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Representative design: Does the addition of a defender change the execution of a basketball shot?

Adam D. Gorman [a, b, *], Michael A. Maloney [a, c]

[a] Movement Science – Skill Acquisition, Australian Institute of Sport, Canberra, Australia
[b] School of Health and Sport Sciences, University of the Sunshine Coast, Sippy Downs, Australia
[c] College of Sport and Exercise Science, Institute of Sport, Exercise and Active Living, Victoria University, Melbourne, Australia

A R T I C L E I N F O

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A B S T R A C T

Objective: The aim of this study was to examine the influence of a defender on the performance of a motor skill from an invasion sport.
Design: Highly skilled basketball players performed different variations of basketball shots using a randomised test schedule.
Method: Participants completed a total of 30 test trials comprising 6 trials of 5 different shot types in both defended and undefended conditions.
Results: The presence of a defender led to significant changes in several behavioral measures including faster shot execution times, longer jump times, and an increase in the amount of time that the ball spent in the air as it travelled to the basket after being released from the shooter's hand. These behavioral changes were accompanied by an overall decline in shooting accuracy of over 20%. Defended shots also tended to elicit greater amounts of movement variability which, when interpreted in conjunction with the other findings, suggests that participants were attempting to adapt their movements to accommodate for the changing demands of the performance environment. Comparisons across different shot types revealed that the influence of the defender was generally context and task dependent.
Conclusions: The results have important implications for representative task design, and highlight how the manipulation of key information sources can have a marked effect upon behavioral responses.

The highly refined perceptual-motor skills exhibited by athletes in the sporting domain have been identified as a key distinguishing feature of expert performance (e.g., Abernethy & Russell, 1987; Button, MacLeod, Sanders, & Coleman, 2003; Temprado, 2002; for overviews, see; Abernethy, 1994; Williams, Davids, & Williams, 1999). Theoretical explanations derived from ecological psychology propose that one of the critical factors underpinning skilled performance is the close coupling between perception and action termed the "perception-action coupling" (Davids, Araújo, Button, & Renshaw, 2007; Gibson, 1979; Gibson & Pick, 2000; Michaels & Beek, 1995; Renshaw, Davids, Shuttleworth, & Chow, 2009). Under this framework, a reciprocal relationship exists between the perceptual information used to guide movement, and the movements that help to guide the uptake of perceptual information (Gibson, 1979; Gibson & Pick, 2000; Renshaw et al., 2009). The implication is that skill acquisition requires the individual to become selectively attuned to the critical sources of information that exist within the performance environment in order to facilitate both an appropriate and timely motor response (Araújo, Davids, Bennett, Button, & Chapman, 2004; Headrick et al., 2012; Müller et al., 2009; Renshaw et al., 2009; Travassos, Araújo, Duarte, & McGarry, 2012). This is likely to be particularly important in the dynamic and fast-paced setting of many sporting contests where performers are required to continuously adapt their behavior to suit the changing task constraints (see Bartlett, Wheat, & Robins, 2007; Davids, Glazier, Araújo, & Bartlett, 2003).

The influence of the perception-action coupling on the performance of various motor tasks has been demonstrated by the findings from empirical research (e.g., Renshaw, Oldham, Davids, & Golds, 2007; for an overview see; Pinder, Davids, Renshaw, & Araújo, 2011). In experimental tasks where perceptual information has been either removed or degraded, performers have been shown to produce significantly different movement patterns

* Corresponding author. University of the Sunshine Coast, School of Health and Sport Sciences, Locked Bag 4, Maroochydore DC, Queensland 4558, Australia.
E-mail address: agorman@usc.edu.au (A.D. Gorman).

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compared to those used during tasks that are more representative of the target environment (e.g., Pinder et al., 2011; Pinder, Renshaw, & Davids, 2009; Renshaw et al., 2007; Rojas, Cepero, Oña, & Gutierrez, 2000; Travassos, Duarte, Vilar, Davids, & Araújo, 2012). Such evidence not only highlights the importance of the relationship between perception and action, but it also demonstrates the potential influence of this factor in the design of experimental tasks or skill practice sessions (Pinder et al., 2011).

The notion of "representative design" advocated by Brunswik (1956) argues that tasks should be created in such a way as to ensure that the same degree of functionality and fidelity exists in both the experimental environment and the desired target environment, thereby enabling the experimental results to be generalizable (Hammond & Bateman, 2009; Hammond & Stewart, 2001; Pinder et al., 2011). In the inherently uncertain, dynamic, and often complex environment of many sporting contests, successful performance relies upon the capability of the performer to perceive and accurately interpret the diverse array of proximal cues (i.e., information that is readily available to the performer such as observing the specific movements of a defender) in order to infer distal events (i.e., a remote variable that cannot be directly perceived such as the specific intentions of an opponent) (Araújo & Kirlik, 2008; Araújo, Davids, & Passos, 2007; Brunswik, 1943, 1956; Chow, Davids, Button, & Renshaw, 2016; Hammond & Bateman, 2009). Thus, in the sporting domain, practice tasks should be representative of the interdependencies between the performer and the environment to enable the performer to learn the correspondence between the probabilistic (i.e., uncertain) proximal cues and the distal variables of interest (Brunswik, 1943, 1956; Araújo & Kirlik, 2008; Pinder et al., 2011; see also; Araújo, Davids, & Hristovski, 2006). This notion was investigated by Travassos, Duarte, et al. (2012) who found that the regularity (i.e., the consistency of passing speed) and the accuracy of passes executed by experienced futsal players tended to vary as a function of the representativeness of the practice task. When the task required passes to be executed in conditions with predetermined passing options (less representative task), the accuracy of the passes increased and ball speed became more regular compared to the passes observed in a competitive game. In contrast, the passes performed in practice scenarios where there were a greater number of passing options (more representative task), tended to elicit passes that were a closer match to those observed in competition, exhibiting reduced accuracy and more irregular ball speed. As the representativeness of the environment increased, so did the fidelity of behavioral responses: Passes became more variable, just like those observed in the competition environment (Travassos, Duarte, et al., 2012; see also Pinder et al., 2011). However, while the study reported by Travassos, Duarte, et al. (2012) is one of the few to apply the concept of representative design to a practice task derived from an invasion sport (i.e., a sport where attackers invade the territory of an opponent; see Almond, 1986; Ellis, 1983; Gréhaigne, Godbout, & Bouthier, 2001), none of the experimental conditions (apart from the competitive game) included defensive players. As such, the authors recommended that future studies should attempt to include defenders to further examine the influence of this factor upon performance.

Despite the theoretical and practical implications of a comparison across defended and undefended conditions, there are only a limited number of published studies within this area (for examples, see Hughes, Watkins, & Owen, 2010; Orth, Davids, Araújo, Renshaw, & Passos, 2014; Rivilla-Garcia, Grande, Sampedro, & van den Tillaar, 2011; Rojas et al., 2000; van der Wende, 2005). Of the studies that exist, the results have shown that players tend to change their movement pattern to adapt to the demands created by the presence of a defender (e.g., Hughes et al., 2010; Rivilla-Garcia et al., 2011; Rojas et al., 2000). For example, Rojas et al. (2000) found that the action responses of professional basketball players were tightly coupled to the presence of a defender. When performing jump shots against a defender, the release angle of the ball, and the vertical velocity of the ball during the initial elevation phase of the shot, were greater compared to the values observed in an undefended condition. The authors summarised their results by suggesting that the presence of a defender encouraged the players to increase the speed and release height of the ball, both of which were likely to be adaptations designed to prevent the defender from blocking the shot (see also Rivilla-Garcia et al., 2011; van der Wende, 2005). In invasion sports such as basketball, where the close proximity of players can mean that a defender is able to have a considerable perturbing effect upon the actions of an attacker, tasks requiring the performer to execute a skill against an opponent may provide a more representative design that generalizes to the target environment (Rojas et al., 2000; see also; Brunswik, 1956; Pinder et al., 2011).

In addition to preserving the ecological validities of distal and proximal cues, the study of performer-environment interactions should also sample multiple variations of the task to which findings are to generalize (Brunswik, 1956). While the investigation conducted by Rojas et al. (2000) detailed the movement adaptations that occur in the presence of a defender, the study featured a blocked design where only one variation of the basketball shot was performed repeatedly (for similar examples, see Hughes et al., 2010; McLean, Lipfert, & van den Bogert, 2004). Representative design argues that tasks should be sampled from the target environment in the same way as participants are sampled from the target population (Brunswik, 1943, 1956; Hammond & Bateman, 2009; Hammond & Stewart, 2001). Task sampling considers a range of relevant task variations performed in a randomised fashion (Brunswik, 1943; 1955). For instance, when assessing a single stimulus variable such as a defender, task sampling would include a representative set of situations and conditions where the defender would act as a perceptual variable (Brunswik, 1943). Thus, performing blocked repetitions of a single task from an invasion sport is, in itself, non-representative, and so responses may be different to those required in a more randomised (representative) environment containing several task variations (see Pinder et al., 2011). The use of a randomised design that includes several variations of a motor task could also help to determine whether certain variables elicit more changes in movement behaviors than others. Previous research has shown that variations of the same task, differing only by defender proximity and the positioning of players relative to the scoring zone, can have a marked influence on the movement characteristics of performers (Headrick et al., 2012; Orth et al., 2014). For example, when the defender is in close proximity to an attacker during a cross pass to a team-mate in soccer, the average running velocity of the attacker increases and the speed of the attacker's kick decreases, compared to when the same scenario is performed with the defender positioned at a greater distance from the attacker (Orth et al., 2014). Similarly, the relative proximity to goal of an attacker competing against a defender in soccer has also been shown to influence player behaviors, with closer proximities exhibiting significantly different behaviors compared to more distant proximities (Headrick et al., 2012). This evidence suggests that the degree of defensive perturbation that can be exerted by an opponent may vary, depending upon the nature of the constraints and the ways in which they impact upon the performance of the task (Headrick et al., 2012; Orth et al., 2014). This rich understanding of organismic behavior in these contexts is only possible through these researchers sampling multiple variations of the same task (see Brunswik, 1956).

Finally, an interesting aspect of performance that has only rarely