EXTERNAL FOCUS OF ATTENTION AFFECTS SHOT ACCURACY IN ELITE ARCHERS

Andrea Vrbik[1], Iris Zavoreo[1,2], Ivan Vrbik[3]

[1] University of Zagreb, Faculty of Kinesiology
[2]Clinical Hospital Sestre Milosrdnice, Zagreb
[3] University of Slavonski Brod

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Abstract

The intention of this study was to find out if external focus of attention, steering the archers' focus on distal movement effects, will provide better shooting accuracy expressed as higher number of 10 points and higher overall result. The subject sample was consisted of 10 elite male archers, with average age 25.8 years. The sample of variables was derived from observed characteristics of entities in different shooting conditions. A measure of arrow distance from the center of the target face was used in order to estimate shooting precision. The testing consisted of three different shooting conditions: C1- free focus of attention, C2 – internal focus of attention and C3 – external focus of attention. The analysis showed that the highest results were obtained in condition of externally oriented focus of attention (C3), and the lowest results in condition of internally oriented focus of attention (C2). Friedman's ANOVA did not show statistical differences between the conditions, but they were found between C2 and C3 in afterwards administered Wilcoxon's test (p=0.047).

Keywords*:* archery, constrained action hypothesis, precision, top athletes*.*

Introduction

On last held Olympic Games in Rio, Korean archer Kim Woojin, set a new World record scoring 700 points out of 720 possible. The strength of the bow is expressed as the measure of bow weight, and in men it is around 50 pounds (cca. 25 kg), and an average bow weighs around 4 kg. Top archers during practice sessions shoot around 300 arrows, which calculated in a cumulative weight drawn amounts a total of 7 tons. An arrow weighs approximately 20 grams and travels to the target at 240 km/h. An Olympic qualification tournament implies shooting at 70 m distance, while the center of the target (10 points ring) has the diameter of 12 cm. In order to hit the ten ring, an archer, considering that all elements of technique were done correctly, is not allowed to move the arm more than one tenth of a degree. Isn't that fascinating? What does one need for such an accomplishment?

According to Acikada, Ertan and Tinazci (2004), the key factors of success in archery include general (strength, endurance, balance and flexibility) and specific motor abilities (intermuscular coordination, rhythm, timing and specific precision), along with different psychological factors, such as concentration, relaxation and different types of attention (Zeplin et al., 2014), followed by visual focus (Acikada et al., 2004).

Maximal development of motor and functional abilities, detailed selection of morphological type and body composition, the whole pallet of different training operators and training contents and precise mechanics of the specific movements are a part of the top level sport. Considering the occurrence of fewer and fewer differences between elite athletes, the impact of the mental aspect of the sport comes more to attention as an equal part of this integral system. Caterini et al. (1993) noted that besides mental attention, archery is connected with visual and selected attention as well. During shooting, mental attention predominates in the first part of activity execution, but visual attention plays a key role in the afterward part.

In literature, attention is described as the ability to select important stimuli and selective structuring of the field of perception. There are different categories of attention, among which selective attention is the most explored in the field of sport. The reason backing this statement lies in the fact that one of the subcategories of the selective attention refers to giving instructions from coach to athlete (Memmert, 2009), when the coach has enormous potential of steering athlete's attention. In their review article, Wulf, Shea and Lewthwaite (2010) pointed out influential factors that enhance motor learning, such as observational practice, feedback, self-controlled practice and focus of attention.

Focus of attention was observed from different aspects and was characterized as associative (focused on body senses) or dissociative (blocking

of senses created by physical labor), wide or narrow, and by direction (internal or external). During years of research in sport, scientist tried to investigate different focus of attention: in golf, basketball, baseball, tennis, darts, swimming, high jump, volleyball and in football (An, Wulf and Kim, 2013; Lohse et al., 2013). Advantages and differences of different focus of attention were proven in different levels of sports expertise (Wulf and Su, 2007; Memmert, 2010; Vickers, 2010; Neumann and Thomas, 2011; An et al., 2013), and also in retention and transfer (Carpenter et al., 2012).

There were a few researches studying focus of attention in structurally similar sports to archery, such as golf and darts. Lohse et al., (2010) in their study with 12 subjects playing darts, managed to analyze the change in motor performance as a function of focus of attention. The external focus of attention led to better performance (less errors), shortening of the time needed for preparation between shots, and lower EMG activity of the upper arm muscles. Furthermore, Lohse et al. (2013) performed a similar experiment with 15 subjects playing darts. External focus of attention caused better performance and larger variability in throwing hand, following high correlations of body dimensions (position and shoulder, elbow and wrist velocity). In their research with 24 golfers, An et al., (2013) demonstrated that the subjects who undertook external focus of attention showed greater carry distance, X-factor stretch and an increase in angular velocities of the pelvis, shoulder and wrist, pointing out that a single external focus note can be sufficient to elicit an effective whole body coordination pattern.

The aim of this study was to find out if external focus of attention, steering the archers' focus on distal movement effects, will provide better shooting accuracy expressed as higher number of 10 points and higher overall result.

Methods

The subject sample was consisted of 10 elite male archers, with average age 25.8 years, all without any attention disorders in their anamnesis. Subjects were training 5 to 6 times per week on average, 3 to 5hours in duration, considering the weather conditions and given time at hand. All of the subjects had one or multiple of the following references: World or Europe champion, World or European record holder, World cup finalist, national champion and National record holder. All subjects gave their written consent for participation, and this particular survey was approved by Science and Ethical Commission on Faculty of Kinesiology in Zagreb.

The sample of variables was derived from observed characteristics of entities in different shooting conditions. Therefore, in order to estimate shooting precision, a measure of arrow distance from the center of the target face was used, shown as a number of points in a standard way of scoring. The experiment was made in standard conditions of indoor field set-up, target placed at 18m distance, and target face standard triple φ40mm, with center target face positioned at 1,30m. One target face consisted of 5 concentrically placed circles valued 10 to 6 from approved standard equipment (Word Archery Rules and Regulations, 2020). All subjects used their own equipment, which was a standard commercially available archery equipment in concordance with the rules.

The experiment was divided in three separate measures for each subject. Every measurement consisted of warm up (3 ends x 3 arrows) and testing (10 ends x 3 arrows). Estimated time of warm up and testing by subject was about 45 minutes. The testing consisted of three different shooting conditions: C1- free focus of attention, C2 – internal focus of attention and C3 – external focus of attention. All subjects were first measured in C1 condition and then in C2 or C3 by a random choice. According to World Archery rules and regulations, the allowed time for one end, consisted of three arrows, is 120 seconds. Every archer set his own rhythm and tempo in each end. Between ends, the estimated time for rest was that needed for the arrows to be picked up from target and results scored (approx. 90 sec.). In all three conditions, subjects were told to try to be as much precise as they can. In C1 condition subjects got no special instructions. In other two conditions, subjects were directed via verbal instructions on different aspects of shooting: C2 – coordinated arms movement and release (movement of the body parts – internal focus), and C3 – on center of the target (bull's eye) and arrow flight (movement effects – external focus of attention). Concretely, in C2, before every end (10 ends in sum), an archer received a following instruction: "Focus on movement of your arms and shoulders and smooth release. If you are restless and experience tremor in bull's eye, try to fix it in a way to concentrate on better push – pull action and patiently waiting for a smooth surprising release. Try to be as precise as you can." In C3, archers received following instruction: "Focus on bull's eye and arrow flight. If you are restless and experience tremor in bull's eye, try to fix it in a way to concentrate on your sight's pin and letting it *melt* with the center and on the follow-through and arrow flight. Try to be as precise as you can." (Lohse, Sherwood and Healy, 2010; Lohse et al. 2013).

The praxis in social experiments often imply a manipulation check, which is an additional check consisted of qualitative data and provides a researcher certain proof that measured variables truly reflect observed characteristics (Peh et al., 2011; Abdollahipour et al., 2014). In case of this experiment, after every end in C2 and C3 conditions, the subjects were asked if they complied to the condition instructions in order to interpret obtained data with maximum certainty. Their answers were administered and noted by the experimenter in a form of questionnaire. The

subjects were clearly informed that their honest feedback is very important for the experiment, and were encouraged in sense of giving as straight answer as possible.

Central and dispersive parameters were calculated for all variables. Since there was a deviation from normal distribution, as a non-parametric alternative to one factor ANOVA for repeated measures, Friedman's test was used, along with Wilcoxon's test.

Results and discussion

Basic descriptive parameters are presented in the Table 1: in each shooting condition (COND) 300 arrows were shot. The arithmetic mean (AM) varied from 9.60 in control shooting condition (C1) and internally oriented focus of attention condition (C2), to 9.69 in externally oriented focus of attention (C3).

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Table 1. Descriptive parameters of elite archers in different shooting conditions

COND.	N	AM	MED	MOD	MODE FRQ.	SUM	MIN	MAX	VAR	SD
C1	300	9.60	10	10	200	2880	7	10	0.42	0.65
C2	300	9.60	10	10	192	2879	7	10	0.34	0.58
C3	300	9.69	10	10	214	2907	8	10	0.26	0.51

COND. – shooting condition; C1 – control shooting condition; C2 – internal focus of attention; C3 – external focus of attention; N – number of arrows shot; AM – arithmetic mean; MED – median; MOD – mode; MODE FRQ. – mode frequency; SUM – sum of points, MIN – minimum result; MAX – maximum result, VAR – variance; SD – standard deviation.

From the total of 3000 possible points, in C1 condition of shooting, the result was 2880, with 7 seven point scores, six 8 point scores, eighty-seven 9 points scores and 200 ten points scores. In C2 condition of shooting, the result was 2879, with 1 seven point scores, 11 8 point scores, ninety-six 9 points scores and 192 ten points scores. In C3 condition of shooting, the result was 2907, with no seven point scores, seven 8 point scores, 79 nine points scores and 214 ten points scores.

In order to establish the relationship between different shooting conditions (C1, C2, C3) and points shot (10-6) the normality of distribution was tested with Kolmogorov – Smirnov test which indicated a significant deviation from normal distribution. Therefore, in order to find out which shooting condition caused scoring the highest arrow score, an alternative method to one factor analysis of variance was used, a non-parametric Friedman's ANOVA. This method is used in ordinal scales for the same subject sample measured in three or more time points, or conditions (Pallant, 2009). After confirming the statistically significant difference between conditions, next step were subsequent individual Wilcoxon's tests in order to establish the difference of interest (Pallant, 2009) presented in Table 2.

Table 2. The results of Friedman's test and Wilcoxon's test of ranks

COND	N	FRIEDMAN ANOVA	WILCOXON TEST
C1	300		U1:U2 p = 0.811
C2	300	p = 0.112	U1:U3 p = 0.079
C3	300		**U2:U3 p = 0.047**

COND. – shooting condition; C1 – control shooting condition; C2 – internal focus of attention; C3 – external focus of attention; N – number of arrows shot

The analysis showed that the highest results were obtained in condition of externally oriented focus of attention (C3), and the lowest results in condition of internally oriented focus of attention (C2). Friedman's ANOVA did not show statistical differences between the conditions, but they were found between C2 and C3 in afterwards administered Wilcoxon's test (p=0.047). Although, the observed descriptive parameters of results of the elite archers in diverse shooting conditions do not indicate large differences, examined from the competition relevance point of view, they make significant result ranking position distinction. The main tendency in competitive archery is to score as

higher possible score, with large number of 10 points, which was the case in externally oriented focus of attention shooting condition (C3).

Precision is defined as a qualitative motor ability which allows one to hit a certain dynamic or static target at a given distance by throwing or aiming (Milanović, 1997). Archery is a sport of precision and accuracy, meaning that it is imperative to hit a center of the target as often and as accurate as possible (Podržaj, 1998; Frangilli V. and Frangilli M., 2005), performing accurate body movements and positions related with specific coordination. Mentioned is based on kinesthetic information from the memory and receptors and perfect balance and harmony with the visual target (Milanović, 1997; Čižmek, 2007; Čižmek and Peršun, 2011; Vrbik et al., 2015). In this experiment with elite archers, external focus of attention contributed to better results and higher precision compared to internal focus of attention or non-guided condition (no instruction on focus localization). In many studies which dealt with different focus of attention and its impact on precision, similar results were obtained. Two groups with two different intervention focus (external and internal) were observed in golf (Wulf, Lauterbach and Toole, 1999). Better precision was noticed in both groups along the experiment duration, but significantly better was in the external focus group. Better precision in external focus of attention over internal focus of attention was also noted in volleyball players during tennis serve (Wulf et al., 2002) and in elite basketball players during free throw (Zachry et al., 2005). The external focus group (basketball rim) had better precision and more accomplished free throws then internal focus group (wrist joint). In their experiment Lohse et al. (2010) tried to explain in which way external focus of attention changes the movement itself on a dart board motor task under different focus of attention. Better precision was noticed under external focus of attention, but interestingly different movement variability was perceived under different focus localization. During external focus of attention, the motor control system tunes in a way to optimize the objective goal of the task (center of the target), while internal focus of attention is concentrated on movement itself. Therefore, in external focus of attention, one notices higher precision (movement outcome), and also higher variability between certain body parts. Concretely, this means that during dart throws in external focus of attention, position and angle velocity of certain joints change in space from throw to throw, indicating that using external focus of attention may facilitate compensatory variations during movement to preserve the movement effect, whereas focusing on the movement may reduce movement variability (through increased muscle stiffness) but at the expense of the movement outcome (Wulf and Prinz, 2001).

Although significant, the obtained smaller differences in results could be explained in several ways. Firstly, since the subject sample consisted of elite archers, their participation in this experiment could only be arranged during preparation or transition period through the season periodization, which undoubtedly implicit certain physical and mental setup different than that during competition period. Additionally, recreating competition surroundings during practice and especially with an ongoing experiment is still very challenging for both researchers and practitioners and could be the potential disturbing factor in not being *in the zone* at the desired time. Secondly, according to anecdotal statements, when faced with lesser performance or result, archers tend to overthink and overanalyze their technical performance, switching their focus from distal to more proximal and slowly moving away from the relaxed state of movement and mind. One of the key technical elements of elite archery performance is the release, described as unhindered exit of the bow string from the archer's back fingers as a consequence of the relaxation of the finger flexor muscles during active moving of the back scapula towards spine (Čižmek, 2007). Frequent mistakes during release often include lateral deflection of back fist (Horsak and Heller, 2011), inaccurate contraction of the finger flexor muscles, activation of the finger extensor muscles and the prolapse of the scapula which directly affects the shot (Ertan, 2009; Ertan et al., 2003; Ertan et al., 2011). This technical element is exceptionally complex and even with elite archers it demands synthetic method of practice and repetition in order to automatize this fine-tuned composition of different physical, mental, audio and visual senses. According to constrained action hypothesis (Wulf, McNevin and Shea, 2001; McNevin, Shea and Wulf, 2003) during internal focus of attention (on movement itself), the motor system does not direct the attention to the task outcome, but it regroups in order to decrease the possible errors in body position. This new reorganization optimally functions with the task of accurate kinematic body positioning in the space, but consequently leads towards lesser accuracy of the outcome.

Conclusion

Elite sport today is a game of millimeters and hundredths of a second. Scientists, coaches, practitioners and athletes strive to identify and hierarchically position all skills, specific features and mental states responsible for success in a certain activity, optimal levels of this characteristics and states, training methods, and possible differences in real competition conditions in relation to the required states and characteristics. Top archery shooting includes perfect performance of the elements of the technique by precise repetition of all kinematic parameters of chosen or key body coordinates with the outcome of accurate and desirable positioning of the arrows in the center of the target face. For that reason, the mental aspect in archery has a very important place in the success equation, and special attention should be put on choosing adequate orientation of focus during shooting. A vast number of research studied the influence of different focus of attention in different sports, but this research is the first one done with the top archers. In this research top archers demonstrated higher result values, i.e. better shot precision when shooting in externally oriented focus of attention condition compared to internally oriented and freely oriented focus of attention (control condition).

It is important to say that this paper has some limitations. A relatively small subjects sample was due to the availability of top archers caused by their athletic obligations, travels to tournaments and camps, academic and family duties and commitments. A larger number of subjects would undoubtedly provide more reliable data. Furthermore, although the subjects were asked to give their honest feedback in the manipulation check, their truthfulness and complete answer independence could not be fully determined. Hopefully, the scientific contribution of this paper will broaden the understandings of the orientation of focus of attention process and its impact on the outcome of the motor activities (result).

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Corresponding information:

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Correspondence to: Andrea Vrbik
University: University of Zagreb
Faculty: Faculty of Kinesiology
Phone: +385 99 69 48 662
E-mail: nea1370@hotmail.com