Assessing Hitting Skill in Baseball using Simulated and Representative Tasks

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ABSTRACT

Previous research has demonstrated that the ability to accurately anticipate the outcome of dynamic and representative situations under standardized conditions is an effective predictor of skill-level in many complex domains, including sport (for a review, see Suss & Ward, 2015). Moreover, skill at anticipating the outcome as early as possible, in addition to making the correct anticipatory decision, and skill at recognizing the play are equally important (e.g., Fadde, 2006; Jones & Miles, 1978; Savelsbergh, Williams, Van Der Kamp, & Ward, 2002). The current research aims to leverage this body of research in developing and evaluating a commercially available software tool designed for the assessment of such sports skills developed by Axon Sports. In this research we use the Axon Sports Baseball Hitting Assessment tool to measure anticipation and recognition skill in an NCAA baseball team. The results provide support that recognition and anticipation accuracy are useful indicators of skill in sport and extend the application of this body of work into a real-world setting.

KEYWORDS

Macrocognition; Decision making; Recognition; Anticipation; Sport

INTRODUCTION

In many naturalistic domains, the ability to predict the future outcome or the consequences of the current situation, including skill at anticipating 'what others will do next' is a necessity for making good decisions about how to respond in that situation, and for executing those decisions effectively. The use of such macrocognitive functions are the hallmark of expertise (e.g., Hoffman, Ward, Feltovich, DiBello, Fiore, et al., 2014). This is particularly true in sport situations. In football, for instance, a successful quarterback must proactively anticipate the type of play, such as a blitz or a particular coverage that their opponents will employ next in order to avoid using an overly reactive strategy. Likewise, a successful soccer goalkeeper must anticipate the direction of a shot prior to the foot of the striker kicking the ball, and a successful baseball hitter must anticipate the trajectory and speed of a pitch prior to the ball leaving the pitcher's hand, or risk not being able to reach, or hit, the ball in time before it crosses the goal line, or plate, despite executing a good decision. Frequently, such anticipations have to occur prior to any obvious initiation of play (e.g., the ball being snapped) or prior to the appearance of more easily recognizable cues (e.g., ball flight in soccer and baseball) in order to maximize the chances of success within the available time window. While readily apparent in these sports examples, early and accurate anticipation is critical to successful performance in many dynamic and complex domains, including driving, aviation and surgery to name but a few (for a review, see Suss & Ward, 2015).

A large body of research exists on macrocognitive functions, such as anticipation, situation assessment, and recognition—frequently termed 'perceptual-cognitive skills'—in sport. Typically, the sports research examining these perceptual-cognitive skills has required participants to predict, assess, recognize, or respond to the outcome of real-world scenarios recreated under standardized conditions using representative tasks simulated task environments A popular constrained-information task (see Crandall, Klein & Hoffman, 2006), used to measure anticipation skill, is the temporal occlusion method (see Haskins, 1965; for reviews, see Ward, Suss, & Basevitch, 2009; Suss & Ward, 2015). This method, similar to the SAGAT (Endsely, 1995) albeit with a much longer history, is used to present, near-first-person, video-based scenarios (e.g., unfolding patterns of sport play) to participants up until a particular point in the play (e.g., foot-to-ball contact in soccer, racket-to-ball contact in tennis) where the participant has to make a critical prediction or decision. At this critical moment, the stimulus is typically occluded from participant's vision (e.g., Ward, Ericsson, & Williams, 2013; Belling, Suss, & Ward, 2014) or the last frame of action is frozen on screen (e.g., Johnson & Raab, 2003)—without being given access to the actual outcome of the play—and the participant is asked, for instance, to predict their opponent's next action, decide on a course of action for themselves, or execute their preferred course of action.

Across several studies, researchers have demonstrated that expert athletes are more accurate and/or faster than novices when anticipating the outcome of particular plays from their domain of expertise (e.g., Abernethy, 1990; Abernethy & Russell, 1987; Burroughs, 1984; Williams & Davids, 1995). For example, Abernethy and Russell (1987) used a first-person, video-based simulation to assess badminton players' skill at anticipating where their opponent would hit the shuttlecock. The simulation was occluded at varying times around the moment when the opponent's badminton racket hit the shuttlecock (e.g., before, at, after racket contact with the shuttlecock). Expert badminton players were able to anticipate the flight path of the shuttlecock more accurately than novice players. Subsequent analyses of eye gaze data revealed that expert players used more information from earlier in the action sequence than novice players. While novice players fixated on the racket of the opposing badminton player, experts fixated on the arm of the opponent in addition to the racket. Similar findings were presented by Abernethy (1990) when experts and novices anticipated squash shots.

In a similar study, expert and novice tennis players attempted to identify the future location on a tennis court where an opposing player would serve the ball (Jones & Miles, 1978). The simulated scenarios were occluded during the serving action, before, at and after contact of the server's racket and the tennis ball. Experts anticipated the location of the serve more accurately than novices, but this effect was more profound in the earlier occlusion conditions. The data suggested that experts (but not novices) were able to make decisions based on their skill at detecting and interpreting subtle information cues that were only available in the action sequence prior to the point of racket-ball contact.

Further evidence that experts are more skilled than novices at accurately anticipating situational outcomes using only early cues was provided by Rosalie and Müller (2013). In a live-combat situation, karate athletes' vision was occluded (using liquid crystal occlusion goggles) either immediately prior to an opponent's attack, just after the opponent's head movement (i.e., the onset of an attack), or immediately after an opponent began their attack. At each occlusion point, expert karate athletes were significantly better than chance at blocking the attacks of their opponent. Those below expert level, termed near-experts, were only able to block effectively if they saw their opponent begin the attack. Novices could not block attacks when they were occluded at any point. In rare cases where expert athletes have waited longer than lower skilled athletes to respond (e.g., Savelsbergh et al., 2002), they have typically been more accurate than novices—who have also needed to make more corrective movements than experts. Hence, the data suggest that experts are likely to confirm their early anticipations with information presented later in the action sequence. In contrast, where lesser skilled athletes respond quickly they typically act on uninformative (e.g., use low ecological validity) cues.

In sum, across a number of studies, skilled athletes have been shown to anticipate the outcome of dynamic situations in their sport with greater accuracy using earlier situational cues. Such findings offer a potential explanation as to why expert athletes are able to perform at a reliably superior level compared to their novice counterparts in related contexts in their natural ecology (for a review of transfer effects see Ward et al., 2006). However, it is likely that other perceptual-cognitive skills, such as recognition skill, may precede successful anticipation. This assertion is consistent with current descriptive and theoretical claims about intuitive decision making (see Klein, 1993). In the sport of baseball, in addition to investigating anticipation skill (e.g., capability to anticipate the end-location of the pitch, specifically the height and distance from one's body as it crosses the plate), a handful of researchers have also investigated the ability to recognize the type of pitch prior to release or in the early stages of the pitch trajectory (e.g., fastball, curveball, changeup, slider). Both are important skills for baseball hitters. In the context of training, Burroughs (1984) examined both pitch location and pitch recognition. Using a pretest-training-posttest design, Burroughs observed that athletes that received video simulations designed to train the ability to recognize and locate pitches as they crossed the batting plate performed better at these tasks (although not significantly so) than a control group that received no training. The training effect remained present in a six-week follow up test.

More recently, Fadde (2006) investigated the transfer of training of these baseball-specific perceptual-cognitive skills to hitting performance in an actual baseball game. NCAA Division 1 collegiate baseball players were placed into a training and control group that were ranked equally by the team's coaches. The training group engaged in video-based simulation training designed to improve pitch recognition and pitch location. Training was completed during a two-week period. Following the two-week training period, the team completed its 18-game pre-conference schedule games. During those games, the training group recorded a significantly higher batting average than the control group. The batting average is the number of hits for a given batter divided by that batter's number of times at-bat (i.e., number of times facing a pitcher in-game) and is a widely accepted metric of hitting skill in baseball.

Within baseball, a growing body of evidence has been accumulated which shows that video simulation methods can be effective for measuring and training the requisite macrocognitive functions (or perceptual-cognitive skills) for successful performance in naturalistic settings (e.g., Fadde, 2006; Burroughs, 1984). The development of measurement tools and simulation methods is necessary if the extant research is to be extended to diagnosing, predicting, and remediating macrocognitive deficiencies in the world of professional sport. In the current research we examine the relationship between coaches' ratings of performance on the field and their macrocognitive function, as assessed on a synthetic assessment tool. This tool (The Axon Sports Baseball Hitting Assessment; Axon Sports BHA) was developed by Axon Sports, http://www.axonsports.com. It uses scenario-based simulation and associated assessment software to measure skill at recognizing the type of pitch (pitch recognition), predicting its location as it crossed the plate (pitch location), and using both skills in tandem (zone hitting). This tool not only presents participants with temporally occluded baseball pitches similar to previous research, but also automatically records accuracy and time of response using a specific mode of interaction.

Since we expected Axon Sports BHA's measures of pitch recognition (PR), pitch location (PL) and zone hitting (ZH) to provide valid indices of perceptual-cognitive skill necessary for superior batting performance, we predicted that a main effect of skill on performance on these tasks, such that higher skill levels would answer more trials correctly. Typically, these perceptual cognitive skills improve as players develop and as level of skill or expertise increases (e.g., Ward & Williams, 2003). Moreover, we expected to observe a main effect of occlusion on performance on these tasks, such that performance during late occlusion trials was superior to performance during early occlusion trials. Lastly, we expected to observe an interaction effect of occlusion by skill, such that the main effect of skill increases during early occlusion trials when compared to late occlusion trials, in line with the previous research (Rosalie & Müller, 2013).

METHODS

Participants. The participants in this research were 23 NCAA baseball players. The players completed the Axon Sports BHA (see below) from their native hitting stance (right-handed/left-handed). Eight batters completed the left-handed batter version of the assessment and fifteen completed the right-handed batter version. The assessment took approximately 20 minutes per participant. After completing the assessment, participants received individualized feedback detailing their strengths and weaknesses.

Materials. The Axon Sports BHA is composed of video simulations comprised of video footage filmed from the batter's perspective of three pitchers throwing fastballs, curveballs, changeups, and sliders. The video simulations were presented on 65-inch touch screen monitor.

In the Axon Sports BHA tool, participants are presented with three separate hitting tasks. Pitch Recognition (PR) required participants to select the correct type of pitch (e.g., fastball) from among the pitches thrown by a particular pitcher (e.g., fastball, curveball, changeup) by touching the area of the screen corresponding to that type of pitch in a multiple choice format. Pitch Location (PL) required participants to select from nine subzones, representing the strike zone in baseball, as to which subzone the ball would pass through when crossing the plate. Zone Hitting (ZH) presented participants with an area of the strike zone and a type of pitch (e.g., fastball). When the participants recognized that type of pitch heading into the highlighted area of the zone (i.e., both pitch-type and pitch-location criteria were met), they were instructed to press a button on the screen to indicate swinging at that pitch. All three tasks contained late and early occlusion conditions. Participants saw more of the pitch during the late occlusion condition and less of the pitch during the early occlusion condition.

Procedure. Participants completed each task (PR, PL, and ZH) at late and early occlusion, respectively. This process was completed for each of the three pitchers. Prior to completing PR, PL, and ZH for each pitcher, participants viewed three familiarization trials in which they could adjust their stance facing the monitor to maximize lifelikeness. Once the assessment was completed, participants were debriefed and received highly detailed and individualized feedback about their performance on each of the tasks and about each of pitchers to help identify them their strengths and weaknesses on the assessment.

Analysis. Early occlusion performance was measured as the number of correct responses during trials set to early occlusion (out of 81 total trials). Late occlusion performance was measured as the number of correct responses during trials set to late occlusion (out of 81 total trials). Overall performance was measured as the number of correct responses during all trials (out of 162 total trials). Coaches' ratings of batting skill were elicited from the coaches of the collegiate team—who had extensive experience working with each of the players. Ratings ranged from five to one: Five indicated an excellent batter; Four indicated a good batter; Three, an average batter; Two, below average batter; One, considerably below average batter. Factorial ANOVA was employed to observe the effect of skill and occlusion on accuracy. Skill ratings (1-5) were entered as a between subject variable. Occlusion point (early/late) was entered as a within subject variable. Partial eta squared ($\eta\rho^2$) was calculated to estimate effect size.

RESULTS

Descriptive statistics can be found in Table 1. Recall that we hypothesized a main effect of skill on performance. This effect was observed, $F(4,22) = 9.03$, $p < .001$, $\eta\rho^2 = .67$. We also hypothesized a main effect of occlusion point on performance. This effect was observed, $F(1,22) = 4.69$, $p = .04$, $\eta\rho^2 = .21$. Lastly, we hypothesized an interaction effect of skill and occlusion point on performance. This effect was not observed. In fact, a significant effect was observed in the direction opposite from what hypothesized, $F(4,22) = 3.23$, $p = .04$, $\eta\rho^2 = .42$.

Skill	*n*	Early Occlusion	Late Occlusion	Overall
5	5	42.6 (3.13)	50.6 (5.08)	93.2 (7.98)
4	2	37 (1.41)	36.5 (.71)	73.5 (2.12)
3	5	41 (3.81)	39.8 (3.70)	80.8 (5.26)
2	4	40.25 (2.22)	42.25 (1.26)	82.5 (3.11)
1	7	36.86 (2.85)	39.14 (4.02)	76 (4.36)
Skill effect		$F(4,22) = 3.39$, $p = .03$, $\eta\rho^2 = .43$	$F(4,22) = 8.85$, $p < .01$, $\eta\rho^2 = .66$	$F(4,22) = 9.03$, $p < .01$, $\eta\rho^2 = .67$

Table 1. Skill group, *n*, early occlusion performance mean (SD), late occlusion performance mean (SD), overall performance mean (SD), and skill effects.

DISCUSSION

Our first hypothesis was supported. We observed a significant main effect of skill on performance. Players rated as more skilled by their coaches performed better on the Axon Sports BHA. Our second hypothesis was also supported. We observed a significant main effect of occlusion point on performance. When given access to less information, participants performed worse than when given access to more information on the Axon Sports BHA. Lastly, our third hypothesis was not supported. We observed a significant interaction effect between skill and occlusion point on performance in the opposite direction from what we hypothesized. The effect of skill increased during late occlusion trials compared to early occlusion trials.

The data indicate that the ability to accurately recognize the type of pitch and locate the pitch in advance of crossing the plate (and the combination of these two in the zone hitting task)—key perceptual-cognitive skills that can be assessed using representative simulation tasks—are useful predictors of on-the-field hitting skill (as rated by coaches), in addition to being contender skills for training designed to accelerate expertise (see Burroughs, 1984; Fadde, 2006; Hoffman et al., 2014). Our results suggest that assessments of the specific perceptual-cognitive skills measured provide a useful index of hitting skill for collegiate baseball teams seeking the top talent. Given the logistical issues associated with scouting, and the prevalence of home computers and ‘app’-based technology (e.g., iPads), such a test might provide a useful and alternative means to gather data on future talent. Future research should examine whether the observed effects between measures of performance across PR, PL and ZH and subjective coaches’ ratings of skill extend to more objectives measures of skill and hold at other levels of baseball skill (e.g., professional).

The interaction effect of skill by occlusion point was opposite to what we hypothesized. Late occlusion performance was significantly more predictive of skill than early occlusion performance, though early occlusion performance alone was still significantly predictive of skill and the results from both occlusion points combined yielded the highest effect size (see Table 1). This suggests that performance at both occlusion settings predict skill even though late occlusion was more predictive. We speculate that this unique finding is because, even within our near-expert-level sample, participants were forced to guess more often during early occlusion trials than we expected. This is a testament to the difficulty of this assessment. This pattern of results also suggests that a high measurement ceiling exists on the Axon Sports BHA. Accordingly, we also speculate that an expert-level sample (e.g., professional team) might display the hypothesized effect (i.e., more predictive power during early occlusion) in line with previous research (see Rosalie & Müller, 2013). Future research should examine the relative contribution of early and late occlusion in sport and other domains of interest to naturalistic decision making research (e.g., military, law enforcement, driving) in order to maximize the effectiveness of applied tools that are similarly designed to the Axon Sports BHA.

In general, this research demonstrates the utility of macrocognitive function in sport and offers further support for the use of perceptual-cognitive skills as a predictor of real-world skill in sport domains (see Abernethy, 1990; Abernethy & Russell, 1987; Burroughs, 1984; Williams & Davids, 1995). The data offer initial critierion validation of the Axon Sports BHA and associated measures of PR, PL, and ZH. The present research offers a straightforward method, albeit using a technologically advanced means, for bridging the gap from academia to more applied settings, particularly within sport. Future research should seek to validate the current methods using higher skilled players, more objective measures of on-the-field performance in baseball and other sports, and in other complex and dynamic domains where accurate anticipation and decision making are critical to successful performance (e.g., military, law enforcement, driving).

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