



## Action preferences and the anticipation of action outcomes



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### ARTICLE INFO

#### Article history:

Received 15 November 2013  
Received in revised form 8 July 2014  
Accepted 12 July 2014  
Available online 2 August 2014

#### PsycINFO classification:

2323  
2330  
3720

#### Keywords:

Anticipation  
Motor actions  
Situational probability  
Performance analysis  
Penalty  
Handball

### ABSTRACT

Skilled performers of time-constrained motor actions acquire information about the *action preferences* of their opponents in an effort to better anticipate the outcome of that opponent's actions. However, there is reason to doubt that knowledge of an opponent's action preferences would unequivocally influence anticipatory responses in a positive way. It is possible that overt information about an opponent's actions could distract skilled performers from using the advance kinematic information they would usually rely on to anticipate actions, particularly when the opponent performs an 'unexpected' action that is not in accordance with his or her previous behaviour. The aim of this study was to examine how the ability to anticipate the outcome of an opponent's actions can be influenced by exposure to the action preferences of that opponent. Two groups of skilled handball goalkeepers anticipated the direction of penalty throws performed by opponents before and after a training intervention that provided situational probability information in the form of action preferences (AP). During the training phase participants in an *AP-training* group anticipated the action outcomes of two throwers who had a strong preference to throw in one particular direction, whilst participants in a *NP-training* group viewed players who threw equally to all directions. Exposure to opponents who did have an action preference during the training phase resulted in improved anticipatory performance if the opponent continued to bias their throws towards their preferred direction, but decreased performance if the opponent did not. These findings highlight that skilled observers use information about action preferences to enhance their anticipatory ability, but that doing so can be disadvantageous when the outcomes are no longer consistent with their generated expectations.

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### 1. Introduction

The 2006 FIFA World Cup quarter-final between Germany and Argentina was an exciting game whose result, like many other football matches, was decided by a penalty shootout. Intriguingly, observers around the world watched on as the German goalkeeper, Jens Lehmann, prepared for the shootout by taking a small piece of paper from inside his sock that showed him where the Argentinian players typically directed their kicks in penalty situations. By doing so, Lehmann was attempting to enhance his likelihood of success by using supplementary information about the individual action preferences of his opponents. Lehmann's awareness of the kicking preferences of his opponents appeared to help him, as Germany went on to win the penalty shoot-out by five goals to three as a result of Lehmann successfully saving two penalties from his Argentinian opponents. Consequently, the story about the small piece of paper Jens Lehmann kept inside his sock has become a legendary fable in footballing folklore, and this and other similar stories have most likely played a role in the proliferative use of

probabilistic information in professional (and semi-professional) sport. However, whilst it might seem intuitive to think that knowledge about an opponent's action preferences should help in these types of scenarios, it is possible that Lehmann's success came about in spite of – rather than as a result of – his knowledge of the action preferences of his opponents. The very explicit information about the action preferences of an opponent could encourage skilled performers to adopt strategies that are less reliable than the ones they would typically use. In essence, by expecting one particular action outcome to occur, the skilled performer may be less likely to use the information that they have consistently relied on throughout their development to anticipate the outcome of their opponents' actions.

The ability to anticipate the actions of others is an important skill that supports the way humans interact. Movement-specific (kinematic) information can provide useful insights into a person's identity, mood, intention, and crucially, about the likely outcome of their movement (Blake & Shiffrar, 2007). For instance, skilled athletes across a broad range of different sports are better than novices at predicting the outcome of their opponents' actions (Abernethy & Russell, 1987; Jones & Miles, 1978). As a case in point, skilled soccer goalkeepers (like Jens Lehmann) are able to anticipate the likely outcome of an opponent's penalty kick even before the moment the ball is kicked. They do so by observing the movements of the kicker's hips, supporting (non-kicking) leg, and kicking leg to provide clues about where the ball is likely to

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be directed (Savelsbergh, van der Kamp, Williams, & Ward, 2005; Savelsbergh, Williams, van der Kamp, & Ward, 2002). Skilled athletes develop the ability to pick-up this advance kinematic information by virtue of experience, particularly when the temporal demands of the task become excessive (Weissensteiner, Abernethy, Farrow, & Müller, 2008). This information allows skilled performers to account for the tight time-constraints inherent in many sporting tasks by reacting earlier (Shim, Carlton, Chow, & Chae, 2005) and/or by facilitating their performance to ensure that they arrive in time to intercept their target (Dicks, Davids, & Button, 2010).

Whilst it is well established that action outcomes can be anticipated on the basis of kinematic information, more recent research has shown that non-kinematic information can also be used to facilitate the anticipation of action outcomes. Abernethy, Gill, Parks, and Packer (2001) demonstrated that *situational probability* information could be used to anticipate action outcomes based on the particular context in which the action was performed. In their study, expert and less-skilled squash players took part in simulated on-court match play whilst wearing liquid-crystal goggles that allowed their vision to be occluded at different moments during their opponent's stroke. Following visual occlusion, participants were required to continue to complete their response (by playing a return shot). Not surprisingly, if occlusion took place during the hitting action of the opponent, the expert players could better anticipate the direction to move in to play an appropriate response. More interestingly though, the expert players were also better able to anticipate the best direction to move in when occlusion took place *before* their opponent commenced their hitting action. That is to say, they were able to respond even when kinematic information about the opponent's shot was absent. Evidently, the skilled players were using their opponent's *position on the court* to predict the likely direction of the opponent's shot. This result demonstrates that skilled performers use contextually-specific information – in this case the court position of the opponent – to guide their anticipatory responses (see also Loffing & Hagemann, 2014). Crucially, this result raised the possibility that next to the pick-up of advance kinematic information, expert performers could also use a variety of probabilistic information to aid in their anticipation of action outcomes (see also Buckolz, Prapavesis, and Fairs (1988) and Paull and Glencross (1997), similar to the way that a priori information, 'priors', can influence motor behaviour, see Berniker, Voss, and Körding (2010), Körding and Wolpert (2004) and Narain, van Beers, Smeets, and Brenner (2013)).

Despite the pioneering contribution of the Abernethy et al. study, surprisingly few studies have since sought to examine the influence of probabilistic information on anticipatory performance. One exception is a recent study by Farrow and Reid (2012) who assessed the ability of junior tennis players to anticipate movement outcomes, in their case tennis serves, based on the game score when playing a specific opponent in a simulated match situation. Skilled junior players predicted the direction of tennis serves viewed on a television screen from the perspective of a receiving player, with serves shown as a series of games and sets, and the match-score shown prior to each serve. Critically, and unbeknown to the participants, the first serve in each game was always hit in the same direction. The analysis of participant response times found that a group of experienced junior players were able to detect and use this pattern to expedite their anticipation of subsequent serves. These results show that additional information about situational probabilities, in this case the game score, can help to enhance the speed with which skilled players react to actions. Further, it highlights that the ability to anticipate action outcomes on the basis of situational information appears to encapsulate information that is available both independently of, and specific to, the opponent producing the action. Whilst Abernethy et al.'s study points to the use of generic information (in that case court position) that is most likely to be available irrespective of the particular habits of the opponent, Farrow and Reid show that player-specific information (in that case the shot played by the opponent on a particular point) can also aid anticipatory performance.

Together, these studies provide examples where information about situational probabilities can be used based on particular contextual information (such as the court position of an opponent or the game score); however, similar types of probabilistic information can also be available even when most of this contextual information is absent. Individual performers can have a bias in the type of action they perform in any given scenario, even though there might normally be no specific advantage when performing that given action. For instance, there should be no specific advantage in aiming a penalty kick towards any particular corner of a goal if both the kicker and the goalkeeper are standing in line with the centre of the goal. However, actors can still possess their own individual *action preferences* in these situations, that is, there can be a bias in the relative distribution of their preferred actions. These action preferences may arise as a result of the actor's greater proficiency in executing one particular motor action over others, and/or simply because of their previous success when performing that action. Athletes tend to learn about the action preferences of their opponents, though historically athletes have been left to search for and identify these biases in their opponents' actions themselves. However, many professional sporting organisations now employ performance analysts to watch games and document probabilistic information on behalf of the players and coaches (e.g., Hughes & Bartlett, 2002). The example of Germany in the World Cup quarter-final highlights this, with players actively using information about action preferences in an effort to enhance their anticipatory ability. This raises the question of whether doing so is likely to provide an advantage – or a disadvantage – to the person attempting to anticipate the action outcomes of their opponent.

It seems reasonable to expect that knowledge of an opponent's action preferences should help to facilitate success when seeking to anticipate the outcome of their actions. Intuitively, learning that an opponent is more likely to perform one action over any other should lead to a better response; in essence, the observer will be expecting a particular outcome and should, as a result, be better prepared to respond to it. For instance, Navia, van der Kamp, and Ruiz (2013) have shown that when soccer goalkeepers are told that an opponent will direct a higher proportion of kicks in one direction, this knowledge of action preferences facilitates performance by improving both response time and response accuracy (see also Barton, Jackson, & Bishop, 2013). However, there are two key issues to consider which suggest that this might not necessarily always be the case. First, it is entirely possible that explicit guidance about the likely outcome of an action could well be a disadvantage as it could distract skilled performers from making the types of well-learned responses that they are accustomed to enacting. Skilled performers develop their expertise by using advance kinematic information to guide their motor responses (Shim et al., 2005), and they are thought to do so without necessarily having explicit knowledge of how or why the response was performed (Farrow & Abernethy, 2002; Jackson, Warren, & Abernethy, 2006; Mann, Abernethy, & Farrow, 2010). Therefore, by drawing attention towards particular outcomes or sources of information, additional information about the likely outcome may distract skilled performers from picking-up on the kinematic patterns they would usually rely on to anticipate action outcomes. The second key issue to consider is that, whilst knowledge of action preferences may provide some form of advantage when the opponent acts in accordance with their existing preferences, it may be a distinct *disadvantage* if there is incongruence between the expected and actual actions performed by the opponent (e.g., Gray, 2002a, 2002b). If the expected outcome (based on information about action preferences) matches the performed action, and hence also the advance kinematic information, then it seems plausible that the knowledge of the action preference should facilitate an advantage that is above and beyond that possible when relying on kinematic information alone. In contrast, if the expected outcome is in conflict with the advance kinematic information then it seems reasonable to expect that the information about action preferences may harm rather than support anticipatory performance.

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