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Full Length Article

Implicit learning increases shot accuracy of football players when making strategic decisions during penalty kicking

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ABSTRACT

Implicit learning has been proposed to improve athletes' performance in dual-task situations. Yet, only a few studies tested this with a sports-relevant dual-task. Hence, the current study aimed to compare the effects of implicit and explicit training methods on penalty kicking performance. Twenty skilled football players were divided in two training groups and took part in a practice phase to improve kicking accuracy (i.e., without a goalkeeper) and in a post-test in order to check penalty kick performance (i.e., accuracy including a decision to kick to the side opposite the goalkeeper's dive). Results found that the implicit and explicit training method resulted in similar levels of decision-making, but after implicit training this was achieved with higher kicking accuracy. Additionally, applications for football players and coaches are discussed.

1. Introduction

The human capacity to perceive the intricacies of the environment and make appropriate decisions within an instant is astonishing. This capacity is especially developed in elite athletes, who – unlike less skilled players – usually can maintain perceptual and performance accuracy despite the many (unexpected) changes and high pressure, which characterize competitive sports situations (Mann, Williams, Ward & Janelle, 2007; Sibley & Etnier, 2004). In fact, competitive performance situations typically require the athlete to address multiple tasks simultaneously (Ripoll, Kerlirzin, Stein & Reine, 1995). Movement automaticity is a pertinent factor in the athlete's capacity to execute multiple tasks. For instance, it is by virtue of the automatization of action that skilled football players can at the same time decide whether to pass the ball to a teammate, shoot on goal, or dexterously dribble by opponents *and* maintain control over the ball. By contrast, less skilled players must attend to their actions and the ball, requiring a good amount of cognitive resources. Consequently, at the same timing making strategic decisions more likely results in overloading, hampering the skilled players' ability to produce accurate actions.

An effective way to accelerate automaticity of action is through implicit learning. It has been shown that following implicit learning methods, performance decrements caused by simultaneously executing a second task (e.g., backward counting or tone identification) are significantly reduced compared to explicit learning methods (Lam, Maxwell, & Masters, 2009; Maxwell, Masters,

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Kerr & Weedon, 2001; Poolton, Masters & Maxwell, 2005). Explicit learning methods stimulate the accumulation of declarative knowledge about how to move, and result in a prolonged reliance on conscious control in action execution. Instead, implicit learning methods directly promote the built-up of procedural knowledge by circumventing working memory such that the accumulation of declarative knowledge is minimized (e.g., Masters, 1992; Masters & Maxwell, 2004; Maxwell, Masters & Eves, 2003). The resulting reduction in working memory involvement allows for the concurrent execution of additional tasks. Accordingly, action execution following implicit learning has been argued to be more robust under dual tasks situations than after explicit learning (MacMahon & Masters, 2002; Masters, Poolton, Maxwell & Raab, 2008). Additionally, implicit methods result in better performance maintenance in high-pressure situations (Masters, 1992; Maxwell, Masters & Eves, 2000).

A sport situation par excellence that can involve both dual tasking and high-pressure is the penalty kick in football, if, that is, the penalty taker adopts a goalkeeper-dependent strategy. In the goalkeeper-dependent strategy, the kicker intends to direct the ball to the side opposite of the goalkeeper's dive (van der Kamp, 2006). A successful penalty kick requires that the penalty taker produces an accurate, well-controlled kicking action *and concurrently* accurately watches the goalkeeper and makes strategic decisions to which side to kick the ball. In other words, it is a defining feature of the goalkeeper-dependent strategy that a conscious decision is made while kicking. This makes the goalkeeper-dependent strategy essentially a dual task.

It is to be expected that practicing kicking skill and accuracy in an implicit manner will benefit penalty kick performance with a goalkeeper-dependent strategy compared to performance following an explicit intervention to improve kicking accuracy. This conjecture, however, is largely based on studies that investigated the effects of dual tasking using a second task that is largely irrelevant to sports situations (e.g., participants respond to auditory tones or generate letters in a random sequence, see Beilock, Wierenga, &, Wierenga, & Carr, 2002; Carr, Etnier, & Fisher, 2013; Lam, Maxwell, & Masters, 2009). In these studies, dual tasking serves to assess action automaticity. That is, dual tasking helps to infer the amount of conscious control a participant needs to maintain action performance levels (Lam, Maxwell, & Masters, 2010). The primary motor action is considered automatized and without need of conscious control, if concurrent performance with a second task does not result in performance decrements relative to single task performance (Abernethy, 1988). Although many researchers have examined implicit learning methods for sports-related tasks, only few studies included the effects of sports-relevant concurrent tasks to test the automaticity of action (Masters et al., 2008; Raab, Masters & Maxwell, 2005).

One example is the study by Masters et al. (2008). These authors investigated the resilience of action against dual tasking following implicit and explicit learning interventions using decision-making in a complex sport task. Participants first practiced a table tennis shot either implicitly (i.e., analogy learning) or explicitly (i.e., six step-by-step verbal instructions) and were then tested in two decision-making conditions. The low-complexity condition required participants to aim balls to left or right side depending on their colour, while in high-complexity condition the regularity between ball colour and side alternated. The participants' ability to accurately hit the ball to the correct side was only jeopardized for the explicit learners in the high-complexity condition. The implicit learners maintained action performance levels in both decision-making conditions. This suggests that following implicit learning participants had more cognitive resources available for decision-making, presumably due to a higher degree of automatization of the table tennis shot.

Our aim here was to investigate whether implicit learning methods, which aim to improve kicking accuracy, promote – after practice – kicking accuracy when adopting the goalkeeper-dependent strategy, which requires players to make strategic decisions regarding the side to shoot. More in general, we tested the benefits of implicit learning in the context of a sport-relevant dual task. As briefly mentioned above, football players can either adopt a goalkeeper-independent or goalkeeper-dependent strategy when taking a penalty kick (van der Kamp, 2006). On the one hand, in the goalkeeper-independent strategy, the kicker decides where to aim the ball before starting the run-up to the ball and holds on to that decision irrespective of the goalkeeper's actions. In the goalkeeper-dependent strategy, on the other hand, the kicker intends to kick to side opposite of the side the goalkeeper is going to dive. The final decision on the side to kick the ball thus depends on the goalkeeper's actions. Accordingly, the kicker must extract information from the goalkeeper's action during the run-up and the execution of the kick to decide kick direction. Anticipating and deciding where to kick at the same time as producing the run-up and the kick action defines taking a penalty kick as a dual-task. Morya, Ranvaud and Pinheiro (2003) suggested that when the time available to make the decision is reduced, for instance because the goalkeeper starts moving late, this adversely affects a kicker's ability to accurately direct the ball to the side opposite to the goalkeepers dive. Indeed, it has been reported for in-situ penalty kicking situations that penalty takers require approximately 500–600 ms to accurately and forcefully kick the ball to the intended side; with less time available decision making and/or kicking accuracy was jeopardized (Bowtell, King & Pain, 2009; van der Kamp, 2006, 2011). If implicit learning methods indeed lead to a reduction in the contribution of cognitive resources to produce actions, then the implicit practice of kicking accuracy might diminish the adverse affects on decision-making and kicking accuracy.

In sum, the current study examined whether an implicit learning method enhances kicking accuracy and/or decision making among penalty takers who adopt a goalkeeper-dependent strategy in comparison to explicit methods. To this end, two groups of high skilled football players practiced kicking accuracy in either an implicit or an explicit manner. We manipulated the degree of implicit and explicit learning during three practice sessions by varying the order and saliency of changes in task difficulty, which is (partly) based on validated protocols that induce different amount of errors during practice (i.e., errorless learning, Maxwell, Masters, Keer, & Weedom, 2001). Task difficulty was manipulated by using differently sized target areas (cf. Poolton, et al., 2005). Accordingly, the participants that underwent the implicit method started each session with low task difficulty (i.e., large target area) with task difficulty gradually increasing (i.e., small target areas) toward the end of the sessions. In contrast, participants who followed the explicit method were presented with continuous changes in task difficulty, with differences between subsequent trials being so large