ORIGINAL ARTICLE

Effect of implicit and explicit learning on the dart throwing task in the morningness-eveningness people

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ABSTRACT

The interaction of constraints causes learning. It was examined how explicit and implicit learning affected the dart-throwing task in morningness-eveningness people to test this claim. 120 morning-type individuals (AgeM ± SD = 23.38 ± 2.58) were chosen using the MESSi questionnaire. Then, randomly divided into four 30-person groups: explicit morning practice, implicit morning practice, explicit evening practice, and implicit evening practice. Each group received 10 training sessions (3 sets of 10 attempts). Mixed ANOVA (4x4) demonstrated significant main effects of different tests, group, and group test interaction. Additionally, Tukey's test demonstrated that explicit training groups outperformed implicit training groups in both immediate and delayed retention tests. The retention test with a two-week delay and transfer test outperformed explicit training groups. So, it can be said to some extent that implicit practice outperforms explicit. Learning will last longer if this practice is based on individual characteristics like circadian rhythm.

Keywords: Learning, Circadian rhythm, Implicit practice, Explicit practice, Dart throwing.

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INTRODUCTION

Education is critical in all aspects of development, growth, learning, and psychological, cognitive, and physical factors. Training in physical education is done with movement interventions; different training methods are introduced and used in this direction. Among the many types of interventions in motor learning, one of the most widely used ones that has attracted the attention of researchers in recent years is implicit and explicit (traditional) learning (Ellis, 2009). In traditional methods, it is assumed that learning progress occurs due to a verbal-cognitive stage (Kleynen et al., 2014). It is thought that in this comprehensive stage, he/she acquires his/her expressive knowledge about points such as the rules or facts of skill implementation, ultimately leading to mastery of the skill (Ellis, 2009). However, to achieve automaticity, the learner needs an active working memory or is involved in executing the skill because verbal knowledge is related to working memory (Kleynen et al., 2014).

Compared to the traditional teaching method, implicit learning has been proposed as an alternative or effective method in coaching and sports psychology books (Gulbin et al., 2013; Raab et al., 2016). In implicit learning methods, motor skill acquisition is thought to occur as a result of procedural knowledge (not verbal knowledge) (Maxwell et al., 2000). This knowledge is inaccessible to consciousness and does not depend on working memory processing (Savani et al., 2022). In other words, learners in this method cannot verbally describe the technical points of the skill (Leh et al., 2022).

Therefore, implicit learning focuses on the automaticity of the skill or the execution of the skill with little awareness (Maxwell et al., 2000). Although in traditional learning, the attempt is to perform the skill automatically, it is thought that procedural knowledge is more effective in achieving automaticity and probably requires less time (Modchalingam et al., 2023). This issue has also been confirmed in experimental studies. In this regard, Kal, Prosée, Winters, & Van Der Kamp, (2018) by reviewing 39 studies in this field showed that implicit learning is more effective than explicit learning(Kal et al., 2018).

Based on the perspective of ecological dynamics (Davids et al., 2012), working memory, expressive knowledge, procedural knowledge, and even education are not the only factors that determine learning. Instead, learning, acquiring, and performing skills as a result of the interaction between organismic constraints (such as working memory, procedural knowledge, verbal knowledge, physical strength, psychological factors, etc.), environment (such as light, night, or day, morning or afternoon, presence or absence of spectators, environmental changes of specific sports, and the task (such as the rules of any sport or exercise manipulation) occurs (Newell, 1986). This shows that working memory (procedural and verbal knowledge) in explicit and implicit learning is only one constraint of organismic constraints that can affect learning, and this effect is related to other limitations, such as environmental and task constraints. One of the environmental constraints that can affect a person's learning is the changes in the circadian rhythm, which also affects the active memory (procedural or expressive knowledge) and the cognitive factors of people (organismic constraint) (Garren et al., 2013). In this regard, some people are morning- types (their memory is more active in the morning), and others are evening types (Garren et al., 2013).

Circadian rhythm is introduced and recognized as an effective factor in alertness and memory retention (Souza et al., 2022). In this regard, Natale & Cicogna, (2002) have shown in their study that the circadian rhythm affects working memory performance(Natale & Cicogna, 2002). In another study, Lyons & and Roman (2009) investigated the effect of circadian rhythm on the structure of working memory in 15 male participants and found that the structure of memory is set based on a circadian pattern(Lyons & Roman, 2009). In this study, it was shown that the peak performance in working memory occurs in morning- types people in the

early hours of the morning and evening-types people in the early hours of the night, more recent research (Curran et al., 2019; Fernandez et al., 2020; Price & Obrietan, 2018) also confirmed this issue. It seems that the environmental constraint (circadian rhythm) affects the organismic constraints of people (working memory) in the decision-making factor. Leone, Slezak, Golombek, & Sigman, (2017) in their study in this field asked morning- types participants to make about 40 decisions in a computer game that was tested in two sessions, morning and afternoon, and as a result, stated that the people who took the test in the morning worked slower but made more correct decisions(Leone et al., 2017). The people who took the test in the evening acted faster but made fewer correct decisions. However, the study in motor learning is limited in this direction, and by conducting a study in this field, it is possible to improve the performance and learning of sports skills in athletes/non-athletes and help them learn faster and better.

Reviewing the above contents shows three important issues:

1. Training methods by affect working memory (procedural or verbal knowledge) affect the learning and performing of motor skills.
2. Training is not the only factor affecting working memory, and working memory is only one of the constraints affecting motor learning.
3. Learning is the result of the interaction of environmental constraints, tasks, and individuals.

Although these issues are accepted from the perspective of ecological dynamics, their empirical investigation based on the authors' information in the background review is limited. Therefore, to reach a specific result and to confirm the point of view of ecological dynamics, we investigated the effect of the environmental condition (circadian rhythm) on the organismic constraints (morning- types and evening types) through the amount of learning to throw darts in implicit and explicit practices. Therefore, the aim of this study was to the effect of implicit and explicit learning on learning to throw darts, considering the circadian rhythm of morning-types and evening types.

MATERIALS AND METHODS

This was a semi-experimental study with a control group. At first, for the test MANCOVA: Repeated measure within interaction; f = 0.25, a = 0.05, and 1-B = 0.80 (Brocken, van der Kamp, Lenoir, & Savelsbergh, n.d.; Motoki, Saito, Nouchi, Kawashima, & Sugiura, 2019) G*Power software showed that at least 87 subjects are needed. Therefore, in this study, 120 men over the age of 18 were purposefully selected based on the MESSI (active morning) questionnaire from (Blinded for Reviewer). The demographic information of the subjects is shown in Table 1. There was no significant difference between the groups. Inclusion criteria included: 1) being over 18 years old, 2) all participants being morning-types according to the MESSI questionnaire, and 3) commitment to cooperation throughout the test. This study was approved and conducted in 2021 by the Ethics Committee of the Movement Behaviour Department, Faculty of Physical Education, (Blinded for Reviewer), and all participants signed a written consent form before entering the study.

Table 1 Demographic characteristics (Mean ± SD).

Variable	All N = 120	G1* N = 30	G2* N = 30	G3* N = 30	G4 N = 30	F	*p*
Age (years)	23.38 ± 2.58	23.07 ± 1.99	23.12 ± 2.54	25.16 ± 2.82	22.19 ± 2.99	2.11	.21
Weight (kg)	80.04 ± 5.73	78.44 ± 7.3	80.01 ± 6.4	81.11 ± 4.1	80.6 ± 5.14	1.88	.33
Height (cm)	178.99 ± 5.9	177.57 ± 5.4	179.46 ± 7.83	180.33 ± 6.69	178.33 ± 3.69	2.52	.12

Measuring instruments

MESSI questionnaire

MESSi is a self-report instrument consisting of 15 items. The total items are divided into three subscales, each consisting of five items: morning affect, evening affect, and distinctiveness. The items on the morning affect subscale measure morning preferences (early schedules). while the eveningness subscale items assess evening preferences (late schedules). The remaining five items form the differentiation subscale, i.e. the domain dimension of this instrument. Each item is answered using a 5-point Likert scale and scored from 1 to 5. The validity and questionnaire of this questionnaire have been reported by Morales et al. (2017) for the age group of 18-30 years old (Díaz-Morales et al., 2017). This has been confirmed in other studies (Rahafar et al., 2017).

Procedure

To conduct this study, a MESSI questionnaire was distributed among students (masked for reviewer). Then, according to the purpose of the study, 120 morning-type people were selected. In the next step, these people were randomly divided into four groups of 30 people. The classifications were done by someone who did not know the participants. Group One at 9-11 on Mondays and explicitly, Group Two practiced darts at 9-11 on Tuesdays implicitly, Group Three explicitly practiced darts at 17-19 on Mondays, and Group 4 implicitly practiced darts on Tuesdays at 17-19. At the beginning of each session, the subjects of two groups were given three types of training for correct throwing and how to perform dart throwing. This training was conducted by an expert trainer with 10 years of experience in dart training (37 years). The coach had no information about the division of groups. In the first training, the proper way of taking was presented. The subject was told to use his thumb to find the centre of gravity of the dart. Then, keep the dart in the width of the finger, turn its tip out, keep your wrist up, and note that the dart is in line with the target. In the second training, the subjects were told how to stand, and they were reminded that their weight should be more on the front leg and the distance between the legs should be shoulder-width apart. In the third type of throwing feedback, the subject was told to have a soft, coordinated throw and continue the movement. In this step, the trainer showed the movement pattern in each step (Cline et al., 2009; Schmidt et al., 2018). In addition to receiving no instructional instructions, the implicit groups were also engaged in a secondary task of counting down numbers (Masters, 1992). This test is a useful tool for presenting a dual task that has been used many times in previous studies (Geroin et al., 2018). In this task, the subjects had to say numbers from 3726 to zero with the condition that they had to subtract four digits from the numbers each time, and the second number was the first number minus 4 (Geroin et al., 2018).

Ten training sessions were provided for each group. In each session, each person did three sets of 10 attempts. For throws, at the beginning, it was reminded to throw with the handedness hand. The way of scoring and the distances (173cm distance between the board and the ground, 293cm distance between the player and the board) were by the scoring of international darts competitions, which is shown in Figure one. In this section, the outer thin lines were awarded twice each grade. If the dart hits the wide parts, it gets its score; the inner thin line gets three times the score; if the dart hits the middle (inner bull), it gets 50 points; and if it hits the (outer bull), it gets 25 points. All training and testing stages were done in the gymnasium of (masked for reviewer).

After the practice sessions, four types of tests were taken from the subjects. The tests were performed by a third person who did not know about the initial classification and practice. 1- Instant retention test immediately after finishing the last training attempt. 2- A delayed retention test was one day after the last training session. 3- a delayed retention test two weeks after the last training session. 4-Transfer test two weeks after the last training session in such a way that we increased the throwing distance by half a meter (Simpson et al., 2022).

The number of test attempts was 10 attempts and the time of all tests was around 2 pm. Before the test, a warm-up was done, which included slow running, muscle stretching, and relaxation.

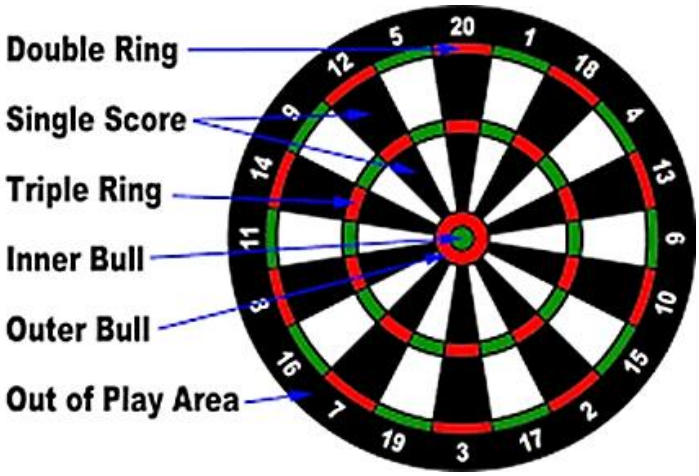

Figure 1. How to score darts.

To make sure that the implicit training was done correctly, we asked the subjects to participate in an oral declarative knowledge test after the transfer test, and everyone was asked if they could describe the correct throwing method in full detail. (Masters, 1992). The results showed that the explicit training groups mentioned more details about how to execute the dart-throwing skill. The one-way analysis of variance statistical test showed a significant difference between the groups ($p < .001$).

Statistical analysis

The normality of data distribution was checked using the Shapiro-Wilk test, and the homogeneity of variances was also confirmed with the Levene test ($p > .05$). Differences between groups and measurements were analysed using the composite analysis of variance test (4x4). ANOVA's Post Hoc test with Tukey's correction was used to examine differences between groups and measurements.

RESULTS

The results of the composite ANOVA test about groups and measurements showed that the main effect of different tests is significant ($f(3,348) = 9.362$, $p < .001$, $\eta^2p = 0.075$). Also, the main effect of the group was statistically significant ($f(3,116) = 15.577$, $p < .001$, $\eta^2p = 0.287$). A significant statistical interaction was also observed between the test and the group ($f(9,348) = 32.004$, $p < .001$, $\eta^2p = 0.453$) (Table 2).

As can be seen in the graph (Figure 2), both explicit training groups performed better than the implicit training groups in the instant retention test and the one-day delayed retention test. But with time, their performance decreased so that in the retention test with a delay of two weeks and the transfer test, both of them were ranked lower than the implicit learning groups.

Table 2. Intra-group and inter-group comparisons.

	Explicit exercise in the morning (1)		**Implicit exercise in the morning (2)**		**Afternoon explicit practice (3)**		**Afternoon implicit practice (4)**		**Intergroup Post-hoc test**
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Instant retention (a)	16.97	6.27	10.67	1.99	16.40	3.22	8.01	2.21	F(3,116)=39.25 *p*<.001,η²p=0.504 1>2 & 1>4 & 1=3 3>2 & 3>4 & 2>4
Retention one day later (b)	13.72	3.66	11.36	3.08	13.12	2.77	8.96	1.45	F(3,116)=16.68 *p*<.001,η²p=0.301 1>4 & 1>2 & 1=3 2=3 & 3>4 & 2>4
Retention after two weeks (c)	11.96	3.93	15.37	4.64	48199.64	2.23	12.91	2.13	F(3,116)=14.49 *p*<.001,η²p=0.273 2>1 & 1=3 & 1=4 2>3 & 2>4 & 4>3
Transfer (d)	9.56	2.73	14.75	2.78	7.24	2.45	12.10	3.78	F(3,116)=35.30 *p*<.001,η²p=0.477 2>1 & 1>3 & 4>1 2>3 & 2>4 & 4>3
Intragroup Post-hoc test	F(3,87)=15.80 *p* < .001 η²p=0.353 a>b – a>c a>d – b=c b>d – c>d		F(3,87)=16.06 *p* < .001 η²p=0.356 a=b – c>a d>a – c>b d>b – c=d		F(3,87)=72.21 *p* < .001 η²p=0.713 a>b – a>c a>d – b>c b>d – c>d		F(3,87)=25.71 *p* < .001 η²p=0.470 a=b – c>a d>a – c>b d>b – c=d		

Note. Sign (=) means no significant difference and sign (<) means a significant difference.

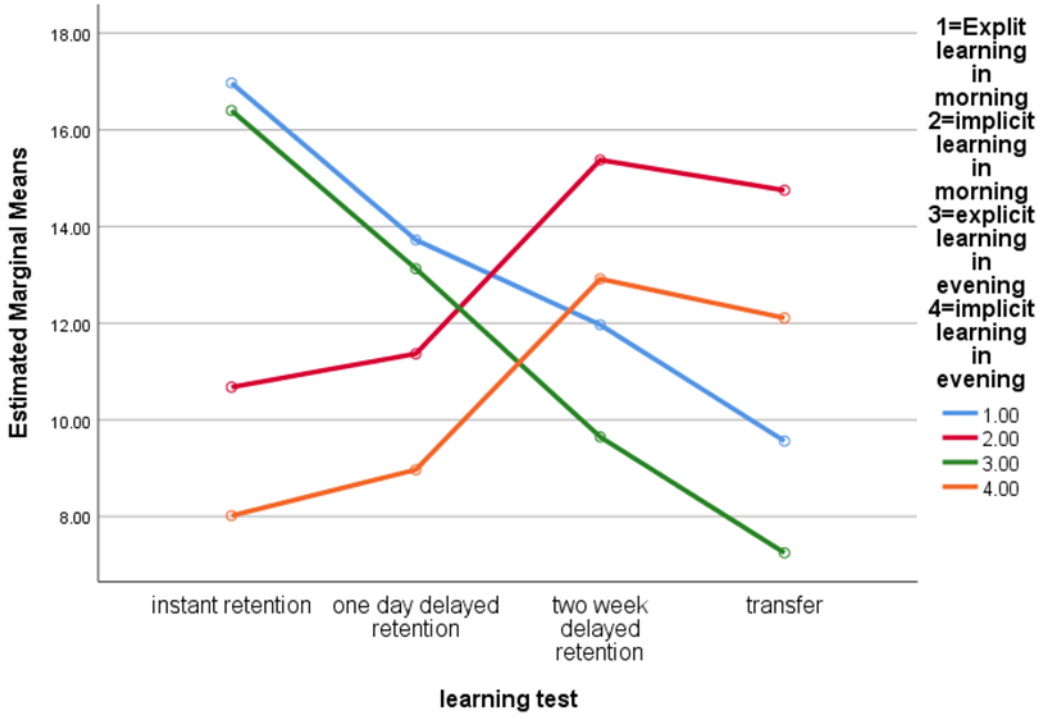

Figure 2. The process of changes in scores of groups during different stages of measurement.

DISCUSSION

This study investigated the effect of implicit and explicit learning on the dart-throwing task, taking into account the circadian rhythm in morning- types and evening types. The results showed that explicit training in the phase of instant retention and one-day delayed retention compared to implicit training helps to perform dart throwing more. However, in the two-week delayed retention and the transfer test, the group that was trained implicitly performed better. In this regard, the interesting results are that the evening-types group with implicit training performed better than the morning-types group with explicit training. These results emphasize the importance of the type of training in the first place; however, aligning the type of training with individual and environmental constraints can help in movement performance. Although no study has been done in sports science in line with the present study, our results agree with the results of Leone et al., (2017) in that They also emphasized that the circadian rhythm (being evening-types / morning- types is aligned with decision accuracy) can be effective in making the right decisions, and people who are morning- types make more accurate decisions in playing computer games in the morning(Leone et al., 2017).

In explaining the results of this study, the role of implicit practice compared to explicit practice in learning and performance should be highlighted. According to the results of this study and previous studies (Kal et al., 2018), the intervention with the implicit training method has a greater effect on learning and sports performance. In this regard, it can be said that those who practice in an obvious way do not need to think about the execution of skills at every stage of performance, and this issue is more important in single skills such as throwing darts. In other words, by performing the first throw or the first few throws, he reaches relative automaticity, and his mind is almost not involved in performing the skill (Kal et al., 2021; Schmidt et al., 2018). But in implicit practice, given that the learner is engaged in another activity, they need to recover their mind in each performance to perform the skill correctly. This issue may hinder one's performance in the early stages of learning, but in the long term, it helps in one's learning (Kal et al., 2021; Leh et al., 2022). This was confirmed in our results. It can also be said that in implicit practice, one's procedural knowledge is considered, which is more effective for learning than expressive knowledge (Leh et al., 2022). This is important because in general, expressive knowledge requires knowledge of verbal cues about the skill, and since in the implicit practice in each step, the learner must restore the performance of the skill, therefore, the implicit practice has an effect on the procedural knowledge (effective in learning) (Ellis, 2009). The interesting discussion in the context of the results of this study is that individual characteristics such as evening types and morning- types affect people's learning and performance. Although this topic has been discussed in the literature related to ecological dynamics (Wood et al., 2023) and the Newell & Simon model (1972) for decades(Newell & Simon, 1972), in this study, this issue has been confirmed experimentally. In this regard, our results show that people who are morning- types when they practice in the morning are better at learning than people who are evening types. This issue shows the interaction between the environment and the person, which is in the model of Newell & Simon, (1972) (Newell & Simon, 1972).

The model of Newell & Simon, (1972) (Newell & Simon, 1972) specifically states that a person's performance is the result of the interaction between individual characteristics such as psychological factors, environmental factors such as whether it is night or day, and tasks such as the rules of any sport. Undoubtedly, being day or night affects humans and based on light changes and even climate changes, humans are different from each other (Curran et al., 2019; Fernandez et al., 2020; Price & Obrietan, 2018). In this regard, it can be said that one of the reasons for individual differences or individual characteristics is the impact of the environment on humans (Price & Obrietan, 2018). Therefore, the alignment of training to learn more with changes in the circadian rhythm makes each person learn according to their characteristics, which this issue showed in our study leads to learning and performing more sports performance. However, this discussion is not limited here;

our results show that practice can even overcome personal preferences. Because evening-types people who trained implicitly performed better than morning-types people who trained explicitly. This topic again points to the complexity of the sciences related to learning and sports training and emphasizes that learning results from complex interactions of many factors.

The strength of this study is that, for the first time in motor learning, we tried to put environmental factors alongside individual factors and emphasized the effectiveness of the type of exercise, taking into account the individual's and the environment's limitations. However, one of the limitations of this study was that we only selected morning- types, and we do not know what the results would be for evening types. Because people of the evening types may have different training abilities, the research results can be expanded in future studies considering this issue. Finally, it is better to consider other characteristics, such as gender, in future research because research has shown that women and men have different training abilities.

In general, the results of the present study showed that implicit training is better than explicit training. Nevertheless, if this exercise is based on individual characteristics such as circadian rhythm, it will have a more lasting and better effect on performance and learning. In this regard, to learn to throw darts, choosing the proper training method is very helpful and is, first and foremost, important. However, learning sports skills is very complex and results from the interaction of many factors. Therefore, training should be designed based on environmental and individual characteristics.

AUTHOR CONTRIBUTIONS

Behrouz Ghorbanzadeh: review and editing, formal analysis and funding. Rasoul Yaali: writing – review and editing, supervision, project administration, investigation, conceptualization. Behzad Mohammadi Orangi: writing original draft, investigation, data curation. Zahra Miri: writing original draft, methodology, investigation.

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DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

DATA AVAILABILITY STATEMENT

The data of this research is available based on request from corresponding author.

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