Journal of Applied Sciences

ISSN 1812-5654

ANSInet
an open access publisher
http://ansinet.com

Journal of Applied Sciences 7 (17): 2423-2429, 2007
ISSN 1812-5654

Effect of Attention of Focus Feedback on Error-Detection Capability in Bimanual Coordination Task

[1]Mohsen Shafizadeh, [1]Abbas Bahram and [2]Ahmad Farokhi
[1]Department of Physical Education,
Tarbiat Moallem University, Hessari Ave, Mirdamad Blv, Tehran, Iran
[2]Department of Physical Education, Tehran University, Iran

Abstract: The aim of present investigation was to study the effect of attention of focus feedback on the error-detection capability. Forty eight (24 males and 24 females) undergraduate students who participated in this study voluntarily divided into four experimental groups according to estimation condition (estimation/no estimation) and focus of feedback (internal/external). The task was bimanual coordination that the subjects should to move two slides from back to front to produce given relative phase (in phase) and move a pointer to intercept a ball at given movement time. Mixed factorial analysis of variance (ANOVA) showed that in acquisition phase, there were the estimation and feedback interaction effect on relative phase and estimation, feedback and trials interaction effect on movement time for Absolute Constant Error (ACE) and Root-Mean-Square-Error (RMSE). In addition, in the retention phase, there was an estimation and feedback interaction effect on relative phase for ACE, so no estimation-internal and estimation-external groups were better than other groups. In conclusion, learners' sensitiveness to sensory information that focuses their attention to movement effect or external-focus comparing to movement itself or internal-focus, increase learning. Thus, one of the effects of external-focus feedback on motor learning is error-detection capability that it added to other mechanisms that proposed in this regard previously.

Key words: External-focus feedback, internal-focus feedback, error-detection capability

INTRODUCTION

One of the important issues in the learning of motor skills is feedback. There are two kinds of feedback. Intrinsic feedback that produced by sensory information such as visual, auditory, kinestitics and so on that results from within body. Another feedback source is outside of body that produced by others or a special instrument which called augmented feedback (Magill, 2004).

One of the augmented feedback functions that recently has considered in several studies is attention of focus function (Shea and Wulf, 1999; Wulf *et al*., 2002). Even so, every information in before movement (instruction) and after movement (feedback) can facilitated the learning but how these information for proper application can attended the learner depended on it's attention on movement itself (internal-focus) or movement effect or outcome (external-focus) (Schmidt and Wrisberg, 2004). Most investigators (Shea and Wulf, 1999; Wulf *et al*., 2002, 2001; Wulf and Weigelt, 1997, 1998, 1999; Poolton *et al*., 2006; Black, 2004; Hiraga *et al*., 2005) have shown that the external-focus information had better learning than internal-focus information.

Some theories or hypothesis (Wulf *et al*., 2001, 1998; Wulf and Prinz, 2001; Zachry *et al*., 2005; Vance *et al*., 2004; Poolton *et al*., 2006) proposed for the effects of external-focus information on the learning of motor skills.

Wulf *et al*. (2001) in their study showed that external-focus information caused a reduction in attentional needs for motor system but internal-focus information involved more information processing for motor control. In addition, Wulf and Prinz (2001) stated that internal-focus information act as frequent feedback, because it attended one's foci on the movement process that can deteriorated learning. According to the common coding view (Wulf *et al*., 1998), efferent and afferent codes can be generated and maintained in a commensurate way only at a distance level of representation. William James in his ideomotor principle proposed that every representation of a movement awakens in some degree the actual movement. On the contrary, the accumulation of explicit rules to guide performance was responsible for the

Corresponding Author: Mohsen Shafizadeh, Department of Physical Education, Tarbiat Moallem University, Hessari Ave, Mirdamad Blv, Tehran, Iran Tel: 0098-21-88428959

performance deterioration of internal-focus under secondary task loading conditions (Poolton *et al*., 2006). Also, constrained action hypothesis (Wulf *et al*., 2001, 2002; McNevin *et al*., 2000) stated that with internal attention, consciously control of movement constraints the motor system by interfering with automatic motor control processes. On the other hand, external attention might allow the motor system to more naturally self-organized, unconstrained by the interference caused by conscious control attempts. Recent studies (Vance *et al*., 2004; Zachry *et al*., 2005) have revealed that the external-focus benefits could to explain through movement economy. They demonstrated that the electromyography (EMG) activities in external-focus were significantly lower than internal-focus in barbell-curl and free-throw tasks. Collectively these theories verified the facilitation of the automatic process and reducing the conscious control of motor system by external attention that lead to the effective performance and learning.

The purpose of present investigation was to study the effect of attention of focus feedback on the error-detection capability. As mentioned above, the previous studies have considered the learning effectiveness of attention of focus other than error-detection capability. The function of feedback on error-detection is well documented in the Adam's close-loop (1971) and schema theories (Schmidt and Lee, 2005). KR develops recognition schema and perceptual trace through the evaluating of the actual movement outcome and sensory information relationships. If these two information sources had any differences, the KR provides some information for the performers to reduce their errors. According to response hypothesis how one is engaged prior to receiving KR may not be independent of how one uses KR. In other words, after the completion of a trial, the learner will estimate how successful he/she was on that trial. The learner then assesses the correctness of this estimation by comparing it to the KR received. Based on this comparison, a response hypothesis, or plan, is derived for the next response (Guadagnoli and Kohl, 2001).The error estimation in addition to reinforcement role can attended the performer on the executing movement and therefore the learners evaluation from their performance is one of the helpful activities that might developing error detection capabilities (Swinnen, 1988). Shapiro *et al*. (1984) with applying different estimation/no estimation combination in timing task, revealed that in the transfer phase the error of estimation group was lesser errors than other no- estimation groups. Swinnen (1988) in gymnastic skills showed that movement error estimation by the performer resulted in better performance.

According to closed-loop and schema theories, if the augmented feedback can facilitated the learning, also, the kind and how the feedback is presented is important. Swinnen *et al*. (1990) in their study showed that the use of instantaneous feedback can discourage the processing of intrinsic response-produced feedback which would lead to the learning of the capability to detect errors in future performances. Guadagnoli and Kohl (2001) in the study with force production task showed that, the group that received 100% KR and was required to error estimation during acquisition, performed best during retention. Thus, response planning for the future trials facilitated through the use of intrinsic feedback with receiving frequent KR.

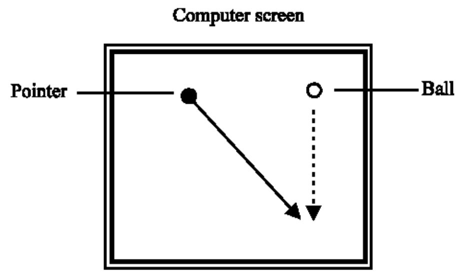
Thus, the question of error-detection capability in this investigation have focused for two reasons: the effect of attention of focus feedback on the error-detection capability as a mechanism of learning process and alternatively, as a type of feedback presentation (internal/ external attention of focus).It means that, if the augmented feedback can helps the performer in movement correction whether it can be acceptable through the attention of focus function. Second, which part of movement (pattern/outcome) components might be benefit from the error estimation and feedback-focus? Previous findings had methodological limitations in studying the two components of motor programs of movement skills (Wulf *et al*., 2002) and in this study the separate measurements is used for movement pattern and outcome.

MATERIALS AND METHODS

Subjects: A total of 48 (24 females and 24 males) undergraduate students (range 20-25 years) from the Teacher Training University have participated in this experiment, voluntarily. None of them had prior experience with the task and all of them were right handed and naïve as to the purpose of the experiment.

Apparatus and task: The apparatus that used for this experiment (Fig. 1) was bimanual coordination simulator. This apparatus consisted of two parts: hardware and software. In the hardware part, two sliding aluminum lever moved with two hands to produce target coordination pattern (in phase). In the screen monitor, a moving ball should to intercept with a pointer that moved through the sliding levers. The right lever motion form back to forth, displaced the pointer to the down and the left lever motion from back to forth, displaced the pointer to the right. So, with two lever motions simultaneously, the pointer displaced in the oblique line from up-left to down-right. The task was to intercept the moving ball with the sliding levers in the given location and movement time. In

A



B

Fig. 1: A. Apparatus: two aluminum slides should to move in-phase from back to front through extension of right and left arms simultaneously, B. Coincident-timing task in which the pointer should to intercept with ball in a given location as show by arrows

the other word, the subjects should to move levers simultaneously according to zero relative phases (in phase coordination pattern). The ball that dropped vertically and arrived to the given location in the 3000 m sec^{-1}. Also, the ball in the first half of the trajectory was appeared, but in the second half of the trajectory disappeared, thus the subjects couldn't observe their outcome and depended to the augmented feedback.

Procedure: The experiment conducted in the motor behavior lab of physical education department. All participants informed the procedure of the task before did it. Participants according to the experiment purpose sat on behind the table and took the sliding levers with their hands. The levers placed in the back position, in start point. Participants informed that the good results depended to the oblique displacement of pointer in zero relative phase (in phase) and synchronizing of the ball and pointer velocity. This information showed graphically and numerically in green color on computer monitor. It noted that, in all trials the pointer was revealed but the ball in the half of its motion was appeared. Thus in the final point of the ball motion it's not observable and subjects couldn't use intrinsic feedback. The organization of practice was constant in all trails.

The estimation groups should to report subjectively their movement time and relative phase at interception point after 5 sec of each trail completion and before receiving augmented feedback. On the other hand, the no-estimation groups did anything in KR-delay interval. The external-focus feedback group estimated the relative phase of the levers and time difference between ball movement time and pointer. The internal-focus feedback group estimated the difference of two hands relative phase and movement time. The feedback information for two groups was different according to their attention of focus. For external-focus it was related to actual relative phase of levers and time difference between ball movement time and pointer as a motor pattern and parameter, respectively. In parallel, for internal-focus it was related to actual relative phase and movement time of hands. This information appeared in red color on computer monitor until 10 seconds and then disappeared. The experiment consisted of two phases, acquisition and retention. The acquisition phase had 90 trails that divided into 6 blocks of 15 trails. After 24 h the retention test performed in which all participants performed 15 trails without feedback and subjective estimation on the initial task.

Dependent variable and data analysis: The dependent variables of this experiment were timing and relative phase accuracy and general measure of error (accuracy and consistency) that computed as following equations:

$$|CE| = \Sigma \mid (X_i\text{-}T)/n|$$

Where the trail (s) movement time and relative phase (X_i) subtracted from goal movement time and relative phase (T) for all trials to compute performance accuracy.

Root Mean Square Error (RMSE) as a measure of general error obtained from following equation:

$$RMSE = \sqrt{\Sigma\,(X_i - T)^2 / n}$$

The four dependent measures in acquisition were subjected to a 2 (focus-feedback) * 2(estimation condition) * 6 (block of trails) mixed analysis of variance (ANOVA) with repeated measure on last factor. In retention, a 2 (focus-feedback) * 2 (estimation condition) analysis of variance was used to measure program and parameter learning. The Newman-Keuls method was used for all post hoc comparisons. Statistical significance was set at $p<0.05$.

RESULTS

The results of Absolute Constant Error (ACE) and Root Mean Square Error (RMSE) for relative phase and movement time presented in Fig. 2-5, respectively.

Acquisition phase: Relative phase. The results indicated that there was significant interaction for attentional-focus *estimation condition for absolute CE, $F(1, 220) = 3.66$, $p<0.05$ and RMSE, $F(1, 220) = 3.31$, $p<0.05$ but there was not significant main effects, $p>0.05$. Newman-Kauls post

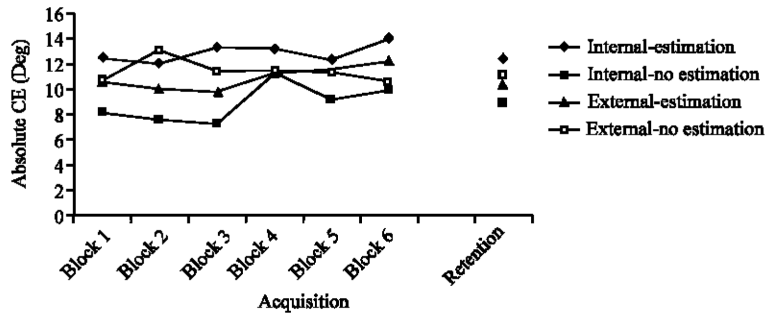


Fig. 2: Relative phase absolute CE in acquisition and retention phases

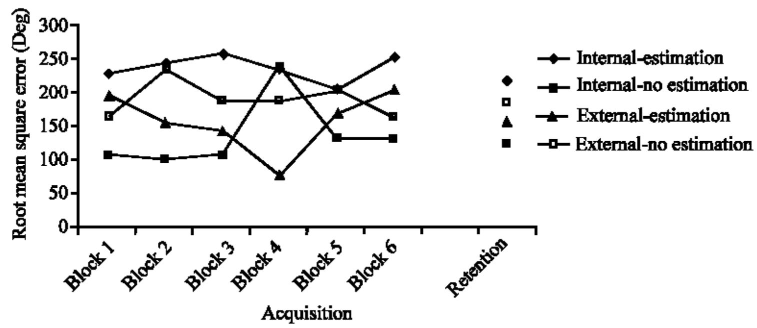


Fig. 3: Relative phase RMSE in acquisition and retention phases

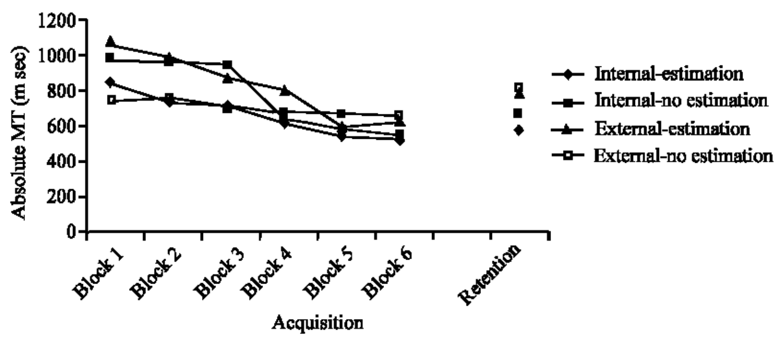


Fig. 4: Movement time absolute CE in acquisition and retention phases

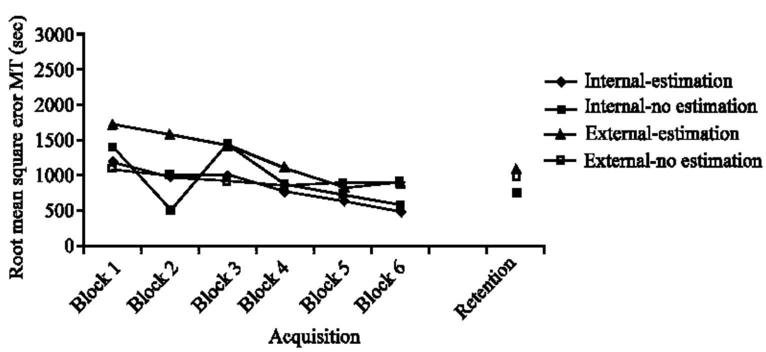


Fig. 5: Movement time RMSE in acquisition and retention phases

hoc test showed that no estimation-internal focus and estimation-external focus groups had better performance than other groups.

Movement time: The results showed that there was significant interaction for attentional-focus * estimation condition*blocks of trails for absolute CE, $F(5,220) = 2.44$, $p<0.05$ and RMSE, $F(5,220) = 2.17$, $p<0.05$. Newman-Keuls tests showed that estimation and no estimation internal-focus groups had lower error in fifth and sixth block of trails than other groups.

Retention phase: Relative phase. The results of ANOVA for absolute CE showed no significant main effects and interaction for attentional-focus and estimation condition, $p>0.05$. But for RMSE the results showed that there was a significant interaction for estimation condition* attentional-focus, $F(1, 44) = 4.41$, $p<0.05$. Newman-Kauls post hoc test showed that no estimation-internal focus and estimation-external focus groups had better learning than other groups.

Movement time: The results for absolute CE and RMSE showed no significant main effects and interaction for attentional-focus and estimation condition, $p>0.05$.

DISCUSSION

The purpose of present investigation was to study the effect of attention of focus feedback on the error-detection capability. The findings have revealed that the performance and learning of bimanual coordination pattern in estimation-external focus and no estimation-internal focus groups and performance of movement time in internal focus groups were better than other groups. In the other word, error detection capability development through error estimation practice depends on type of attention of focus feedback. It means that after estimation, if feedback focuses the performer attention externally resulted in better learning of coordination pattern, but if it focuses the performer attention internally can deteriorate the learning of bimanual coordination. These findings supported the previous studies on the error detection, but they referred to the other aspects than attention of focus feedback. For example, Swinnen *et al.* (1990) showed that immediate feedback had a detrimental effect on error detection capability. Guadagnoli and Kohl (2001) have shown that the frequent KR after subjective estimation is more beneficial than the least KR for response plan. In fact, the present study has demonstrated that not only KR frequency but also attention of focus of KR has a significant role for response planning. It means that, the performer can received subtle information through frequent KR and error detection practice that attended their attention on them. It can be stated that as the learner become more proficient in producing their movement, they also become more adept at recognizing and correcting errors that occur. Since, the errors may be due to faulty movement selection or to improper execution of the intended action, with practice learners begin to pay more attention to relevant sensory feedback information. Practitioners can enhance the development of learner's error detection capability by encouraging them to become sensitive to movement-produced feedback. One way instructors might do this is to ask individuals to estimate what they feel happened before the instructor gives them any feedback. Having individuals estimate characteristics of their movements or the outcomes they produced requires them to devote attention to the feedback that arises from the action. This type of practice helps increase learners' familiarity with such (informational) feedback, leading to an improved capability of detecting errors (Schmidt and Wrisberg, 2004).

In addition, the present findings can support the constrained action hypothesis. According to this hypothesis (Wulf and Prinz, 2001; McNevin *et al.*, 2000) trying to consciously control one's movements constraints the motor system by interfering with automatic motor control processes that would normally regulate the movement. Focusing on the movement effect might allow the motor system to self-organize more naturally, unconstrained by the interference caused by conscious control attempts and resulting in more effective performance and learning. It appears that automaticity can be considered in essentially two ways. First, the specialized information-processing structures are learned with practice and that they handle portions of the processing requirements of the overall task such as feature detection and movement selection. By handling information-processing in this way the performer decreases the interference with other cognitive activities. Another view is possible in some tasks that are predictable and stereotyped; a major process of learning appears to be shift from higher level of conscious control to a lower level programming control. With predictable tasks, the regularities of the environmental information can be learned and therefore can be anticipated during performance. If so, then the performer does not have to process this information directly but rather preprograms the long sequences of movement based on the prediction of the environmental information. For example, the experienced drivers no longer have to watch their feet as they move from accelerator to brake in the car. Thus being able to avoid processing environmental information leaves those conscious information processing activities free for other task cues and makes the task appear automatic at least with respect to particular kinds of activities. It seems that this fact to hold truth for present findings. Informational feedbacks that attended the performer's focus on environmental cues rather than limbs through error estimation in predictable condition result in effective performance and learning and enhance natural self-organization. According to present results, the estimation-external focus group had lower pattern error than other groups because they used external cues that helped them to adapt to needs of task, e.g., to get a whole picture of correct movement pattern.

Since, invariant feature of motor program for bimanual coordination task in present experiment enhanced through estimation or no estimation practice with regard to type of attention of focus feedback, but the learning of parameter (MT) remained the same can be explained through the separation of generalized motor program and parameter viewpoint. Even though error detection capability development demonstrated for GMP (Swinnen, 1988) and parameter (Schmidt *et al.*, 1990; Guadagnoli and Kohl, 2001; Wulf *et al.*, 1994) in the present investigation, but the parameter error detection had a temporarily effect. This result is in contrary to previous researches (McNevin *et al.*, 2000; Wulf and Weigelt, 1997; Shea and Wulf, 1999; Black, 2004) in which parameter leaning enhanced with external-focus instructions. One reason might be the type of practice. In the present study subjects practiced constantly but not variable. This kind of practice does not facilitate parameterization and feedback has no significant effect on it (Schmidt and Wrisberg, 2004). In spite of practice condition, the present investigation have revealed that the learning effectiveness of external-focus feedback as have demonstrated in previous studies can be generalized in two components of motor program, specially movement pattern that there were some methodological limitations for measuring it in previous investigations.

In conclusion, this study revealed that presenting external-focus feedback after error estimation facilitated the learning of relative phase (pattern) but presenting internal-focus feedback after error estimation deteriorated it, thus it is suggested that the instructors utilize external-focus feedback after asking the performers to estimate their errors, but through utilizing internal-focus feedback does not ask performers to estimate their errors. These findings supported previous hypothesizes about the function of external-focus information in the learning of motor skills, in which one of the consequences of learning is error-detection and external-focus feedback can develop this capability through connecting augmented feedback with sensory feedback. These findings are added to previous explanations about the mechanisms of external-focus effect on motor learning.

ACKNOWLEDGMENT

We would like to thank Gabriele Wulf (University of Las Vegas, USA) for her helpful suggestions on methods and research design.

REFERENCES

Adams, A., 1971. A closed -loop theory of motor learning. J. Motor Behav., 3: 111-149.

Black, C., 2004. Internal focus of attention is superior to external focus when training is extended to several weeks. In: Proceedings of the NASPSPA Congress, 15 June, 2004, Canada.

Guadagnoli, M.A. and R.M. Kohl, 2001. Knowledge of results for motor learning: The relationship between error estimation and frequency. J. Motor Behav., 33: 217-224.

Hiraga, C.Y., J.J. Summers and J.J. Temprado, 2005. Effects of attentional prioritization on the temporal and spatial components of an interlimb circle-drawing task. Hum Movement Sci., 24: 815-832.

Magill, R.A., 2004. Motor Learning, Concepts and Applications. 6th Edn., McGraw-Hill Company.

McNevin, N.H., G. Wulf and C. Carlson, 2000. Effects of attentional focus, self-control and dyad training on motor learning: Implications for physical rehabilitation. Phys. Ther., 80: 373-385.

Poolton, J.M., J.P. Maxwell, R.S.Masters and M. Raab, 2006. Benefits of an external focus of attention: Common coding or conscious processing. J. Sports Sci., 24: 89-99.

Schmidt, R.A., C. Lange and D.E. Young, 1990. Optimizing summary knowledge of results for skill learning. J. Hum. Movement Sci., 9: 325-348.

Schmidt, R.A. and C.A. Wrisberg, 2004. Motor Learning and Performance. 3rd Edn., Human Kinetics Publisher.

Schmidt, R.A. and T.D. Lee, 2005. Motor Control and Learning. 4th Edn., Human Kinetics Publisher.

Shapiro, D.C., R.A. Schmidt and S. Swinnen, 1984. Error estimation and the structure of the practice session. Scientific Program Abstracts of the 1984. Olympic Scientific Congress.

Shea, C. And G. Wulf, 1999. Enhancing learning external-focus instructionsand feedback. Hum. Movement Sci., 18: 553-571.

Swinnen, S.P., 1988. Post performance activities and skill learning. J. Hum. Movement Sci., 8: 315-338.

Swinnen, S.P. and R.A. Schmidt, D.E. Nicholson and D.C. Shapiro, 1990. Information feedback for skill acquisition: Instantaneous KR degrades learning. J. Exp. Psychol. Learning Mem. Cogn., 16: 706-716.

Vance, J., G. Wulf, T. Tollner, N. McNevin and J. Mecer, 2004. EMG activity as a function of the performer's focus of attention. J. Motor Behav., 36: 450-459.

Wulf, G., T.D. Lee and R.A. Schmidt, 1994. Reducing KR about relative versus absolute timing: Differential effects on learning. J. Motor Behav., 26: 362-369.

Wulf, G. and C. Weigelt, 1997. Instructions about physical principles in learning a complex motor skill: To tell or not to tell. Res. Q. Exerc. Sport, 68: 362-367.

Wulf, G., M. Hob and W. Prinz, 1998. Instructions for motor learning: Differential effects of internal versus external focus of attention. J. Motor Behav., 30: 169-179.

Wulf, G., B. Lauterbach and T. Toole, 1999. The learning advantage of an external focus of attention in golf. Res. Qu. Exerc. Sport, 70: 120-126.

Wulf, G., C. Shea and J. Park, 2001. Attention and motor performance: Preferences for and advantages of an external focus. Res. Qu. Exerc. Sport, 72: 210-218.

Wulf, G. and Z.W. Prin, 2001. Directing attention to movement effects enhances learning: A review. Psychonomic Bull. Rev., 8: 648-660.

Wulf, G., N. McNevin and C. Shea, 2001. The automaticity of complex motor skill learning as a function of attentional focus. Q. J. Exp. Psychol., 54: 1143-1154.

Wulf, G., N. McConnel, M. Gartner and A. Schwarz, 2002. Enhancing the learning of sport skills through external-focus feedback. J. Motor Behav., 34: 171-182.

Zachry, T., G. Wul, J. Mercer and N. Bezodis, 2005. Increased movement accuracy and reduced EMG activity as the result of adopting an external focus of attention. Brain Res. Bull., 67: 304-309.