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## Practice Specificity through Manipulation of Vision during Futsal Penalty Kick

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### ABSTRACT

**Background:** The purpose of the present research was to examine how much learning futsal penalty kick depends on visual information **Objective:** The participants were twenty female students ( $22.87 \pm 2.72$  yrs.) who were randomly divided into full vision and ambient vision groups and participated in 15 training sessions. **Results:** Both groups participated in the post-test at the end of the training session, and retention and transfer tests were respectively conducted 8 and 10 days later. Independent and paired t-tests as well as repeated measures ANOVA were used for data analysis. The results showed that the participants in both groups learned the task similarly, but they had the best performance in familiar visual conditions. **Conclusion:** Their performance significantly deteriorated in a visual environment different from the one they experienced during practice. The present findings provide evidence in support of the specificity of practice hypothesis.

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## INTRODUCTION

One of the main goals of training is to achieve optimal performance. Many theories and models have been proposed that emphasize on desirable performance elements. Practice specificity is one such theory that has emerged in the area of motor control and learning and originates in Thorndike's theory of identical elements Thorndike *et al* (1901). Henry (1958) expanded Thorndike's theory and proposed the Specificity Hypothesis of Motor Behavior, which suggests that the underlying attributes of a motor skill or task are specific to that skill or task and not transferable (task-specific) Henry (1958).

Proteau (1992) proposed the Specificity of Practice Hypothesis, which suggests that learning must be specific to the sources of afferent feedback used to guide one's movement during practice. Proteau and Carnahan (2001) added more details to this theory and posited that learning is specific to the sources of afferent information used to ensure optimal accuracy during practice. When that information is withdrawn in a transfer test, performance suffers because the person has no reliable source of reference with which to evaluate his or her movement. Basically, learning involves a sensorimotor representation that integrates motor components with the sensory information available during practice Proteau (1992), Park *et al* (2003), Proteau *et al* (1987).

The specificity of practice hypothesis has been extensively supported from different psychological, physiological, and biomechanical perspectives. In this research, various somatosensory components (visual, auditory, tactile, olfactory, and proprioceptive) Paradisis *et al* (2001), Proteau *et al* (1987) and performance Coull *et al* (2001), biomechanical components such as pattern Lockie *et al* (2003), Zelazo *et al* (1993), angle Knapik (1983), and speed Scott *et al* (2007), physiological components such as muscle strength, range of motion, involved muscle groups, and muscle contraction Folland *et al* (2005), Schott *et al* (1995), energy systems Godfrey & Whyte (2006), Laursen *et al* (2003), processing components such as training model McCullagh & Caird (1990) and playing position Reilly (2007), and underlying psychological components such as arousal Coull *et al* (2001), Movahedi *et al* (2007) and moods Henry (1958).

The research on specificity effects has mainly been carried out in controlled laboratory conditions. Proteau and colleagues conducted extensive laboratory research to provide strong empirical evidence in support of specificity of practice hypothesis through vision. They examined the subjects' performance of an aiming task with moderate (200 trials) or extensive practice (2000 trails) to see how much performance benefits from vision of the performing limb. The results showed that performance is enhanced when subjects are permitted vision of the performing limb. Also the subjects who benefited from vision of the performing limb in the training period

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were not able to maintain performance in the transfer task. Their findings support the view that performance is strongly dependent on visual information Proteau *et al* (1987). This research led to a series of studies on performance and visual conditions. These studies have supported the specificity of practice hypothesis in motor tasks such as manual and video-aiming, walking, tracking, and elementary neuromotor patterns (stepping and sitting) in infants Adams *et al* (1972), Isabelle & Proteau(2007), Knapik (1983), Yoshida *et al* (2004), Park & Shea(2003) , Proteau(1992), Proteau *et al* (1998), Tremblay and Proteau(1998), Zelazo *et al* (1993).

Specificity of practice hypothesis through auditory feedback has seldom been studied Coull *et al* (2001). Apparently, the auditory sense requires more training than the visual sense in order to be integrated with learning and performance. In Wright and Shea (1991), participants worked on learning specific patterns of key pressing movements on a computer. They were again tested with either the same auditory stimuli or different stimuli. It was found that performance in retention was greatest when the same auditory stimuli were present Wright & Shea(1991),

Researchers have also studied underlying psychological elements such as arousal Movahedi *et al* (2007) and moods Adams *et al* (1972) in examining specificity of practice. Movahedi *et al.* (2007) supported this hypothesis by examining arousal in a real sports context. In this study, a low-arousal and a high-arousal group practiced a cognitive-motor task (basketball three-point shot). The results showed significant decline in performance in both groups under different arousal conditions Movahedi *et al* (2007).

Although many studies have been conducted in support of the specificity of practice hypothesis, some studies have rejected this hypothesis using gross motor tasks Whiting *et al* (1972).

In these studies, reliance on sources of afferent information did not increase linearly with practice. Some contradictions are due to the skill level of the participants. For instance, Robertson *et al.* (1994) found that expert gymnasts relied less on visual feedback than novice gymnasts, and withdrawal of visual information did not affect the performance of expert gymnasts. In contrast, performance of novice gymnasts suffered greatly in the no-vision condition Robertson *et al* (1994).

Bennett and Davids (1995) examined the performance of powerlift squat in intermediate, skilled, and less skilled lifters under three conditions: full, ambient, and no vision. Skilled lifters exhibited a high level of positioning accuracy and timing consistency across conditions. This finding rejected the specificity of learning hypothesis Bennett & Davids(1995) Whiting and Savelsbergh (1992) also studied the role of practice in gross movements. The participants performed ball-catching in the dark and in the light. The results showed that the participants had similar accuracy in the pre and post-test transfer conditions. Therefore, transfer had no detrimental effect on performance and again the specificity of practice hypothesis was rejected Whiting *et al* (1992).

Similarly, Lidor and Singer (1994) used athletes to determine if training condition had any effect on performance outcome. Participants threw a paddleball at a target during conditions of quiet and noise. The results showed that there was no difference in error during transfer conditions Lidor and Singer (1994). Scott and Gray (2007) studied specificity of practice in baseball batting to find whether performance is better under simplified conditions or real-time condition. These findings suggest that the common technique of holding pitch speed constant during batting practice is not the optimal way to prepare for game conditions Scott and Gray (2007).

Because the results obtained in laboratory conditions cannot be positively generalized to real conditions, the present research tries to test the specificity of practice hypothesis in a real sports context. Also to our knowledge, no study has examined this hypothesis using visual feedback in an open skill. Therefore, the purpose of the present research is to test whether learning and performance of futsal penalty kick is dependent on visual information.

#### *Methodology:*

The participants of this research were 40 randomly selected female students ( $22.87 \pm 2.72$  yrs.). They had no experience in playing futsal and had no musculoskeletal or functional limitations. They also signed an informed consent prior to participating in the research.

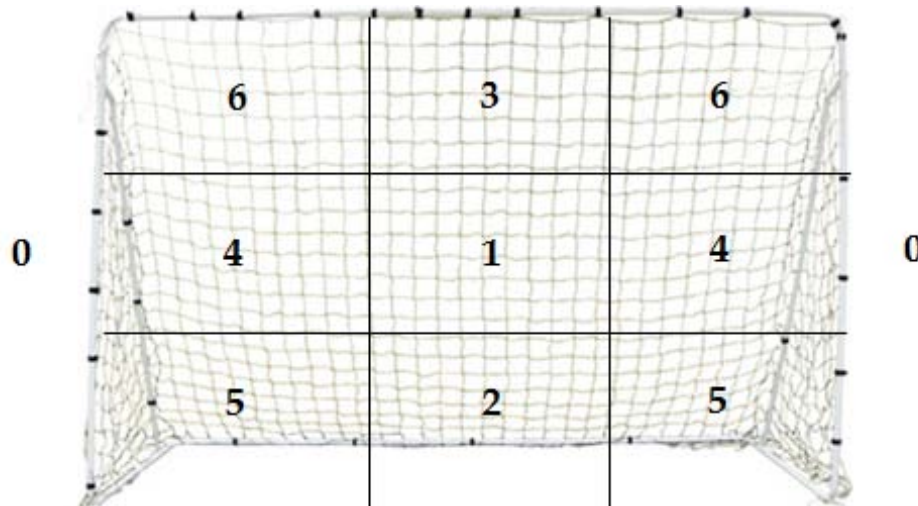
#### *Experimental Task:*

Accuracy in futsal penalty kick was used as the experimental task.

#### *Instrument:*

Because there were no valid instruments for measuring futsal performance, the test was developed based on a similar task for soccer penalty kick Mojtahedi (2008). Developing tests is one of the main stages of a measurement protocol which, if done carefully, can yield more accurate results. Thus, 7 experienced coaches with A and B coaching licenses helped the researcher in developing the tests. These coaches unanimously agreed that the upper and lower corners of the net, especially the upper corners, are the most difficult locations for a goalkeeper to catch the ball. They also agreed on a 6-m distance between the ball and the net, which is the

exact distance of penalty mark from the net in futsal. They argued that 12 to 18 trials in each session is necessary for optimal learning in novice players. The nets were accordingly divided into 6 areas with 4-cm wide tapes. The scores were as follows: 6 points for upper corners, 5 points for lower corners, 4 points for the sides, 3 points for upper mid area, 2 points for lower mid area, 1 point for the middle area, and 0 points for the goalposts, crossbar, or outside the net (Figure 1). At least three judges (2 coaches and 1 referee) were needed to verify and score the penalty kicks. If the penalty kicks did not have enough speed, they would be repeated.



**Fig. 1:** Scoring penalty kicks

Before data collection, the validity and reliability of the test was examined. To this end, a number of futsal players from Iranian Futsal Super League and 1st Division were ranked by B License coaches based on their ability in futsal penalty kick. Then, the players performed the test in full vision conditions (18 trials) and their performance was scored by two coaches and a referee. The correlation between the scores and their ranking was 0.79. Also test-retest reliability was assessed using a group of novice players. They performed the test in full vision conditions and a correlation coefficient of 0.76 was obtained.

#### *Procedure:*

After selecting the participants, they were randomly divided into two groups: full vision condition in a naturally lit environment, and ambient vision condition with light focusing on the net. In each session, they warmed up for 20 minutes under the supervision of a coach, and a referee checked the air pressure of the footballs. Sessions were different for each group, and were held in a standard sports center with advanced facilities. The participants attended the sessions in sports apparel. Before any intervention, the test procedure was explained to the participants using the motor learning method provided by Schmidt (1991), which consists of task presentation, instruction, demonstration, and modelling. Thus, verbal explanation was complemented by demonstration of the task with 18 repetitions by an expert player.

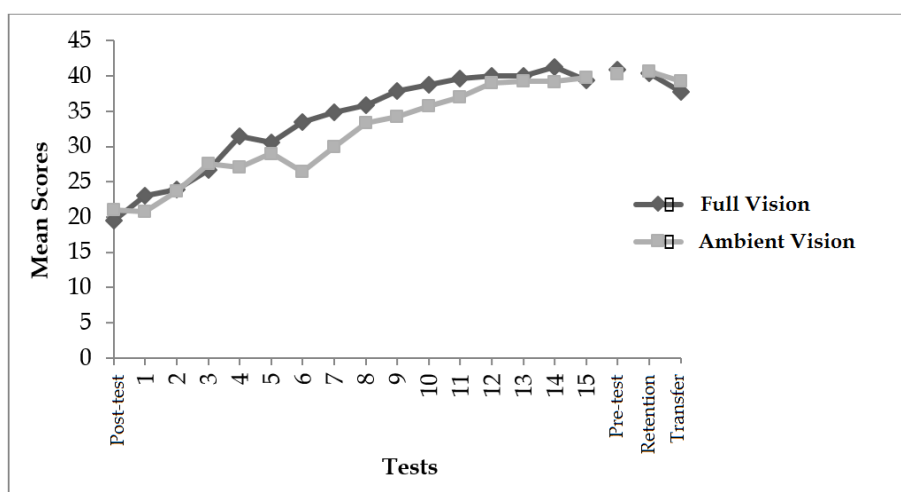
In the pre-test, the participants practiced the task for 15 minutes after the warm-up, and they were informed of their mistakes by their coach. Then, they performed 18 trials of the futsal penalty kick task. In acquisition sessions, each participant performed 18 trials of the task in their respective training environment (full vision or ambient vision). During the tests, informational and instructional feedback was provided to them to help improve their performance. Further, verbal praise was used to increase motivation in acquisition sessions. Each trial in each session was assessed and scored by three referees. If they believed that a penalty kick did not have the necessary speed, the participants would repeat it. Each group participated in a 5-week training period with 3 sessions per week. In each session, the participants completed 6 blocks of 3 trials (penalty kicks), and there was a 4-minute rest between blocks. Post-test was performed one day after the training period. Also retention (the same visual environment as the pretest) and transfer tests (different visual environment) were respectively performed 8 and 10 days later (18 trials).

#### *Analysis:*

Descriptive statistics such as mean and standard deviation were used to describe and organize the data. After ensuring the normal distribution of the data and homogeneity of variances, the data were analyzed using independent t-test (to examine mean differences in the pre-test), repeated measures analysis of variable, and paired t-test (to compare the performance of participants in retention and transfer tests) at the 0.05 significance level.

**Results:**

Figure 1 shows the mean scores of the participants in the futsal penalty kick task for both full and ambient vision groups and for different stages (pre-test, 15 acquisition tests, post-test, and retention and transfer tests).



**Fig. 2:** Mean scores of full and ambient vision groups in the futsal penalty kick task

As shown in Figure 2, both groups learned the task almost similarly in the acquisition period (sessions 1-15). The difference is that the full vision group had a more stable growth in skill acquisition than the ambient vision group. However, performance in both groups suffered considerably in a different visual environment.

Independent t-test was used to examine mean differences between the pre-test scores of full and ambient vision groups. Based on the results of this test, there is no significant difference between the pre-test scores of the two groups ( $t(70) = 13.0, p = 0.5$ ). Repeated measures analysis of variance was used to examine whether training under two different visual conditions has led to different acquisition and learning in the groups and whether there are significant differences in mean scores during the testing period. The results are provided in Table 1.

**Table 1:** A summary of the results of repeated measures ANOVA to examine differences in futsal penalty kick accuracy at different stages (pre-test, 15 acquisition sessions, post-test, and retention and transfer tests) and for different groups (full and ambient vision)

Source of Variability		Sum of Squares	df	Mean Squares	F	P
Intra-Subject	Factor (training)	16.256.50	5.54	2935.47	61.11	0.000
	Group × Test	457.61	5.54	82.63	1.72	0.13
	Error	4788.63	99.68	48.04		
Inter-Subject	Group	284.85	1	284.845	0.95	0.34
	Error	8396.89	18	299.83		

Since the results of Mauchly's sphericity test were statistically significant, Greenhouse-Geisser procedure was applied to correct the degrees of freedom. As shown in Table 1, the analysis shows that the effect of training sessions is significant, because the obtained F-value (61.11) is greater than the critical value. In contrast, no significant group effects or group-by-training effects were observed. Therefore, there is no significant difference between full vision and ambient vision groups in mean scores at different stages of the research.

To test the specificity of practice hypothesis, the mean scores of the participants in the transfer (different visual environment) and retention tests (similar visual environment) were compared in both full and ambient vision groups using paired t-test. The results are provided in Table 2.

**Table 2:** The results of paired t-test to compare the mean retention and transfer scores of the participants

Group	Futsal Penalty Kick Accuracy				Paired t-test			
	Retention Test		Transfer Test		t-value	Sig.	df	p-value
	Mean	SD	Mean	SD				
Full Vision	40.40	6.22	37.80	6.58	2.60	0.03	9	0.05
Ambient Vision	40.60	3.20	39.30	4.00	2.51	0.03	9	0.05

Based on the data in Table 2, paired t-test showed a significant difference between mean transfer and retention scores in the full vision group.

Also using paired t-test, the mean retention score was compared to the highest score (peak performance) of the participants during the training and post-test (14th session for the full vision group and the post-test for the ambient vision group). The results are provided in Table 3.

**Table 3:** The results of paired t-test between the mean retention score and the highest score obtained under similar visual conditions

Group	Futsal Penalty Kick Accuracy				Paired t-test			
	Best Score		Retention Score		t-value	Sig.	df	p-value
	Mean	SD	Mean	SD				
Full Vision	41.30	5.72	40.40	6.22	0.95	0.37	9	0.05
Ambient Vision	4.30	3.20	40.60	4.57	0.28	0.78	9	0.05

According to the data in Table 3, there is no significant difference between the highest score (peak performance) obtained under similar visual conditions (14th session for the full vision group and the post-test for the ambient vision group) and the mean retention score of the participants in both groups. This finding supports the specificity of practice hypothesis in futsal penalty kick.

#### *Discussion and Conclusion:*

The purpose of the present research was to examine the dependence of learning futsal penalty kick on the visual environment. The results showed that the participants in both groups had similar scores in acquisition and retention of the skill and achieved their peak performance in similar visual conditions, while performance suffered significantly when the visual conditions changed.

A closer look at Figure 2 reveals that the participants in full and ambient vision groups had a declining growth in futsal penalty kick accuracy over 15 acquisition sessions. That is, the difference in mean scores between the 10th and the 5th session (8.1 in the full vision group and 6.7 in the ambient vision group) is less than the difference in mean scores between the 5th session and the pre-test (10.7 in the full vision group and 8 in the ambient vision group). Moreover, the difference in mean scores between the 15th and the 10th session (0.7 in the full vision group and 4.1 in the ambient vision group) is less than the difference in mean scores between the 10th and the 5th session. In fact, the participants in both full and ambient vision conditions had a fast growth in the beginning sessions (slope of the curve is sharper), but in later sessions progress occurs more slowly. This is consistent with Snoddy's (1926) power law of practice. According to this law, there is a high level of improvement at the initial stages of practice. But after that, more practice leads to lower rates of improvement. This law was clearly supported by the performance of both visual groups in futsal penalty kick.

The data in Figure 1 are also consistent with the general performance characteristics that were first introduced by Magill (2010). The first one is performance improvement over a period of time. The participants of the present research showed this characteristic in futsal penalty kick accuracy. In other words, practice in both full and ambient visual conditions gradually improved the performance of the participants. Another important performance characteristic is consistency which was demonstrated by the participants. Based on this characteristic, performance is consistent if the participants perform better in the retention and transfer tests compared to the first session. In futsal penalty kick, the mean score in the pre-test (19.90 in the full vision group and 21.00 in the ambient vision group) and the first session (23.90 in the full vision group and 20.70 in the ambient vision group) is higher than the mean score in the post-test (40.90 in the full vision group and 40.30 in the ambient vision group), the retention test (40.40 in the full vision group and 40.60 in the ambient vision group), and the transfer test (37.80 in the full vision group and 39.30 in the ambient vision group). Performance in the transfer test was slightly lower than peak performance (41.30 in the full vision group and 40.60 in the ambient vision group), but it was nonetheless greater than the mean score in the pre-test and the first session.

Another performance characteristic observed in the participants was adaptability. Performance is adaptable when changing the properties of the acquisition environment in the retention test leads to no significant difference between the transfer scores and pre-test scores. In the present research, the participants in the full vision group were tested in ambient visual conditions in the transfer test and had a significantly lower score than the retention test. This was also true for the participants in the ambient vision group. However, the decrease in transfer scores is not so much as to lead us to believe no learning has taken place, because transfer scores are significantly higher than pre-test scores. Thus, both groups demonstrated adaptability in performing the futsal penalty kick task. The other general performance characteristic demonstrated by the participants is stability of performance over time. Figure 1 indicates that in both full and ambient vision groups the difference in scores in initial sessions is greater than that of the middle sessions, and this is also true about the middle and final sessions. In other words, the performance of the participants is variable in early sessions, but it becomes more stable over time. Therefore, we can conclude that the trend of improvement in learning futsal penalty kick in both full and ambient vision groups is consistent with what Magill (2010) calls the general performance characteristics in learning a motor skill.

Another topic related to performance of motor skills is learning plateau during the acquisition of motor skills. The plateau effect can be observed in the participants of both full and ambient vision groups during the acquisition stage Schmidt (1991), Schmidt & Lee (2005), Magill (2010). More accurately, the participants in the full vision group experienced a lack of improvement or decrease in performance (plateau) between the 1st and 2nd sessions, the 4th and the 5th sessions, and the 11th and the 13th sessions. Plateau effect was observed in the ambient vision group between the pre-test and the first session and between the 12th and the 15th session.

The main purpose of the present research was to examine the specificity of practice hypothesis through visual manipulation in a futsal penalty kick task. The results showed that the participants in both full and ambient vision groups had their peak performance in similar visual conditions, while their performance suffered significantly when visual conditions changed. The mean skill acquisition score of the participants in the full vision group was  $19.90 \pm 3.35$  in the pre-test. In the post-test and in similar visual conditions, the participants obtained a score of  $40.90 \pm 6.37$ , which was not statistically significant from the best score obtained in similar conditions (14th session,  $41.30 \pm 5.71$ ). However, their performance significantly declined in different visual conditions in the transfer test ( $37.80 \pm 6.58$ )—that is a 3.5 decrease compared to the mean score. The same thing was true for the ambient vision group. The mean score of participants in this group was  $21.00 \pm 3.65$  in the pre-test and  $40.30 \pm 4.57$  in the post-test and in similar visual conditions. Their post-test score was not significantly different from the best score obtained in similar visual conditions (post-test,  $40.30 \pm 4.57$ ). The performance of these participants significantly declined in different visual conditions (full vision), leading to a score of  $39.30 \pm 4.00$ . This score was lower than the best mean obtained in the same visual conditions as those of the acquisition stage (retention test,  $40.60 \pm 4.57$ ). Thus, we can conclude that the performance of the participants was closest to the peak performance in visual conditions similar to the acquisition stage, while their performance suffered in different visual conditions. This supports the specificity of practice hypothesis, which states that learning is specific to the sources of afferent information available during practice. This finding is consistent with the results of Movahedi *et al.* (2007), Salehi *et al.* (2013), and Isabelle and Proteau (2007).

The decline in performance during transfer test was more evident in the full vision group than the ambient vision group (3.5 vs. 1.3). This can be because the participants in the full vision group became more adapted to their visual environment than the ambient vision group. Also in general, practice in full visual conditions was easier than practice in ambient visual conditions due to its similarity to everyday life. This can be inferred from the less unstable performance of the full vision group in the acquisition stage. Thus, modifying visual conditions for the full vision group in the transfer test led to greater deterioration of performance compared to the performance of the ambient vision group.

In general, the present findings support the specificity of practice hypothesis and are consistent with most studies that use simple aiming tasks Proteau *et al.* (1987), Proteau & Carnahan. (2001), Scott & Gray (2007). However, this hypothesis has faced serious challenges from studies on gross motor skills. For instance, Bennett and Davids (1995) examined novice and skilled power lifters performing a squat under three visual conditions. The results showed that manipulation of visual feedback did not affect the performance of skilled lifters, but the performance of novice lifters deteriorated. This finding is not consistent with the specificity of practice hypothesis, since based on this hypothesis reliance on a specific source of feedback increases with practice. They proposed that visual feedback information is the main source of afferent information for movement control in early stages of learning, but it is progressively substituted by other information such as kinesthetic information. In motor tasks in which direct vision of the limbs is not critical, intensive practice creates a sensorimotor representation that is not reliant on vision.

Similar studies of gross motor skills such as beam walking Robertson *et al.* (1994) and one-hand catching Bennett & Davids (1995) have also rejected the specificity of practice hypothesis. For instance, in Whiting and Savelsbergh (1992), the participants performed a one-handed ball catching task in a fully lit room or a dark room where only the ball was lit. The results that participants in both conditions performed with equal accuracy during the transfer test. Therefore, transfer did not have a detrimental effect and one again the specificity of practice hypothesis was rejected. However, by changing the methodology and replicating these studies, Proteau *et al.* (1998) concluded that the specificity of practice hypothesis holds true for these gross motor tasks as well, and it is better to have a better control over actual sources of afferent information when testing this hypothesis.

This hypothesis has been supported by some recent studies, such as Movahedi *et al.* (2007) who tested this hypothesis through the level of arousal in a cognitive motor skill (basketball free throws). In this study, 37 male physical education students were divided into a high-arousal and a low-arousal group. The participants performed the task for 18 sessions (15 trials per session). At the end of this period, the participants were tested under similar and different arousal conditions. The results of the transfer test indicated that performance significantly deteriorated when the participants were tested in different arousal conditions.

Salehi *et al.* (2013) also supported the practice specificity hypothesis. The participants performed free basketball throws under two visual conditions: full vision and ambient vision. Training lasted for 15 sessions, and in each session the participants performed 15 trials of the task. Immediate retention and transfer tests were performed two hours after the final session. Delayed retention and transfer tests were performed 10 days later.

The results indicated no difference between the two groups in acquisition performance, while performance suffered under different visual conditions.

The present findings provides insights for coaches and trainers about how to develop exercise protocols for athletes. Our results show that coaches must try to make training conditions (including visual feedback) as much similar to contest conditions as possible, which will allow athletes to achieve peak performance and success.

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