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Morning-Evening Types in Kindergarten, Time-of-Day and Performance on Basic Learning Skills*

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ABSTRACT

Research on the combined effect of diurnal type and time of day on school/ preschool performance is still scarce, probably because until recently there were no non-invasive questionnaires measuring diurnal type in younger children. To our knowledge, in the literature studies on the so-called synchrony effect only exist for adolescents and adults and no work has been conducted on prepubertal children. This study investigated in kindergarten the relationship between morning-evening types with time-of-day and performance on a battery of tests covering basic skills involved in preschool learning. The sample comprised 80 children between 5 and 6 years old (M = 5.42, SD ± 0.495): 36 morning (45%) and 44 evening (55%) types, classified according to the Children's Chronotype Questionnaire (Werner et al., 2009; PT version, Couto et al., 2014). The children completed a battery of tests related to kindergarten learning (Vitória de La Cruz, PT version, 2012) at four times in the kindergarten day (9:30-10:00; 11:30-12:00; 13:30-14:00; 15:00-15:30). Analyses indicated: an asynchrony effect on the Constancy of Form test, as M-E types performed better in their non-optimal moments, reaching significance in M-types; time-of-day effects in the Verbal (13:30-14:00 > 11:30-12:00), Quantitative Concepts (15:00-15:30 > 9:30-10:00/ 11:30-12:00/ 13: 30-14:00) and Position in Space (11:30-12:00 > 13:30-14:00) tests. These results suggest the "synchrony effect" may be a simplistic hypothesis, and better performances are not necessarily associated to early times in the school day. Replication studies are necessary.

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Keywords:
Morningness-eveningness, children, time of day, optimal time, basic learning skills.

Introduction

The diurnal type (morningness-eveningness), often called chronotype, reflects relatively stable inter-individual differences linked to circadian rhythms entrained by the light/dark cycle, and specifically related to the acrophases (peak hours) of circadian rhythms (Gomes, 2005; Roenneberg, Wirz-Justice & Merrow, 2003; Silva et al., 1996). In general, morning types (M-types) prefer getting up and going to bed early, while evening types (E-types) prefer later bed times and rise times (Adan et al., 2012). Other physiological data also confirm differences between M- and E- types (Cavallera, Boari, Guidici & Ortolano, 2011; Cavallera & Guidici, 2008). Compared to E-types, M-types reach temperature and melatonin acrophases earlier, and secrete higher levels of adrenalin and cortisol during the first hours of the day. The influence of genetic

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factors has been studied (e.g., Archer et al., 2003; Pereira, Tufik & Pedrazzoli, 2009, Roenneberg, 2015), even though environmental factors may also play a role (e.g., Le Floc'h, Clarisse & Testu, 2014). M- and E-types are located near the opposite tails of a Gaussian distribution, with intermediate types being the most numerous as consistently shown by population-based questionnaire studies (for a review, see Levandovski, Sasso & Hifalgo, 2013; Spruyt & Gozal, 2010).

One important area of study in adolescents and adults on morningness–eveningness orientation concerns variations in cognitive functions depending on the time-of-day. Performance on different cognitive tasks seems to be influenced by the synchrony between diurnal type and time of day (i.e., better performance in the morning than later in the day for M-types compared to better performance later in the day than in the morning for E-types) and in some instances by their asynchrony (i.e., better performance later in the day than in the morning for M-types and better performance in the morning than later in the day for E-types) - in other words, depending on whether individuals are tested during their optimal or non-optimal moments (Adan et al., 2012; Diaz-Morales & Escribano, 2014). Specifically, a number of school relevant tasks involving cognitive variables such as attention (Clarisse, Le Floc´h, Kindelberger & Feunteun, 2010), working memory (Fabbri, Mencarelli, Adan & Natale, 2013; May, Hasher & Foong, 2005), fluid intelligence (Goldstein, Hahn, Hasher, Wiprzyca & Zelazo, 2007), executive functions (Hahn et al., 2012) and verbal fluency (Isakandar et al., 2016) vary in synchrony with chronotype. Surprisingly, although studies reporting synchrony effects are far more numerous, recent research indicates that during non-optimal times of day (i.e. asynchrony) individuals could also perform better on some tasks, namely on spatial intelligence sub-tests (Song & Stough, 2000), and in tasks involving decision making (Dickinson & McElroy, 2012), implicit memory (May et al., 2005), implicit learning (Delpouve, Schmitz & Peigneux, 2014) and creative processes (Wieth & Zacks, 2011). According to the literature, it therefore appears that the emergence of synchrony or asynchrony effects depends on the cognitive activities involved (e.g., Díaz-Morales & Escribano, 2014). It is important to recall that there are various rhythms of cognitive performance with acrophases occurring at different times of day. For example, the results of memory tests in children and adults show variations during the day: the short-term memory peak occurs in the morning; whereas, long term memory performance is better in the late afternoon (Crépon, 1985; Folkard, 1979; Folkard & Monk, 1980; Folkard, Monk, Bradbury & Rosenthall, 1977; Klein 2001, 2004; Reinberg, 1995, 1999, Testu, 2000). Furthermore, to understand performance variations of long term memory it is necessary to take into account the time of day when the information is presented and when the delayed recall takes place (Testu & Clarisse, 1999). Moreover, the time of the day at which a cognitive test is optimally completed can depend on the specific parameters of the task, its duration and difficulty, and the way it is administered, e.g., collective vs individual (Clarisse et al., 2010; Schmidt et al., 2007; Testu, 2000).

Although in recent years studies investigating synchrony/asynchrony effects on performance have increased, the majority of published research has focused separately either on the differences between M- and E-types per se, or on the time-of-day effects or oscillations in performance. In terms of research investigating differences between diurnal types, eveningness orientation has been associated with poorer academic achievement (Beşoluk, Önder & Deveci, 2011; Escribano, Díaz-Morales, Delgado & Collado, 2012; Gomes, Tavares, & Azevedo, 2011) but positively associated with cognitive abilities, and morningness negatively associated with cognitive abilities but positively with academic performance (Preckel, Lipnevich, Schneider & Roberts, 2011*).* Explaining these apparently inconsistent findings remains a challenge. In addition, studies among undergraduates have highlighted links between morningness-eveningness and thinking styles (Díaz-Morales, 2007; Fabbri et al., 2007; Giampietro & Cavallera, 2007). In general, morning types tend to be left-brained thinkers, preferring verbal and analytic strategies in processing information, while evening types are more right-brained thinkers who tend to be more creative and intuitive. For instance, Díaz-Morales and Escribano (2013) studied the relationship between circadian preferences and thinking styles and the impact on self-reported school achievement in preadolescents and adolescents. M-types (left-brained thinkers) reported the highest subjective level of achievement, and E-types (right-brained thinkers) the lowest. Recently using functional magnetic resonance imaging Schmidt et al. (2015) reported an interaction between chronotype, time of day and the modulation of brain activity by working memory in the thalamus and the middle frontal cortex. During the morning session the M-type exhibited higher activity than the E-type in the middle frontal gyrus, while during the evening session the E-type exhibited higher thalamic activity than the M-type.

Regarding time-of-day research, chrono-psychological studies, mainly in the context of young children in French schools have focused on observing sleep patterns or the time-of-day effects on school variables and cognitive activities (Batejat, Navelet & Blinder, 1999; Challamel et al., 2001, Feunteun, 2000; Gates, 1916; Guerin et al., 2001, S. Jarraya, Jarraya & Souissi, 2014; Leconte-Lambert, 1994; Le Floc'h, Clarisse, & Testu, 2014; Testu, 1979, 1982, 1984, 1996, 2000; Testu & Clarisse 1999) without considering the interaction between diurnal type preferences and time of day. In the primary school years (6 to 11 years of age) the standard pattern highlighted shows that attention and intellectual performance reach the achrophase by the end of the school morning, deteriorate during the lunch break (batyphase), and then increases during the afternoon. This profile of school performance seems to be independent of geographic origin (Testu, 1994b) and has been called the "classic pattern" by Testu (1994a; 1996; 2000). However, the opposite was found for "preschoolers (4–5 years of age)" for whom the achrophase occurs in the first morning session, then performance declines, rises again during the lunch break and then declines during the afternoon (Janvier & Testu, 2007). According to these authors there are many factors to be taken into account in the analysis of daily changes of performance, including age, type of task, the activated sensory modality, diurnal type, motivation and fatigue.

In sum, recent years have revealed a growing and renewed interest in the combined impact of diurnal type (morningness-eveningness) and time of day, a topic which is virtually unexplored in young children, and which deserves further investigation given the wide range of findings. This work aimed to study the relationship between morning-evening types with the time of day and performance on a battery of basic learning skills in kindergarten. We expected children to perform better when tested at moments of the day coinciding with their preferred biological clock time. The absence of data in kindergarten children led us to formulate the more intuitive synchrony hypothesis as a starting point for our research, but asynchrony effects should not be excluded considering some recent evidence.

Method

A double-blind experimental design was used. The examiner and the participants had no information about the diurnal type (Marôco, 2014). The study was conducted in accordance with ethical recommendations for human chronobiological research (Portaluppi, Smolensky & Touitou, 2010), and was approved by: [1] the directors of Portuguese General Education of the Ministry of Education (ref.:0372400002); [2] the Ethics and Deontology Committee of the University of Aveiro (ref.: 2/2014); [3] the head 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 head, offering all levels of education ranging from kindergarten up to 12th grade of high school); [4] teachers of all the preschool classes, after informed consent by parents/ guardians.

Participants

The sample comprised 80 children of between 5 and 6 years old (M = 5.42, SD ± 0.495): 36 M-type (45%) and 44 E- type (55%), from an initial pool of N=130 children including all diurnal types. Distribution of M-E types by age [Total: M-type and E-type] were: 5- year-olds (47: 23 and 24) and 6- year-olds (33: 13 and 20). For M-types there were 13 boys and 23 girls, and for E-types there were 21 boys and 23 girls. Children with special educational needs (SEN) were excluded from the sample (as well as those referred for medical evaluation due to probable SEN) according to information provided by parents and teachers. Children lived in an urban area and attended kindergarten following the traditional Portuguese 5-day school week (i.e.: Monday, Tuesday, Wednesday, Thursday and Friday). In Portugal kindergarten classes in the morning are from 9:00 to 12:00 with a break from 10:00 to 10:30. However, parents may leave their child at school from 8:00 if necessary. After lunch, in the afternoon the classes follow the same structure, from 13:30 to 15:30 with a break from 14:30- 15:00. The children who participated in the study usually had lunch at school between 12:00 and 13:30.

Instruments

The children's chronotype questionnaire (CCTQ). Portuguese version (Couto et al., 2014, adapt. from the original by Werner et al., 2009) was used to determine the children's diurnal type. This questionnaire was designed to be completed by parents/guardians of 4 to 11 year-old children, and it comprises 27 items

covering demographic information, questions about preferences and usual sleep-wake patterns during children's free and school days. Three measures of chronotype can be obtained from the CCTQ: mid-sleep point on free days using the correction suggested by Roenneberg et al. (2004); chronotype score (item 27); and morningness/eveningness scale score (sum of items 17 to 26 with higher scores indicating greater eveningness). The latter measure was used in the present study to determine diurnal type, using the percentiles 20 or 80 as cut-off points to define M- or E-type children respectively (in order to include not only definitive types but also a large part of those usually labeled as moderately M- or E-types). Cronbach's alpha coefficients were $\alpha = 0.728$ in the Portuguese national sample (Couto et al., 2014) and $\alpha = 0.768$ in the present study.

The battery of basic skills for preschool learning (BPE). Portuguese version (Vitória de La Cruz, GEGOC-TEA, 2012) is a battery of tests developed for 5 to 6 year-old kindergarten children consisting of eight tests assessing basic learning skills which supposedly correspond to curricular components at this level of education. The tests are taken collectively and are preceded by an example, for practice purposes. Description of the subtests:

[i] Verbal - consists of 16 items, each containing four pictures. The subject should identify the picture corresponding to the word or oral instructions given by the examiner (e.g., "mark the picture of the house");

[ii] Quantitative Concepts - consists of 14 items, each one displaying four pictures. The subject should identify the picture corresponding to the quantitative concept and/ or the numbers or oral instructions given by the examiner (e.g., "mark the picture that has the most points inside");

[iii] Auditory Memory – involves a notebook containing 14 pictures. For this test, children must first look at the ceiling of the room with the notebook face down, so that they cannot look at the pictures. The examiner then gives the name of 7 pictures orally. After that, children turn the notebook over and mark the pictures mentioned by the examiner;

[iv] Constancy of Form - composed of 2 items. Each item shows one key-picture followed by a series of pictures. The subject should mark all the pictures that look exactly like the first one;

[v] Positions in Space - consists of 7 items. Each item presents a key-picture followed by 4 pictures, and the subject should mark all the pictures that are displayed in exactly the same orientation as the first one;

[vi] Spatial Orientation - consists of 8 items. Each item displays a key-picture followed by a space to be filled. The subject must reproduce the picture in this space, i.e., exactly the same size and position.

[vii] Visual Motor Coordination - consists of 6 items. Each item shows a path between a picture A and B. The subject should draw the path from picture A to B without lifting the pencil and without touching or crossing over the edges which delimitate each path;

[viii] Ground-Figure - composed of 6 pictures. The subjects should mark in pencil all the pictures that look exactly the same as the ones previously given by the examiner.

The BPE sub-tests require a combination of different cognitive processes. The Verbal and Quantitative Concepts tasks are relatively complex and involve: auditory attention, visual attention, conceptual processes, explicit information retrieval, strategic operations of retrieval, and require extensive activation of long term memory. The Auditory Memory task involves auditory attention and demands a greater activation of working memory. The Constancy of Form, Space Positions, Spatial Orientation, Visual Motor Coordination and Ground-Figure tasks would appear to involve the following cognitive processes: visual attention, perceptual processes, implicit information retrieval, and a greater activation of working memory.

Procedure

Data were collected in two phases: [a]after their informed consent parents/ tutors responded to the CCTQ; [b] children completed the BPE at different times of day. The CCTQ was administered during the second school term. The BPE was administered during the third term in May and June, coinciding with spring in the northern hemisphere. Tests began two weeks after the end of the Easter holiday break in order to ensure that a circadian rhythmicity typical of school periods had been restored. Monday was excluded from the testing schedule due to the disruption of rhythm (activity/ rest) between the school week and the weekend (Testu, 2000). The scheduling of each session took into account the typical kindergarten schedule in Portugal (described in the participants section) as well as research on school chrono-psychology (Testu, 2000). Therefore, the following times of day were defined for administering tests: "beginning of the morning class" (9:30-10:00), "end of the morning class" (11:30-12:00), "beginning of the afternoon class" (13:30-14:00)

and "end of the afternoon class" (15:00-15:30). To neutralize the effects of automatic learning (Testu, 2000) we used a Latin Square (4x4) to counterbalance the order of treatments (Alferes, 2012) and to randomly determine the sequence of the BPE sub-tests, cf. Table 1.

Table 1. Latin square (4x4) randomization of the sequence of BPE sub-tests according to the time-of-day.

Sequence	9:30-10:00	11:30-12:00	13:30-14:00	15:00-15:30
A	V/AM	QC/CF	PS/SO	VMC/GF
B	QC/CF	V/AM	VMC/GF	PS/SO
C	VMC/GF	PS/SO	QC/CF	V/AM
D	PS/SO	VMC/GF	V/AM	QC/CF

Note: *BPE sub-tests – V (Verbal)/ ME (Auditory Memory)/ QC (Quantitative Concepts)/ CF (Constancy of Form)/ PS (Position in Space) / SO (Spatial Orientation)/ VMC (Visual Motor Coordination) / GF (Ground Figure).*

Then, kindergarten classes (n=8) were randomly assigned by the sequences of BAPAE sub-tests (Alferes, 2012), cf. Table 2.

Table 2. Random distribution of preschool classes according to sequences of BPE sub-tests.

			Test series	
	A	B	C	D
Classes (C)	C1/C5	C7/C8	C2/C6	C3/C4

The same investigator administered the BPE at all the session times and for all the classes. Prior to sample collection a pilot experiment was performed in another class, in order to practice the procedure for administering the BPE sub-tests, to anticipate difficulties and define specific procedures for dealing with them.

Data Analysis

Definitely and moderately M- versus E- types were aggregated and classified using the 20th and 80th percentiles (criteria adapted from the Horne & Östberg's (1976) classification). Normative percentile values specifically identifying the M/E scale of the CCTQ were taken from a previous study at a national scale (Couto et al., 2014). Neither type was excluded. Regarding BPE sub-test scores we used the percentile values for each age group according to the available norms for Portuguese children (Vitória de La Cruz, Portuguese version, GEGOC-TEA, 2012). Across variables the values for asymmetry and kurtosis were between -2 and +2 which are considered near enough to a normal univariate distribution (George & Mallery, 2010), and therefore parametric statistics were used (Marôco, 2014). For each BPE sub-test two-way ANOVAs were performed, considering two main factors (time-of-day; M vs. E type) and an interaction effect (M-E type*Time of Day). Since BPE is composed by a variety of tests requiring the combination of diverse cognitive processes, therefore the univariate effects were those of substantive interest in our analyses, and for that reason no MANOVA was previously conducted (cf. Keselman et al., 1998). The effect size was measured by means of partial eta squared (η^2_p) with reference ANOVA values of Cohen (1988), and ANOVA values observed Power (π) in accordance with Marôco (2014). Statistical analyses were conducted using IBM SPSS Statistics 22.

Results

Table 3 reports the mean performances and standard deviations (SD) for all the tests for M and E types at the different times of day (see in Appendix). ANOVAs 2x4 by diurnal type and time of day (Table 4) revealed the following significant results (p<.05): [i] main effect of time-of-day in the Verbal ($F_{(3, 77)} = 3.350$, $p = .023$; $\eta^2_p = .115$; $\pi = .740$), Quantitative Concepts ($F_{(3, 64)} = 6.198$, $p = 0.001$; $\eta^2_p = 0.225$; $\pi = 0.954$) and Space Positions ($F_{(3, 64)} = 3.290$, $p = 0.026$; $\eta^2_p = 0.130$, $\pi = 0.727$) tests; [ii] main effect of M- vs. E- types in the Constancy of Form ($F_{(1, 64)} = 6.771$, $p = 0.011$; $\eta^2_p = 0.096$; $\pi = 0.727$), and Spatial Orientation ($F_{(1, 58)} = 8.048$; $p = 0.006$; $\eta^2_p = 0.122$; $\pi = 0.797$) tests; [iii] interaction effects of M-E type*Time–of-day for the Constancy of Form test ($F_{(3, 64)} = 4.218$, $p = .009$; $\eta^2_p = .165$; $\pi = .837$).

Table 3. Means on BPE performance subtests for the whole sample, and MT and ET, at each of the testing session times.

	9:30-10:00	11:30-12:00	13:30-14:00	15:00-15:30
	Total			
Verbal	44.9 (±33.9)	43.9 (±26.4)	68.0 (±27.3)	70.7 (±23.9)
Quantitative Concepts	38.1 (±32.3)	33.9 (±29.3)	29.5 (±20.6)	62.8 (±27.3)
Auditory Memory	34.7 (±23.9)	39.0 (±25.8)	43.2 (±29.3)	40.4 (±25.8)
Constancy of Form	70.0 (±34.9)	57.8 (±30.1)	62.8 (±23.5)	72.1 (±26.5)
Positions in Space	56.0 (±28.7)	68.3 (±32.6)	36.5 (±37.7)	49.1 (±34.8)
Spatial Orientation	56.5 (±30.2)	60.0 (±34.1)	53.5 (±34.6)	61.0 (±33.0)
Visual Motor Coordination	73.7 (±22.2)	71.0 (±29.9)	65.1 (±25.6)	60.8 (±32.5)
Ground-Figure	63.4 (±26.8)	69.4 (±30.7)	57.2 (±36.5)	58.8 (±32.8)
	M-type			
Verbal	43.2 (±37.3)	30.0 (±30.7)	67.6 (±29.3)	72.4 (±21.6)
Quantitative Concepts	26.5 (±48.3)	38.0 (±42.6)	29.3 (±18.7)	62.4 (±31.1)
Auditory Memory	50.0 (±27.9)	38.0 (±34.0)	48.9 (±36.2)	45.3 (±32.9)
Constancy of Form	26.7 (±26.6)	49.0 (±29.5)	65.8 (±25.3)	70.7 (±27.6)
Positions in Space	50.8 (±28.6)	61.5 (±31.2)	47.0 (±45.0)	15.6 (±18.5)
Spatial Orientation	39.0 (±17.6)	45.1 (±32.4)	53.0 (±42.1)	46.4 (±51.8)
Visual Motor Coordination	72.3 (±22.5)	62.8 (±30.0)	46.8 (±32.8)	73.6 (±30.8)
Ground-Figure	58.1 (±28.1)	64.1 (±33.3)	45.8 (±33.2)	47.6 (±30.4)
	E-type			
Verbal	45.8 (±34.1)	50.2 (±22.9)	68.3 (±26.5)	66.5 (±28.8)
Quantitative Concepts	42.8 (±25.3)	31.5 (±20.2)	29.8 (±25.1)	63.2 (±24.6)
Auditory Memory	24.5 (±15.0)	39.5 (±23.1)	38.0 (±21.0)	33.0 (±4.88)
Constancy of Form	87.3 (±18.9)	63.2 (±30.7)	58.1 (±21.9)	73.5 (±26.4)
Positions in Space	60.7 (±29.0)	78.5 (±34.8)	30.3 (±33.5)	64.3 (±29.4)
Spatial Orientation	77.2 (±29.2)	74.8 (±31.3)	53.8 (±32.5)	67.6 (±20.1)
Visual Motor Coordination	77.2 (±29.2)	74.8 (±31.3)	53.8 (±32.5)	67.6 (±20.1)
Ground-Figure	71.3 (±24.9)	74.2 (±28.5)	62.4 (±38.2)	65.6 (±33.9)

Table 4. Results of two-way ANOVAs on each BPE subtest.

Source	*SS*	*df*	*MS*	*F*	*p*	*η*
Verbal						
E-/M-type	304.093	1	304.093	0.379	.541	.07
Time-of-day	11316.236	3	3772.079	4.696	.005	.42
Interaction	1344.240	3	448.080	0.558	.645	.15
Error	51405.576	64	803.212			
Quantitative Concepts						
E-/M-type	118.669	1	118.669	0.149	.701	.04
Time-of-day	14834.295	3	4944.765	6.198	.001	.47
Interaction	871.501	3	290.500	0.364	.779	.13
Error	51062.021	64	797.844			
Auditory Memory						
E-/M-type	2235.218	1	2235.218	3.518	.080	.21
Time-of-day	451.320	3	150.440	0.213	.887	.1
Interaction	1288.613	3	429.538	0.617	.613	.16
Error	46009.873	65	707.844			
Positions in Space						
E-/M-type	3532.384	1	3532.384	3.582	.063	.22
Time-of-day	9131.841	3	3243.947	3.290	.026	.36
Interaction	7822.173	3	2607.391	2.644	.056	.32
Error	65081.617	66	986.085			
Constancy of Form						
E-/M-type	4666.545	1	4666.545	6.771	.011	.30
Time-of-day	3331.579	3	1110.526	1.611	.195	.26
Interaction	8721.435	3	2907.145	4.218	.009	.40
Error	44109.980	64	689.218			
Spatial Orientation						
E-/M-type	7340.369	1	7340.369	8.048	.006	.34
Time-of-day	297.937	3	99.312	0.109	.955	.07
Interaction	3019.850	3	1006.617	1.104	.355	.23
Error	52899.406	58	912.059			
Visual Motor Coordination						
E-/M-type	640.210	1	640.210	0.837	.364	.11
Time-of-day	1841.514	3	613.838	0.803	.497	.18
Interaction	4743.444	3	1581.148	2.067	.113	.29
Error	49718.385	65	764.898			
Ground-Figure						
E-/M-type	3412.884	1	3412.884	3.338	.072	.21
Time-of-day	2767.369	3	922.456	0.902	.445	.19
Interaction	183.849	3	61.283	0.060	.918	.05
Error	67480.03	66	1022.45			

SS= Sum of Squares; *df*= degrees of freedom; *MS*= mean square; *F* =F statistic; *p* =significance level; *η* = eta.

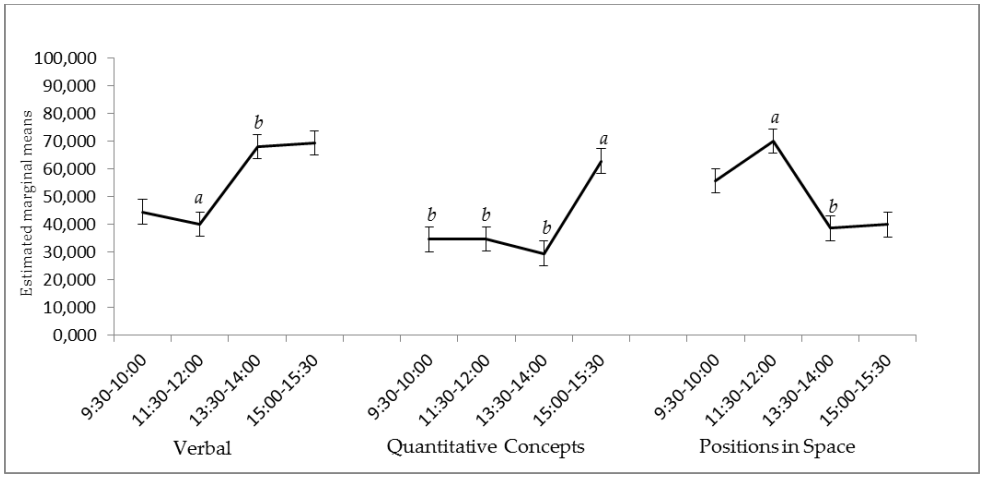


Figure 1. Time-of-day effects in performance on Verbal, Quantitative Concepts and Space Positions sub tests. Different letters (a and b) were used to indicate significant differences in post-hoc tests *(p*<.05, *post-hoc,* Tukey HSD).

Note: *Different letters (a and b) were used to indicate significant differences in post-hoc tests (p<.05, post-hoc, Tukey HSD): Verbal a (13:30-14:00) compared to b (11:30-12:00); Quantitative Concepts a (15:00-15:30) compared to b (9:30-10:00/ 11:30-12:00/ 13: 30-14:00) and Positions in Space a (11:30-12:00) compared to b (13:30-14:00).*

Figure 1 shows mean scores of subtests indicating significant main effects of the time-of-day and the results of the post-hoc tests (letters *a* and *b* mean statistically significant differences between the signalized groups). In the Verbal test children performed better in the first afternoon session [*a* (13:30-14:00)] than in the second morning session [*b* (11:30-12:00)]. In the Quantitative Concepts test performances in the last afternoon session [*a* (15:00-15:30)] were better than those in the morning sessions [*b* (9:30-10 / 11:30-12)] and the first afternoon session [*b* (13:30-14:00]. In the Positions in Space test performances were better in the second morning session [*a (*11:30-12:00)] than in the first afternoon session [*b* (13:30-14:00)]. The main effect of M vs. E type in the Constancy of Form test revealed that the mean performance of E types was better than that of M types. The same was found for the Spatial Orientation test where E-type children performed better than M-type children.

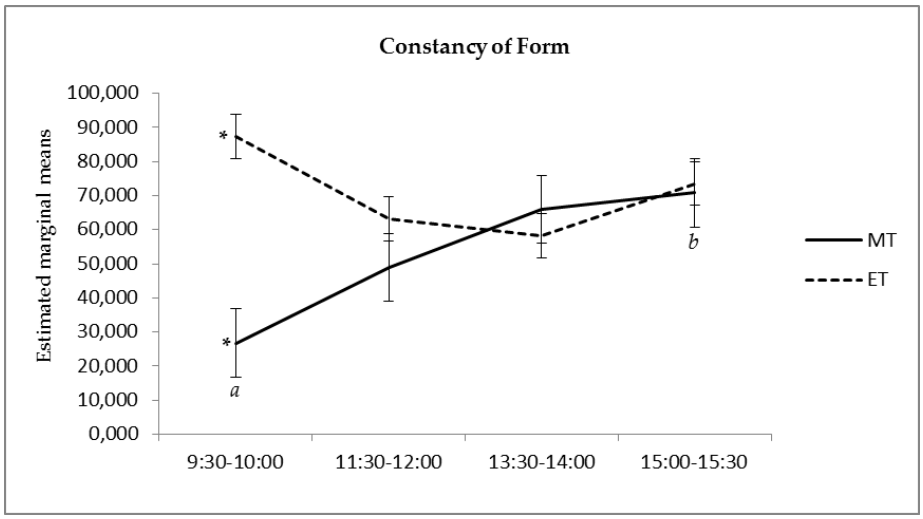


Figure 2. Scores in the BPE sub-test Constancy of Form according to the M-E type* time-of-day (p<.05) in preschool. Different letters (*a* and b) and (⋆) were used to indicate significant differences in post-hoc tests.

Note: *Different letters (a and b) or asterisks (⋆) were used to indicate significant differences in post-hoc tests: a (9:30-10:00) compared to b (15:00-15:30) for M-type; and M-types (*) compared to E-types (*) in the first morning session (9:30-10:00).*

Figure 2 represents the significant interaction effect between M-E type*Time–of-day in the Constancy of Form test - post-hoc statistically significant differences were signalized either using asterisks *or* using different letters. The mean values suggest that E-types achieved higher scores in the first morning session

(9:30-10:00) and M-types achieved higher scores in the last afternoon session (15:00-15:30). Post-hoc tests further demonstrate that M-types obtained statistically lower mean scores in the first morning session [*a* (9:30-10:00)] than either in the last afternoon session [*b* (15:00-15.30)] or for the E-type mean score at the same morning session [*].

Discussion and Conclusion

This study aimed to investigate in an ecological preschool context the effects of the interaction between M-E type and time-of-day on performances in tests of basic skills that supposedly correspond to the curricular components at this level of education. The results obtained here are of interest because previous studies on (a)synchrony effects were conducted with adolescents and adults, and did not test young children, neglecting the potential implications of optimal/non-optimal moments on performance in these developmental years. Our results are firstly discussed in terms of the interaction effects. Secondly, the main effects of time-of-day are addressed, and lastly the main effects of diurnal type are also discussed.

The initial hypothesis of our research predicted children would perform better when tested at optimal times, i.e., moments of the day coinciding to their preferred biological clock time: in the morning for M-types and in the afternoon in E-types. Contrary to what was expected we did not find any synchrony effects in our preschoolers. Instead, findings suggest an asynchrony effect, which reached significance in M-types (better performance at non-optimal moment), specifically in the Constancy of Form test. In the remaining tests, performances were not influenced by the interaction time-of-day*diurnal-type. Our findings resemble a few studies with adolescents and adults that reported asynchrony effects. Song and Stough (2000) found that in spatial intelligence sub-tests, M-type students had lower scores in the morning and higher scores in the afternoon, and on the contrary, the E-types performed better in the morning than in the afternoon (no differences were found in other intelligence sub-tests). Wieth and Zacks (2011) concluded that in tasks that involve creativity M- and E-types seem to benefit from non-optimal times of day. Examining the research literature, it seems probable that the emergence of synchrony or asynchrony effects depends on the cognitive activities required by each task. It is fundamental to recognize that there are diverse rhythms of cognitive performance with acrophases occurring at different times of day. Moreover, the time of day at which a cognitive test is optimally completed may be influenced by the specific parameters of the task as already suggested (Clarisse et al., 2010; Schmidt, *et al*., 2007; Testu, 2000). May et al. (2005) found that younger and older adults showed an increase in implicit memory during non-optimal compared to optimal times of day, whereas the synchrony effect was observed for explicit memory. Thus, tasks involving conscious, deliberate efforts to process and retrieve information are more successful at peak/optimal than at off-peak/non-optimal times of day; on the contrary, for perceptually based tasks automatic unconscious responses are more likely to be produced at off-peak/non-optimal than at peak/optimal times of day. According to May and Hasher (1998), May (1999), and May et al. (2005) during non-optimal times of day resources are less readily available and therefore automatic. On the other hand, lower levels of processing resources are associated with reductions in inhibition influencing the momentary contents of working memory. This lowered inhibition may increase the contents of working memory. It is important to notice the cognitive processes involved in the Constancy of Form test which include spatial attention, visual attention, perceptual processes, implicit information retrieval and greater activation of working memory, which therefore may explain the best performances at non-optimal times of day in this task. Delpoeuve, Schmitz and Peigneux (2014) found the same kind of results with university students using an implicit learning task (artificial grammar learning), i.e. in tasks involving automatic processes M- / E-types benefit from off-peak times possibly due to less efficient executive functions. In line with Yoon, May and Hasher (1999) the authors proposed the hypothesis that such a beneficial effect could be accounted for by a decrease in the efficiency of inhibition processes.

The significant main effects of time of day in the present study are consistent with previous findings. In fact, regarding the results on the Verbal test children performed better in the first afternoon session (13:30-14:00) than in the second morning session (11:30-12), and in the Quantitative Concept test they performed better in the last afternoon session (15:00-15:30) than in the first afternoon session (13:30-14:00) and the morning sessions (9:30-10:00/ 11:30-12). Janvier & Testu (2007) found attention patterns depend on the child´s age. For "kindergartners (5-6 years old)" they observed that the achrophase occurs in the first school morning session, then it declines, rises again during the lunch break and then increase during the afternoon. This pattern differs for "preschoolers (4-5 years old)" only in the last afternoon session, when attention

declines. Furthermore, the Verbal and Quantitative Concepts tests consist of relatively complex tasks involving different cognitive processes (auditory attention, visual attention, conceptual processes, explicit information retrieval), and engaging greater activation of long term memory. As mentioned before, results of memory tests in children and adults have shown that short-term memory is better in the morning than in the afternoon, whereas long term memory is better in the late afternoon than in the morning, and this could explain our present results. Since both tests involve long-term-memory, our results therefore seem to agree with findings from the 1970's and 1980's showing that performance acrophases occur in the late afternoon for long-term memory tasks, and in the morning for short-term memory tasks (Folkard, 1979; Folkard, Monk, Bradbury & Rosenthall, 1977; Folkard & Monk, 1980). On the other hand, in the Space Position test our sample performed better in the morning than in the afternoon. This test involves working memory, possibly explaining the morning preference. This test also requires spatial and visual attention, and therefore Leconte-Lambert's (1994) study in children of 3-5/ 5-6 years old on the daily fluctuations in performance in tests of auditory and visual attention is also of relevance here. In fact, they concluded that performance in a visual test was the opposite of that in an auditory attention test. In the latter, children performed better in the afternoon than in the morning; whereas in a visual attention task children's performances were better in the morning than in the afternoon. This pattern of results is in line with our findings of higher scores in the morning in the Space Position test. Moreover, it also seems relevant to interpret further the previously mentioned higher afternoon scores for Verbal and Quantitative Concept tests, since both involve not only auditory attention but also greater activation of long term memory, as mentioned previously.

Lastly, regarding the significant differences we found between diurnal types. Studies with adolescents and undergraduate students have associated eveningness to poorer academic achievement but positively associated it with cognitive abililities, and morningness has been negatively linked to cognitive abilities, but positively linked to academic performance. In line with these results, our data suggest a main effect for M versus E type children in the Constancy of Form and Spatial Orientation tests, with E-types performing better than M-types. To date, there is no satisfactory explanation for this intriguing difference. To explain this kind of association Preckel et al. (2011) suggests that E-types may have difficulty adjusting to the universal schedule of academic institutions that are generally characterized by an early start to the day. At the same time, the frequent need to overcome the constraints of everyday life might lead evening types to develop higher problem solving capabilities.

In conclusion according to these results: [i] the "synchrony effect" may be a simplistic hypothesis, since diurnal types may benefit from lowered inhibition occurring at non-optimal times of day for tasks that involve more perceptual processes and implicit information retrieval, and also automatic processing; [ii] higher performances are not necessarily associated to early times in the kindergarten day; [iii] eveningness seems to be linked to cognitive abilities in young children, as has been shown in adolescents and adults. Since this is the first study in Kindergarten children addressing (a)synchrony effects, further studies are now necessary. Although we have collected a relatively large sample (the 3 kindergartens of the selected parish, totaling 8 classes) we investigated only one school cluster, therefore care should be taken in generalizing the present findings to other children. Our testing sessions were scheduled according to the Portuguese kindergarten school day and following previous chronopsychology research in children, therefore larger differences could perhaps be expected if mores extreme early and late schedules had been contrasted. Future studies with young children are now required to further explore which tasks benefit from optimal and non-optimal times of day depending on the child's diurnal type.

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