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Time of day, Intellectual Performance, and Behavioral Problems in Morning Versus Evening type Adolescents: Is there a Synchrony Effect?

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Abstract

We administered measures of fluid and crystallized intelligence to Morning- and Evening-type adolescents who were tested either during a morning session or an afternoon session, at times chosen to reflect the limits of the average school day schedule. For the fluid intelligence measures, there was a synchrony effect, with better performance at times that matched individuals' preferences. A composite measure of the subtests used (block design, digit span, and vocabulary) computed to a 6 point difference in IQ estimates. We also assessed the behavioral adjustment of these participants and found heightened levels of maladaptive behavior for Evening-type adolescents. Adolescents tested at their nonoptimal times of day and adolescents who are Evening-types appear to be at risk for poor academic performance and Evening-types appear to be at risk for behavioral adjustment problems.

Keywords

Chronotype; Intellectual performance; Adolescence; Time of day; Synchrony effect

1. Introduction

Articles in the popular press suggest that the school day starts too early for adolescents. The scientific evidence for such claims is limited and typically ignores the potential importance of the synchrony between an individual's time of day preference, or 'chronotype,' and the time at which cognitive operations are performed. This is likely nontrivial because recent research with adults suggests that performance on a number of school relevant tasks (such as attention and memory) varies in synchrony with chronotype, with better performance in the morning than later in the day for Morning-types and better performance later in the day than in the morning for Evening-types (e.g., Hasher, Goldstein, & May, 2005; Intons-Peterson, Rocchi, West, McLellan, & Hackney, 1998; May, 1999; Yoon, May, Goldstein, & Hasher, in press).

Of particular interest for school performance is the fact that children move away from being Morning-types towards being Evening-types early in adolescence (e.g., Kim, Dueker, Hasher, & Goldstein, 2002; Roenneberg et al., 2004), a change that when coupled with an early start to the school day and potential sleep deficits (e.g., Andershed, 2005; Carskadon, Wolfson, Acebo, Tzischinsky, & Seifer, 1998), may create special problems for Evening-type teens. Research on sleep, for example, suggests that for adolescent girls in Brazil, school performance

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improves through the school day while self-reported sleepiness decreases (Andrade & Menna-Barreto, 1996). There is also evidence that rising early for school, even for as few as two days a week, results in greater complaints about difficulties in attention and concentration in the classroom by fifth grade children (Epstein, Chillag, & Lavie, 1998; see also Wolfson & Carskadon, 1998). There is also some evidence that behavioral problems are more common in poor sleepers than in control age mates (Sadeh, Gruber, & Raviv, 2002).

In the present study, we explore the potential importance of the age-related shift from Morningness to Eveningness for school performance. To this end, we assessed intellectual and behavior patterns for Morning- and Evening-type adolescents aged 11-14 who were tested in the morning versus in the afternoon, at times that were in synchrony with their preferred time of day versus at times that were not. Because IQ is a reasonably good predictor of classroom performance (Wechsler, 1991), we assessed intellectual potential using three subtests of a widely used measure of intelligence, the Wechsler Intelligence Scale for Children-III (WISC-III). Behavior patterns were assessed using the Child Behavior Checklist (CBCL), a widely used instrument that assesses social competence and behavior problems (Achenbach & Rescorla, 2001).

Based on evidence in the young adult literature showing synchrony effects in fundamental executive processes (e.g., Hasher, Zacks, & May, 1999; May, 1999; Yoon et al., in press), we predicted that adolescents tested at times that are in synchrony with their preferred time of day would perform significantly better on fluid intelligence measures than adolescents tested at their non preferred time of day. In contrast and again based on previous studies with adults (e.g., Hasher et al., 2005), we expected no differences on a measure of well established knowledge (i.e., vocabulary test). Also, we predicted that Evening-type adolescents would be more likely to manifest behavioral and school related problems compared to their Morning-type peers. The results are dramatic: IQ assessments varied greatly (the equivalent of about 6 IQ points) as a function of the match between optimal time of day and testing time. As well, data from the CBCL suggest that Evening-type adolescents are differentially likely to be at risk for academic, social, and behavioral/emotional problems.

2. Method

2.1. Participants and Recruitment

Using a telephone interview protocol, we administered the Children's Morningness-Eveningness Preferences scale (CMEP; Carskadon, Vieira, & Acebo, 1993) to 259 young adolescents (132 males, 127 females) ranging in age from 11-14 years ($M = 12.48$, SD = 1.07). From this pool, the scores of 80 young adolescents (41 males, 39 females) at ages 11 ($n = 20$), 12 ($n = 21$), 13 ($n = 19$), and 14 ($n = 20$) years fell into the two outer quartiles on the CMEP and, as a result, they were classified as Morning- or Evening-types.

2.2. Design

Twenty participants were assigned to each of four conditions created by crossing chronotype (Morning- or Evening-type) and testing time (morning or afternoon), with comparable numbers of males and females in each. There were no significant differences between those assigned to optimal and nonoptimal testing times in age, gender, grade in school, self-reported amount of sleep, or parental education levels. All participants were tested during the summer.

2.3. Materials

2.3.1. Children's Morningness-Eveningness Preferences (CMEP) scale—This 10-item, multiple-choice scale was adapted by Carskadon et al. (1993) from the widely used Horne-Ostberg Morningness-Eveningness Questionnaire (MEQ; Horne & Ostberg, 1976).

Scores range from 10 (Extreme Evening preference) to 42 (Extreme Morning preference). Cut-off scores for Morningness and Eveningness, based on the outer quartiles of CMEP scores of the telephone sample, were 32 and above for Morning-type and 24 and below for Evening-type. The CMEP is known to have good reliability (Kim et al., 2002), a finding which we confirmed with the present sample (see below).

2.3.2. Child Behavior Checklist (CBCL)—This inventory assesses social competence and behavioral problems relevant to classroom performance; it is highly reliable and valid and can be completed by parents or guardians (Achenbach & Rescorla, 2001). Scores on three scales (Activities, Social, and School) make up the Total Competence score. A Total Problems Score is comprised of Internalizing (Anxious/Depressed, Withdrawn/Depressed, and Somatic Complaints), Externalizing (Rule-Breaking Behavior and Aggressive Behavior), and neither (Social Problems, Thought Problems, Attention Problems, and Other Problems) syndrome groupings. T-scores (converted from raw scores) provide cut-off points for borderline/clinical range criteria, which help identify scores of concern for behavioral/emotional problems. The cut-off point is 37 for the Total Competence score, 65 for syndrome scores, and 60 for the Internalizing, Externalizing, and Total Problems scores.

2.3.3. WISC-III Subtests—Following standard procedures, we administered the Vocabulary, Block Design, and Digit Span subtests from the WISC-III (Wechsler, 1991). Vocabulary provides a highly reliable estimate of verbal ability, an aspect of crystallized intelligence (Kaplan & Saccuzzo, 2005), and correlates well with Verbal and Full Scale IQ (Wechsler, 1991). Block Design provides a reliable measure of nonverbal reasoning and is a reasonable proxy for Performance IQ. Digit Span (Forward and Backward) provides a measure of short-term (auditory) memory. Together with Block Design, Digit Span correlates well with Full Scale IQ and provides a reasonable estimate of fluid intelligence (Kaplan & Saccuzzo, 2005). Age based standardized scores (range 1-19) are available for all three subtests and were used as dependent variables.

2.3.4. Procedure—Participants who obtained extreme telephone CMEP scores were invited to participate in a laboratory-based session. Participants were randomly assigned to either a morning session (8-10 am) or an afternoon session (1-3 pm). These times were chosen to reflect the limits of the average school day schedule. Testing was individually administered.

Parents or guardians completed the CBCL while adolescents completed the CMEP for the second time and reported their bedtime and wake-up time for the previous night. The WISC-III subscales were administered in the following order: Block Design, Vocabulary, Forward Digit Span, and Backward Digit Span. Participants were compensated $5 and reimbursed for transportation.

3. Results

3.1. Chronotype Preferences

3.1.1. Telephone interview assessment—Mean CMEP scores declined consistently with age: age 11 (M = 29.69; SD = 4.96; n = 59); age 12 (M = 27.84; SD = 4.57; n = 73); age 13 (M = 27.30; SD = 5.49; n = 70); age 14 (M = 26.23; SD = 4.08; n = 57). The movement away from Morningness associated with increasing age was reliable, $F(3, 255) = 5.30$, $p = .001$, $\nu^2 = .06$, replicating other findings (e.g., Kim et al., 2002; Roenneberg et al., 2004).

In order to assess the reliability of the telephone-based CMEP scores we re-administered the CMEP to the 80 adolescents who came into the lab. The correlation between the telephone and laboratory CMEP scores was highly reliable ($r = .93$, $p < .001$). We used the initial CMEP scores assessed through the telephone interviews to conduct all subsequent analyses. The

CMEP scores for the 80 laboratory study participants were as follows: age 11 (*M* = 29.80; SD = 6.88; *n* = 20); age 12 (*M* = 28.48; SD = 6.23; *n* = 21); age 13 (*M* = 26.79; SD = 7.56; *n* = 19); age 14 (*M* = 25.50; SD = 6.42; *n* = 20).

3.1.2. Laboratory assessment—Because our goal was to assess performance as a function of the synchrony between chronotype and time of testing independent of the age of the participants, we first conducted a 2 (Chronotype: Morning-type vs. Evening-type) × 2 (Testing Time: morning vs. afternoon) ANOVA with age as the dependent variable. Consistent with norms reported in previous research (e.g., Kim et al., 2002), Evening-type adolescents (M age = 12.75, SD = 1.10) were older than Morning-type adolescents (M age = 12.23, SD = 1.10), $F(1, 76) = 4.45$, $p = .04$, $v^2 = .06$. Despite considerable effort, we were unable to recruit sufficient Evening-type younger children and Morning-type older children to reduce this difference. Nevertheless, this finding does reflect the representation of chronotypes in the population. For interpretation of the subsequent results, it is critical to note that no other effects were reliable (*Fs* < 1). Thus, the average ages of participants tested in the morning versus the afternoon did not differ, nor did the average ages of the Morning-types tested in the morning differ from those tested in the afternoon and similarly for Evening-types at the two testing times. Therefore, all further analyses were collapsed across age. As well, because of the distribution of ages, we used standard scores for both the WISC-III subtests as well as for the CBCL scores.

An additional goal was to assess performance as a function of the synchrony between chronotype and time of testing independent of sleep duration of the participants. To this end, we conducted a 2 (Chronotype: Morning-type vs. Evening-type) × 2 (Testing Time: morning vs. afternoon) ANOVA with amount of sleep prior to the study as the dependent variable. This score was computed as the difference between self-reported sleep and rising times on the night before and morning of the laboratory session. Morning-type adolescents (*M* = 9.40 h, SD = 1.11) reported longer sleep times than Evening-type adolescents (*M* = 8.72 h, SD = 1.91), $F(1, 76) = 3.97$, $p = .05$, $v^2 = .05$. Also, adolescents tested in the morning (*M* = 8.71 h, SD = 1.41) reported shorter sleep times than adolescents tested in the afternoon (*M* = 9.41 h, SD = 1.70), $F(1, 76) = 4.11$, $p = .05$, $v^2 = .05$. The interaction between chronotype and time of testing was not significant ($F < 1$), confirming that adolescents tested at their optimal time of day (*M* = 9.00 h) did not differ in the amount of sleep from those tested at their nonoptimal time of day (*M* = 9.12 h). Despite this critical equivalence, we entered reported sleep duration as a covariate into the intellectual performance analyses. Controlling for sleep duration did not alter any conclusions.

3.2. WISC-III Tasks

Two separate 2 (Chronotype) × 2 (Testing Time) ANOVAs were conducted on the standard scores on Vocabulary and for the mean of the combined Block Design and Digit Span standard scores, with the latter measure providing a reasonable estimate of fluid intelligence (Kaplan & Saccuzzo, 2005). No main effects were found (all *ps* > .45); neither chronotype alone nor testing time alone could account for differences between adolescents tested at their optimal and nonoptimal times of day on any of these measures. The Chronotype × Testing Time interaction was not significant for the Vocabulary subtest, $F < 1$ (see Fig. 1a), replicating findings suggesting that access to semantic knowledge and other forms of crystallized intelligence does not change across the day (Hasher et al., 2005).

For the fluid intelligence measure, the Chronotype × Testing Time interaction was significant, $F(1, 76) = 5.16$, $p = .03$, $v^2 = .06$. Adolescents tested at their optimal times of day (*M* = 12.08, SD = 2.49) significantly outperformed adolescents tested at their nonoptimal times (*M* = 10.86, SD = 2.24), $t(78) = 2.29$, $p = .03$, $d = .52$ (see Fig. 1b).

3.3. CBCL

Checklists were completed by 78 parents (66 mothers and 12 fathers) and 2 relatives. We compared T-scores from Morning- and Evening-type adolescents on those scales most relevant to behavior and school performance (see Table 1). Analyses were also carried out using standard scores ($M = 100$, SD = 15) as the dependent variables on the relevant CBCL scales, computed as recommended by Achenbach and Rescorla (2001). Overall, the findings did not differ substantively from those obtained using T-scores. Therefore, it was decided to use the more conservative T-scores.

3.3.1. Competence scales—Relative to Evening-type adolescents, Morning-type adolescents received higher scores on the Social scale, $t(78) = 2.27$, $p < .05$, $d = .51$, on the School scale, $t(67) = 2.22$, $p < .05$, $d = .50$, and on the Total Competence scale, $t(78) = 2.84$, $p < .01$, $d = .64$.

3.3.2. Syndrome scales—Relative to Evening-type adolescents, Morning-types scored lower on the Attention Problems scale, $t(58) = 2.44$, $p < .05$, $d = .55$, and on the Aggressive Behavior scale, $t(58) = 2.41$, $p < .05$, $d = .54$, suggesting that Evening-type adolescents have greater behavioral problems at home and school.

3.3.3. Normal and borderline/clinical ranges—Using the composite Total Problems scale, we assessed whether chronotype discriminates between scores falling into the normal versus borderline/clinical range of the composite. A 2 (Chronotype) × 2 (Range: Normal vs. combined Borderline and Clinical) chi-square test yielded significant results, $\chi^2(1) = 6.65$, $p = 0.01$, $\omega = .74$. For Evening-types, 12 of the 40 (30%) were in the borderline/clinical range, while for Morning-types 3 of the 40 (7.5%) were in the borderline/clinical range. Thus, Evening-type adolescents were four times more likely than Morning-type adolescents to exhibit behaviors that place them within the borderline/clinical range for serious behavioral problems.

4. Discussion

There have been many attempts to assess the way in which the performance of children and adolescents varies across the day, with a decidedly mixed pattern of results (e.g., Dunn, Dunn, Primavera, Sinatra, & Virostko, 1987; Klein, 2001; Morton & Kershner, 1985). However, none of these studies systematically assessed the performance of children or young adolescents as a function of their individual Morningness or Eveningness preference *and* the time at which testing occurred. We report the first such study and we note that the times of testing we used were consistent with school hours.

Our findings confirm a synchrony effect for adolescents: measures of fluid intelligence (Digit Span and Block Design) vary such that performance is better at optimal compared to nonoptimal times of day. Like others (e.g., Hasher et al., 2005), we found no differences across the day for well established (crystallized) knowledge, here vocabulary. Using an estimate of the Full Scale IQ score and collapsing across the fluid and crystallized measures reported here, we found approximately a 6 point difference in Full Scale IQ equivalents as a function of the match between an individual's circadian arousal pattern and the time of testing. In the intervention literature (for a review, seeBrooks-Gunn, 2003), successful programs report changes of no more than 3-4 IQ points. For example, even extensive training with music lessons for one year (Schellenberg, 2004) showed smaller IQ differences than those reported here.

We note two important limitations to the current study. The first is that this study was conducted in the summer when adolescents may have more control over their sleep schedules than they do during the school year. The synchrony effects seen here may then actually underestimate those seen during the school year, particularly for Evening-types, who likely suffer from sleep deficits on school nights (Carskadon et al., 1998; Sadeh et al., 2002).

The second limitation stems from our use of subjective estimates of sleep duration. Of course, these are not likely to be as reliable as more objective estimates that assess activity patterns across the day. Although the present findings suggest that the synchrony between chronotype and time of testing is important over and above differences in sleep, no strong conclusion should be drawn without objective measures of duration and quality of sleep.

We note that the present findings are useful in establishing the existence of a synchrony effect in the cognitive performance of adolescents, as has been found before in young and older adults (e.g., Hasher et al., 2005). We note particularly that for those adolescents close to meeting the criteria for access to special education or gifted courses, the IQ synchrony effect reported here is the kind of a difference that could have serious consequences. This, of course, remains to be determined by future research. The current results are also useful in confirming the reliability of the CMEP, and particularly of a telephone administration of the test.

The mechanisms that underlie the adolescent shift away from Morningness may have environmental, social, and biological underpinnings (Carskadon et al., 1993; Kim et al., 2002; Roenneberg et al., 2004). Whatever the source of this shift, our evidence suggests that Evening-type adolescents are far more likely than Morning-types to fall into the borderline/clinical category of the most widely used behavioral assessment instrument. A recent study by Andershed (2005). That study suggests that Evening-type adolescents are more likely to have difficult family relations, as well as poorer relations with peers and teachers than non Evening-types. It is possible that Evening-type adolescents may have particular difficulties adjusting to the typical early morning start to the school day found in many parts of the world, and over time these difficulties may be compounded to create very substantial problems for academic and social success.

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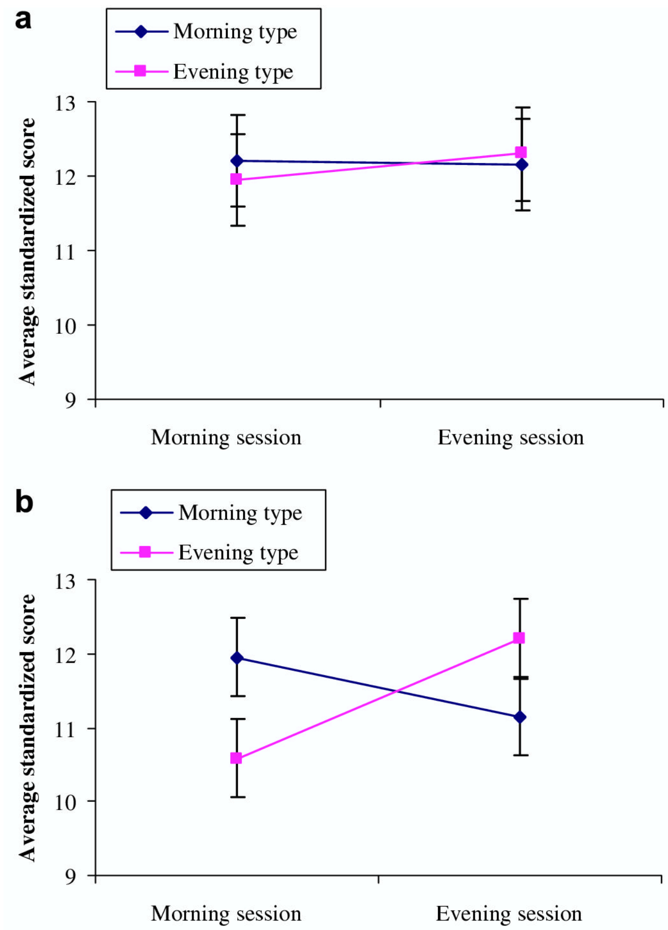

Fig. 1.
Means (+SE) for (a) crystallized intelligence (Vocabulary) and (b) fluid intelligence (Block Design and Digit Span combined) by chronotype and testing time.

Table 1

Mean Scores (and Standard Deviations) for CBCL scales by Chronotype

Variable	**Chronotype**		***p* value**[b]
	Morning (*n* = 40)	**Evening (*n* = 40)**	
CBCL Competence scales[a]			
Activities scale	53.50 (9.37)	50.05 (9.05)	ns
Social scale	51.83 (9.36)	47.13 (9.16)	*
School scale	50.85 (5.34)	47.38 (8.33)	*
Total Competence scale	53.93 (9.94)	47.65 (9.81)	**
CBCL Syndrome scales[a]			
Anxious/Depressed scale	55.48 (6.33)	56.63 (7.24)	ns
Withdrawn/Depressed scale	54.83 (5.69)	54.48 (5.88)	ns
Somatic Complaints scale	54.98 (6.02)	55.83 (6.08)	ns
Social Problems scale	54.85 (5.97)	54.93 (6.51)	ns
Thought Problems scale	54.83 (5.96)	56.80 (7.12)	ns
Attention Problems scale	53.88 (4.33)	57.58 (8.55)	*
Rule-Breaking Behavior scale	52.23 (2.61)	54.00 (5.73)	ns
Aggressive Behavior scale	52.30 (3.82)	55.53 (7.57)	*
Internalizing grouping	51.98 (10.00)	52.90 (10.10)	ns
Externalizing grouping	47.03 (8.11)	50.38 (10.96)	ns
Total Problems Score	49.00 (9.55)	52.23 (10.68)	ns

Note: ns = not significant.

[a] All reported means are based on CBCL T-scores (Achenbach & Rescorla, 2001).

[b] Independent samples *t*—tests.

* $p < .05$.

** $p < .01$.