

*Full Length Research Paper*

# Effect of interaction between eye-hand dominance on dart skill

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The purpose of this research was surveying the effect of interaction between eye hand dominance on dart skill. Twenty healthy male subjects (age:  $21.43 \pm 1.33$ ) from University of Shahid Chamran were served as the participants for this study. Subjects were divided into two groups: unilateral (right eye and right hand or left eye and left hand) group (10 subjects) and cross lateral (right eye and left hand or left eye and right hand) group (10 subjects). Each group trained for 12 sessions in the same condition. The acquisition test was made after the last training session and the retention test was made 1 week later. The scores of pre-test, acquisition and retention were recorded. Subjects threw 60 darts in each training session. Porta (Roth, 2002) and Hole in the card test (Sage, 1984) was used to select eye dominance and Edinburgh questionnaire (Oldfield, 1971) was used to determine handedness. Values of  $p < 0.05$  were chosen as significant. The results of dependent t-test (paired t-test) analysis showed that there was a significant difference between the pre-test, acquisition and retention between two groups that showed both groups learn dart skill. On the other hand, the subjects of two groups improved significantly in acquisition and retention phases rather than pre-test phase. Moreover, the results of independent t-test showed that there was no significant difference between unilateral and cross lateral in acquisition and retention tests. Our findings revealed that interaction between hand and eye dominance does not affect dart skill.

**Key words:** Unilateral, cross lateral, dart.

## INTRODUCTION

Most people tend to use one side of their bodies more easily, more frequently, and more dexterously than the other side and this is often characterized by left- or right-handedness by the dominant use of a left or right foot (Suttle et al., 2008).

Laterality is defined by the American Heritage Medical Dictionary as "preferential use of limbs of one side of body." Knowing one's laterality pattern (dominance of eye, hand, and foot) makes it possible to suggest situations adapted for learning skills more efficiently, to detect and guide young talents, to optimize the work of limbs for each side of the body and to achieve powerful coordination (Laborde et al., 2009).

It has been demonstrated that the ocular system is not

an exception and that an individual will usually prefer to use one eye rather than the other for certain tasks. Ocular dominance is not correlated with other types of lateral body dominance, such as handedness (Suttle et al., 2008). This preference leads to numerous perceptual effects: subjects are more accurate using their dominant eye images which appear clearer and larger when viewed by the dominant eye and stabilized retinal images fade slower when viewed by the dominant eye (Shneur et al., 2006).

The concept of handedness has shaped most considerations of the functional asymmetry or laterality of the human movement system. To a significant degree, the privileged status of handedness has arisen because, more formally, a person's preference for hand use can be assessed in straightforward ways by either a questionnaire or a battery of performance test (Balasubramania, 2000).

Ninety percent of people are right-handed, 80%

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right-foot, 70% right-eyed, about 60% are right-eared (Saudino et al., 1998) and about 35% of right-handers and 57% of left-handers are left-eye dominant (McManus et al., 1999).

People whose eye dominance and handedness are in the same side are named unilateral or uncross (right-hand and right-eye or left-eye and left-hand) lateral and people whose eye dominance and handedness are not same side are named cross lateral (right-eye and left-hand or left-eye and right-hand) (Payne et al., 2002).

It is clear that visual information is critical to performance sport skill. If the visual system does not receive messages accurately or quickly enough, performance may suffer. It is important for visual systems to be functioning at advanced levels because athletic performance can be one of the most rigorous activities for the visual system (Deborah, 2009). The dominant eye will focus directly toward external stimulus, such as an oncoming ball or the movement of the opponent. This suggests that the dominant eye should play a significant role in the development of sport skills, from aiming tasks, such as archery and golf-putting to faster-paced sports, such as tennis and soccer (Steinberg et al., 1999).

Considering sports like shooting, it seems that interaction between hand preference and eye dominance is an effective factor on performance. The uncrossed eye-hand pattern is distinctly more successful than the crossed eye-hand, given the features of activity, motionless target, and nonexistent time pressure. Moreover, to aim at the target, athletes have to align two points between eye and target. So, it is an advantage to use the arm corresponding to the sighting eye (unilateral eye hand pattern) (Deborah, 2009). However, the amount of this effect on different sport skills is significantly variable.

In addition, the vision requirements of each sport are different. The breakdown of visual skills by sport shows these differences and the relative importance of these skills to each sport (Gardner, 1995). For example, researches claimed that there is no significant difference between unilateral and cross lateral in baseball skill (Goss, 1995; Portal, 1998). But, novice unilateral (uncrossed lateral, right eye and right eye dominance) were better than novice crossed laterals (left eye and right hand dominance) in archery when they did not use sights (Laborde et al., 2009).

There is another fact about effect of interaction of eye-hand dominance on some sport skills. In task conditions characterizing duel sports, the dominant eye is requested and functionally connected via the lateral geniculate nucleus to the ipsilateral hemisphere. On the contrary, concerning manual responses, the responding hand is connected via its motor area with the contralateral hemisphere. Consequently, the functional connection between visual input and motor output involves only one hemisphere for subjects presenting a contralateral relationship between the dominant eye and the responding hand. These subjects, therefore, do not need

such an interhemispheric transfer, relatively expensive in time. The result for them is an advantage in reaction times, compared to subjects with ipsilateral dominant eye and the responding hand (Azémar et al., 2008). Although dart needs accuracy more than speed, aiming at far targets, such as those in basketball or darts, appears to use a different form of visuo-motor control. Vickers's results provide support for an open-loop mode of control in dart. In open-loop models of control, vision on the target is used to organize the aiming commands prior to the final movement, which is run-off without any need for feedback. Open-loop models argue that since the aiming commands are set early during sustained fixation, there is no need to maintain vision on the target as the dart is thrown (Vickers et al., 2000). So, regarding these different results and differences which potentially exist in different sports, it can be said that the effect of relationship of eye-hand dominance with dart shows interesting results.

On the other hand, this subject can be beneficial in selecting an effective method to teach sport skills, like dart. Brain is an important component in determining how humans learn, but brain cannot learn by itself. Eyes, ears, hands, and feet are all mechanisms of information transportation to the brain. They provide stimulant information that brain can use to make appropriate decisions about learning. Although dominant preferences vary over time, ultimately, the right or left side of each of these senses will tend to dominate and function more efficiently than the other when it comes to learning (Deborah, 2009).

Moreover, the challenge is to find an appropriate system to determine learning strengths and weaknesses and this can be addressed through the use of dominant preferences (Deborah, 2009). The increasing diversity of students and the current standards reform movement are two additional developmental areas supporting the use of various learning styles. With increased diversity, students will have a wide variety of learning needs (Bellanca, 1998; Curry, 1999). Educators need to understand dominance profiles because the research suggests incongruities between learning preferences of teachers and preferences of the students they teach. Knowledge in this area can help physical educators determine best teaching practices and applications to enhance learning. Dominance profiles can give the teacher and/or student an understanding of how she/he learns best. This understanding can create an awareness of strengths and weaknesses in ones teaching approach so that all students are taught according to their inherent learning preferences. The standards reform movement also suggests that by understanding the variety of inherent learning styles in students, teachers can increase performance, hence meeting higher standards mandated by the reform initiatives (Deborah, 2009). So, it seems that interaction can be effective for some skills, for example, unilateral group learned rifle skill better than cross lateral (Jones et al., 1999).

This variability in eye dominance among the student population could play a key role in developing an appropriate individualized lesson plan; thus, its determination should be included in the lesson plan (Steinberg et al., 1999).

It seems that eye–hand dominance quality (unilateral and cross lateral) can affect the accuracy of performance in many sports but there are many results that show disagreeing results. On the other hand, more affective styles can be selected to teach some sport skills by recognizing lateral preferences; therefore, the aim of the present study is to compare unilateral and cross lateral in acquisition and retention phases in dart throwing skill.

## METHODOLOGY

### Subjects

One hundred male students (age  $21.43 \pm 1.33$  years) who studied in Shahid Chamran University of Ahvaz, Iran, in 2010, were randomly selected before the administration of the tests. All subjects completed the Edinburgh questionnaire (Oldfield, 1971) to determine handedness and did Porta (Roth, 2002) and Hole in the card test (Sage, 1984) to determine eye dominance. Subjects who had one of the following qualities were deleted from the study:

- i. Subjects who used glass or lens
- ii. Subjects who had experience in aiming skill especially in dart.
- iii. Subjects who got a mark between -40 and +40 ( $-40 < X < +40$ ) in Edinburgh questionnaire (subjects were ambidextrous)
- iv. Subjects who could not see the target just by one eye (right or left) in both Porta and Hole in the card tests (in this part, there was tendency to delete people who had neither eye dominance nor weak eye dominance)

Finally, 10 subjects were selected as unilateral group (8 subjects were right-eye and right-hand, 2 subjects were left-eye and left-hand dominance) and 10 subjects were selected as cross lateral group (8 subjects were left-eye and right-hand, 2 subjects were right-eye and left-hand dominance).

### Eye dominance

#### *Hole in the card test*

Each subject held a card ( $25 \text{ cm}^2$ ) with both hands stretched and extended straight forward to the target. There was a hole in the middle of the card (0.5 cm diameter) and subjects could see the target by this hole. Target was a black circle (with 1 cm diameter at 2 m distance) in white paper. When the target was sighted, the examiner covered alternately each of the subject's eyes, and asked if the target was still visible. The eye with which the subject viewed the target was the dominant sighting eye (Sage, 1984).

#### *Porta test*

The observer extended one arm and then with both eyes open, aligned the index finger with a distant object. The observer then alternated closing the eyes or slowly drew the thumb/finger back to the head to determine which eye was viewing the object (that is, the dominant eye) (Roth, 2002).

## Methods

Dart-throwing accuracy was used as a performance measure in this study. In accordance with World Darts Federation rules, the dart board was used. The dart board was positioned 2.37 m from the foot line and uppermost edge at a height of 1.73 m.

Each subject performed 30 trials of throwing darts to warm up. The score of these hits were not recorded. These 30 trials were thrown in 5 blocks, subjects rested for 30 s after each block. After 2 min, subjects threw 30 darts like previous step but in this stage, the score of darts were recorded. The summation of scores of the first session was considered as the subjects' scores in the pre-test phase.

Experimental training was performed 4 weeks, 3 times per week (12 sessions). This experiment consisted of acquisition and retention. The scores in the last session were regarded as the acquisition scores. One week later, each subject threw 30 darts and the scores were recorded as retention. In this phase, there was no throwing as warm up.

### Measurements

The dartboard was made up of three circles and the scoring was as follows:

- a) 5 points for darts inside the bull's-eye;
- b) 3 points for darts inside the triple-score circle (but not in the bull's-eye);
- c) 1 point for darts inside the double-score (outer) circle (but not inside the triple-score circle).

Darts missing the dartboard were given 0 points (Bindarwish et al, 2006). Therefore, each participant's final score of trials could be ranged from 0 to 150 points.

### Statically analysis

Dependent t-test was used to measure acquisition and retention in both unilateral and cross lateral groups. Also, independent t-test was used to compare retention and acquisition in dart skill between unilateral and cross lateral group. Values of  $p < 0.05$  were found significant. Statistical analyses were performed using the SPSS version 18 for Windows.

## RESULTS

In order to assess differences between pre-test and retention phases of the study, dependent t-test (paired t-test) was used. The results are shown in Table 1.

As shown in Table 1, there is a significant difference between scores of pre-test and retention in unilateral ( $p=0.001$ ,  $t= 8.139$ ) and cross lateral ( $p=0.001$ ,  $t= 11.387$ ). So, the scores of subjects increased significantly in retention phase in comparison with pre-test values. This result shows that both groups learn dart skill.

In order to measure differences between pre-test and retention phases of study, dependent t-test (paired t-test) was used. The results are shown in Table 2.

As shown in Table 2, there is a significant difference between scores of pre-test and acquisition in unilateral ( $p=0.001$ ,  $t= 10.940$ ) and cross lateral ( $p=0.001$ ,

**Table 1.** Results of dependent t-test to compare pre-test and acquisition in unilateral and cross lateral group.

Group	Pre-test		Acquisition		t	p
	M	SD	M	SD		
Unilateral	31.600	4.376	51.700	6.583	8.139	0.001
Cross lateral	32.100	4.840	54.00	6.055	11.387	0.001

**Table 2.** Results of dependent t-test to compare pre-test and retention in unilateral and cross lateral group.

Group	Pre-test		Retention		t	p
	M	SD	M	SD		
Unilateral	31.600	4.376	50.900	2.846	10.940	0.001
Cross lateral	32.100	4.840	53.300	3.368	14.236	0.001

**Table 3.** Results of independence t-test to compare acquisition and retention between unilateral and cross lateral groups.

Group	Unilateral		Cross lateral		t	p
	M	SD	M	SD		
Acquisition	51.700	6.583	54.00	6.055	- 0.813	0.427
Retention	50.900	2.846	53.300	3.368	- 1.721	0.102

$t = 14.236$ ). So, the scores of subject are increased significantly in acquisition phase in comparison with pre-test values. These results show that the learning of two groups was constant.

For assessing the comparison of comparing unilateral and cross lateral in acquisition and retention phases of study, independent t-test was used. The results are shown in Table 3.

Results showed that there are no significant differences in acquisition ( $p=0.427$ ) and retention ( $P=0.102$ ) phases. So, interaction between eye and hand dominance do not have any significant effect on dart skill. In other words, there is no difference between cross and lateral unilateral groups in dart throwing.

## DISCUSSION

The present research aimed at surveying the effect of interaction between eye- hand dominance on dart throwing skill. In order to accomplish this, amateur males were divided in two groups; unilateral (right eye and right hand or left eye and left hand) and cross lateral (right eye and left hand or left eye and right hand). The results showed that all subjects of the two groups improved in dart throwing skill and their scores were better in acquisition and retention in comparison with scores in

pre-test phase. However, there was no significant difference between unilateral and cross lateral, neither in acquisition nor retention phase. This identifies that interaction between eye and hand dominance does not affect dart skill.

When a person is required to make a discrete manual aiming movement to a stationary target, the eyes normally get fixed at the target before any movement preparation begins. This provides the control system with visual information about the position of the target and later, the hand moves toward the target (Binsted et al., 2001). So, according to this information, eyes identify movement of hand in skills like dart. Also, accuracy in darts was affected by the temporal control of quiet eye (QE) (in the dart throw, QE was defined as the final fixation on the target prior to the extension of the arm toward the target) fixation relative to the alignment, flexion, and extension phases of the throw. Hits occurred when QE was of longer duration and occurred during late alignment and early flexion (Vickers et al., 2000). So, it seems that surveying vision system can be beneficial.

Posner and Raichle (1994) describe three networks of visual attention (posterior orienting, anterior executive, and vigilance). They describe the posterior orienting network as being responsible for the control of the direction of gaze in space. This network, which is located in the parietal region, functions to direct visual attention to

specific locations of interest and importance in a task. In the dart throw, this network may have been responsible for directing QE to the target during the alignment phase of each throw. The second network, the executive anterior network, may be responsible for the sustained concentration one sees during highly competitive games of darts. In the dart throw, this may have been responsible for the longer duration of QE, characteristic of higher levels of skill and accuracy. The anterior network imposes higher-order understanding on a task and allows the performer to control an action relative to specific goals. The vigilance network co-ordinates the functions of the posterior and anterior networks and prevents unwanted or distracting information from gaining access to both systems (Vickers et al., 2000). So, these networks are the same in healthy people and there are no differences between unilateral and cross lateral. So, effective nervous factors on accuracy in dart relate to special networks that are not different between two groups with different eye hand dominance.

Consequently, duration of gaze in dart can affect the level of skill and accuracy. Again, it can be found that success in dart in which accuracy is the most important factor for success, to a large extent, depends on duration of fixating eye, not interaction between eye-and hand. Interaction of eye-hand dominance does not have any effect on effective factors on dart performance.

Our results support the findings obtained from assessing the effect of ocular dominance on the performance of professional baseball players showed that hand-ocular dominance patterns do not have any effect on batting average (Laby et al., 1998).

In addition, a critical literature review was done on 4 articles (Adams, 1965; Goss, 1998; Portal, 1998) which are about the relationship of eye dominance and baseball batting showed that the overall reviewed studies do not suggest any effect of the eye dominance/batting side relationship on batting performance. It appears that other measures of visual system function, such as visual reaction time, eye movement skills, or dynamic stereoacuity are more likely to correlate with batting performance. The results of the present study agree with these results (Goss, 1998).

Unlike the result of the present study, unilateral eye-hand pattern is more successful in archery when the bow is used with no sights, but this effect of laterality seems to be eliminated in practitioners by their use of a specific accessory, the sight (Laborde et al., 2009).

There is disagreement between the study of archery and the present one. This contractor may result from protocol of both studies. Archery requires repetition of the same gesture many thousands of times, leading to automation. This may be based on complex cognitive changes in the central nervous system. The process of motor learning may perhaps be associated with changes in the laterality pattern (Laborde et al., 2009). But in this study, there were 12 sessions in 4 weeks to learn dart

skill and subjects threw 720 darts. Also, there are potential differences between dart and archery that can make variety of results, like visual adjustability. Based on Gardner category (Gardner, 1995), this visual skill is the most important skill in archery while it has the lowest importance in success in dart skill.

Moreover, a study showed an association between eye dominance and training for rifle marksmanship (Jones et al., 1999). These findings showed that the subjects with unilateral had qualification scores that were significantly higher than subjects with crossed dominance to achieve rifle qualification. He approved that the earning of rifle marksmanship is influenced by eye dominance. Individuals who shoot right-handed and are left-eye dominant or who shoot left-handed and are right-eye dominant do not learn marksmanship skills as readily as individuals who have matched eye and hand dominance. These studies disagree with the present study.

It seems that the reason of conflict is that if you shoot off the right shoulder with strong left eye dominance and you have both open eyes during the act of shooting, you will experience "cross firing" and will shoot inconsistently as a result. In the cross firing, the eye that is above the rib must be the one that the shooter uses to make the correct target/barrel relationship. If it is not, the wrong eye will take over as the gun is brought to the point of aim and the barrels will be pointing in the wrong place as the shot is triggered. The right-shoulder, left-dominant-eyed shooter will shoot behind a left-to-right crossing target and in front of right-to-left (Blakeley, 2003). Every person has a dominant eye that processes and transmits information to the brain a few milliseconds faster than the other one. The dominant or sighting eye also guides the movement and fixations of the other eye (Knudson et al., 1997). So, maybe this is the reason for existence of differences between performances of unilateral and cross lateral in rifle and archery skills.

On the other side, cross laterals shoot off using the dominant shoulder and non-dominance eye set above the rib (Blakeley, 2003) since processing of visual input of dominant eye is more preferred in comparison with the other eye (Rice et al., 2008) and dominant eye processes and transmits information to the brain a few milliseconds faster than the other (knudson et al., 1997). So, as a result, it seems that brain directs movement of hand based on the input of eye dominance and since there is distance between two eyes, the information of eye dominance while target is seen by non-dominance (above the rib) cannot guide the hand for shooting. In dart throwing, there is no aiming by the special eye and usual movement of hand which is selected by information of eye dominance. So, these consistent results are related to potential differences between rifle, archery and dart. On the other hand, different quality of rifle, archery, and dart is the main reason of disagreeing results of the previous studies (Jones, 1996; Laborde, 2009) and this study.

Sugiyama showed that mean scores for right-eyed (unilateral) were higher than the mean scores for the left eyed (cross lateral) in Golf (Thain, 2002). This result is inconsistent with our results. There are some points that should be considered. First, he just selected right-handed subjects, while unilateral and cross lateral involve left hand-right eye and left-hand and left-eye people. In addition, right-handed subjects with right-eye dominance have better spatial orientation than right-handed subjects with left-eye dominance and the involvement of the frontal cortex in cognitive and motor processes is decreased in subjects with the left-eye dominance (Lazarev et al., 2007). Therefore, maybe differences between unilateral and cross lateral in putting Golf are not related to interaction between eye-hand dominance and these differences refer to difference of right-eye dominance and left-eye dominance. Also, the obtained data suggest that the role of the thalamic-frontal-medial cortical system of selective attention decreases in subjects with left-eye dominance (Lazarev et al., 2007). But in the present study, subjects with left-hand (right-eye, left-eye) and right-hand (right-eye, left-eye) were selected as well.

This result also indicated that putting performance was higher in the right eye condition (using only right eye) than the left eye condition (using only left eye) for either the right-eyed or the left-eyed subjects. It is suggested that the right eye may play a fairly important role in judging the direction and hitting the ball straight in putting than the left eye because the right eye is normally positioned behind the ball whereas the left eye is positioned between the ball and the cup (Thain, 2002).

## Conclusion

In conclusion, the effect of interaction between eye and hand dominance on performance in each sport depends on the type of sports and visual skills which can affect performance in those sports. Thus, the results of this study approve that this factor does not affect dart throwing.

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