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# Identifying Especial Skills for Air Gun Shooting in Skilled Male and Female Shooters

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## ABSTRACT

The present study attempted to investigate the emergence of especial skill in shooting with air gun at two skill levels (skilled, novice). The population studied here included all male and female shooters from the city of Semnan. The study was conducted on a sample of 40 shooters, consisting of two groups of women with the mean age of 21.33±2.26 and two groups of men with the mean age of 23.44±23.44, who displayed their shooting abilities with air guns from five points (8, 9, 10, 11, 12 meters) from the target. The test was conducted in 4 sets (with 15-minute rest intervals) each consisting of 5 blocks of 25 with 20 shots at each point (100 shots in all). The gap between each set was the resting time of 15 minutes. A significant difference was found between the actual and predictive scores in all groups ($p<0.05$): the differences found between actual and predictive scores were significant at P=0.012 for skilled male shooters, P=0.023 for novice male shooters, P=0.001 for skilled female shooters, and P=0.021 for novice female shooters. These findings of this study support the emergence of especial skill in all groups of air gun shooters.

**KEY WORDS:** ***Especial Skill, Schema Theory, Practice Specificity, Linear Regression.***

## INTRODUCTION

An important topic in motor control and motor learning consists of different theories that try to explain the mechanism involved in controlling movements. Each theory emphasizes the role played by certain factors. Two major theories of motor learning and motor control mechanisms are Schmidt's schema theory and Adam's closed-loop theory. In his theory, Schmidt (1975) included a general linear relation observed in bimanual set shots at non-4.5-m distances from the basket, in addition to other findings on generalizability in motor control (1, 2). According to the schema theory, a single motor programme controls performance at any distance, making it possible through a generalizable programme to provide all parameters of overall force and timing of the task performed at any (reasonable) distance. Such observations are in line with the view that memory representation in motor skills must be sufficiently general to make it possible to prevent two potential problems (storage, novelty) in motor control (1). On the other hand, Adams suggests that skilled movements are formed when a single representation dominates all other representations, and the representation associated with the correct movement, distinguished from other forms of representations, becomes a specific basis (modal) in memory for an accurate performance

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of the action. In this view, actions of the learner are such that the feedback about them matches the feedback from the perceptual trace. Adams proposed that, this way, the action is controlled through a closed loop using the currently generated feedback and by assessing this feedback with reference to the perceptual trace. Therefore, all skilled movements are represented in a single, specific perceptual trace (1, 3, 4). An important area of research related to mechanisms involved in motor learning and memory representations is the relatively new subject of especial skills (4). In a study on throws from various distances by elite basketball players, Keetch *et al.* (2005) found a negative relationship between shots made and the distance to the basket (1). According to these studies, accuracy dropped at greater distances from the basket (4). These findings, however, are not new, as the principle of force invariance in motor control can predict such results (5). However, a far-fetched finding of this study is that at 4.5 m from the basket the performance accuracy is much greater than the accuracy predicted for the adjacent points. Keetch *et al.* called this memorial representation an 'especial skill', which is a highly specific skill (in free throw) within a general class of abilities (set shots) (1). This was a really important issue for motor control theories, including the schema theory (4). To test the visual-context hypothesis as a factor involved in the emergence of especial skills, Keetch, Lee, and Schmidt (2008) asked skilled basketball players to perform free-throw shots at the free-throw line or some other points located at a similar distance from the basket but at different angles. Skilled players were expected to exhibit identical performance at similar distances from the target. However, the performance for shots taken at the point in front of the basket (perpendicular to the backboard) was significantly different from that of shots taken at other angles. Thus, 'visual-context learning' was proposed as a potential factor involved in especial performance of skilled players (6). Simons *et al.* (2009) identified especial motor skills at different distances for baseball players. Their findings confirmed the existence of especial skills at standard distances (7). Breslin *et al.* (2010) explained the emergence of especial skills by the learned-parameter hypothesis. For this, they manipulated the parameter 'force' in free-throw shots for skilled and novice basketball players to find a significant difference between the actual and predicted performance in throwing a standard-weight ball, while no significant difference was observed when throwing a heavier ball (8). In another study, Breslin *et al.* (2012) examined how practice affected especial skills. Using constant and variable practices for set shots by novices, they found constant practice to be effective in the creation of especial skills (9). A few years later, Czyz *et al.* (2013) examined the role of age and skill levels in especial skills and showed their impact on groups with greater experience in practising basketball (10). In the same vein, Czyz *et al.* (2015) studied ten skilled basketball players to identify the role of the visual aspect in the emergence of especial skills. The study was done in two situations: normal and blurred vision (using lenses). Data analysis with the Bayesian analysis and generalizability model supported the role of vision data in the creation of especial skill (11). Taheri *et al.* (2011) examined massive amounts of practice and especial skills in throwing darts. Their analysis of the average performance of players at seven points indicated that, given these massive practices at standard distance, their actual performance was significantly different from the one predicted by regression (12). They proposed a balanced model to explain the potential reasons behind these results. The model explains how motor learning at an advanced level includes general and special impacts. It also explains how massive amounts of practice focused on a particular point in closed skills can lead to a deterioration of performance at adjacent points (at different distances and angles). One method proposed to evaluate this model is to record the EMG and the electrical activity of the brain in skilled players while performing throws at different locations and compare the data obtained by this process (12). This represents a good subject for future research to answer many relevant questions. Abdolshai *et al.* (2013) and Abdolshai, Jaberi Moghadan, and Vaez Mosavi (2015) worked with elite, skilled, and novice players in regular and lineless badminton courts to determine their especial skills in short and long services. In addition to the emergence of

especial skills, their findings indicated that the effect did not work in the absence of visual cues in a lineless court, thereby confirming the visual-context hypothesis (13, 14). The findings seem to confirm the interpretation based on specificity, on the one hand, and to be paradoxically consistent with the predictions made by the schema theory, on the other. Surely, investigations into this subject require further research. Studies on generality and specificity of motor skills have clearly shown that, currently, no single general theory of motor control or motor learning can explain the two types of results found in studies on especial skill (1). Thus, the present study focuses on specificity and generality of motor skills, given the limited evidence, relative newness of especial skill as an area of study, and mixed results found by studies in this sphere that failed to provide clear answers to some questions, including: 'Are effects of especial skills observable in other sports (*e.g.*, air gun shooting)? To which hypotheses of motor control and learning is the emergence of especial skills related? Do different levels of skills impact especial quality of a skill? And does gender play a role in especial skills?' The present study attempts to examine the emergence of especial skills by studying male and female shooters at two skill levels (novice and skilled). It should be noted that air gun shooting skill is a closed skill practised by aiming at a fixed target. Unlike other tasks in sports like basketball and baseball, shooting does not need to be practised at different distances and, therefore, especial skills are more likely to emerge in shooting. The authors intended to examine whether only particular types of tasks generate especial skills or tasks (like shooting) with a more accurate start and ending and lower variability in practice and competition are also consistent with especial skills.

## MATERIALS AND METHODS

**Participants.** The sample studied here consisted of novice and skilled male and female air gun shooters in Semnan, Iran. The subjects were selected through convenient sampling and then assigned to groups in a random fashion. The participants were selected from both novice and skilled levels. The inclusion criteria for the skilled group were previous appearance in the first or second division of the league, and regular and continuous practice. It should be noted that novices consisted of individuals with at least three months to at most one year of experience in air gun shooting, without any previous title in regional and nationwide competitions (15, 16). In all, 40 participants were assigned to four groups (10 members per group): skilled male shooters (mean age ± SD = 26.43±2.38), novice male shooters (20.46±3.7), skilled female shooters (24.44±1.32), and novice female shooters (18.22±3.2). None of the participants were aware of the objectives of our study.

**Protocol.** Before the study began, the participants completed a consent form to indicate their willingness to take part in the study. In an orientation meeting, they received instructions on resting, sleeping, and diet (avoiding or reducing caffeinated food) and were asked to inform the tester of any potential problem in any of these areas so that the procedure could be altered accordingly. Then, the complete test instructions were given to the subjects. No additional viewer or other persons were present during the test in order to minimize distraction in the subjects and control interventions by other variables. In the beginning of the session, each subject received questions to gather personal data (e.g., age, height, weight, practice background, practice hours per week, membership of clubs or the national team, physical injury, titles). The male and female subjects in each group took standard aiming test using air guns in a standard indoor range at 10 m from the target. To identify especial skills, subjects performed air gun shooting at 5 parametric points located at 8, 9, 10, 11, and 12 m from the target. Unlike other sports, studying especial skills in shooting at 8, 9, and 10 m did not require marking the court since the shooter could use manual or electric target positioner to adjust the distance. However, like in previous studies, markings were used at 11 and 12 m. It should be noted that the air gun shooter adjusts his rifle and point of sight with reference to an iron rod. In order to create identical performance situations, in the present study two rods similar to one regularly used at 11 and 12 m were placed at all parametric points to help the shooters at these distances. While on the shooting line, and

before shooting, shooters were given 10 minutes. They also received a number of bullets for sighting in before score shooting. The participants were also given an opportunity to adjust and sight in their rifles for accurate shooting. Sight-in bullets were not included in determining scores. Each shot had 10 points; which means shooters could score on the scale of 0 to 10, depending on the spot where the bullet hit the target. Targets were removed and given to a referee for scoring. Scores determined by the referee were recorded by the tester. We ran 4 sets of 25 shots. Each set consisted of 5 blocks of 5 shots at 5 distances (20 shots at each distance), totalling to 100 shots. Shooters were given 10 minutes to rest between the sets. Performance orders for shooters were counter matched: half the shooters performed the trials starting from a shorter distance toward a greater distance (Point 1 to 5) and the other half performed trials starting from the farthest points to nearest ones (5 1o 1), resulting in a hard-to-easy and easy-to-hard task variations. Three testers supervised the testing process. The first one was in charge of adjusting and accurately controlling distances. The second one was responsible for observing techniques and errors and recording scores. The third controlled the number of shots, sets, and rest intervals. Scores were assigned on the basis of the accuracy of shots in terms of the closeness to the centre (10 for bullets hitting the bull's eye, 9 for bullets hitting the ring immediate to the bull's eye, and so on).

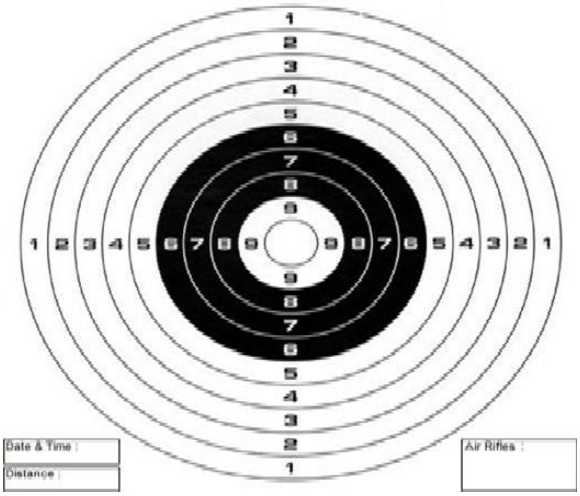


**Figure 1.** Scores for standard air gun targeting test

**Data Analysis.** Once the protocol was implemented and data were collected, normality of the data was tested with the Shapiro-Wilk test, while scatter plots were used to test the hypothesis of homoscedasticity. To analyze the data, we first used descriptive statistics based on the measures of central tendency and indices of dispersion in tables and then inferential statistics, particularly regression tests, given the nature of the variables. First, we calculated the mean performance score over five parametric points for each individuals and then used these mean values to construct regression equations and develop a regression model for the four groups. Finally, we employed one sample t-test to compare actual performance scores of shooters with the scores predicted by the regression equation for all five distances. The data were analyzed by the SPSS 22, while Excel 2013 was used to plot the figures and tables. The significance level for all tests was $P<0.5$.

## RESULTS

We used questionnaires to gather participants' demographics as shown in the table below.

**Table 1.** Male and female shooters' demographics

| Skill level | Gender | Age | sports background (year) |
|---|---|---|---|
| Novice | Male | 20.46±3.7 | 2.88±1.65 |
| | Female | 18.22±3.2 | 2.48±1.2 |
| Skilled | Male | 26.42±2.38 | 8.37±2.28 |
| | Female | 24.44±1.32 | 7.89±2.5 |

Univariate normality was assessed using the Shapiro-Wilk test at 0.05 (Table 2).

**Table 2.** Data Normality of the Especial Skill

| Variable | Gender | the Shapiro–Wilk test | | |
|---|---|---|---|---|
| | | Statistic | DF | Significance |
| Novice | male | 0.953 | 73 | 0.760 |
| | female | 0.874 | 59 | 0.540 |
| Skilled | male | 0.989 | 98 | 0.595 |
| | female | 0.974 | 80 | 0.096 |

As seen in Table 2, the data distribution for both genders in the criterion variable (shooters' success) is normal.

In the next step, we used standardized residuals to examine outlier values for the dependent (criterion) variable. The value ranged from 0 to 1 for novice women, -0.75 to 1.25 for skilled women, -0.65 to 1.472 for novice men, and 1 to -1.33 for skilled men. No outlier was observed since all values lay within the range -3 to +3. Regression analysis for all groups showed a significant relationship between air gun aiming at five parametric points. Therefore, it was possible to construct a regression equation and compare the actual success rate with predictive scores.

The relationship was also confirmed by other regression indices. The values found for F confirmed the difference between the 10-m point (the regular practice distance) and other parametric points as predicted by the present study. Another index reported by this study, $R^2$, had a value near 1, showing that the regression model had a good fit for all groups. It should be noted, however, that $R^2$ of the skilled female shooters was greater than that of the other groups. In addition, the negative values of β in the regression results point to a negative relationship between the criterion variable and the predictive variable (i.e., the success rate at five parametric points) (17, 18).

By comparing the predictive scores obtained by the regression with the mean actual performance scores, we found that, at 10-m distance, the mean predictive score for novice men was 88.90, while the mean actual score (i.e., the success rate at the same distance) was 79.32, showing a significant difference (p=0.023). The predictive and actual scores at the same distance for skilled men was 83.26 and 92.90, respectively, again demonstrating a significant difference (P=0.012). These scores for novice women were 74.60 and 83.50, respectively, indicating a significant difference (P=0.021). For skilled women, we found significantly different scores of 85.23 and 95.60, respectively (p=0.001). Predictive scores for the four groups were significantly smaller than the actual scores at 10 m, confirming the presence of especial skill. It should also be noted that fitting line showed lowered performance as the distance from the target increased. As shown in these models, the regression line was higher in the initial trial and at two initial distances, and was consequently lowered as a result of greater distance from the target, leading to a bell-shaped curve for shooters' performance.

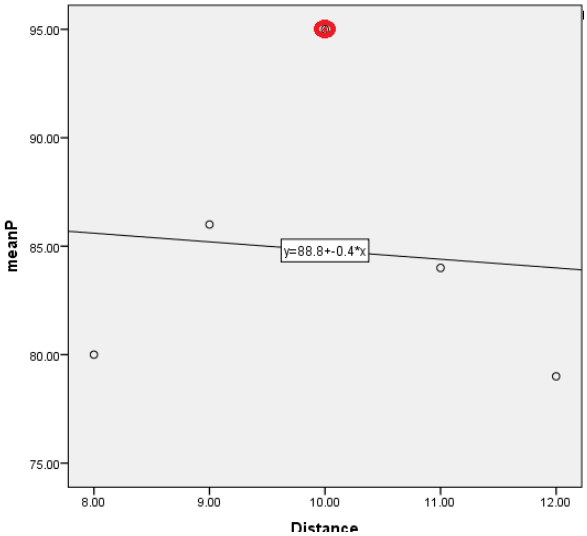


**Figure 2.** Linear regression model for comparing especial skill point with other parametric points in Skilled Women Shooters. $R^2$=0.984, β=-0.099, p=0.001.

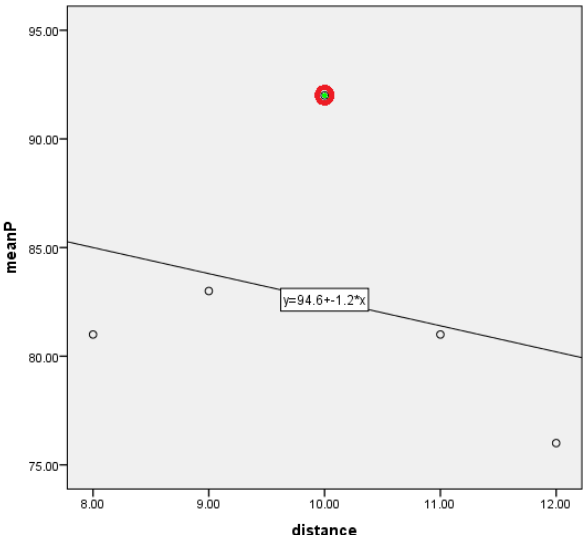


**Figure 3.** Linear regression model for comparing especial skill point with other parametric points in Skilled Men Shooters. $R^2$=0.933, β=-0.093, p=0.012.

In the next step, we examined the mean actual performance score at different parametric distances, and as expected, significant differences in scores were only observed at 10 m from the target (Table 3).

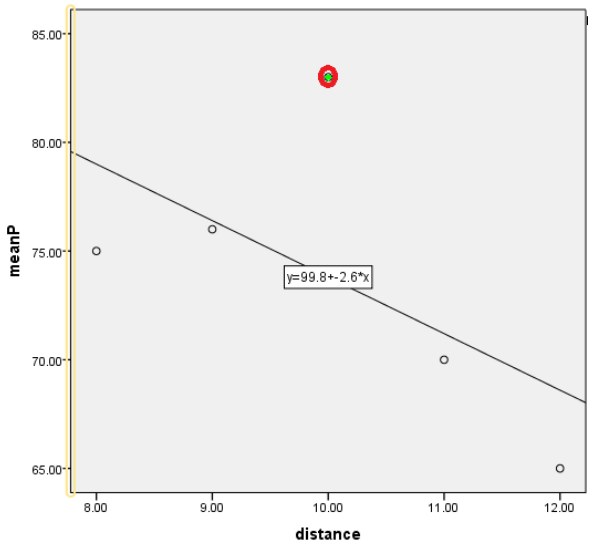


**Figure 4.** Linear regression model for comparing especial skill point with other parametric points in Novice Women Shooters. $R^2$=0.973, β=-0.621, p=0.014.

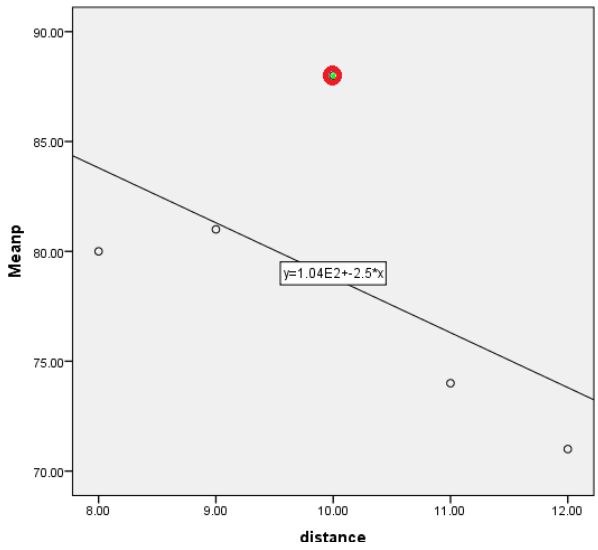


**Figure 5.** Linear regression model for comparing especial skill point with other parametric points in Novice Men Shooters. $R^2$=0.972, β=-0.574, p=0.021.

This also may, to some extent, confirm the emergence of especial skill in air gun aiming at 10 m for the four groups.

## DISCUSSION

The present study attempted to identify especial skills in air gun aiming among male and female novice and skilled shooters. Our findings confirmed the presence of especial skills in air gun aiming among the members of the four groups of participants (skilled male, skilled female, novice male, and novice female shooters), as mean scores in actual performance of the skilled male and female shooters were significantly different from the predictive regression scores, consistent with the findings of Keetch *et al.*, Simons *et al.*, and Taheri *et al.* (1, 7, 12). Our findings for two groups of skilled shooters (significant difference between mean actual and predictive scores) at 10 m from the target (actual distance in air gun shooting) can be compared to the findings of Keetch *et al.* (2005), who identified especial skill in basketball players and examined elite performers' throws at different distances from the basket (1). In addition, it is interesting to note that our results were in line with those of Taheri *et al.* (2011) who studied dart throws (given the similarity and nature of the tasks in the two studies). By analyzing the average performance in the throwing of darts from seven distances, they showed that massive amounts of practice from the standard distance resulted in a significant difference between the actual performance scores and predictive scores obtained in regression (12). It should be noted that our findings for novice shooters were not consistent with the findings of Czyż et al. (2012) and Abodoshahi et al. (2013) since our results for the two groups of novice shooters produced evidence indicating the emergence of especial skills in air gun shooting, while Czyż *et al.* (2013) tested set shots among four groups with different age and practice experience and observed effects on especial skill only in the more experienced groups not among the novice players (10). Furthermore, in examining the especial skill in long and short badminton serves performed by novice players, Abdolshai, Jaberi Moghadan, and Vaez Mosavi (2015) did not find such skills (14). Therefore, the fact that the results of our study are not consistent with their findings can be attributed to the different nature of the tasks in the two studies (i.e., fine skills involved in shooting vs. gross skills in badminton). It should be noted that the shooting or firing line is almost always fixed (to the metal rod), while in tasks like long or short service in

badminton, the actual distance is not exact (compared to air gun shooting) and can vary to some extent. Further, the points of sight, clarity, and light have considerable impact on shooting performance. Since our findings are linked to generality and specificity of motor skills, it is obvious that generality cannot be used as a basis to explain the impact of especial skills on specific improvements. In short, according to the schema theory, no single movement within a set of actions can be improved more than other movements in the same set. Instead of considering a new motor programme for especial skill, the schema theory proposes a single general motor programme for all actions within a set of action and attributes the advantage produced at 4.5 m from the basket to choice of parameters (6).

**Table 3.** Difference between mean actual performance score and individual scores at five parametric points

| Group | **Parametric points** | **M** | **SD** | **SE** | **t** | **DF** | **p** |
|---|---|---|---|---|---|---|---|
| Novice woman | 8 | 75.80 | 10.47 | 3.31 | -1.20 | 9 | 0.56 |
| | 9 | 76.70 | 7.36 | 2.32 | -0.180 | 9 | 0.86 |
| | 10 | 83.50 | 7.35 | 2.32 | 3.88 | 9 | 0.004 |
| | 11 | 70.90 | 6.26 | 1.98 | -0.45 | 9 | 0.66 |
| | 12 | 65.40 | 8.04 | 2.54 | -1.47 | 9 | 0.176 |
| Skilled woman | 8 | 80.60 | 6.60 | 2.08 | -2.62 | 9 | 0.58 |
| | 9 | 86.20 | 7.68 | 2.43 | 0.21 | 9 | 0.83 |
| | 10 | 95.60 | 3.09 | 0.97 | 10.53 | 9 | 0.000 |
| | 11 | 84.60 | 2.67 | 0.84 | -0.33 | 9 | 0.74 |
| | 12 | 79.40 | 3.77 | 1.19 | -4.25 | 9 | 0.62 |
| Novice man | 8 | 80.60 | 6.11 | 1.93 | -1.91 | 9 | 0.088 |
| | 9 | 81 | 4.02 | 1.27 | -0.63 | 9 | 0.54 |
| | 10 | 88.90 | 2.18 | 0.69 | 13.88 | 9 | 0.000 |
| | 11 | 74.90 | 6.50 | 2.05 | -0.93 | 9 | 0.373 |
| | 12 | 71.20 | 4.54 | 1.43 | -2.18 | 9 | 0.06 |
| Skilled man | 8 | 78.60 | 9.28 | 2.93 | -2.34 | 9 | 0.058 |
| | 9 | 82.90 | 5.82 | 1.84 | -0.804 | 9 | 0.44 |
| | 10 | 92.90 | 4.87 | 1.54 | 5.68 | 9 | 0.000 |
| | 11 | 81.50 | 4.50 | 1.42 | 0.45 | 9 | 0.66 |
| | 12 | 76.80 | 4.98 | -2.67 | -2.67 | 9 | 0.058 |

However, our findings confirmed the presence of specificity-related effects in motor skills that must be considered in motor control theory. According to this specificity-based view, each motor skill learned is represented in memory along with the sensorimotor information present during the initial practice (19, 20). Studies on performing and learning sensorimotor skills have shown that specific information (e.g., motor and visual feedback information) acquired during multiple trials becomes a vital factor in maintaining performance in retention tests. In contrast, when the information is eliminated in retention tests or other forms of information (i.e. information useful in performance under 'normal' conditions) are used, performance accuracy will not remain at the same level. In this regard, the visual-context hypothesis states that successful performance at 10 m is the result of massive practice at a fixed angle and distance; in other words, unique visual information associated with the throw line is a part of memory representation, and performance will drop if this information is omitted. In fact, superior performance of the skilled group at 10 m from the target indicates that visual conditions of the practice become a part of the learned representation of sensorimotor information, supporting the visual-context hypothesis. Evidence from the present study on the emergence of especial skills in air gun aiming confirms the impact of specificity in motor control, and only one theory has described in details the process of specificity in motor learning. According to Adams (1971), feedback from purposive actions is stored in memory for actual performance. With more practice, a stack

of representations is stored in the memory, creating a structure that represents a frequency bar chart, which changes in shape as practice continues. Awareness of the outcomes during practice leads to a stronger representation of correct actions without reinforcing perceptual traces of incorrect actions. Skilled movements are formed when a single representation dominates all other representations, and the representation associated with the correct movement, distinguished from other forms of representations, becomes a specific basis (modal) in memory for accurate performance of the action. According to Adams' closed-loop theory, all skilled movements are represented in a single specific perceptual trace. However, another part of our results point to a bell-shaped curve for participants' performance at various distances and, under these conditions, one cannot explain the impacts of especial skill on a particular improvement in performance results merely by relying on generality. On the other hand, specificity of motor skills cannot be used as a basis to explain the usual relationship between distance and subjects' performance. This presents a challenge in choosing general or specific motor skills, which shifted our focus to a balanced model (the bell-shaped curve for shooters' performance). An analysis presented here was related to the fitting line over the bell-shaped curve of shooters' performance, and this model justified, to some extent, the poorer performance at smaller/greater distances from the target. As seen in Table 4, the greater the distance from the firing line (10 m), the poorer is the performance of shooters. These findings are also in line with those of Taheri *et al.* (2011) on skills involved in throwing darts. This consistency can be attributed to the small variability and an almost exact distance in both air gun shooting and dart throwing (12). The findings suggest that memorial structures are specific to highly practised tasks (unlike Schmidt's generalized programme) and the shooter is be able to generalize this superior performance to shoot from adjacent positions. We examined the balanced model to explain potential reasons behind these findings. The model explains how motor learning at an advanced level includes general and special impacts. It also explains how massive amounts of practice focused on a particular point in closed skills can undermine performance at adjacent points (at different distances and angles). One method proposed to evaluate this model is to record the EMG as well as electrical activity of the brain in skilled players while they throw from different positions and then compare the data obtained in this process. The results of Breslin *et al.* (2010) do not support this part of our findings, as they found no significant difference between movement patterns (relative timing) in free throws performed at 4.5 m from the basket and those performed at closer or farther distances, pointing to a similar pattern at different distances in the absence of individual programmes specifically developed for different points (particularly at highly practised distances) (8). Only the balanced model can integrate a generalized (general) motor programme and special (specific) programme, and is completely consistent with the view of Keetch *et al.* (2008) that 'combined generality with specificity', in a way that advantages of practising at a certain distance can be generalized for other distances not been included in practices (6). Another view, called 'learned parameters', proposes that what is learned from multiple practices at a certain distance leads to the ability to choose a particular, and relatively optimal, set of parameters for successful shooting at 10 m, which, in its general form (1975), shifts shooting from the correct distance to the target. These specific parameters may not be learned at other distances as few practices are carried out at such points. Therefore, the learned parameter hypothesis predicts that players probably use identical parameters with the same accuracy at all positions. In general, the present study and a similar one previously have shown that the schema theory is not capable of explaining all implications of especial skills, and Adams' closed-loop theory only covers specificity of a skill within a class of skills, while the balanced model integrates specificity and generality into a single model of motor learning. Future research can study the emergence of especial effect in a variety of tasks by making use of studies that rely on measures of visual attention and kinematics of the movements of the whole body to examine motor learning. The tasks that can be examined from this point of view include aces in

tennis or volleyball or arrows propelled from different distances and striking the central part of the target in archery. It is not clear whether automaticity of especial skill remains intact under such conditions as fatigue or distraction, and, therefore, future research can focus on examining how this could change under these conditions.

## CONCLUSION

The findings of the present study support the emergence of especial skill in air gun aiming for four groups of shooters. The regression model has an acceptable fit for all groups, although it presents a better fit for skilled men and women compared to novice shooters. In addition, the difference between actual performance and predictive scores is significant only at 10 m from the target, with no significant difference observed at other parametric distances.

### APPLICABLE REMARKS

- Coaches should pay particular attention to especial skills in developing training programmes, and regularly employed skills should be performed in the same manner during practice.

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