ripe to start walking the bridge with the tools provided by chronobiology. Circadian variations in cognitive performance are reviewed by Valdez et al., including changes in attention, working memory, and executive functions, as well as their implications for school performance.

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Anacleto et al. compared two coexistent time schedules in school children, in particular regarding exposure to light, indicating that educational schedules can act as social zeitgebers and therefore affect circadian rhythms. Valuable data can be obtained by the analysis of census and surveys aimed at the general population, which, according to the study by Vigo et al., can be considered as proxies of sleep behavior in different age and social groups; in this particular case, applied to adolescents from households facing extreme poverty.

As for specific interventions, Owens et al. review the evidence in favor of delaying high school start times in the United States. As the authors suggest, this information will be very useful for other school districts that need to decide on further actions regarding schedules. Of course these changes are based on the well-known fact that adolescents are typical "owls" in terms of their chronotypes, and Randler et al. expand our knowledge of this situation by reporting a significant association of chronotype and affective state in this particular age range. The study by Laberge et al. identifies the factors associated with the decrease in sleep duration in adolescents that work, and suggest specific interventions to address this problem. Another basic intervention is to educate the students in terms of their chronotypes and their sleep needs, and that is precisely the proposal by Brown Shulke & Zimmermann, who urge college faculty and staff to advise young undergraduates about the influence of sleep and chronobiology on their general performance and behavior.

In summary, we believe that we can certainly start walking confidently the bridge between neuroscience/physiology and education. We only need to take a good clock with us.

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