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Predicting school achievement: The role of inductive reasoning, sleep length and morningness–eveningness

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Adolescents move to evening orientation just when school schedule becomes earlier. Whereas school achievement has been associated to morningness orientation during morning school schedule, some studies have indicated that evening people are more intelligent. In this study the relative contribution of Morningness–Eveningness (M–E) in the prediction of school achievement, after controlling for age, sex/gender, inductive reasoning and sleep length was analyzed. Participants were 887 adolescents (aged 12–16). School achievement was evaluated using *Grade Point Average* (GPA), inductive reasoning was evaluated by reasoning subtest of *Primary Mental Abilities* (PMA-R), sleep length was calculated from rise time and bedtime questions, and M–E was evaluated by *Morningness–Eveningness Scale for Children* (MESC). Evening adolescents scored higher on PMA-R and obtained lower GPA. Inductive reasoning, age, sex/gender, sleep length and M–E accounted for 19% variance percentage on GPA. M–E was a significant predictor of school achievement even after controlling for traditional predictors, albeit slightly.

1. Introduction

Morningness–Eveningness (M–E) refers to individual differences in circadian phase position of spontaneous sleep-wake and subjective alertness rhythms. Individuals can be classified as morning, neither and evening types or considered as oriented to M–E continuum. In general, morning individuals prefer arising early and morning hours for intellectual and physical activities, whereas evening types prefer arising later, feel and perform best at late afternoon or in the evening. Chronotypes differ in (a) biological (sleep-wake cycle, body temperature, the hormones melatonin and cortisol), and (b) psychological functioning (lifestyle, cognitive performance, health) (Adan et al., 2012).

Because chronotypes differ in their sleep-wake patterns as well as in their feeling at their best moment for doing different activities at different times of day, the practical implications of these findings have been applied to diverse fields, such as the design of working schedules (Pisarski et al., 2006) or sport performance (Drust, Waterhouse, Atkinson, Edwards, & Reilly, 2005). Individuals who are able to choose activity times that coincide with their preferred times may have a greater opportunity to optimize their performance levels. However, in order to meet societal demands, evening types must try to function during the morning when they are in their non-optimal time of the day. Concepts such as social jetlag (Wittmann, Dinich, Merrow, & Roenneberg, 2006) and asynchronization (Kohyama, 2009) have been proposed to describe the discrepancy between persons' rhythms and those of the environment. Although several studies analyzed asynchrony between circadian typology and work schedules in adults (see Saksvik, Bjorvatn, Hetland, Sandal, & Pallesen, 2011), less attention has been given to academic performance among adolescents during the school year in a fixed and continuous morning schedule despite the fact that they tend to move away from morningness towards eveningness (Clarisse, Le Floćh, Kindelberger, & Feunteun, 2010; Kim, Dueker, Hasher, & Goldstein, 2002; Onyper, Thacher, Gilbert, & Gradess, 2012; Randler & Frech, 2009). Evening preference during adolescence is consequence of both maturation processes typical of puberty (Hagenauer, Perryman, Lee, & Carskadon, 2009), and changes in the adolescent's relational and social sphere such as school demands, new social opportunities, and less parental supervision (Randler, Bilger, & Díaz-Morales, 2009).

In education, primary interests lie in a full understanding and improvement of learning and achievement processes. Research leaves little doubt that general mental ability is one of the best predictors of school achievement (Gottfredson, 2002; Kuncel, Hezlett, & Ones, 2004). However, research has also been interested in the extent to which other factors contributed to the prediction of school achievement beyond the general factor of intelligence (*g*). For example, Duckworth and Seligman (2005) showed that self-discipline predicted academic performance more robustly than did IQ, even one year later. Therefore, the identification of those factors is especially worthwhile in order to know their predictive power compared to intelligence (Richardson, Abraham, & Bond, 2012). Although several

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factors affect academic performance of students (Hofer, Kuhnle, Kilian, & Fries, 2012), M–E just appears as one of them. Extreme evening adolescents may be particularly adversely affected by morning school schedules (Owens, Belon, & Moss, 2010). Few studies have looked at school-aged adolescents' performance in order to test synchrony effect with better performance at times that match individuals' circadian preference, in the morning versus in the afternoon (May, 1999; Natale & Lorenzetti, 1997). Goldstein, Hahn, Hasher, Wiprzycka, and Zelazo (2007) found that performance was better on Digit Span and Block Design measures when adolescents (11–14 years) were tested at times that were in synchrony with their preferred time of day versus at times that were not. In a later study, Hahn et al. (2012) administered a battery of executive function measures to participants aged between 11 and 14 years who were tested in the morning or in the afternoon; their results indicated that adolescents who were tested at their optimal time of day performed better than adolescents tested at their non-optimal time. A recent meta-analysis study showed that eveningness and academic achievement were consistently and inversely related, whereas eveningness was weakly related to intelligence. On one hand, eveningness has been linked to poor academic achievement (Beşoluk, 2011; Gomes, Tavares, & Azevedo, 2011; Randler & Frech, 2009; Roberts, Roberts, & Duong, 2009). On other hand, evening adolescents may have more difficulties to adjust to morning school schedules and in order to overcome the inconvenience of everyday life might develop higher problem solving capabilities (Preckel, Lipnevich, Schneider, & Roberts, 2011). Moreover, there are positive aspects of evening people, such as the tendency to be creative (Giampietro & Cavallera, 2007), and preference for symbolical and unknown data (Díaz-Morales, 2007) that probably are not encouraged at school.

There is strong evidence that adolescents all across the world fail to get enough sleep, either due to school schedules or other factors including academic and social responsibilities (Gradisar, Gardner, & Dohnt, 2011). As evening types go to bed later than morning types, but have to rise early, they often report short sleep length during the school week. Evening students accumulate a sleep debt over the week and it is well-known that short sleep duration and poor sleep quality are negatively associated with school performance (Gruber, Wiebe, Wells, Cassoff, & Monson, 2010; Meijer, 2008; Onyper et al., 2012; Wolfson & Carskadon, 2003).

Poor school achievement seems to be compounded because morning school schedules and adolescents' circadian evening preference do not match. Although previous studies have claimed an association between M–E and school performance, it seems necessary to use large samples from different cultural contexts (for example, Spain has later lifestyle habits compared to other European countries; Díaz-Morales & Randler, 2008) and to consider grades instead of self-reported measures. Participants in this study were a large sample of Spanish adolescents who attend public high schools in a morning schedule and academic performance was estimated using actual final grades in the major subjects. We expanded on previous research findings by analyzing the relative contribution of M–E in the prediction of school achievement, after controlling for well-documented predictors such as inductive reasoning and sleep length. We hypothesized that: (1) Morningness is related to higher scores on academic performance and lower scores in inductive reasoning, and (2) M–E provides additional variance percentage to prediction of school achievement after controlling for inductive reasoning and sleep length.

2. Method

2.1. Participants

In this study 887 adolescents aged between 12 and 16 years (*M* = 14.2, SD = 1.48) participated. Of the sample, 52.5% (466) were girls. All adolescents were studying Compulsory Secondary Education in three public schools in an urban area located in the east of the Community of Madrid (Spain) which comprises several cities with a population of over 100,000 people each one. Approximately 35% of the active population works in the industrial sector. The socioeconomic status is middle class. The board of directors authorized the study after obtaining the parents' permission. Participation was voluntary, unpaid and anonymous.

2.2. Instruments

2.2.1. Morningness–Eveningness

The *Morningness–Eveningness Scale for Children* (*MESC*) has 10 items about the preferred timing of certain activities such as rest, tests, sleep timing, and so forth (Carskadon, Vieira, & Acebo, 1993). Items have a response scale with four or five options and the total score ranges from 10 (eveningness) to 43 (morningness). Spanish version was used (Díaz-Morales & Gutiérrez, 2008). The internal consistency (Cronbach's alpha) was $\alpha = 0.70$.

2.2.2. Inductive reasoning

The inductive reasoning subtest (R) from the Primary Mental Abilities battery (PMA-R; Thurstone, 1938) was used. PMA-R comprises 30 letter series items. The rule (or rules) underlying a given sequence must be extracted for selecting the correct alternative in a maximum time of 6 min. The Cronbach's alpha was $\alpha = 0.86$.

2.2.3. Sleep length

Questions about rise time and bedtime on weekdays were adapted from the *School Sleep Habits Survey* (Carskadon, Seifer, & Acebo, 1991). Specific questions were: What time do you usually go to bed on weekdays? What time do you usually wake up on weekdays? From these data, sleep length was calculated (time in bed).

2.2.4. School achievement

The board of directors authorized the use of grades in all students. Grade Point Average (GPA) was calculated in common subjects: Spanish language, mathematics, English language and social sciences. Official grades ranged from 0 (worst) to 10 (best).

2.3. Procedure and data analysis

The questionnaires were completed during a typical Spanish (morning) school day (08:30–14:15 h) in groups of about 25 adolescents in two different days (one for measuring of M–E and sleep habits and the other for inductive reasoning). The study was performed in October, 2010. Data were analyzed using analysis of variance (*ANOVA*), to contrast the effect of age and sex/gender on *M–E*, *inductive reasoning*, *school achievement*, *sleep length*; analysis of covariance (*ANCOVA*) to contrast the effect of chronotype and sex/gender on *school achievement*, *inductive reasoning* (age and sleep length as covariates) and on *sleep length* (age as covariate). In order to analyze the contribution of each previous variable on school achievement, a *hierarchical regression analysis* was performed. *Bonferroni* test was used in multiple post hoc comparisons. The SPSS-X statistical package was used (version 15).

3. Results

First, preliminary analyses were performed. In order to meet statistical requirements, skewness and kurtosis were examined. The frequency of the distribution was similar to the normal distribution in all variables.

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Table 1
Means, standard deviations (SD) and number of participants according to age and sex/gender for morningness–eveningness (M–E), inductive reasoning, school achievement, and sleep length (sleep length expressed in decimal format: 7.50 is 07:30 h).

	12			13			14			15			16			Total		
	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*
M–E																		
Girls	26.66	3.98	73	25.29	4.26	92	24.65	4.22	91	24.26	4.27	116	24.69	3.96	94	25.00	4.21	466
Boys	27.21	4.48	63	26.41	4.66	88	24.71	4.85	95	25.10	4.65	93	25.52	4.36	82	25.68	4.68	421
Total	26.91	4.21	136	25.84	4.49	180	24.68	4.54	186	24.63	4.46	209	25.08	4.16	176	25.32	4.45	887
Inductive reasoning																		
Girls	12.10	5.06	73	13.76	6.16	92	15.99	5.44	91	16.16	5.96	116	15.23	5.50	94	14.83	5.84	466
Boys	11.84	5.75	63	12.48	5.09	88	14.20	5.47	95	16.12	5.27	93	14.98	5.73	82	14.06	5.63	421
Total	11.98	5.37	136	13.13	5.68	180	15.08	5.51	186	16.14	5.65	209	15.11	5.59	176	14.46	5.75	887
School achievement																		
Girls	6.29	1.80	73	5.74	1.89	92	5.65	1.86	91	5.18	2.02	116	4.92	1.50	94	5.50	1.88	466
Boys	5.77	1.85	63	5.66	1.99	88	5.32	1.89	95	4.65	1.91	93	4.57	1.92	82	5.16	1.97	421
Total	6.05	1.83	136	5.70	1.93	180	5.48	1.88	186	4.95	1.99	209	4.75	1.71	176	5.34	1.93	887
Sleep length																		
Girls	8.62	0.74	73	8.32	0.88	92	8.08	0.81	91	8.02	0.84	116	7.79	0.84	94	8.14	0.87	466
Boys	8.78	1.06	63	8.63	0.85	88	8.27	0.76	95	7.95	0.89	93	7.88	1.04	82	8.27	0.97	421
Total	8.69	0.91	136	8.47	0.88	180	8.18	0.79	186	7.99	0.86	209	7.83	0.93	176	8.20	0.92	887

Respecting the effects of age and sex/gender on *M–E*, *inductive reasoning*, *school achievement*, *and sleep length* (see Tables 1 and 2), *morningness* decreased with age and boys reported a higher score on morningness than girls. *Inductive reasoning* increased with age. *School achievement* decreased with age and girls attained higher grades than boys. Finally, *sleep length* decreased with age and boys reported more sleep length than girls.

Second, MESC values of 22/29 corresponding to 25/75 percentiles of this sample were used to categorize circadian types: morning- ($n = 227$, 25.6%), neither- ($n = 380$, 42.8%) and evening-type ($n = 280$, 31.6%). Subsequent analyses were performed with extreme chronotypes (morning and evening types).

With respect to the effect of chronotype and sex/gender on *school achievement* and *inductive reasoning* (age and sleep length as covariates; see Tables 3 and 4), evening types scored higher on inductive reasoning than morning types (estimated marginal mean = 15.02 (SE = 0.39) *vs.* 13.87 (SE = 0.34). However, the former obtained lower school achievement than morning types, $M = 4.98$ (SE = 0.12) *vs.* $M = 5.44$ (SE = 0.11). As is known from previous analyses, girls obtained higher school achievement than boys, and the effects of the covariates were significant. Next, the effect of chronotype and sex/gender on sleep length was analyzed controlling for age. Evening types reported shorter sleep length.

Finally, respecting the contribution of *age*, *sex/gender*, *sleep length*, *inductive reasoning* and *morningness* on the prediction of *school achievement*, one hierarchical regression analysis was performed (see Table 5). First, age and gender were included in step one, accounting for a percentage of variance of 6.2% on *school achievement*, $F_{change}(2,884) = 28.98$, $p < 0.001$. Second step, *sleep length* increased the percentage of variance explained by 1.4%, $F_{change}(1,883) = 13.59$, $p < 0.001$. Third, *inductive reasoning* accounted for an additional 11%, $F_{change}(1,882) = 118.79$, $p < 0.001$, and finally, *morningness* increased the percentage of variance explained by 0.8%, $F_{change}(1,881) = 9.04$, $p < 0.01$. The model accounted for 19% of total variance on *school achievement*. Regarding individual predictors of *school achievement*, results indicated that being younger ($\beta = -0.26$), female sex/gender ($\beta = -0.08$), longer sleep length ($\beta = 0.11$), higher scores on inductive reasoning ($\beta = 0.35$), and morning preference ($\beta = 0.10$) were significantly associated with higher school achievement.

4. Discussion

The results of this study showed that among adolescents from 12 to 16 years, who go to school in a morning schedule (08:30 to 14:15 h), school achievement was related to M–E after controlling for age, sex/gender, sleep length and inductive reasoning. It would be expected that adolescents who scored higher on inductive reasoning obtained higher GPA. A large amount of research has demonstrated that general cognitive ability (inductive reasoning is a good estimation of *g*) is one of the strongest predictors of academic performance (Gottfredson, 2002) and has also been related to more prestigious occupations and earns higher incomes (Schmidt & Hunter, 2004). Nevertheless, it seems that other factors may have a relevant effect on academic performance beyond cognitive measures (Duckworth & Seligman, 2005). Evening types scored higher on inductive reasoning than morning types even when age (which is positively associated to both inductive reasoning and M–E) was controlled for (15.02 *vs.* 13.87), whereas the former obtained lower school achievement (4.98 *vs.* 5.44). Roberts and Kyllonen (1999) found that more evening United States Air Force recruits were significantly more intelligent than morning types, even though they were evaluated in the morning (from 08:00 to 12:00). Kanazawa and Perina (2009) sought to replicate that finding in a large representative sample of Americans, and found that controlling for several demographic variables, more intelligent children were more likely to grow up to be nocturnal adults who go to bed and wake up late on both weekdays and weekends. The authors explained this relation according to the Savanna–IQ interaction hypothesis which postulates that more intelligent individuals have less difficulty to solve evolutionary novel problems such as nocturnal activities for which there are no predesigned psychological adaptations (Kanazawa & Perina, 2009). Eveningness has been viewed as a handicap (i.e. related to affective disorders or substances consumption), but also as an honest signal from an evolutionary perspective (i.e. men's mating success or adjust to seasonal changes in light) (Randler et al., 2012). In consequence, from an evolutionary perspective, evening preference could have at least some advantage which could be analyzed in depth in future studies.

Morningness was associated with higher school achievement. Giannotti, Cortesi, Sebastini, and Ottaviano (2002) found lower performance among evening adolescents aged 14–18 years, whereas Beşoluk (2011) and Randler and Frech (2006) found that

Table 2
Statistical data (F_s and signification level) and Bonferroni post-hoc test on each variable according to age and sex/gender.

	$F_{Age}(4,877)$	$F_{Sex/Gender}(1,877)$	$F_{Age*Gender}(4,877)$	*Bonferroni post-hoc test (p < .01)*
Morningness–Eveningness	7.44***	5.19*	0.38	12 vs. 14, 15, 16
Inductive reasoning	15.25***	3.66	0.87	12 vs. 14, 15, 16; 13 vs. 14, 15, 16
School achievement	13.59***	8.14**	0.42	12 vs. 15, 16; 13 vs. 15, 16; 14 vs. 15, 16
Sleep length	26.51***	5.10*	1.21	12 vs. 14, 15, 16; 13 vs. 14, 15, 16; 14 vs. 16

* $p < .05$.
** $p < .01$.
*** $p < .001$.

Table 3
Estimated marginal means (*M*), standard error (SE), and number of participants (*n*) in inductive reasoning, school achievement, and sleep length according to chronotype and sex/gender.

	Evening types			Morning types			Total		
	M	SE	*n*	*M*	SE	*n*	*M*	SE	*n*
Inductive reasoning									
Girls	15.20	0.52	121	14.23	0.49	135	14.72	0.35	256
Boys	14.84	0.55	106	13.51	0.48	145	14.17	0.36	251
Total	15.02	0.39	227	13.87	0.34	280	14.45	0.25	507
School achievement									
Girls	5.12	0.17	121	5.67	0.16	135	5.39	0.12	256
Boys	4.84	0.18	106	5.20	0.16	145	5.02	0.12	251
Total	4.98	0.12	227	5.44	0.11	280	5.21	0.08	507
Sleep length									
Girls	7.88	0.08	121	8.29	0.07	135	8.09	0.05	256
Boys	7.87	0.08	106	8.54	0.07	145	8.20	0.06	251
Total	7.87	0.06	227	8.42	0.05	280	8.14	0.04	507

Note: Age and sleep length as covariates (in inductive reasoning and school achievement). Sleep length expressed in decimal format (7.50 is 07:30 h).

Table 4
Statistical data (F_s and signification level) and Bonferroni Post-Hoc test on each variable according to chronotype and sex/gender controlling for age and sleep length.

	$F_{Chronotype}(1,501)$	$F_{Sex/Gender}(1,501)$	$F_{Chronotype*Gender}(1,501)$	Age as covariate	Sleep length as covariate
Inductive reasoning	4.67*	1.18	0.13	21.58***	1.02
School achievement	7.05**	5.29*	0.32	21.68***	7.96**
Sleep length	47.34***	2.36	2.96	48.26***	–

* $p < .05$.
** $p < .01$.
*** $p < .001$.

Table 5
Hierarchical regression analysis on school achievement considering age, sex/gender, sleep length, inductive reasoning and morningness–eveningness.

	β	*t*	R^2	ΔR^2
Step 1				
Age	−0.23	−7.12***	0.062	
Sex/Gender	−0.09	−2.83**		
Step 2				
Age	−0.19	−5.60***	0.076	0.014
Sex/Gender	−0.10	−3.10**		
Sleep length	0.13	3.69***		
Step 3				
Age	−0.26	−7.93***	0.185	0.110
Sex/Gender	−0.08	−2.61***		
Sleep length	0.13	4.17**		
Inductive reasoning	0.34	10.90***		
Step 4				
Age	−0.26	−7.86***	0.194	0.008
Sex/Gender	−0.08	−2.79**		
Sleep length	0.11	3.29**		
Inductive reasoning	0.35	11.12***		
Morningness–Eveningness	0.10	3.01**		

Note: Sex/Gender: 0 = girls and 1 = boys.
** $p < .01$.
*** $p < .001$.

pre-university students with morning preference seemed to be at an advantage in university entrance examinations. According to the synchrony effect, adolescents show better performance at times that match their individual preferences for the time of day (Hahn et al., 2012). Given that learning and evaluation at school are realized in the morning (in this study from 08:30 to 14.15 h), morning types would achieve better attention and memory levels and probably better academic performance (Clarisse et al., 2010). In a visual search, as well as in a task involving logical, spatial, and mathematical reasoning, the best performance was recorded during the respective optimal times of day (Natale, Alzani, & Cicogna, 2003). Moreover, the preference for evening hours appears as a permanent lifestyle of evening adolescents from secondary school to the beginning of university (18 years). Many studies have demonstrated that people with a proclivity towards eveningness are more likely to exhibit characteristics that are negatively related to academic achievement (Cavallera & Giudici, 2008). Evening adolescents tend to act out in an independent and nonconforming manner and resist following traditional standards (perhaps early morning schedules), also they tend to be creative, something that probably is not promoted at school (Díaz-Morales, 2007; Giampietro & Cavallera, 2007; Mecacci & Rocchetti, 1998). On the other hand, morning people scored higher on the personality trait of Conscientiousness (Randler, 2008), which is considered the best personality factor in the prediction of academic and work performance (Poropat, 2009).

The present study provides further evidence that M–E should be considered as a predictor of GPA supporting recent previous research (Preckel et al., 2013). This point is especially important given that research is considering the incremental explanatory power of M–E in the study of academic achievement after controlling for traditional variables such as age, sex/gender, inductive reasoning and sleep length. The implications of these findings may include the need for greater flexibility in the timing of classes which may allow students to find a more natural sleep–wake cycle and improve their academic performance (Eliasson, Lettieri, & Eliasson, 2010).

The present study has some limitations. Regarding the measure of sleep length, it may be overestimated because the time to fall asleep was not considered. On the other hand, in this study data from parents or about parental monitoring were not collected. Parental supervision seems to play an important role in adolescents' habits and may act as a protective factor against several adolescents' problems related to health, sleep or daytime functioning (Gangwisch et al., 2010; Short et al., 2011). Future studies about school achievement should include parental influence on sleep and study habits. Finally, the design of the present study was comparative and correlational, and most of the variables were collected using self-report (except for grades). Thus, caution should be used in drawing inferences from our findings.

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