Scandinavian Journal of Educational Research
Vol. 48, No. 4, September 2004

Carfax Publishing
Taylor & Francis Group

Planning Middle School Schedules for Improved Attention and Achievement

JOSEPH KLEIN
School of Education, Bar-Ilan University, 52900 Ramat-Gan, Israel

ABSTRACT *The literature describes research comparing scholastic success in the morning and afternoon in elementary and high schools. The present study examines the relationship between time of day and scholastic performance in middle school. The progress of 850 seventh and eighth grade students in academic subjects taught at different hours of the day was studied. Mean achievement, as expressed in final grades, rose moderately from morning lessons to those conducted at later hours. Significant but temporary declines in achievement were observed immediately after the 10:00 recess and again during the 13:00 lesson. Variance within classes increased sharply during the day. Previous studies attributed such changes to biological rhythms. This paper indicates that many diurnal changes in scholastic performance may be clarified by integration of concepts of biological rhythms with current theories with respect to attention level. Implications of these findings for planning daily school schedules are discussed.*

Key words: *biological rhythms; school schedules*

INTRODUCTION

The questions of whether and how the organization of school class schedules affects scholastic accomplishment has arisen periodically as part of the debate over holistic change in educational institutions. Among those school managements that consider the beginning of the school day best for success in learning, efforts are made to schedule the 'main' subjects early in the day. When schools do not relate time of day to learning effectiveness, class scheduling is delegated to administrative personnel whose guiding principles are purely technical and psycho-educational factors are irrelevant. Psychological and bio-psychological research has tended towards the concept of an interaction between the time of day at which tasks are performed and the efficiency of performance. Past research has indicated differential achievement in acquisition of reading skills at various times of the day. The contribution of scheduling to academic performance of older pupils, studying a broad range of subjects, should be examined.

Interest in the connection between time of activity and memory level began as

ISSN 0031-3831 print; ISSN 1430-1170 online/04/040441-10 © 2004 Scandinavian Journal of Educational Research
DOI: 10.1080/0031383042000245825

early as the first half of the twentieth century (Gates, 1916). To date, more than 100 human functions have been shown to change in accordance with the circadian cycle (Mayo Clinic, 1995). This expresses itself in daily fluctuations in biochemical and physiological activity (Arendt *et al.*, 1989). Examples of biorhythms are the changes in cardiac activity (Lammer, 1989) and body temperature (Blake, 1971; Colquhuom, 1971; Andrade & Menna, 1996) that take place during each 24 hour period.

The effects of biorhythms are evident in a functional decline during the early afternoon hours. This phenomenon, with its concomitant feeling of fatigue and lower work output, was first attributed to post-lunch sluggishness. However, later studies demonstrated that the temporary slump in performance occurs even when people do not eat a midday meal (Blake, 1971; Javierre *et al.*, 1996); today the slowdown is ascribed to biorhythms.

Folkard (1979) identified diurnal changes in cognitive ability, which he attributed to the dominant function of the left hemisphere in the morning and the right hemisphere in the afternoon. Research on cognitive activity in the brain indicates that the left hemisphere controls the processing of acoustic information, the performance of routine tasks and short-term memory. The right hemisphere is responsible for incorporation of visual stimuli with little semantic information and conceptual tasks that include changes in distribution of information within the brain and long-term memory. The works of Perri and Dawson (1988), and Natale and Lorenzetti (1997) confirm the existence of diurnal changes in long- and short-term memory potential.

The interaction between biorhythms, time of day of studies and academic achievement has been examined among students of various ages. In the lower elementary school grades more progress was found in reading competence during the afternoon hours than the morning hours (Carbo, 1984; Davis, 1987; Barron *et al.*, 1994). Morton and Kershner (1985) noted that the more capable pupils are the main beneficiaries of reading studies in the afternoon. During these hours they demonstrated high proficiency in the acquisition of skills involving immediate and superficial word assimilation. Their accomplishment in deep semantic processing of words was the same whether they learned in the morning or afternoon. The performance of pupils with lower academic abilities declined in the afternoon hours in subjects that required analogous reasoning. The explanation given was that these pupils learned primarily by activation of verbal cognitive processes controlled by the left hemisphere, which is more active in the early morning hours. Different results emerged from a study by Zephaniah (1987), who reported an increase in reading achievement in the afternoon hours among both low and high ability pupils. She recommended investigation of the connection between time of day, academic potential and scholastic progress during the teenage years, when diurnal changes that occur in blood plasma hormone levels exert an effect on memory.

Morton and Diubaldo (1995) compared the results of spelling tests among 12 year olds who learned in the morning or the afternoon. No significant differences were found between them. In another test conducted among children of this age left-handed children were found to be more attentive during the afternoon hours in

tasks involving numbers. Right-handed pupils scored higher in the morning (Morton & Kershner, 1993). The findings were explained by the dominance of the left hemisphere in the morning and of the right hemisphere in the afternoon.

Opinions are divided with respect to the most effective hours for maintenance of attention of individuals of high school age and older. Biggers (1980) and Klein (2001) reported heightened attention in the morning and lower levels in the afternoon. Pinchback (2001) obtained similar findings when he investigated learning effectiveness in post-high school ages. He found that college students recorded more progress in algebra in the morning than in the afternoon.

Dunn (1985) indicated that, for teenagers, the afternoon hours are more effective for learning. Monte *et al.* (2000) concurred. They found that the most effective learning times for grades 10–12 were the afternoon and evening hours. Andrade and Menna (1996) measured the oral temperature of 18 girls aged 16 whose study day began at 07:15 and ended at 16:45. Their temperature rose gradually during the day and correlated significantly with a rise in their scholastic performance. A positive connection between body temperature and quality of function was reported in earlier studies as well (Altabet, 1995).

Some maintain that biorhythms have an indirect influence on the achievement of high schoolers. Individuals at this age require about 9 hours sleep every night (Maas, 1988). Because of diurnal changes, adolescents are usually alert in the late evening hours and therefore go to sleep late (Gail, 2001). To be in school at 08:00, they must rise early, thus they incur a large sleep deficit. The results are impaired memory potential, lower attention levels (Dingers & Kribbs, 1991) and increased mental fatigue. They find it difficult to deal with complex assignments and their academic accomplishments decline (Wolfson & Carskadon, 1998). Dahl (1999) found that students are especially prone to fatigue when the source of motivation stems from assignments involving abstract concepts.

Attempts have been made to start the school day at a later hour. A study conducted in middle schools examined the effect of postponing the first lesson from 07:40 to 09:40. Some teachers reported an improvement in students' attention and a reduction in discipline problems, but an overwhelming majority faced increased problems of motivation and behaviour in the latter part of the school day. Most teachers were of the opinion that the schedule change had resulted in harder work for them and deterioration in the performance of their pupils (Kubow *et al.*, 1999).

Another experiment, conducted by the Center for Applied Research and Educational Improvement (CAREI), found that the merit of a late start depended on the socioeconomic status of the pupils, the geographic location of the school and differential needs and expectations among students, their parents and teachers. The effectiveness of the altered schedule was measured subjectively, by asking the teachers, pupils and parents involved what they thought of it. Fluctuations in students' grades were not examined. In the light of these findings, Gail (2001) suggested that any decision about changing the opening time of the school day should be made locally, on the basis of information culled from the entire community: teachers, pupils and their families and other agents in the area in which the school is situated.

The institution of flexible school hours was one means proposed to meet the diverse needs and expectations of students. Such an approach would allow them to choose courses at hours that they felt would be most efficacious for their learning (Kubow *et al.*, 1999). Ammons *et al.* (1995) found that students were usually accurate in identifying the hours that were optimal for their own progress.

The information amassed to date about the connection between hour of study and academic accomplishment is still limited in scope. It has been investigated in a few subjects, with emphasis on the acquisition of reading skills in elementary school. More extensive research has been conducted on attention levels of pupils at different times of the day. Most of the findings dealt with alertness of elementary and high school students in the morning and afternoon. Difficulty in concentrating at certain times does not necessarily indicate poor performance during those periods. Teachers who note flagging attention often employ a variety of corrective measures. They may utilize active learning and integrate materials that create greater motivation and stimulation. At times students themselves may also try to overcome these problems, especially in subjects they feel are important to them.

The relationship between the time of learning and scholastic attainment should be investigated on a more comprehensive empirical basis, in order that clear conclusions might be drawn about its scope, nature and causes. This requires the examination of changes in achievement hour by hour during the day, as they are expressed by a wide age range in the study of a variety of subjects. In addition, individual differences in performance at each hour of the day should be monitored. This information may assist curriculum planners to develop more accurate guidelines for determination of the most desirable time of day for learning specific subjects. This could be especially helpful for small schools with limited budgets that cannot offer the same courses in both the morning and afternoon.

The present study helps to clarify this issue by examining diurnal changes in achievement among middle school students.

METHOD

Participants

The research sample included 25 randomly selected seventh to ninth grade classes studying academic subjects requiring intensive reading, among them literature and history. Classes were held at different times of day, in the early morning, late morning and early and mid-afternoon. Some subjects were offered once a week. When, as in most cases in the study, several meetings a week were required, all lessons were conducted at the same hour of the day. The total number of students in the 25 classes was 850, with an average of 34 per class, a minimum of 27 and a maximum of 41. All of the participants attended school 6 days a week and 10 months per year, followed by a 2 month annual vacation. The school day began at about 08:00 and ended no later than 14:30. On certain days, studies ended earlier. There was no lunch break, but the pupils had 5–10 minute recesses between lessons and one 20 minute snack and activity break at about 10:00.

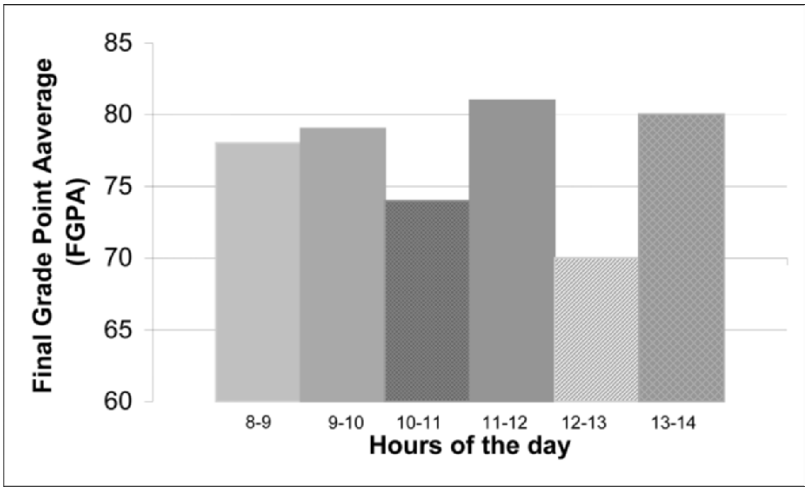

FIG. 1. Mean scholastic achievement according to the hour at which the lesson began.

Procedure

The following information was gathered for each class and subject: the day of the week, the time the lesson began and data with respect to the performance of each student in the class in that subject. The latter was expressed as the annual mean achievement of each student, the final grade point average (FGPA). The range of possible scores was 0–100.

In those cases in which a class was offered once a week, the distribution of grade averages was determined according to the day of the week on which the lesson was given. This was done in the light of studies that correlated the timing of lessons, at the beginning, middle or end of the week, with scholastic performance (Russell & Bernal, 1977; Rodriguez, 1985; Buckman *et al.*, 1995).

FINDINGS

The level of academic achievement varied during the day. A gradual increase from the morning hours to noon can be seen in Figure 1.

For the lesson given immediately after the long 10:00 recess, there was a significant decline in performance, in comparison with the mean score for the lesson preceding the break ($t = 2.96$, $p < .01$). During the session that started between 11:00 and 12:00, achievement was the highest found during the day, significantly surpassing that of the previous period ($t = 3.80$, $p < .001$). A steep slump occurred during the class commencing between 12:00 and 13:00 ($t = 9.06$, $p < .001$). Thereafter, an increase in the mean score was recorded for the period that began between 13:00 and 14:00 ($t = 7.95$, $p < .001$). As can be seen by the *t*-test data, all differences were significant.

In the light of reports of a growing gap in performance between pupils with different levels of scholastic competence in the later hours of the elementary school day, this trend was examined in the present work. The standard deviation of all the

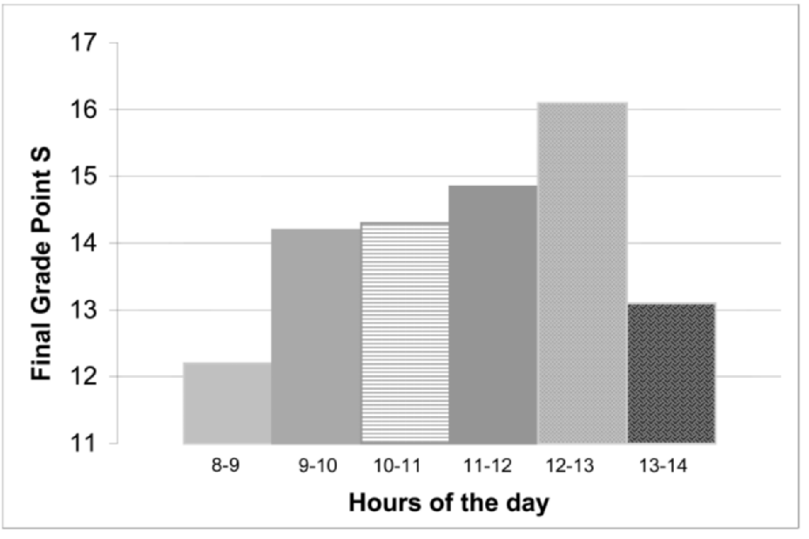

FIG. 2. Distribution of standard deviations of academic achievement according to the hour at which the lesson began.

grades recorded for each class in the study was determined. Figure 2 presents the standard deviations of academic achievement in terms of the FGPA for lessons given throughout the school day.

Variance in achievement increased from the morning hours until the early afternoon hours. The 10:00 recess did not affect this trend. The variance peaked for the lessons beginning between 12:00 and 13:00; at the same time a sharp decrease from the performance level of the preceding hour was recorded. This indicates a disparity among pupils in the degree of deterioration in achievement, from a moderate reduction to a drastic slump.

The study also investigated the contribution of day of the week on which the lesson was given to explain the variance in accomplishment. This variable contributed less than 1% to explaining the variance. The finding was not significant.

DISCUSSION

There is little information in the literature with respect to the relation between organization of the school timetable and scholastic performance. The findings of this study confirm the hypothesis that learning achievement in middle school varies with the time of day at which classes are held.

The beginning of the day was characterized by a sharp transition from the subdued physical and cognitive functions of the night hours to the higher level of activity required for school and study. Subsequent adjustment to the changing situation was gradual. This can be seen in the moderate rise in mean achievement from the morning to the afternoon hours.

The lesson that took place after the long 10:00 break was marked by a decline. This phenomenon has not been reported previously in the literature. It evidently

stemmed from a temporary drop in attention as a result of the prolonged recess. The vigorous sport in which some of the students participated probably contributed to physiological arousal that interfered with concentration in the first half of the lesson following the recess. In the classes beginning between 11:00 and 12:00 the influence of the distractions of the 20 minute break had already waned and students returned to a higher level of performance.

The most prominent decline in achievement was evident in the lessons starting between 12:00 and 13:00. Functional decline during these hours has been documented in industry and other work environments unconnected to the education system. The findings here indicate their applicability to the learning domain in schools as well. Teachers have also noted the early afternoon slump. The fact that the participants in this study had no meal after their 10:00 snack break supports Blake's (1971) contention that the temporary decline in functioning in the early afternoon hours is not connected to post-lunch sluggishness, but to biological rhythms. What remains is to identify the specific psycho-biological processes responsible for this behaviour.

During prolonged undertakings, mental fatigue develops gradually, as is reflected by a weakening of cognitive processing abilities (Schwartz, 2000) and a lack of desire to persevere in the task (Brown, 1994). Drory (1982) found that deterioration in quality of performance of extended assignments principally appears among people who are less capable. Most workers with high potential manifest a greater facility in coping with mental fatigue. This finding helps to explain the increasing disparity in accomplishment among the pupils of a class. Competent students succeeded in harnessing their personal resources to cope with attention difficulties encountered during the long school day. Weaker students, lacking the tools with which to contend with these problems, were unable to sustain concentration and maintain a high level of performance all day. As a result, variance in achievement increased with time. Even when mean scholastic achievements declined in the lesson following the long 10:00 break and in lessons commencing between 12:00 and 13:00 the gap widened between low and high achievers. This reinforces the contention that the latter are better able to cope with distractions.

During the final lessons of the school day performance rose, almost equaling that at noon. At the same time the gap in variance narrowed. It is possible to discern a parallel between the phenomena observed at the beginning of the day and the end. After the night and again after the 12:00–13:00 slump in achievement, performance was high and variance low. It would seem that a period of relaxation, whether overnight or of 1 hour, generated motivation, increased concentration and promoted achievement among both strong and weak pupils. Pat El (1998) recommended scheduling recesses during extended assignments in order to limit the decline in attention and to avoid cumulative mental fatigue.

The question that arises is what happens in the late afternoon hours. Classes for participants in this study ended at about 14:30, making it impossible to examine the extent of variance that would have occurred later in the day. The similarity in achievement profiles during the first and last parts of the school day elicits the hypothesis that were the school day lengthened, the gap would grow between high

and low level achievers, as it did in the morning hours. Empirical verification is required.

The investigation of the contribution of day of the week on which classes were held was based on a number of subjects in the study that were taught only once a week. At the beginning of the week pupils did not do better as a result of the renewed energy with which they presumably returned to their books nor did they achieve less in comparison with other weekdays because of lingering distractions. There was no difference between the first and the final days of the school week, confuting the conjecture that cumulative fatigue and burnout during the week would cause a decline in performance. Pupils did not seem to perceive the semantic sequence of the school week, first day of studies, second, third, etc., as an unbroken, progressive task that would trigger a loss of attention.

It is very probable that the biological rhythms of teachers, not treated in this work, also contribute differentially to the achievement levels of their students. The interaction between the biorhythms of teachers and pupils has not been studied. Investigation of this matter may well offer new insights with respect to diurnal changes in student achievement.

The findings of this research support the recommendation to integrate principles of educational psychology during the organization of school schedules. In planning the daily timetable those responsible must take into account the subjects in which classes perform best. At the same time it is necessary to note which study hours are most effective among pupils with different academic potentials. These two issues are often incompatible. For instance, during the first hour of the day, when the average class accomplishment is not at its highest, the low variance indicates a possible advantage for weaker pupils. The decision as to which of these approaches deserves priority is situational, dependent on the make-up of each school population.

School administrators must determine which subjects to schedule for the hours during which attention is typically low and, conversely, the times that are more conducive to high attention. There are those who maintain that the time slots with the highest potential for scholastic success should be reserved for fields that are thought to be most important. Adoption of this opinion requires recognition of adverse effects with regard to the subjects considered secondary. Relegation of these study programmes to more problematic hours, when attention is known to be low, constitutes a signal to the students and their parents that the staff attributes lesser importance to such courses. Poor levels of accomplishment during these less favourable hours will only add to the negative attitude towards the subjects.

Alternatively, the classes with primary status might be scheduled for the hours during which attention is usually low. This is most feasible at the high school level. The suggestion is based on the assumption, still lacking empirical verification, that the motivation for accomplishment in those subjects and recognition by the students of the difficulty in maintaining attention during such hours will help them to take steps to overcome the problem of concentration. An additional possibility is to plan courses involving a lot of activity, such as technology and sports, during the hours of decreased alertness. The nature of the classes should counteract the tendency of

a decline in attention. Educators, rather than administrators, who lack experience in the application of the concepts of educational psychology, should resolve this matter.

In conclusion, most of the diurnal changes in scholastic achievement may be explained by taking into account the theories of biological rhythms, as well as the link, described in the literature, between the scope of tasks and attention level. Continued mapping of effective learning times for each age group, for each hour of the day, may help to provide a more detailed and complete explanation of these changes and their causes. Such mapping becomes more essential as the availability of a variety of learning environments increases and as distance learning, which can be conducted at all hours of the day and night, becomes more accepted.

REFERENCES

ANDRADE, M. M., & MENNA, B. L. (1996). Diurnal variation in oral temperature, sleepiness and performance of high school girls. *Biological Rhythm Research*, *27*(3), 336–342.

ALTABET, S. C. (1995). Intelligence (Doctoral dissertation, Hofstra University). *Dissertation Abstracts International*, *55*, 9B.

AMMONS, T. L., BOOKER, J. L., & KILLAMON, C. P. (1995). The effects of time of day on student attention and achievement. University of Virginia (ERIC Document Reproduction Service No. ED 384 592).

ARENDT, J., MINORS, D. S., & WATERHOUSE, J. M. (1989). Basic concepts and implications. In J. ARENDT, D. S. MINORS & J. M. WATERHOUSE (Eds.), *Biological rhythm in clinical practice* (pp. 3–8). London: Wright.

BARRON, B. J., HENDERSON, M. V., & SPURGEON, R. (1994). Effects of time of day instruction on reading achievement of below grade readers. *Reading Improvement*, *31*, 59–60.

BIGGERS, J. L. (1980). Body rhythms: The school day and academic achievement. *Journal of Experimental Education*, *49*, 45–47.

BLAKE, M. J. F. (1971). Temperament and time of day. In W. P. COLQUHOUN (Ed.) *Biological rhythms and human performance* (pp. 109–148). New York: Academic Press.

BROWN, I. D. (1994). Driver fatigue. *Human Factors*, *36*(2), 298–314.

BUCKMAN, D. C., KING, B. B., & RYAN, S. (1995). Block scheduling: A means to improve school climate. *NAASP Bulletin*, *79*, 9–18.

CARBO, M. (1984). You can identify reading styles and then design a super reading program. *Early Years*, *15*, 80–83.

COLQUHOUM, W. P. (Ed.) (1971). *Biological rhythms and human performance*. New York: Academic Press.

DAHL, R. E. (1999). The consequences of insufficient sleep for adolescents: Links between sleep and emotional regulation. *Phi Delta Kappan*, *80*(5), 354–359.

DAVIS, Z. T. (1987). Effects of time of day of instruction on beginning reading achievement. *Journal of Educational Research*, *80*, 138–140.

DINGERS, D. F., & KRIBBS, N. B. (1991). Performing while sleepy: Effects of experimentally induced sleepiness. In T.H. MONK (Ed.), *Sleep, sleepiness and performance, human performance and cognition* (pp. 97–128). New York: Wiley.

DRORY, A. (1982). Individual differences in boredom proneness and task effectiveness at work. *Personnel Psychology*, *35*, 141–151.

DUNN, R. (1985). It's time to handle instructional time correctly. *Early Years*, *16*, 47–49.

FOLKARD, S. (1979). Time of day and level of processing. *Memory and Cognition*, *7*, 247–252.

GAIL, C. (2001). *On my own time: The conflict between adolescent sleep needs and high school start times*, Occasional Paper no. 38. Maine, USA. College of Education and Human Development University of Maine and Penquis Superintendents' Association.

GATES, A. L. (1916). Diurnal variation in memory and association. *Publications in Psychology*, *1*, 323–343.

JAVIERRE, C., VENTURA, J. L., SEGURA, R., CALVO, M., & GARRIDO, E. (1996). Is the post-lunch dip in sprinting performance associated with the timing of food ingestion? *Journal of Physiology and Biochemistry*, *52*, 247–253.

KLEIN, J. (2001). Attention, scholastic achievement and timing of lesson. *Scandinavian Journal of Educational Research*, *45*(3), 301–309.

KUBOW, B. K., WAHLSTROM, K. L., & BEMIS, A. E. (1999). Starting time and school life: Reflection from educators and students. *Phi Delta Kappan*, *80*(5), 366–371.

LAMMER, B. (1989). Circadian rhythms in the cardiovascular system. In J. ARENDT, D. S. MINORS & J. M. WATERHOUSE (Eds.), *Biological rhythm in clinical practice* (pp. 51–70). London: Wright.

MAAS, J. B. (1988). *Power sleep: The revolutionary program that prepares mind for peak performance*. New York: Vilgard.MAYO CLINIC (1995). Circadian rhythms: These 24-hour cycles keep you on schedule. *Mayo Clinic Health Letter*, *13*, 3.

MONTE, A. E., DASILVA, C. F., & SILVERIO, J. M. A. (2000). Biological rhythms in education. *Psychologia Teoria Investigaca e Practica*, *5*(2), 301–312.

MORTON, L. L., & DIUBALDO, D. (1995). Circadian differences in hemisphere-linked spelling proficiencies. *Journal of Neuroscience*, *81*, 101–110.

MORTON, L. L., & KERSHNER, J. R. (1985). Time of day effects upon children's memory and analogical reasoning. *The Alberta Journal of Educational Research*, *31*, 26–34.

NATALE, V., & LORENZETTI, R. (1997). Influences of morningness–eveningness and time of day on narrative comprehension. *Personality and Individual Differences*, *23*, 685–690.

PAT EL, L. (1998). *The connection between the order of checking exams, the time spent checking the exams and the seniority of the teacher and between the grades given in a composition examination*. Unpublished master's thesis, Bar Ilan University, School of Education, Ramat Gan, Israel.

PERRI, S., & DAWSON, J. (1988). *The secret our body clocks reveal*. New York: Rawson Associates.

PINCHBACK, C. L. (2001). Types of errors exhibited in a remedial mathematics course. *Focus on Learning in Mathematics*, *13*(2), 53–62.

RODRIGUEZ, J. R. (1985). Season, day of week may affect behavior. *NAASP Bulletin*, *69*, 101–104.

RUSSELL, M. B., & BERNAL, M. E. (1977). Temporal and climatic variables in naturalistic observation. *Journal of Applied Behavior Analysis*, *10*, 399–405.

SCHWARTZ, D. A. (2000). Fatigue of inhibitory processes in selective attention: Experimental support for a theory of international thought and action (Doctoral dissertation, University of Michigan). *Dissertation Abstracts International*, *61*, 2B.

WOLFSON, A. R., & CARSKADON, M. A. (1998). Sleep schedules and daytime functioning in adolescents. *Child Development*, *69*, 875–887.

ZEPHANIAH, T. D. (1987). Effects of time of day of instruction on beginning reading achievement. *Journal of Educational Research*, *80*, 138–140.