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## Sleeping Habits Explaining Academic Vulnerability and Household Influence: Co-sleeping and the Impact on Children's Fluid Intelligence

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**Abstract:** The main goal of this study is to examine the differences between school-aged children with different chronotypes who are only children or have a sibling in the household, regarding their sleeping habits and performance in intelligence tasks. The main measures used were Chronotype Questionnaire for Children and Raven's Coloured Progressive Matrices. This study analysed 46 Portuguese children (Mean=8.67; SD=1.034, range 7-11 years of age) without sleep or educational/psychological disturbances, attending the first grade. The differences regarding chronotype and whether they were only children or not were examined. Then the performance of the sample in the Raven's Progressive Matrices tests was evaluated. The Mann-Whitney U test showed that 'only' children had higher fluid intelligence scores only in the afternoon. The chronotype did not differentiate this population and it is concluded that the type of household is the main moderator: Not being an only child was, in general, the best predictor in the test. Results suggest that different sleeping times (e.g., bedtime and wake-up time) and different chronotypes did not have different effects. However, having siblings proved to be an advantage regarding the child's performance. Re-education of sleeping practices, especially examining the influence of co-sleeping in families, is essential for the intellectual development of children.

**Keywords:** *Chronotype, fluid intelligence, household, Raven's Progressive Matrices, sleep.*

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### Introduction

The relationship between sleeping habits, the periods of the day when tasks are performed and reasoning in school-aged children remains poorly studied. In fact, there are no studies that fully examine this relationship when testing non-verbal reasoning. Early sleep research focused on cognitive functioning related to early or late sleep habits in an adolescent population (Wolfson & Carskadon, 1998) or in child populations with disorders, such as hyperactivity and attention deficit (Owens et al., 2000). The studies kept on focusing on this topic: Sleep disturbances and impact on the attention span of children with pathologies (Archbold et al., 2004; Ashworth et al., 2015; Cortese et al., 2009; Dimitriou & Halstead, 2021; Fallone et al., 2001; Lambert et al., 2016). The study of this relationship in conjunction with the vigilance variable or the influence of household habits has been done more recently, but it continues to focus on children with pathologies (Couturier et al., 2005; Mehri et al., 2020). However, the study by Cortesi et al. (2004) stands out. The authors have analysed parental influence and intrafamily sleeping habits on children's' sleep quality (anxiety, resistance to sleep, daytime sleepiness), presenting it as "cosleeping" or "co-sleeping. They have shown that it has negative results regarding the sleep quality of the youngest when they sleep together (in the same room) or with families who work in shifts, for example. In all studies examined, co-sleeping refers to sharing a bed with parents and not with siblings. Co-sleeping had already been studied previously with a view to understanding and identifying the anxiety that parents and children experience due to sleeping together (Hayes et al., 1996; McKenna et al., 1993; Rath & Okum, 1995), or to determine behaviours differentiated according to ethnicity as regards the sleep of children and families (Lozoff et al., 1984). In fact, the study of differences in sleep habits at home according to ethnicity, therefore with greater importance when analysing nations with high multicultural representativeness, such as the US, has been more in-depth (Becker et al., 2017; Milan et al., 2007; Sadeh et al., 2011). In Portugal, multiculturalism is increasing and it is important to examine it in future: Different groups of immigrants and ethnic groups have different behaviours regarding the habits of tasks performed at

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home and sleep hygiene. This difference will have implications on the children's reasoning and their alertness on school days, since in terms of schedules, school activities are the same for all students.

In this cultural and ethnic comparison, there is something very specific to be studied regarding sleep and implications for children: The perception of families varies considerably according to their ethnicity and origin (Sadeh et al., 2011). Our study focuses on one of the dimensions mentioned above and we can integrate it in this "co-sleeping" concept: The fact that the household has more than one child can influence sleep and the cognitive performance of the evaluated child.

Family life and sleep habits with siblings and parents have an impact worth examining regarding the management of spaces, habits and disturbances in children's sleep and wakefulness (Jenni et al., 2005; Liu et al., 2003). However, the literature does not show enough data to identify the variable regarding the 'only child' condition or the context of sleeping with siblings and the impact on reasoning.

We found a recent national study that briefly mentions the only child condition as an argument for resistance behaviours when going to bed and for sleep-related anxiety (Lopes et al., 2016). However, sleep problems increase if co-sleeping refers to sleeping with parents (Rangel et al., 2015). Co-sleeping can have a variable impact depending on whether the subject sleeps in the same space as the parents or siblings. Outside the co-sleeping domain, it is important to consider the influence of the household regarding one child or more children in terms of sleeping habits and tasks before bedtime, thus not considering co-sleeping directly.

Mindell et al. (2009), as well as Liu et al. (2003), provide data on the impact of lagged bedtime and activities before bedtime in different family contexts, the variable being the number of people living at home. One of the factors on the N of people living at home is related to large families, where bed and room sharing occurs more often, especially among younger children (Liu et al., 2003). These studies refer to the number of children in the household, but the focus of the analysis is on bedtime and the type of parenting behaviours towards children during that period, and on the devices and televisions that American children have in the bedroom that act as distractors.

Co-sleeping is expected to have a negative impact on daytime sleepiness during school hours and activities. There are no publications on co-sleeping and on the impact on reasoning and the condition of being an only child in households. However, daytime sleepiness in children has been widely studied (Boergers et al., 2007; Golan et al., 2004; Prihodova et al., 2010). These studies on daytime sleepiness also focus on children with disorders, especially in the area of attention span and hyperactivity. As for studies about siblings in the household regarding sleep patterns and time spent at home, they continue to focus on cases with pathologies (Sreelakshmi et al., 2016; Wirrell et al., 2005). There are no studies that examine the following: condition of sleep habits, only child/siblings and the impact on reasoning and school tasks (including the impact on sleep habits and hygiene). It is known that there is a correlation between sleep and developing intelligence in infants (Liu et al., 2003), with cognitive performance declining with poor sleep hygiene. However, almost nothing is known about the relationship between sleep and specific performance in the area we focus on in this study: Fluid intelligence, which is considered, in the face of crystallized intelligence, to be independent from education and environment. Nevertheless, sleep and common practices in the household (experiences and education) can affect this intelligence, which is supposed to be less affected by the subjects' experience.

As for non-verbal reasoning (in the context of fluid intelligence) and evidence such as Raven's Colourful Progressive Matrices (Raven et al., 1947 - MPCR), we found two studies on the relationship between sleep and administered matrices to children. In the first (Ujma et al., 2016), the objective was to examine the difference between genders and sleep regarding the relationship with intelligence. The results revealed that sleep spindles during stage 2 NREM sleep (very important for memory consolidation and when synapses crucial for plasticity and cellular triggering occur) are an indicator of maturation in boys. However, in girls these sleep spindles are signs of intelligence traits because only in this gender group there was a significant relationship between sleep spindles and RPM. In a second study (Gruber et al., 2013), the frequency of sleep spindle was analysed in school-aged children and, on the one hand, it was concluded that there is better performance in WISC-IV tests when the frequency in that sleep stage is higher. On the other hand, this frequency and even duration of sleep stage had no significant relationship with the IQ test (Raven Matrices).

Other polysomnographic studies on school-age children revealed that aspects of narrative memory and fluid intelligence are intrinsically related to high frequency of sleep spindles (Chatburn et al., 2013; Geiger et al., 2011). However, it is important to understand sleep behaviour from another perspective that does not reject these analyses, but within which the chronotype is not mentioned. Individuals, according to their biologically determined preferences for bedtime and waking up, have different chronotypes: The morning type (who get up and fall asleep naturally early, therefore with the acrophase taking place earlier in the daytime) and the evening type (whose sleep and wake up behaviour is inverse to that of the morning type).

In another line, Dimitriou et al. (2015) analysed sleep, fluid intelligence (through the Raven Matrices) and school results of adolescent population in order to understand the impact of consumption of caffeinated (and alcoholic) drinks and use of electronic devices on school days, especially thirty minutes before bedtime. The results of regression correlation analyses revealed a negative correlation, especially between night drinking and scores in the Matrices. Undoubtedly, this

type of habit was found to be a predictor of low fluid intelligence. Studies that address this relationship (with the exception of alcohol) with the school-aged population are unknown to us.

In short, the relationship between sleep and co-sleeping (with a parent, especially the mother) and the performance of school-aged children is significant. However, there is not enough evidence of studies on children's sleeping habits and on the household's sleeping habits focusing on siblings and co-sleeping. These habits include the household and the impact on children's fluid intelligence, also depending on the morning or evening chronotype that can act as a performance moderator.

Accordingly, this study examines the differences between school-aged children with different chronotypes, who are only children or have a sibling in the household, regarding sleeping habits and their performance in Raven's Progressive Matrices tests. The main question is: does being an only child influence sleep patterns and performance in non-verbal reasoning tasks?

## Methodology

### *Research Design*

Given the gap in national and international research relating the impact of sleep habits on children's non-verbal reasoning (in the context of fluid intelligence) and considering household variables as influencing reasoning and attention, this study aims to examine whether the household, specifically with regard to the condition of being or not an only child, influences sleep habits (given the different and expected chronotype: morning and evening). Above all, it examines the reasoning of school-aged children, evaluated using Raven's Colourful Progressive Matrices.

H1. Whether there are significant differences in sleep habits and in the reasoning of morning and evening children considering the context of the household (two conditions: whether or not they are an only child).

### *Sample and Data Collection*

Forty-six Portuguese children, 23 (50%) male and 23 (50%) female, between seven and 11 years of age ( $M=8,67$ ;  $SD=1,034$ ), without identified sleep or educational/psychological disturbances, attending the first cycle of Basic Education (excluding year 1 because of literacy and school preparation of students). In view of gender and chronotype, 12 (50%) male morning children and 12 (50%) female morning children and 11 (50%) evening children of the male gender and 11 (50%) evening children of the female gender were identified.

Regarding the chronotype distributed according to years of schooling: In year 2, there were 10 (41.7%) morning students and 6 (27.3%) evening participants; in year 3, there were 5 (20.8%) morning participants and 5 (22.7%) evening participants, and in year 4 there were 9 (37.5%) morning participants and 11 (50%) evening participants.

The questionnaires were answered in general by the mothers - 33 (71.7%), who came across as the relative with the greatest knowledge of the children's sleeping habits; 7 (15.2%) by the fathers; 4 (8.7%) by both (mother and father); 1 (2.2%) by the grandmother and 1 (2.2%) by the stepmother.

### *Instrument*

The validated Portuguese version of the Raven's Coloured Progressive Matrices test (RCPM/MPCR) was used to measure reasoning (Simões et al., 2003). This test was created by Raven (Raven et al., 1947) and received the designation of progressive due to the increasing difficulty of items and series throughout the evaluation (Simões et al., 2003). The colour version of 1947 consists of 36 items, divided into three series of 12, classified as A, Ab and B (Raven et al., 1947). The series have eight colours (black, white, orange, sky blue, green, red, yellow and dark blue), with the exception of the final items, which are black and white (Simões et al., 2003). The use of colours facilitates the administration of the test and avoids distractors during it (as well as increasing the stimulation and attention of the children to solve the task, as there are colours and geometric shapes).

The test uses items with differentiated geometric shapes. In each shape, children must identify the missing piece through six items that will complete the geometric shape. Thus, this test measures cognitive processes that involve not only attention but non-verbal understanding. Series B contains the items of greatest difficulty, as they assess logical-deductive reasoning (Raven et al., 1947). The version used here results from the evaluation of school-aged populations from rural and urban areas in Portugal (Simões et al., 2003). The target was normative children and children with more or less severe cognitive pathologies (Raven et al., 1947).

The administration of the RCPM test was carried out collectively in sessions with five to nine children. The correction was carried out using automatic answer sheets (Raven et al., 1947). In the correction, one must check if there is only one answer per item, calculate the score obtained in each series, calculate the total score, convert the gross result into a standardized result and determine the time spent on the test (Raven et al., 1947). The results are interpreted through percentiles, and they determine the level of intellectual development, varying between Grade 1 "intellectually superior"

(percentile equal to or greater than 95) and Class V “inferior intellectual capacity” (percentile equal to or less than 5) (Simões et al., 2003).

In view of Simões et al. (2003) gauging study, the scores were lower for younger subjects, with Cronbach's alpha ranging between .80 and .88 in individual and collective terms, respectively. Usually, the highest scores are found in the Ab and B series (Simões et al., 2003). Regarding the validity of the non-verbal reasoning evaluated here, it is important to understand that there are the following levels:

“Concrete and abstract reasoning by analogy”, items Ab12, B8 to B12; “Completion of patterns through structuring and concrete reasoning by analogy”, items A7, A9, A10, Ab4 to Ab11, B3 to B7 and “Completion of a simple and discontinuous pattern”, items A2 to A6, Ab1 to Ab3, B1 and B2, being consistent and identical for different age groups and for both genders. In this study, the evaluated non-verbal reasoning was considered with one variable in the equation: the period when the test was administered (morning or evening). The results are presented in the next section.

### *Procedure*

The administration of the test was carried out collectively in groups of five to nine children, in order to be done more quickly due to the time available for data collection. The correction was made using automatic answer sheets (Simões et al., 2003). In the correction, we checked whether there was only one answer per item, calculated the score obtained in each series, determined the total score, converted the gross result into a standardized result and calculated the time spent on the test. The results were interpreted using a percentile scale, between 1 and 99, whose average value corresponds to the 50th percentile (Simões et al., 2003). Initially, a review of the literature on the topic was carried out in order to define variables that could be measured, which defined the topic of the study.

The study started after authorization by the Directorate-General for Education (DGE) to collect data from state schools was granted. This request was made after the approval of the project “Chronotype and Time of the Day: Impact of the Synchrony Effect on Attention, Reasoning and Processing in School-Aged Children” by the Ethics Committee of Universidade Autónoma de Lisboa in 2017. At the same time, the authorization request was formalized with the School Group of a municipality in the Centre of Portugal, prepared according to the Helsinki model, in order to guarantee anonymity, confidentiality and the possibility of withdrawal at any time. After authorization for the study was granted, the email of each teacher was provided for the delivery of the informed declarations/consents to parents and guardians, during the first quarter of 2017.

Ninety informed consents were handed out to parents of children in years 2, 3 and 4 of schooling from two Portuguese state primary schools. After the return of authorization/consent by parents/guardians, a schedule was established with each class, according to the availability of each teacher and student.

The RCMPs were administered during the second quarter of 2017. Other instruments were used to assess attention and verbal reasoning, but the data is not included in this paper. The instruments were administered twice a day, in the morning at 9:30 am and in the afternoon at 3:30 pm, a week apart, in order to assess the variable time of day.

Through this variable, it was possible to analyse the performance in these two periods and the time when morning and evening children have the best cognitive performance. The characterization of the chronotype was carried out previously, using the Chronotype Questionnaire for Children (Couto et al., 2014). The data for this questionnaire is not the focus of this study, thus it was not described in the Instrument' section. These and another additional data related to this study's materials are available in our SPSS archives and respective syntaxes. All the data of our studies are stored in the repository of this project. Additionally, this work was not preregistered (not applicable).

### *Data Analysis*

The RCMP tests were given scores and the raw results were converted into standardized results, and statistically analysed using the IBM SPSS Statistics software (version 26). The Shapiro-Wilk test was used to analyse the assumptions of the normal distribution of the sample, the most advisable according to Ghasemi and Zahediasl (2012) and due to the fact that the tested population was less than 50 children ( $n=46$ ). Regarding the assumption of homogeneity of variance, the Levene test was used. For all hypothesis tests, we established a statistical significance level ( $\alpha$ ) of .05 (error probability of 5%). In all analyses, the p-value (probability of significance) was reported through the criterion of acceptance or rejection of the null hypothesis ( $H_0$ ).

The Mann-Whitney U test was used to assess the performance of the samples in the morning, since the assumption of homogeneity for that period was not confirmed (there was only sample homogeneity for the afternoon) and, therefore, percentile averages could not be compared.

## **Results**

The results revealed significant differences between the groups of children with regard to the reasoning tests, differentiated according to the two periods (morning period:  $Z = 12,162$   $p = .001$ ; evening period:  $Z = 4,336$   $p = .043$ ).

From the perspective of the “household” variable, the average test score in the evening was higher for children who were only children compared to other children in the morning (the same condition: only children). Therefore, the non-verbal test seems to show greater optimization for school-aged children if administered in the afternoon. See data in Table 1.

The results when the child is part of a household where there are more siblings should be noted: The performances are the same in both periods of the day and higher when the subject is an only child. See data in table 1.

*Table 1. Performance Means in the Non-Verbal Reasoning Test (RCPM) during the Morning and Evening periods*

			Statistic	Bias	Standardized Test Statistic	
RCPM morning	Only child	N	10			
		Mean	47,50	,13	11,92	24,3
		Deviation error	38,170	-1,995 <sup>b</sup>	5,354 <sup>b</sup>	22,520 <sup>b</sup>
		Mean standard error	12,070			
	Not an only child	N	36			
		Mean	75,00	-,01	3,62	68,09
		Deviation error	21,778	-,491	2,218	16,772
		Mean standard error	3,630			
RCPM evening	Only child	N	10			
		Mean	56,50	-,07	11,26	33,50
		Deviation error	35,202	-2,000 <sup>b</sup>	5,999 <sup>b</sup>	18,074 <sup>b</sup>
		Mean standard error	11,132			
	Not an only child	N	36			
		Mean	75,00	-,06	4,04	65,97
		Deviation error	24,024	-,612	3,857	15,515
		Mean standard error	4,004			

In view of the previous results, we should also consider the chronotype of the children in the sample: Half of the children were the morning type and the other half were the evening type. This characterization resulted from the previous administration of the Children’s Chronotype Questionnaire (QCTC), in its Portuguese version (Couto et al., 2014) during the general study. The type of chronotype influenced performance, and evening children were expected to be more attentive in the afternoon.

On the one hand, it is important to mention that in a previous study (Figueiredo et al., 2018), with the same sample and with evidence from WISC-III Portuguese version by Simões (2003) based on Wechsler (1991), evening children on school days slept fewer hours because they went to bed later and had worse performances. On the other hand, it was found that on days without school, morning children and evening children slept on average the same number of hours.

Thus, it is important to analyse the results of the RCPM considering the chronotype. The non-parametric Mann-Whitney U test was maintained due to the non-homogeneity criterion observed in the two samples. The results indicated the absence of significant differences between the morning and the evening ( $Z = -,499, p = .618$ ). As for the results regarding the RCPM test, for the morning and evening groups, there were no significant differences between the morning and the evening types ( $Z = -.357, p = .721$ ).

### Discussion

The study’s hypothesis was partially confirmed: There were significant differences in children’s sleep habits and reasoning according to the household. Only children had higher fluid intelligence scores just in the evening. However, morning and evening children, whether only children or not, did not differ in the tests’ performance. Therefore, as the chronotype is not the differentiator of young school populations, what stands out the most, as expected, is the influence of the household. Specifically, with regard to the number of children per household, not being an only child was the best predictor in the test.

This type of result is probably related to the families’ co-sleeping habits. Given the fact that there were not enough studies examining the only child question in sleep and performance habits and also the lack of consensus among them (Abels et al., 2021; Barry, 2019; Lopes et al., 2016; Rangel et al., 2015), this study is innovative not only at that level, but also regarding the relationship between the influence of the household and reasoning, specifically through evidence obtained from Raven’s Matrices. In part, the data found are consistent with the study by Lopes et al. (2016), which demonstrated that only children have problems such as resistance to sleep and sleep-related anxiety. However, it is important to understand this relationship in the household using the scores obtained in the referred tasks.

On the contrary, there is no consensus when we examine older studies like the one by Falbo and Polit (1986). These authors, through meta-analysis with families whose household had an only child or several, found that only children have the best intellectual and developmental performance. However, after reading more than one hundred studies, the same authors found that there is little consensus about this issue. Still in the 1950s (Nisbet, 1953; Zajonc, 1976), this type of focus was analysed when measuring children’s intelligence, considering the variable ‘family size’ as a predominant factor.

Recently, we have not found any studies that confirm or refute, in a prevalent way, the hypothesis in question. Conversely, recent studies (Lee et al., 2019; Mason et al., 2021; Peng et al., 2019) revealed that young children co-sleeping with parents or siblings had sleep problems or shorter periods of sleep comparing to children who sleep alone. The birth order was also examined regarding the impact on sleep among children (Kim et al., 2017; Kojima, 2019). As regards cognitive or academic performance related to bedsharing with siblings, no literature was found.

In fact, research regarding birth order goes back many years. Although it is old evidence, it is important here for purposes of argument: The largest studies on the relationship between birth order and cognitive development and intelligence concluded that the more siblings in the household, the lower the intelligence and early parental stimulation (Bjerkedal et al., 2007; Retherford & Sewell, 1991). This evidence was tested in a Scandinavian context with interesting results regarding only children's relationships and the family's socioeconomic status (Bjerkedal et al., 2007). Still, our data presents another perspective based on cognitive evaluation through the Matrices. The intellectual results obtained by children with siblings or without them (or fewer) in the study by Downey (2001) indicate that birth order can influence, as well as the N of siblings in the household, and have a negative correlation with the infant's intellectual development. Despite other more recent studies (Barclay, 2015; Havari & Savegnago, 2022) attesting the effect of birth order in intelligence and cognitive functioning, there is no study involving also the sleep variable (co-sleeping).

### Conclusion

Given the results obtained, this type of study and hypothesis test, with evidence of fluid intelligence, should be replicated to confirm the influence of the household and the family's sleep habits on the non-verbal reasoning of school-aged children. We had concluded significant differences in children's sleep habits and reasoning according to household. Only children had higher fluid intelligence scores just in the evening. It is very important to identify and re-educate sleep practices, especially examining the influence of co-sleeping in families and establishing the relationship between these practices and their predictive value in children's performance in terms of their intellectual and academic development.

### Recommendations

Scholars need to conduct extensive research on the relationship between co-sleeping and the performance of school-aged children. There are not enough studies on children's sleep habits and respective households sleep habits with a focus on siblings and co-sleeping. The household and the impact on the children's fluid intelligence also depend on the morning or evening chronotype that can act as a performance moderator. More studies are urgent to examine the chronotype and co-sleeping influence on academic and cognitive performance. Specifically, how fluid intelligence scores are affected by the context of having siblings. Re-education of sleep practices, especially examining the influence of co-sleeping in families, is essential for the intellectual development of children

### Limitations

The birth order must be a variable to be controlled in this study and it is presented here as the only limitation. Further studies should collect that information from the sample to evaluate significant differences regarding the condition of having siblings/being only children.

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