Sleep Habits and Biological Clocks Determined in Children: Cognitive Fluctuations and Intelligence

Sandra Figueiredo[1,2], Odete Nunes[1,2], João Hipólito[1], and Cátia Tomás[3]
[1] Department of Psychology, Universidade Autónoma Luís de Camões (UAL), Lisbon, Portugal
[2] Center for Psychology Research (CIP), Universidade Autónoma Luís de Camões (UAL), Lisbon, Portugal
[3] Universidade Autónoma Luís de Camões (UAL), Lisbon, Portugal
Email: {sfigueiredo, onunes, jhipolito}@autonoma.pt, catiasrtomas@gmail.com

***Abstract*—This study presents evidence of the chronotype significant influence for the cognitive performance of children aged between 7 and eleven years old, specifically for the attention skills. Two groups of children were identified regarding their chronotypes: morning, intermediate and eveningn types. The impact of chronotype or diurnal preference was examined concerning the performance in attention subtest of Wechsler Intelligence Scale for Children (WISC). The subtest was administered in two periods of the day – morning and afternoon - during two weeks. The students answered to the same subtest with one-week interval. The statistical analysis for the chronotype identification (through questionnaire) and for the attention test (WISC) followed the procedures and the score calculation of the original version of the instruments. By using the SPSS, version 24, were carried out comparison statistical tests to confirm performance differences. The different biological preferences of children impacted the attention fluctuation in a significant manner (p< .05) considering the different hours of tests realization which confirmed that biological clocks are determining and affecting the synchrony effect: the optimal performance according to specific periods of the day. These specific periods are determined biologically and with differences among individuals. Even determined biologically, the chronotype shows variation during lifespan. The results of this study highlight the crucial reflexion for the biological studies on the diurnal preferences and their impact in life of human being. Specifically related to Psychology area in order to understand the effect of biological rhythms in the development of young children and the schedules of the assessment settings where they are assigned.**

***Index Terms*—biological rhythms, school children, sleep patterns, cognitive performance, daytime preference**

I. Introduction

This study focused the correlation between the biological clock of young children and the cognitive achievement. Specifically, the circadian rhythms and their impact for the attention of children in the first school grades, attending the same timetables. In the studies of the circadian rhythms it is important to understand the biological clocks to identify individuals' preferences and the execution of specific tasks or activities during the day in an optimal condition. This is the 'synchrony effect' in chronobiology area and that explains the best performance in specific time of the day but according to specific chronotypes [1]-[4]. That optimal condition can occur more than one time in a 24h cycle and for different types of activities, with different cognitive demanding. The biological predisposition – to be morning or evening type – is determinant to understand sleep patterns and vigil preferences. Morning individuals prefer to awake and to work earlier than the evening individuals, resulting in different performances if the different individuals (considering the chronotype variable) execute the same task in the same period.

This evidence might be problematic for the students with different diurnal preferences and attending to the same schedules and the same testing hours. This is not well studied in school-aged children, only recently because the literature published results mostly focusing the adolescents' population [5], [6].

This study intended to manipulate the schedules of tasks to the same children to understand how different diurnal types or chronotypes affect the performance according to the period of the day in which the test was administered [7]. Chronotype is part of the chronobiology scope and respects the diurnal preference and sleep habits of individuals to perform specific activities [1]-[3]. This paper presents a specific part of larger collected data that associates the impact of chronotype in cognition and the consequent effect for academic achievement of young children. Portuguese children were evaluated concerning attention capacity through the coding subscale of Wechsler intelligence scale for children-WISC-IV [8]. The Portuguese version was used and with the scale III [9] for that Test and in different hours of the day and during two weeks (one-week intervall).

II. Method

A. Participants

46 school-aged children, aged between 7 and 11 yr old, 23 (50%) males and 23 (50%) females, Portuguese

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nationality, attending the 2nd, 3rd and 4th grades of Primary School. First graders were not included due to the language proficiency (alphabetization). Children with sleep disturbances were not included.

24 (52,2%) are morning type, 22 (47,8%) are evening type. The intermediate type was not considered for this study. The selection criteria of chronotypes followed this punctuation [10]: extremely morning types (punctuations between <22 and >36), moderate morningness (<23 and >26) and moderate eveningness (<33 e >35). Cut-off scores were determined by percentile analysis: p 25 and p 75 [10].

Concerning grades, 16 (34.8%) individuals attend the 2nd grade; 10 (21.7%) frequent in the 3rd grade and 20 (43.7%) integrate the 4th grade. Concerning the relationship with the chronotype, in the 2nd grade they are 10 (41.7%) morning types and 6 (27.3%) evening types; 5 3rd grade students (20.8%) are morning type and 5 (22.7%) are evening; in the 4th grade, 9 (37.5%) are morning and 11 (50%) are evening type.

Considering the chronotype and the gender variable, 12 (50%) morning types are males and 12 (50%) morning types are females. In the same equitative way, 11 (50%) evening types are males and 11 (50%) evening children are females. See demographic data in Table I.

TABLE I. CARACTERIZATION OF THE SAMPLE BY GENDER, AGE AND GRADES

	Morning type (n = 24)	Evening type (n = 22)	Total (n = 46)
Gender			
Males [n (%)]	12 (50,2)	11 (50)	23 (50)
Females [n (%)]	12 (50)	11 (50)	23 (50)
Age			
Min-max	7-10	7-11	7-11
Mean	8,63	8,73	8,67
Standard-Dev.	0,924	1,162	1,034
Grades			
2nd	10 (41,7)	6 (27,3)	16 (34,8)
3rd	5 (20,8)	5 (22,7)	10 (21,7)
4 th	9 (37,5)	11 (50)	20 (43,5)

B. Variables and Materials

1) Chronotype

The Children's Chronotype Questionnaire [7] was administered in the Portuguese version [10] and was answered by the parents. This instrument was originally based in the measures of Morningness/Eveningness for children (Carskadon et al. 199; Smith et al. 1989). Firstly, the Children's Chronotype Questionnaire assessed the sleep/vigil patterns in school days and in free days (with no school activities). The sleep patterns included: schedules of bedtime, sleepiness, awakeness. Based on these patterns a midsleep point was estimated and determined for each chronotype. The evening types have the tendency to experience poor sleep (less sleep duration).

To calculate the midsleep point, it was used the formula of Roenneberg et al. [11]:

[5 x (sleep period in school days) + 2 x (sleep period in free days) /7].

Secondly, it was assessed the morningness and eveningness with 9 questions and they refer to the diurnal preferences of children concerning sleep and activities schedules. The punctuation: from extreme morningness (10 points) until extreme eveningness (49 points).

Third, parents were assessed concerning their perception about the chronotype of their children.

2) Attention

The Wechsler's coding subscale for children and adolescents (WISC – IV) was used in its Portuguese adapted version [9]. The Portuguese test presented a cronbach' alfa between .62 and .93 [9].

The subscale presents 59 items for the Code A and 119 items for the Code B. The code or coding subscale intends to evaluate attention and processing decoding. According to the time spent to the decoding, there are different punctuations (Table II).

TABLE II. PUNCTUATIONS ACCORDING TO THE TIME OF EXECUTION

Time (seconds)	Punctuation
0-85	+6
86-95	+5
96-100	+4
101- 105	+3
106-110	+2
111 – 115	+1
116-120	0

Source: Adapted from Simões, Rocha, and Ferreira (2003).

C. Procedures and Data Analysis

After the ehtical procedures and data protection accomplished to ensure the participation of children in this study, as well as their parents, the schools were selected and the samples were recruited attending to the criteria mentioned above. The subscale of coding was administered in two periods of the day: 9.30 am and 3.39 pm, with one-week interval. The two sessions were established with the schools approval and with the consent of the parents. The administration of the test was performed in small groups at the school classrooms. The groups were selected according to differentiated chronotypes (morning and evening) previously identified with the first instrument: the questionnaire.

Descriptive and inferential analyses were accomplished by using the SPSS, v. 24, for the scores obtained from the Questionnaire and from the coding subscale (Wechsler Intelligence Scale). First, pearson correlations and percentile calculation were estimated to determine the chronotype; second, we examined the relationship between the variables chronotype and intelligence (attention, specifically focused in this paper).

The performance variability might depend on the period of the day when the coding test was administered.

To compare means of performance between morning and evening types in the morning and in the afternoon periods, the *t*-Student test was selected.

The cut scores for the attention test were estimated regarding the mental age of the subjects and the respective matrix of the Test punctuation [9].

Normality for the sampe was determined with the Shapiro-Wilk test, considering the sample with < 50 individuals. The Levene's test was used to inform on homogeneity of the sample.

III. Results

A. *Comparison between Morning and Afternoon: Scores in the Coding Subscale of Intelligence – the Morning Children*

The *t*-Student (paired t test) revealed significant differences for the morning types in the two sessions – morning and afternoon hours: [t(23) = 2.592, p = .016]. Morning children perform better in morning session than in the afternoon session, considering the exactly same test of attention (Morning: M=13.33, SD=2.944; Afternoon: M=12.13, SD=3.710).

B. *Comparison between Morning and Afternoon: Scores in the Coding Subscale of Intelligence – the Evening Children*

Considering both evaluation periods and the results for the coding subtest among the evening individuals, the paired t test demonstrated no statistical differences between the two periods of the day [t(21) = .113, p = .911]. The means in the two periods were very similar for the evening children.

C. *Comparison between Morning and Evening Children in the Scores of the Coding Subtest, in the Morning and Afternoon Sessions*

The unpaired *t* test displayed results with significant differences in the morning session for both groups of chronotypes [t(44) = 2,604, p = .013], considering that the morning children showed higher means of performance (M=13.33, SD=2.944) compared to the evening peers (M=10.55, SD=4.251), with homogeneity variance (F = 3.113, p = .085).

In the afternoon session, for both groups of children there were no statistical differences [t(44) = 1.376, p = .176] and homogeneity was showed (F= .225, p = .638).

IV. Discussion

The results confirm the influence of the chronotype for the intelligence, specifically referring to the attention fluctuation during the day. More studies should examine this correlation of the chronotype with other specific cognitive skills of school-aged children considering the importance of the intelligence development at this age range. These data are according to a previous study [6], but in conflict with other results [12]-[14] concerning the fact that our study did produced a new insight: there are more evening children than expected. Literature refers children, at this age, as being morning type in their majority. It might be probable that the new generation of populations are changing regarding their biological clocks and eveningness is developing earlier in human being.

On the other hand, against the data of previous authors [15], even with adolescents' sample, the attention did not improve during the day. In our study, on the contrary, children tended to fail in the coding test in the afternoon period. However in the previous study [15] the task was administered three times which could biased the learning of the stimuli and the results. Research on the effects of the time of the day [16] suggested, in prepubescents, that attention tasks might demand more cognitive effort associated to the afternoon period. This hypothesis may explain the approximate means of morning and evening children for the coding test, in that period (3.30 pm). In the afternoon period might be biological variables that produce influence for the performance fluctuation (or optimization) in tasks such as attention and processing.

V. Conclusion

More studies in Biology and Psychology are needed to comprehend the performance variation in humans, mostly school-aged children, during the day and to optimize their school and work schedules in order to promote well-being and homeostasis. The future investigation at our Research Center will be extended to other nationalities of children to examine the correlation between diurnal preferences and specific cognitive abilities in different schedules. The study can also be improved on other perspective: understand how the migration factor may explain changes in the diurnal preferences; how the videogames frequency near the bedtime schedules may influence the cognitive performance for the after morning periods; how the undergraduate students may differ considering diurnal and evening university schedules, mainly observing the students who simultaneously work.

References

[1] D. Goldstein, C. S. Hahn, L. Hasher, U. J. Wiprzycka, and P. D. Zelazo, "Time of day, intellectual performance, and behavioral problems in morning versus evening type adolescents: Is there a synchrony effect?" *Personality and Individual Differences*, vol. 42, no. 3, pp. 431-440, 2007.

[2] R. Matchock and J. T. Mordkoff, "Chronotype and time-of-day influences on the alerting, orienting, and executive components of attention," *Experimental Brain Research*, vol. 192, no. 2, pp. 189-198, 2009.

[3] C. Randler, S. Bilger, and J. F. Díaz-Morales, "Associations among sleep, chronotype, parental monitoring, and pubertal development among German adolescents," *The Journal of Psychology*, vol. 143, no. 5, pp. 509-520, 2009.

[4] A. Schmidt, C. Peigneux, C. P. Cajochen, and F. Collette, "Adapting test timing to the sleep-wake schedule: effects on diurnal neurobehavioral performance changes in young evening and older morning chronotypes," *Chronobiology International*, vol. 29, no. 4, pp. 482-490, 2012.

[5] C. Hahn, J. Cowell, U. Wiprzycka, D. Goldstein, M. Ralph, L. Hasher, and P. D. Zelazo, "Circadian rhythms in executive function during the transition to adolescence: the effect of synchrony between chronotype and time of day," *Developmental Science*, vol. 15, no. 3, pp. 408-416, 2012.

[6] T. Arbabi, C. Vollmer, T. Dörfler, and C. Randler, “The influence of chronotype and intelligence on academic achievement in primary school is mediated by conscientiousness, midpoint of sleep and motivation,” *Chronobiology International*, vol. 32, no. 3, pp. 349-357, 2015.

[7] H. Werner, M. K. LeBourgeois, A. Geiger, and O. G. Jenni, “Assessment of chronotype in four-to eleven-year-old children: Reliability and validity of the children’s chronotype questionnaire (CCTQ),” *Chronobiology International*, vol. 26, no. 5, pp. 992-1014, 2009.

[8] D. Wechsler, *Wechsler Intelligence Scale for Children-WISC-IV*, 4th ed. Psychological Corporation, 2003.

[9] M. Simões, A. Rocha, and C. Ferreira, *Escala de Inteligência de Wechsler para Crianças – Terceira Edição – WISC-III. Manual*, Lisbon: CEGOC-TEA, 2003.

[10] D. Couto, A. Gomes, M. Pinto de Azevedo, S. Bos, J. Leitão, and C. Silva, “The european portuguese version of the children chronotype questionnaire (CCTQ): Reliability and raw scores in a large continental sample,” *Journal of Sleep Research*, vol. 23, no. 1, p. 160, 2014.

[11] T. Roenneberg, T. Kuehnle, P. Pramstaller, J. Ricken, M. Havel, A. Guth, and M. Merrow, “A marker for the end of adolescence,” *Current Biology*, vol. 14, no. 24, pp. 1038-1039, 2004.

[12] J. Martin, M. Gaudreault, M. Perron, and L. Laberge, “Chronotype, light exposure, sleep, and daytime functioning in high school students attending morning or afternoon school shifts: An actigraphic study,” *Journal of Biological Rhythms*, vol. 31, no. 2, pp. 205-217, 2016.

[13] C. Randler and Y. Truc, “Adaptation of the composite scale of morningness for parent report and results from kindergarten children,” *Swiss Journal of Psychology*, vol. 73, pp. 35-39, 2013.

[14] P. Russo, O. Bruni, F. Lucidi, R. Ferri, and C. Violani, “Sleep habits and circadian preference in Italian children and adolescents,” *Journal of Sleep Research*, vol. 16, no. 2, pp. 163-169, 2007.

[15] C. Escribano and J. Díaz-Morales, “Daily fluctuations in attention at school considering starting time and chronotype: An exploratory study,” *Chronobiology International*, vol. 31, no. 6, pp. 761-769, 2014.

[16] K. Van der Heijden, L. MJ de Sonneville, and M. Althaus, “Time-of-day effects on cognition in preadolescents: A trails study,” *Chronobiology International*, vol. 27, no. 9-10, pp. 1870-1894, 2010.

Sandra B. Figueiredo developed ther PhD in Psychology (2010) at University of Aveiro, Portugal, developing instruments and empirical studies about the school achievement of immigrant young children. Recently completed her 6 years post-doctoral research (2018), in Education, at Universidade Autónoma de Lisboa, Lisbon Portugal, with funding from Foundation for Science and Technology (FCT). Currently she is Associate Professor of Psychology of Department of Psychology and Sociology of UAL and she is integrated researcher in Psychology of Center of Psychology Research (CIP) of Universidade Autónoma de Lisboa, Lisbon, Portugal. Also she is co-Editor of the indexed Journal Psique (areas of Psychology and Sociology). The themes she is developing are related to the second language learners’ assessment, cognition and students’ achievement, instruments validation for schools and for skills evaluation, experimental studies in educational field, chronobiology and school performance, among others. She published already around 40 papers at international publications with peer-review and supervised a multimedia project for immigrants’ education support in Portugal.