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Chronotype, cognitive abilities, and academic achievement: A meta-analytic investigation ☆

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ABSTRACT

Four meta-analyses examined relationships between morningness and cognitive ability (total $N = 2177$), eveningness and cognitive ability (total $N = 1519$), morningness and academic achievement (total $N = 3220$), and eveningness and academic achievement (total $N = 700$). The analyses focused on the population effect size (to reveal the effect across studies) and the homogeneity (to determine if the results of the several experiments are sufficiently similar to warrant their combination into an overall result). In all four cases, the aggregated correlations between chronotype and cognitive ability, as well as chronotype and academic achievement were found to be significant. Eveningness was found to be positively related to individuals' cognitive ability ($r = .08$), yet negatively related to indicators of academic achievement ($r = -.14$). Conversely, morningness had a negative relationship with cognitive ability ($r = -.04$) and a positive correlation with academic indicators ($r = .16$). Practical implications, including those pertaining to educational policy, are discussed.

Circadian rhythms, or cyclic fluctuations in physiological and psychological functions, are thought to influence diverse aspects of an individual's life. Study, exercise, eating habits, and adaptability to shift work are just a few domains that are affected by these daily cycles, which generally approach 24 h. Widely acknowledged individual differences in circadian rhythms, commonly called morningness and eveningness, indicate preferences associated with morning or evening activities. A morning-type person is thus someone who gets up easily and is more alert in the morning than in the evening. By contrast, an evening-type person is more alert at night, often sleeping late into the morning. Traditionally, morningness and eveningness have been conceptualized as a trait, lying along a continuum (known as the morningness–eveningness dimension). Most individuals (i.e., around 70%) have a scale position somewhere between the extremes of morningness and eveningness and can be described as a neither (or in some accounts, a combined) type (Achari & Pati, 2007; Cavallera & Giudici, 2008; Cofer et al., 1999; Gaina et al., 2006; Natale & Cicogna, 2002).

Researchers report age and gender differences in individuals' morningness and eveningness. In particular, the inclination towards morningness and eveningness appears to vary across the lifespan. Children are usually predisposed towards morningness. During adolescence a delay of phase preference can be observed (Carskadon, Wolfson, Acebo, Tzischinsky, & Seifer, 1998; Crowley, Acebo, & Carskadon, 2007) reaching a maximum shift towards eveningness at around the age of 20 years. After the age of 50, studies document a pronounced shift back towards morningness (Baehr, Revelle, & Eastman, 2000; Diaz-Morales & Sorroche, 2008; Gau, Soong, & Merikangas, 2004; Giannotti, Cortesi, Sebastiani, & Ottaviano, 2002; Monk & Kupfer, 2007; Roenneberg et al., 2007; Shinkoda, Matsumoto, Park, & Nagashima, 2000; Taillard, Philip, & Bioulac, 1999). In regard to gender, results from studies that have investigated sex differences in circadian phases are somewhat inconsistent, although it appears that women tend to have a greater disposition towards morning characteristics than do men (for reviews see Kerkhof, 1985; Tankova, Adan, & Buela-Casal, 1994). A meta-analysis conducted by Randler (2007) suggests a weak but significant effect of gender on morningness with females being more morning oriented than males.

In addition to age and gender, individuals' proclivity toward morningness and eveningness has been shown to relate to a slew of variables, including mood, temperament, productivity, avocational interests, caffeine consumption, and internal temperature (e.g., Andershed, 2005; Preckel, Lipnevich, Ross, & Roberts, 2011; Tankova et al., 1994). In the last decade, a literature has also emerged documenting relations between diurnal preference and cognitive ability, as well as between diurnal preference and academic

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performance (e.g., Killgore & Killgore, 2007; Preckel & Roberts, 2009; Roberts & Kyllonen, 1999; Schmidt, Collette, Cajochen, & Peigneux, 2007). The latter two relationships are the main focus of the current investigation.

1. Findings on the relationship between chronotype and cognitive ability

Recent reviews document time of day effects on basic and more complex cognitive functions that are contingent upon an individuals' chronotype (Carrier & Monk, 2000; Schmidt et al., 2007). Roberts and Kyllonen (1999), for example, reported that individuals high in eveningness were more likely to do well on measures of memory, processing speed, and cognitive ability, even when those cognitive tasks were performed early in the morning. Further, these authors found that working memory capacity (which is often regarded as the best proxy for general intelligence, or psychometric *g* [see Kyllonen & Christal, 1990]) showed the highest correlation with individuals' morningness and eveningness scores. In particular, high scores on the eveningness scale were correlated with higher scores on the working memory task. Kanazawa and Perina (2009) and Wagner and Roberts (2003) present similar findings showing significant correlations between individuals' chronotype and intelligence, favoring (albeit slightly) persons with a proclivity towards eveningness. However, other studies suggest that relations between chronotype and cognitive ability are more variegated. For instance, Killgore and Killgore (2007) reveal correlations between verbal cognitive ability and eveningness (but not between math ability and eveningness). The latter finding was only true for female participants. Similarly, Song and Stough (2000) found a significant eveningness advantage on the Spatial subtest of the Multidimensional Aptitude Battery IQ (MAB-IQ), but not on any other subtest. Overall, research on relationships between chronotype and cognitive ability remains relatively scant and somewhat inconsistent (Killgore & Killgore, 2007; see also Song & Stough, 2000).

2. Findings on the relationship between chronotype and academic achievement

Relationships between chronotype and academic achievement (especially grade point average [GPA], but also measures derived from class exams and other achievement indicators) appear to be less contradictory. Studies consistently show that eveningness and indicators of academic achievement are strongly and inversely related, whereas morningness and academic achievement are positively related. These patterns hold for both school children (Cortesi, Giannotti, Mezzalira, Bruni, & Ottaviano, 1997; Giannotti et al., 2002; Giannotti & Cortesi, 2002; Giannotti, Cortesi, & Ottaviano, 1997; Wagner & Roberts, 2003) and university students (Kirby & Kirby, 2006; Randler & Frech, 2006; Smith, Reilly, & Midkiff, 1989). In their study, Preckel and Roberts (2009) demonstrate a significant negative effect of eveningness on academic achievement (teacher assigned school grades averaged over grades in Math, German, English, Physics, and Biology which were *z*-standardized within classes before) in a sample of 270 German secondary school students. These results held after statistically controlling for gender, intelligence, each of the Big Five personality factors, need for cognition, and achievement motivation. Similarly, Giannotti et al. (1997) found a significant, positive correlation between students' performance in school and their proclivity towards morningness. Taking into account that during early adolescence students on average move away from morningness and towards eveningness (e.g., Kim, Dueker, Hasher, & Goldstein, 2002; Roenneberg et al., 2004) these findings warrant closer attention.

3. Measuring chronotype

Several self-report questionnaires have been developed to assess individuals' diurnal preferences. Most of these measures treat chronotype as unidimensional (i.e., Morningness Eveningness Questionnaire [MEQ; Horne & Ostberg, 1976]; Diurnal Type Scale [DTS; Torsvall & Akerstedt, 1980]; Circadian Composite Scale [CCS; Smith et al., 1989]). However, results of psychometric studies call the unidimensionality of the morningness–eveningness construct into question (Brown, 1993; Larsen, 1985; Neubauer, 1992; Putilov, 1993, 2000; Putilov & Onischenko, 2005; Putilov & Putilov, 2005; Roberts, 1999a; Wendt, 1977). Based on recent inquiries, researchers have begun to conceptualize chronotype as multidimensional with more information possible if one conceptualizes morningness and eveningness as two, relatively independent, dimensions. This conceptualization leads to four distinguishable chronotypes (besides morning and evening types, lethargic types and high energetic types). To our knowledge, there are two measures employed by researchers based on this conceptualization of chronotype: The Lark-Owl Chronotype Indicator (LOCI; Roberts, 1998, 1999a) and the Sleep–Wake Pattern Assessment Questionnaire (SWPAQ; Putilov, 1990, 1993). For the purposes of the current investigation, we adopt the two-dimensional view of an individuals' chronotype. Of note, failing to consider these two dimensions may mask relationships of considerable practical significance, such as those currently under investigation (Roberts & Kyllonen, 1999).

4. Aims of the present study

The main aim of the present study was to synthesize findings from a number of prior investigations that examined relationships between chronotype and cognitive ability and chronotype and academic achievement. These relationships are intriguing at the very least. Hundreds of studies demonstrate moderate to high positive correlations between cognitive test performance and academic achievement (Deary, Strand, Smith, & Fernandes, 2007; Neisser et al., 1996; Ones, Viswesvaran, & Dilchert, 2005) and, as described in the introductory section of the present review, chronotype is reported to be related to both of these constructs, but in opposing directions (i.e., eveningness is positively related to cognitive test performance, but negatively to performance in school) (see e.g., Cavallera & Giudici, 2008; Roenneberg, Wirz-Justice, & Merrow, 2003; Sadeh, Gruber, & Raviv, 2003). Hence, it is not too fanciful to speculate that chronotype may attenuate or suppress correlations between intelligence and academic performance. This proposition needs to be interrogated. To achieve this main goal, we used the tool of meta-analysis, combining findings from a research corpus and examining the aggregated effect of relationships among chronotype, cognitive ability, and academic achievement.

As noted earlier in this exposition, chronotype needs to be understood as a two-dimensional construct, with the dimensions of morningness and eveningness treated as relatively independent. Hence, in the current paper we analyzed the relationship of cognitive ability and academic achievement with chronotype separately for morningness and eveningness. Thus, a series of meta-analyses that we conducted explored relationships between the following variables: morningness and cognitive ability, eveningness and cognitive ability, morningness and academic achievement, and eveningness and academic achievement. In total, four meta-analyses were conducted. Based on previous findings, we expected a positive mean correlation between morningness and academic performance, a negative mean correlation between morningness and cognitive ability, a negative mean correlation between eveningness and academic performance, and a positive mean correlation between eveningness and cognitive ability. In our analyses we focused on the population effect size (to reveal the effect across studies) and the homogeneity (to determine if the results of the several experiments are sufficiently similar to warrant their combination into an overall result).