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Journal
Proceedings of the Annual Meeting of the Cognitive Science Society, 29(29)

ISSN
1069-7977

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Publication Date
2007

Peer reviewed

Why High School Should Start After Lunch: School-Days Sleep Deprivation and Neurobehavioral Correlates of Stroop Performance in Adolescent Girls

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Keywords: Adolescence; sleep self-report; circadian rhythms; event-related potentials; Stroop interference.

Adolescents have irregular sleep patterns throughout the week. In particular, they sleep through their normal wake times in the mornings on the weekends, and this may be related to a delay in their circadian rhythm of an estimated 2 hours (Hansen, Janssen, Schiff, Zee & Dubocovich, 2005). Such alteration of sleep pattern could create problems in attention and academic ability early in the morning at school and/or throughout the day (Wolfson & Carskadon, 1998). Self-reported shortened total sleep time, erratic sleep/wake schedules, late bed and rise times, and poor sleep quality are negatively associated with academic performance in adolescents (Shin et al., 2003). Adolescence is a critical period where the brain undergoes cortical maturational and cognitive changes (e.g., Luna et al., 2001) and sleep is one key factor that insures that developmental changes and maturation of these cognitive functions are more likely to occur efficiently (Dahl & Lewin, 2002). Recently, this is the focus of one of the most heated debate regarding public policy and school scheduling (see Hansen et al, 2005): Given that adolescents have special needs during the critical adolescent development that may be linked to their intrinsic sleep cycles, should high school start after lunch? Answers concerning this policy question and others have not been addressed using brain research. This Event-Related Potential (ERP) study is an example of how applied cognitive neuroscience can inform school policy.

Method

Participants. Eleven female students (aged 16-18) were recruited from a high school in Interior British Columbia. **Stroop task & ERP data collection**. A version of the standard Stroop task was taken from the battery of provided by STIM (Neuroscan Compumedics Ltd.). Stimulus duration was set at 200 ms with an inter-trial interval of 1000 ms; we measured response time, accuracy, number of correct responses and P300 ERP amplitude. The following electrodes were placed according to the international 10-20 system of electrode placement: Pz, P3, P4, Cz, C3, C4, Fz, F3, and F4. The electro-oculogram (EOG) was positioned vertically above and below the eye; this allowed us to filter out artifacts due to eye movements from the EEG signal of interest. The EEG and EOG systems were amplified by a Neuroscan Synamp2 with low pass filter at 30 Hz and the high pass filter at 1 Hz. All pretesting electrode impedances were below 10 kΩ.

Pre- and post-test affective questionnaires. Before the EEG cap was applied, the participants were required to fill out an *affective questionnaire* that assessed self-report stress and arousal level. After the Stroop task was completed the participants were asked to fill out a questionnaire that assessed the perceived task difficulty and stress difficulty.

2-Week sleep-log questionnaires. The participants were required to fill out a sleep log that indicated their sleeping habits, legal drug intake, amount of exercise, and level of alertness throughout the day, in a period of 2 weeks concomitant with the Stroop and ERP data collection. The participants were required to begin the sleep log on a Thursday and be tested on the following Monday and Wednesday. In this, test-retest design, the participants were tested on the Stroop (ERP) task at the following times on both Monday and Wednesday: 8:30-10:30 am, and 12:15- 1:55 pm. Half of the participants were tested in the morning and the other half were tested in the afternoon. Each participant was tested on the same time on both days. The data fit a 2 x 4 factorial design: Day of the week (Monday or Wednesday), X Time of the day (Morning vs. Afternoon) X type of Stroop stimuli (congruent vs. incongruent).

Results & Discussion

Consistent with previous research, during the two-week period of the study the participants on average slept significantly longer (~ 2 hours) in the weekend as compared to school days, corroborating previous evidence of weekend sleep compensation for school-days sleep deprivation. The only striking differences were found for Stroop performance and ERPs between morning and afternoon. That is, the same individuals performed better and faster (>85% accuracy) in the afternoon than in the morning (~50% accuracy). This was confirmed by significant large early negative (N2) and positive (P3) ERP effects (especially in frontal sites) concomitant with the Stroop performance in the afternoon versus lack of significant ERP wave deflections in the morning. This pattern was correlated within-individuals to the amount of weekend sleep. No other affective, activity or consumption control measure had significant associations with the ERPs and the behavioral data. We conclude that, although preliminary, this is strong evidence that adolescents have indeed special needs regarding school scheduling and that policy should find ways to accommodate their natural circadian rhythms to avoid potentially harmful developmental as well as cognitive unbalances.