

Combined impact of diurnal type and time of day on children's results in a battery of measurements probing reading abilities: Preliminary Results

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Abstract

The present work is part of a larger ongoing research project and it specifically aims to scrutinize whether diurnal-type (morningness- eveningness) and time-of-day have an impact (synchrony effect) on the results obtained by primary school children in standardized measures assessing reading skills and difficulties. Morning- and evening-type children attending the 2nd, 3rd or 4th grades were selected in a Portuguese “School Cluster” Using the Portuguese version of the Werner et al. (2009) Children Chronotype Questionnaire. The selected participants were randomly assigned to assessment sessions in the morning (9:00-10:30) or in the afternoon (16:00-17:30). There were 78 children (40 boys, 38 girls), 39 (50.0%) morning-type and 38 (50.0%) evening-type, 40 assessed in morning sessions and 38 in afternoon sessions. Reading abilities/difficulties were assessed using the Sucena & Castro (2011) battery ALEPE - Avaliação da Leitura em Português Europeu [European Portuguese Reading Assessment battery], by a single evaluator who was blind to each child diurnal-type. Comparing morning and afternoon sessions, morning-types mainly showed similar scores, both in terms of answer correctness and reaction times, excepting for significantly higher scores in three tests in the morning sessions. Evening-types showed similar scores in most tests for answer correctness, but in two tests they achieved significantly higher scores in the morning, and mean reaction times were consistently shorter in the morning in comparison to the afternoon sessions. In 5 out of the 7 ALEPE tests that yield reaction time scores, differences reached, or were close to, statistical significance ($p < 0.05$, or $p < 0.15$, respectively). In conclusion, in spite of evening types' performance seeming in most cases to be unaffected by time-of-day in a standardized battery of tests assessing reading abilities and difficulties, their shorter reaction times when tested in their non-optimal time-of-day (i.e., in the morning) indicates an asynchrony effect. Contrarily to our initial expectations, results obtained so far in evening-type children suggest that specific tasks may benefit from non-optimal moments, as indicated by recent evidence. Support: FCT/COMPETE/QREN – research project PTDC/PSI-EDD/120003/2010.

Keywords: morningness-eveningness, chronotype, children, time of day, optimal time, reading abilities/difficulties

Introduction

Time of day may have an impact on cognitive performances (e.g., [1], [2]). However, until recently, few studies have considered both diurnal type (morningness-eveningness) and time of day when examining the

impact of temporal variables on performance. As Smith et al. [1] stated, time-of-day cognitive fluctuations and inter-individual differences of chronotype have been largely ignored by researchers and practitioners when assessing cognitive abilities. Moreover, studies on this specific topic seem particularly scarce in children.

The present work is part of a larger ongoing research project and it specifically aimed to scrutinize whether diurnal-type (morningness-eveningness) and time-of-day have an impact (synchrony effect) on the results obtained by primary school children in standardized measures assessing reading skills and difficulties.

Methods

1.1. Participants

Participants comprised a total of 78 primary school children (40 boys and 38 girls), 39 (50%) morning-type (21 boys and 18 girls) and 39 (50%) evening-type (19 boys and 20 girls), aged 7-10 yr-old ($M=8.29$, $SD=1.00$), in the 2nd, 3rd or 4th school years, with IQ scores within the normal range or higher (inclusion criteria: ≥ 85 points in the Wechsler Intelligence Scale for Children, 3rd ed. [WISC-III], Portuguese version [3]), and without known language disorders, learning difficulties, cognitive special education needs, or behavioural disturbances.

1.2. Instruments

As part of the larger research project, several tools were used in order to assess intelligence (e.g., WISC-III) and language (e.g., TIL). Measures directly relevant for the present work were the following ones:

- Children ChronoType Questionnaire (CCTQ) of Werner et al. [4] - Portuguese version [5, 6] to assess morningness-eveningness (diurnal type). Three chronotype measures may be retrieved from the CCTQ. The Morningness/Eveningness (M/E) scale (Cronbach alpha = .73) was the measure used in the present study to identify morning- and evening-types, using as cutoff points the 20th and 80th percentiles found in a large reference sample of Portuguese children (higher scores equates to higher eveningness).
- Sucena & Castro battery ALEPE [7] - Avaliação da Leitura em Português Europeu [European Portuguese Reading Assessment battery] to assess reading abilities/difficulties. This standardized battery was developed based on a sample of 6-10 yr-old children without learning disorders, and it aims to assess the main processes underlying reading (namely, phonological awareness, rapid naming, word knowledge, word reading, and pseudoword reading). Based on ALEPE results, one may characterize the reading level of a child respective to her/his age and school year. ALEPE also helps to identify some reasons that may be underlying a learning disorder or developmental dyslexia. It is composed of 12 tests, some of them computerized ones, either focused on written words processing, or on phonological processing. Raw scores are converted in percentile scores (higher values equating to better performance).

1.3. Procedures

The study was approved by the Portuguese General Education Direction of the Ministry of Education, and by the Director of the School “Cluster” where data were collected [In Portugal, a school cluster/“agrupamento de escola” is a group of public schools in the same parish, under the same Direction, offering all levels of education ranging from kindergarten up to 12th grade of high school].

The 80 participants were randomly selected from an initial pool of 261 M- and E-type students attending to the 2nd to 4th school years of the School “Cluster”, whose parents/tutors gave their consent for their participation in the research, and who had been previously identified using the M/E scale of the CCTQ. Then, 40 M types and 40 E types were randomly assigned to assessment sessions in the morning (9:00-10:30) or in the afternoon (16:00-17:30). From the 80 cases collected, 2 of them were excluded because they were meanwhile diagnosed with ADHD. From the 78 final participants, 40 (51.3%) were assessed in morning sessions, and 38 (48.7%) in afternoon sessions, half from each diurnal type. There were no sex, age or school year differences between M- and E-type children, nor between children tested in the morning or in the afternoon.

To prevent fatigue, the administration of the psychoeducational assessment tests was distributed by sessions in different days (one session dedicated to ALEPE, one session dedicated to WISC-III, and one session dedicated to collective measures of intelligence and language). Data collection ran from Tuesday to Friday, excluding Monday due to the disruption rhythm phenomena (activity/ rest) between the school week and the weekend (Testu et al., 2008).

ALEPE data were collected by the same trained evaluator, who was blind to each child diurnal type.

Results

As expectable, no significant mean differences were found between M-types and E-types performance on the ALEPE tests. Therefore, we focused on the analyses of interest, that is, the effect of time of day on ALEPE scores, for each diurnal type, cf. Table 1. M-types: Comparing morning and afternoon sessions, M-types showed similar scores in most tests both in terms of answer correctness and reaction times, and reached significantly higher mean scores in 3 ALEPE tests when assessed in the morning (their optimal time of day) than in the afternoon (a fourth non significant trend was also apparent). E-types showed generally similar scores in the two moments of the day for answer correctness, excepting that, surprisingly, mean scores were higher in the morning (non optimal time) than on afternoon sessions (optimal time) for the ALEPE tests of Simple Words Reading and Consistent Pseudowords Reading ($p < .05$), and non significant trends were found in other three tests (cf. Table 1). In the 7 ALEPE tests that yield reaction times, these were consistently shorter in the morning in comparison to the afternoon sessions, as indicated by higher percentile mean values, with mean differences reaching statistical significance in 3 tests ($p < .05$), and being near significance in 2 other tests ($p < .15$).

Table 1: Mean scores comparisons between morning versus afternoon assessment sessions

ALEPE scores (in percentiles)	MORNING session M (SD) n = 20	AFTERNOON session M (SD) n=19	t	df	p (2-tailed)
MORNING-TYPES					
Metalinguistic phonological awareness of the phoneme	77.55 (38.47)	49.11 (44.16)	2.148	37	0.038*
Word Reading – consistent words	59.85 (35.50)	36.16 (34.17)	2.122	37	0.041*
Lowercase letters writing	78.00 (37.56)	33.53 (40.86)	3.541	37	0.001**
Lowercase letters reading	57.25 (43.22)	35.84 (39.39)	1.614	37	0.115
EVENING-TYPES					
Word reading – simple words	66.75 (37.47)	42.26 (31.97)	2.190	37	0.035*
Pseudoword reading– consistent pseudowords	61.40 (32.06)	32.84 (30.90)	2.830	37	0.007**
Pseudoword reading – total	45.15 (28.80)	30.53 (27.94)	1.608	37	0.116
Metalinguistic phonological awareness of the rhyme (CVC)	71.05 (34.10)	53.37 (37.41)	1.544	37	0.131
Uppercase letters Reading	81.20 (36.53)	60.58 (46.36)	1.538	34.22	0.133
Lowercase letters Reading	62.70 (41.68)	41.53 (40.70)	1.604	37	0.117
Reaction time - Word reading – inconsistent words	70.95 (23.11)	44.21 (37.99)	2.621	29.72	0.014*
Reaction time – total Word reading	68.70 (25.63)	48.37 (36.29)	2.012	32.24	0.053
Reaction time - Pseudoword reading - simple pseudowords	68.65 (29.58)	47.26 (33.51)	2.116	37	0.041*
Reaction time - Word reading – simple words	67.20 (26.72)	49.58 (35.49)	1.758	37	0.087
Reaction time - Pseudoword reading– total	69.20 (28.80)	49.89 (34.92)	1.888	37	0.067

Only statistically significant (* $p < 0.05$ or ** $p < 0.01$) and potentially relevant results ($p < .15$) are shown. ALEPE: Avaliação da Leitura em Português Europeu [European Portuguese Reading Assessment battery]. CVC: Consonant, Vogal, Consonant.

Discussion

In this study we expected a better performance when the testing session schedules were in line with the children's inner biological clock. Interestingly the results suggest both synchrony effects (M-types had better performances at their optimal moment) and asynchrony effects (E-types had better performances at their non-optimal moment) in some specific reading abilities tests. As Díaz-Morales & Escribano [8] concluded in their review, the effects of time-of-day need to be further investigated as they may not follow a pattern merely based on "synchrony and better performance". In fact, recent evidence suggest that implicit memory might be facilitated by more non-conscious, associative processing, and therefore would be better at non-optimal moments of the day when inhibition is lower.

In conclusion, in line with the hypothesis of facilitation resulting from lowered inhibition, it would seem that both M- and E-types could benefit not only from their optimal but also from their non-optimal moments, depending on the nature of the task at hand. However, it was not clear why synchrony effects emerged only in M-types and asynchrony effects emerged only in E-types. The present results should be regarded as preliminary, as further analyses and future research seems to be needed.

Probably, to understand the effects of time of day over performance on each diurnal type, it is necessary to consider the nature of the tasks, in other words, to specifically consider the basic cognitive processes and the level of control required to successfully perform each task.

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References

- [1] Schmidt, C., Collette, F., Cajochen, C. & Peigneux, P. (2007). A time to think: Circadian rhythms in human cognition. *Cognitive Neuropsychology*, 24(7), pp. 755-789.
- [2] Testu, F. (2008). Rythmes de vie et rythmes scolaires. Aspects chronobiologiques et hronopsychologiques. Issy-les-Moulineaux: Elsevier Masson.
- [3] Wechsler, D. (2003). Wechsler Intelligence Scale for Children, 3rd Edition / Escala de Inteligência de Wechsler para Crianças, 3ª edição - WISC III. Manual. Lisbon: CEGOC.
- [4] Werner, H., LeBourgeois, M. K., Geiger, A., & Jenni, O. (2009). Assessment of Chronotype in four- to eleven-year-old children: Reliability and Validity of the Children's Chronotype Questionnaire (CCTQ). *Chronobiology International* 26(5), pp. 992-1014.
- [5] Couto, D., Allen Gomes, A., Pinto de Azevedo, M.H., Clemente, V.M.O., Bos, S.M.C. & Silva, C.F. (2013). Diurnal Type in Children: preliminary results about the European Portuguese version of the CCTQ. *Sleep Medicine* 14(Suppl), pp. e139-e139. DOI: <http://dx.doi.org/10.1016/j.sleep.2013.11.314>.
- [6] Couto, D., Allen Gomes, A., Pinto de Azevedo, M.H., Bos, S.M.C., Leitão, J. A. & Silva, C.F. (2014). The European Portuguese version of the Children ChronoType Questionnaire (CCTQ): reliability and raw scores in a large continental sample [P532]. [Abstract] *Journal of Sleep Research*, 23(s1), pp.160-160. doi: <http://onlinelibrary.wiley.com/doi/10.1111/jsr.12213/abstract>
- [7] Sucena, A., & Castro, S. L. (2011). ALEPE - Avaliação da Leitura em Português Europeu [European Portuguese Reading Assessment battery]. Lisbon: CEGOC-TEA.
- [8] Diaz-Morales, J. & Escribano, C. (2014). Consequences of adolescent's evening preference on psychological functioning: a review. *Anales de Psicología* 30(3), pp. 1096-1104.