

## **An Investigation on the Effect of Fluctuations in Daily and Weekly Rhythm and Chronotype (Morning, Evening and Intermediate Types) in preschoolers Attention performance**

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### **Abstract**

**Purpose:** Attention is a significant factor for the learning process, and it may affect the degree and efficiency of student's learning and their teaching. **Methodology:** Therefore, the present paper aims to examine the effect of the fluctuations in daily and weekly rhythms, and chronotype (morningness-eveningness) on the attention performance of preschoolers. The research's methodology is a causal-comparative one. The statistical population includes 100 preschoolers in Tehran who were selected by purposeful sampling. They were tested in different hours of day (8, 11, 13, and 15) and weekdays (Saturday, Sunday, Tuesday, and Wednesday). **Findings:** The data were analyzed by mixed analysis of variance. The results show that preschoolers' performance is different for different days of week and hours of day ( $p < 0.01$ ). and in comparison with the attention performance of evening and intermediate types, that of morning type shows no significant difference in educational environment during day and week ( $p < 0.01$ ). **Discussion:** The practical implications of these findings for the planning of school schedules are benefit.

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## 1. Introduction

Attention seems intuitively important for learning since children and adolescents have to focus on teacher's instructions and perform the task in a context where sleep length, school schedules and relationship with family or peers are less controlled than in laboratory research (Gomes, Tavares, & Azevedo, 2011). The role of attention is similar to that of a goalkeeper of mind, and this role is played through regulating and prioritizing of processed impulses by central nervous system (Seidman 2006; Meltzer 2011). Preschoolers' executive functions and their attention during preschool period can anticipate well their ability to read and mathematics in later years (Espy, McDiarmid, Cwik, Stalets, Hamby, & Senn, 2004). The physiological rhythms are among influential variables on attention. The physiological rhythms are steady physiological activities with statistically significant periods and amplitudes, and which reoccur at least in two consecutive periods. These rhythms include ultradian, circadian, infradian cycles (Clark, 2005). The circadian cycle has influence on attention (Sharifi, 1998; Klein, 2005; Alcorta, Ponce, Bonnet, 2004; Schmidt, Collette, Cajochen, Peigneux, 2007; Janvier, B., Testu, 2007; Valdez, Reilly, Waterhouse, 2008; Lam, Mahone, Mason, Scharf, 2011; Ponce, C., Alcorta, 2011; Marouf, Khelfane, Testu, 2013; Jarraya, Jarraya, & Souissi, 2014; Escribano, Díaz-Morales, 2014).

Cognitive performance decrease during morning time (from 9 to 11 o'clock); then increase at initial hours of afternoon (14 o'clock) and reach to their peak at four in the end of afternoon. Early studies have shown that circadian rhythm has a significant effect on educational performance; this shows that different cognitive abilities including attention are under influence of circadian rhythm (Goldstein, Hahn, Hasher, Wiprzycka, Zelazo, 2007; Schmidt et al. 2007).

The sleep-wake rhythm (chronotype), besides physiological rhythms, also has an effect upon attention. According to researches, the frequency of sleep-wake rhythm is effective in the formation of children's physiological rhythms, and these in turn have effect directly on the tendency to attention (Montagner, 1983). The processes engaging in cognition including attention (consciousness, selective and steady attention) may be determined through analysis of active brain section, circadian rhythms and the effects of sleeplessness (Valdez et al, 2008). Developmental changes in the sleep processes, circadian cycle, and inequality of circadian cycles in sleep disorders, circadian rhythms, lead to important consequences for cognitive performance. Generally, if awaking is happened at proper biological times, biological clock's activity is useful for human's cognition (attention). But when awakening is happened at improper biological time because of environmental circumstances (jet lag, early school start, long working time, working schedules) or because of disorders in circadian rhythms, then disharmony between circadian and physiological cycles of sleep lead to cognitive disorder (Wright, Lowry, & LeBourgeois, 2012).

The changes in attention components can explain the circadian fluctuations in many cognitive functions (Valdez et al. 2014). It seems that constantly there are minimum attention times in different years, and the first day of week always has the lowest working potential. In contrast, the day before last day of week has the highest working potential (Sharifi, 1998). Since chronotype (morningness-eveningness) and physiological rhythms have a significant role in cognitive processes especially attention, and since the simultaneous effect of these factors on attention performance isn't explored yet, the present paper aims to answer these questions: 1) Is the preschooler's attention performance different during day hours and weekdays in educational environment? 2) Is morning preschooler's attention performance different during day hours and weekdays in educational environment in comparison with an intermediate and evening preschooler?

## 2. Methodology

A causal-comparative method is used in the present paper, and its statistical population is selected by a purposeful sampling. In doing so, according to the paper's aim a preschool with two morning and afternoon shifts was selected in the district eight of Tehran. Using chronotype questionnaire (morningness-eveningness) for children, a group of children was selected for each type of morningness, intermediate and eveningness. The size of sample was determined according to this logic that our research is a comparative one and it needs at least fifteen persons in each group. Using G\*Power software, version 3.0.10, as a F test and entering the inputs of effect size 0.33, alpha 0.05, power 0.95, the answer for the sample size was 95 and for our research the sample size of 100 persons was selected. Then they were tested in different hours of day (8, 11, 13, 15) and different days of week (Saturday, Sunday, Tuesday, Wednesday). And Saturday was considered as the first day of week.

To measure out the morningness-eveningness orientation among preschool children, Children's ChronoType Questionnaire (CCTQ) was employed. The CCTQ is adapted from previous questionnaires by Werner, Molinari, Guyer and Jenni (2008) to assess the morningness-eveningness scale (such as Horne and Ostberg, 1976; Carskadon, Vieira and Acerbo, 1993; Roenneberg et al. 2003) and was prepared by Werner, Labrgvys and Jenny (2009). The CCTQ is a parent-report questionnaire which includes three different parent-report measures of children's chronotype. The Morningness/Eveningness (M/E) scale score is derived from responses to 10 questions about preferred timing of going to bed, getting up in the morning, taking a cognitive test, and completing physical activities, as well as the child's most prevalent behavior in recent weeks (e.g., sleepiness after awakening in the morning and in the evening). Scoring of questions 1, 2, 8 and 9 are done in reverse. M/E scale-scores range from 10 (extreme morningness) to 49 (extreme eveningness). Morning types are classified by a M/E scale score of less than 23, intermediate types by a score of 24–32, and evening types by a score of more than 33. Werner et al. (2008) reported Cronbach's alpha of the scale 0.81 which was in line with the alpha reported by Carskadon et al (1993). The average corrected correlation with the total scale of each question was 0.31 ranging from 0.49 to 0.71, respectively. These indicators suggest that the validity and internal consistency of this scale is desirable. To use this scale in this study, at first scale questions were translated by English into Farsi translator and then translated back into English. After proofreading, the Persian questionnaire was revised again and handed to some psychology professors for checking its content validity.

Attention measurement was done through a simple paper-pen marking test. This test is similar to Zalazo test (1972) and was designed based on the test in the research by Janvier and Testu (2007). In this test, which in fact is a visual identification task, children must identify some specific pictures among many other pictures including diversionary ones. The targeted picture is a heptagon which is shown above the page and other similar pictures must be identified and ticked among ten rows of pictures. There are ten rows on the page, five pictures in each row and one of them is the target. One obtains one score for each correct tick, therefore maximum 10 scores is available. Time limit for the task in Janvier and Testu (2007) research was 55 seconds for 4-6 years old children. A primary study was performed on a peer group to determine a proper norm for the investigation's statistic sample, and a 20 seconds time limit was selected for our sample. Because this test will be performed repeatedly in different time periods for children, to minimize learning effect, we prepared four parallel forms for this test with similar targeted and diversionary pictures and same scoring method, but with different locations for targeted pictures in each row. According to one-

way analysis of variance, these forms statistically have no significant difference and may be used instead of each other.

Obtaining consent from the parents of participants, demographic and morningness-eveningness questionnaires were administrated to parents. Researcher in the main stage of research attended the preschool in times between 8-9, 10-11, 13-14, 15-16, and assessed the children's cognitive performance. These assessments were repeated in five days of week from Saturday to Wednesday. These assessments were performed by researcher and according to instructions of used instruments. The collected data were entered the SPSS, version 23, and were analyzed by mixed analysis of variance.

### 3. Findings

Mean and standard deviation of attention for three groups of children in different hours of day and different weekdays are appeared in table 1 (to summarize data, the columns and rows of total scores aren't shown).

Table 1: Mean and Standard Deviation of Children's Attention for Three Groups in Different Hours of Weekdays

Group	Days of Week	Day's Hours							
		8		10		13		15	
		M	SD	M	SD	M	SD	M	SD
Morning	Saturday	6	1.76	5.47	2	5.35	2.52	5.47	2.32
	Sunday	5.35	1.9	6.76	1.25	7	2.32	7	1.7
	Monday	6.6	1.5	7	2.4	7.12	2.31	7.06	1.88
	Tuesday	6.41	2.06	6.53	2.52	6.47	1.77	6.9	2
	Wednesday	6.24	2.1	6.24	2.33	6.65	2.5	6.65	2
Intermediate	Sa	5	2.52	5.4	2.3	5.32	2.61	6.12	2.1
	Su	6	2.1	6.3	1.2	6.4	1.9	6.23	2.16
	Mo	5.68	1.7	6.11	2	6.4	2.06	6.81	1.78
	Tu	5.58	1.8	5.62	1.6	5.31	1.7	6.5	1.9
	We	5.79	1.71	6.23	1.89	6.12	2.38	6.19	2.26
Evening	Sa	5.62	2.6	5.46	2.64	6.1	2	6.65	2.05
	Su	6.23	1.88	6	2	6	1.84	6.5	1.9
	Mo	5.15	2.29	5.69	1.95	6.38	2	6.81	1.9
	Tu	5.58	1.88	5.62	1.6	5.31	1.78	6.5	1.9
	We	5.19	1.6	5.85	1.7	5.54	1.52	6.54	2.33

There is an independent intergroup variable (children groups at three levels: morningness, intermediate, eveningness), two independent intragroup variables (daily cycle at four levels: 8 o'clock, 11 o'clock, 13 o'clock, 15 o'clock and weekly cycle at five levels: Saturday, Sunday, Monday, Tuesday, and Wednesday) and one dependent variable in terms of distance measurement (attention score), therefore mixed analysis of variance was used to answer the investigation's questions. Mauchly's sphericity test was used to examine the sphericity of data, and its results are appeared in table 2.

**The Results of Mauchly's Test for Determination of Data's Sphericity**

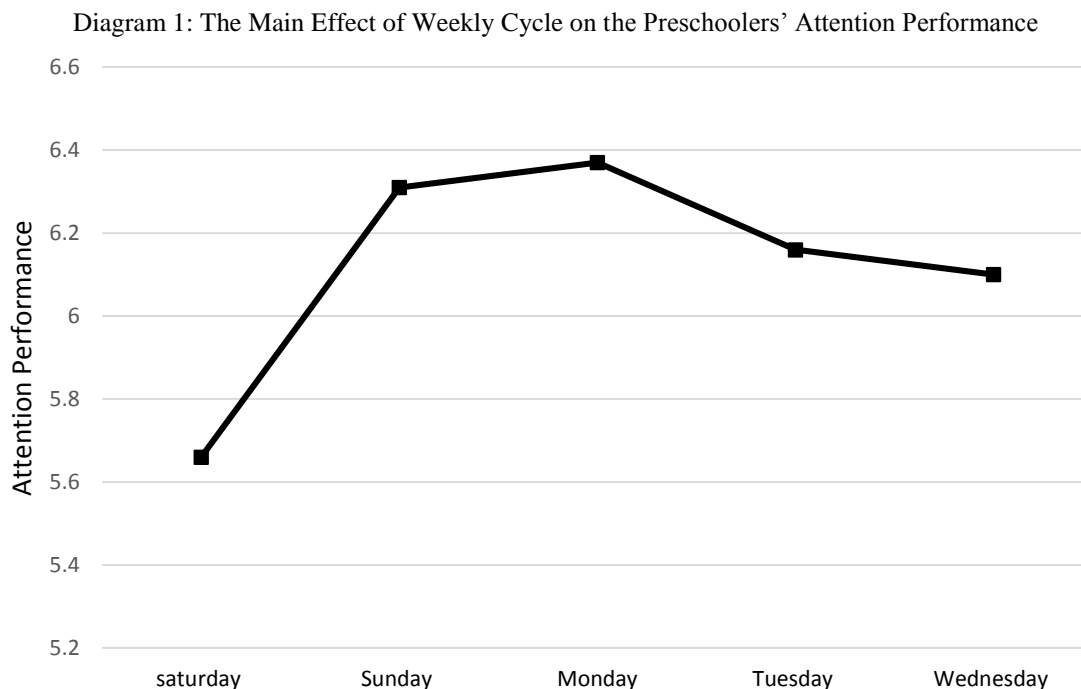
Within-Subject Effect	Mauchly W	Chi-Square	Freedom Degree	Sig.
Weekly Cycle	0.82	18.63	9	0.05
Daily Cycle	0.73	29.72	5	0.001
Weekly Cycle*Daily Cycle	0.08	234	77	0.001

According to the results from Mauchly's test which are shown in table 2, it is clear that sphericity assumption is correct for the main effects of both inter-subject variables. So the corrected Greenhouse-Geisser figures were used for variance analysis of interactional effect of both inter-subject variables.

Table 3: Mixed Analysis of Variance for Attention Performance of Three Groups during Day and Week

Source	Squares Sum	Freedom Degree	Squares Mean	F	Sig.	Eta Square
Weekly Cycle	100	3.65	27.37	5.72	0.001	0.05
Weekly Cycle*Group	57.56	7.3	7.87	1.64	0.11	0.03
Error	1694	354.38	4.78			
Daily Cycle	105.84	2.51	42.16	13.93	0.001	0.12
Daily Cycle*Group	20	5.02	3.98	1.31	0.25	0.02
Error	736.69	243.51	3.02			
Weekly Cycle*Daily Cycle	30.1	7.66	3.92	1.14	0.33	0.01
Weekly Cycle*Daily Cycle*Group	59.97	15.33	3.91	1.13	0.32	0.02
Source	2559	743.79	3.44			

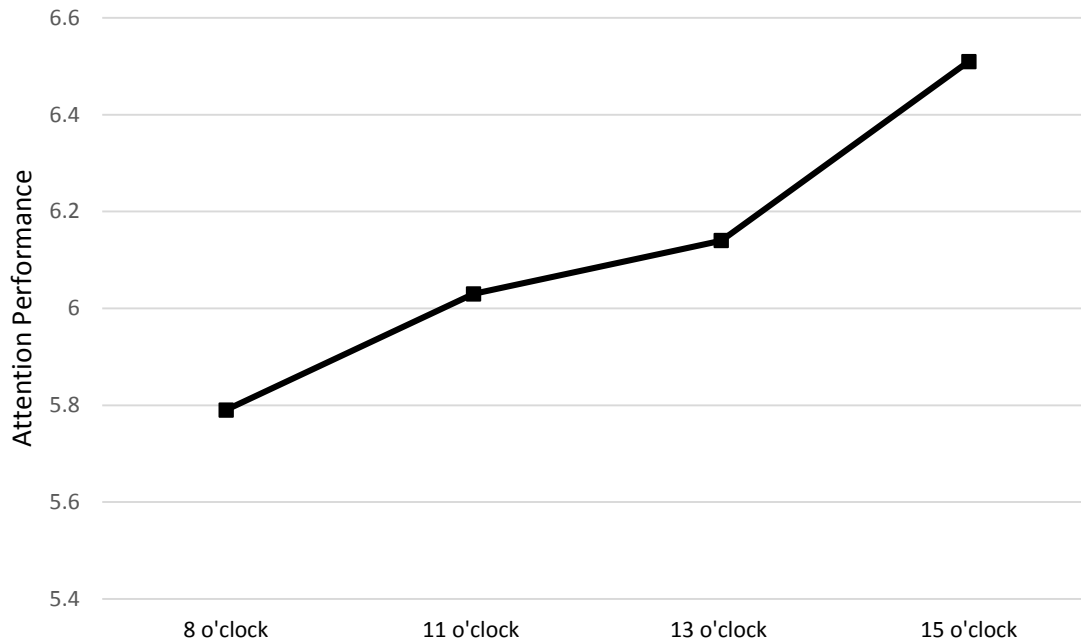
According to table 3 it is clear that the main effect of group on the performance of attention isn't significant. This means that there is no difference between three groups of children, morning, intermediate, afternoon, about their attention performance. But as it is shown in table 3, the main effect of weekly cycle on the attention performance among preschoolers is significant. In other words, there is a significant difference between the children's attention performance during different weekdays. Bonferroni post-hoc test specifies that this difference between Saturday and Sunday and Monday is significant. The main effect of weekly cycle in the preschoolers' attention performance is shown on the diagram 1.



As shown in diagram 1, the preschoolers' attention performance on Saturday is the lowest one and it will increase in later days of week, and in last days of week is stable. Definitely an observable decrease in the performance is visible on Tuesday and Wednesday, therefore the change in attention performance between Saturday and two last days of week isn't significant. According to this diagram, the highest attention performance belongs to Monday. And eta square for the main effect of weekly cycle in table 3 indicates that about 5% of changes in preschoolers' attention can be explained by weekly cycle.

According to table 3 it is clear that none of interactional effects of group and weekly cycle and daily cycle on attention performance is significant. In other words, above three variables don't adjust each other's effect and preschoolers in the three groups show no difference in their attention performance during different weekdays and hours of day. But the main effect of daily cycle is significant. In other words, the preschoolers' attention performance changes generally in different hours of day. Bonferroni post-hoc test specified that this difference between 15 o'clock and other hours also between 8 o'clock and 13 o'clock is significant. The main effect of daily cycle on preschoolers' attention performance is shown in diagram 2.

Diagram 2: The Main Effect of Daily Cycle on preschoolers' Attention Performance



As shown in diagram 2 it is clear that preschoolers have the lowest attention performance at 8 o'clock and the highest on at 15 o'clock. Also it is clear that attention has an increasing trend during day. And according to the reported eta square for the main effect of daily cycle in table 3, about 12% of changes in the preschoolers' attention can be explained by daily cycle.

About the answer to the first question of our paper, analyses on the scores of attention performance and the results from mixed analysis of variance and this matter that the main effect of daily and weekly cycles on the attention performance is significant, show that preschooler's attention performance in educational environment is difference during day and week.

About the answer to the second question of our paper, according to this matter that none of interactional effects of group, daily cycle, and weekly cycle on the attention performance are significant, it is concluded that there aren't enough evidences for difference between the morning preschoolers' attention performance during day and week in comparison with intermediate and afternoon preschoolers.

#### 4. Conclusion

The present study was performed to examine the effect of daily and weekly rhythms and chronotype (morningness-eveningness) on the preschoolers' attention performance. According to data analyses, for the answer to the first question, it is demonstrated that preschoolers have different attention performance during day and week. The result from the present study shows that preschoolers have the lowest attention performance on Saturday and it increases in later days which its peak is on Monday. This result is in agreement with findings from Sharifi (1998), Ma'rouf et al. (2013), Teixeira, Fischer, de Andrade, Louzada, & Nagai (2004), and Teixeira, Fischer, Nagai, Souza, Turte, Repullo-Jr, & Latorre (2005). The lowest efficiency of attention and cognitive performance in Sharifi's research belonged to Saturday and Sunday, and its highest belonged to Monday to Wednesday. The negative effect of weekend holidays is also visible on the diagram of



attention's weekly changes in Ma'rouf's research, in other words, students had the lowest performance on Saturday.

This is because students in weekend are allowed to be wake more, and this change may lead to higher and accumulated fatigue in the beginning of week, hence the attention performance will be decreased. Teixeira et al. (2004, 2005) have already noted the effect of the length of the wake span on attention because of insufficient sleep. Since children must be awaked early in the morning with their parents during working weekdays, they have to go to bed early in the night; therefore, their sleep rhythm will be adjusted in this way, and this affects their attention performance, although the result from examination of the second question disagree with this explanation.

Also the present study indicated that the preschoolers' attention performance generally is different during hours of day; their attention performance at 8 o'clock is the lowest and at 15 o'clock is the highest with an upward trend totally during day. This finding is in agreement with Valdez et al. (2014), Janvier and Testu (2007), Sharifi (1998), and Jarraya et al. (2014a) and Klein (2001). Since both body core temperature and cognitive performance are dependent on daily rhythm, it is possible to justify the lower attention performance by core temperature in early of the morning. According to Jarraya et al. (2014a), the core temperature is dependent on the daily rhythm, and its highest point belongs to 16 o'clock. This is in agreement with Nicolas et al. (2005) and Souissi et al. (2012). We know that both core temperature and body's metabolism decrease during night sleep, and cognitive performances are in relation with metabolism.

These results that cognitive performance is dependent on daily cycle and its highest value is happened in the end of afternoon are in agreement with Guérin, Boulenguez, Reinberg, Di Costanzo, Guran, & Touitou (1993), Testu, F., Bréchon (2008), Montagner (2009), Touiyou, Y., Bégué (2010). But the present paper isn't in agreement with Diaz-Morales, Escribano (2014), Ponce, Alcorta (2011), Jarraya et al. (2014b). Jarraya et al. (2014b) concluded that "cognitive performance in handball goalkeepers were time-of-day dependent, with the best values observed in the morning for selective and continuous attention."

This might be due to boredom and the accumulation of fatigue, both of which would cause cognitive performance to decline in the beginning of morning (Jarraya et al. 2014a).

Analyses of data about the answer to the second question have shown that there is no significant difference between the attention performance of morning preschoolers in comparison with that of intermediate and afternoon ones during day and week in educational environment.

This finding isn't in agreement with Schmidt et al. (2007), Valdez et al. (2008), Wright et al. (2012), Konen, Dirk, Schmiedek (2015), Diz-Morales, Escribano (2014), Gaggioni, Maquet, Schmidt, Dijk, Vandewalle (2014). Diaz-Morales, Escribano (2014) demonstrated that some people have better cognitive performance for their morning activities than afternoon activities, and that night activity and sleep impact upon day's activities and this is the case with night activities and daily performance among adolescences also. Cognitive processes vary over the course of the 24 h day. Time of day dependent changes in human cognition are modulated by an internal circadian timekeeping system with a near-24 h period. The human circadian timekeeping system interacts with sleep-wakefulness regulatory processes to modulate brain arousal, neurocognitive function. Brain arousal is regulated by ascending brain stem, basal forebrain (BF) and hypothalamic arousal systems and inhibition or disruption of these systems reduces brain arousal, impairs cognition, and promotes sleep. The internal circadian timekeeping system modulates cognition and affective function by projections from the master circadian clock, located in the hypothalamic suprachiasmatic nuclei (SCN), to arousal and sleep systems and via clock gene oscillations in brain tissue (Wright et al, 2012)

According to the findings of the present paper it is suggested to other researchers that simultaneous examination of the effect of child's chronotype, of the parents' chronotype and their life styles (especially mother), and kindergarten's shift on the cognitive performances especially attention one to be considered in future investigations. Aiming to obtain an optimized performance and regulation of biological rhythm among preschoolers also it is suggested that a biological timetable to be prepared for them to consider their attention performance in educational activities and syllabuses must be determined based on the children's daily and weekly rhythms. For example, the new learning and educational activities which need higher attention performance must be scheduled for the late morning, afternoon and the middle of week.

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