From Lab to Cage: Turning the Occlusion Research Method into a Sports Training Program

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ABSTRACT
Over the past 30 years, sport science researchers have used the method of *temporal occlusion* to investigate the perceptual-cognitive skills that allow athletes to defy limits of human perception when they return serves, block shots on goal, or hit pitched baseballs. However, the occlusion method has yet to be systematically used to train high-performance athletes. This study describes a 6-month program that used occlusion methods to train the perceptual-cognitive skill of pitch recognition in college baseball batters. The pitch recognition training program combined occlusion training using interactive computer software with live batting cage drills that also incorporated occlusion principles. The cooperating team's batting performance improved significantly, demonstrating that occlusion methods can be used to effectively train advanced perceptual-cognitive skills and thereby improve performance in sports. The combining of computer and *in situ* occlusion tasks has implications for training the recognition component of high-speed decision-making in sports and other domains.

KEYWORDS
Decision Making; education and training; perceptual-cognitive; expert performance; sports.

INTRODUCTION

Recognition-Primed Decision-Making (Klein, 1998) provides a useful model for understanding, and improving, ballistic sports skills such as returning a 130 mile-per-hour serve, blocking a penalty shot, and hitting a wicked googly or a nasty slider (Fadde, 2009). Such actions require athletes to select and execute a complex psychomotor response in time frames that challenge simple human reaction time. Sport science research has shown that these skills are not based upon super-human hand-eye coordination, reaction time, or vision but rather skill-specific schema built through massed experience (Williams & Ward, 2003). As David Epstein notes in *The Sports Gene* (2013), expert performers enjoy a software advantage rather than a hardware advantage. Software, in this case, consists of *perceptual-cogntive* skills that enable expert performers to rapidly recognize patterns and predict outcomes, thereby priming their impossibly fast reactions. The natural questions, then, are if and how expert perceptual-cognitive skills can be systematically trained in order to accelerate expertise.

This paper first describes the laboratory research method of *temporal occlusion* that was developed by sport science researchers as away to isolate and measure perceptual-cognitive skills. The paper then describes an extended sports training program in which computer-based occlusion activities were mixed with *in situ* occlusion activities and implemented with a high-level sports team. The study addresses two critical issues that have previously limited the application of experimentally validated occlusion methods for training perceptual-cognitive skills: 1) transfer from training to performance, and 2) implementation in authentic settings with advanced performers.

Occlusion Methods to Study Perceptual-Cognitive Expertise

Sport scientists have developed a variety of occlusion tasks in which subjects view an opponent's action and categorize the action (e.g., type of tennis serve) or predict the outcome. The view is masked (spatial occlusion) or cut off (temporal occlusion) in different ways to remove perceptual information. If removing a particular piece of perceptual information results in a notable decrement in expert subjects' performance advantage over novices then the occluded information is deemed to have been important to the experts' perceptual advantage

(Williams & Ward, 2003). For instance, when masking a particular part of the bowler's body leads to a reduction in expert cricket batters' ability to "guess" the type of ball being delivered then researchers assume that some of the experts' perceptual advantage is gained by attending to that part of the body during the bowler's run-up motion (Müller & Abernethy, 2012).

In the most commonly used type of occlusion in sport science laboratories, the visual display of an opponent's action is cut off at various points of time during the action. In a typical temporal occlusion study of tennis return-of-serve video clips of a server were variously cut off before the ball was struck, at the moment of racquet-ball contact, and very shortly after contact. Study participants with different degrees of tennis expertise were tasked with categorizing the type of serve while viewing occluded video clips. Expert tennis players were better able to categorize serve type based on less visual information (Scott, Scott, & Howe, 1998). Sport science researchers have used both the findings of occlusion research and the occlusion method itself to train perceptual-cognitive skills. For instance, Farrow, Chives, Hardingham, and Sauces (1998) demonstrated the effectiveness of video-based occlusion training on the return-of-serve skill of intermediate tennis players.

Occlusion Testing and Training of Baseball Pitch Recognition

Temporal occlusion has been used to both test and train *pitch recognition* as the perceptual-cognitive component of baseball batting. Figure 1 shows a typical laboratory-based temporal occlusion task used by researchers to confirm experts' perceptual-cognitive advantage (e.g., Paull & Glencross, 1997) and also to train the same perceptual-cognitive skills (Burroughs, 1984; Fadde, 2006). Figure 2 shows a computer-based version that is also be used for both research and training purposes.

Figure 1. Video-Simulation using Occlusion in lab

Whether in a laboratory setting or on a laptop computer, occlusion training is usually presented in the form of *video-simulation* in which users respond to a video display by inputting a choice (e.g., Pitch Type) or prediction (e.g., Pitch Location) via keyboard, mouse, touch, or voice. Typically, however, users are not required to perform a psychomotor skill such as returning a serve or hitting a pitch. This de-coupling of the perception-action link allows researchers to isolate the perceptual-cognitive component of performance for testing or training purposes but also raises questions of ecological fidelity (Bootsma & Hardy, 1997). The part-task approach of video-simulation contrasts with whole-task video-based simulators, such as depicted in Figure 3, in which a pitching machine propels a ball through a video projection screen to simulate batting.

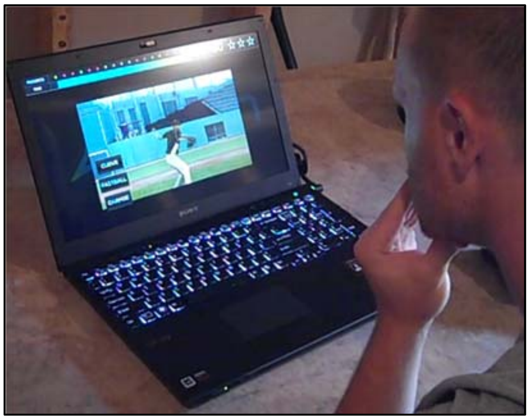

Figure 2. Video-Simulation (courtesy AxonSports)

Figure 3. Video simulator (courtesy ProBatter)

The video simulator shown in Figure 3 is capable of "throwing" a variety of pitches such as fastball, curveball, and changeup. However, the video of the pitcher does not change in relation to the type of pitch delivered thereby denying the user authentic pitch release cues. In essence, the simulator has higher fidelity for the whole task of baseball batting but video-simulation has higher fidelity for the partial task of pitch recognition.

As a part-task recognition-only training method, video-occlusion (temporal occlusion in a video-simulation format) offers a high degree of instructional efficiency (Fadde, 2009). Baseball batters can train an important component skill on a portable device during travel or rehabilitation from injury. However, the issue of transfer of part-task perceptual-cognitive learning to whole-task psychomotor performance looms large.

Occlusion Training and Transfer to Performance

Transfer of learning comes in many forms and terminology is not always consistent. A useful delineation can be made between near transfer and far transfer. *Near transfer* refers to trainees' performance in a video-occlusion task compared to their performance in an *in situ* version of the same task. For example, Burroughs (1984) used his patented Visual Interruption System (Figure 4) to re-create a "live" version of the video-occlusion pitch recognition task that he used to train college baseball players.

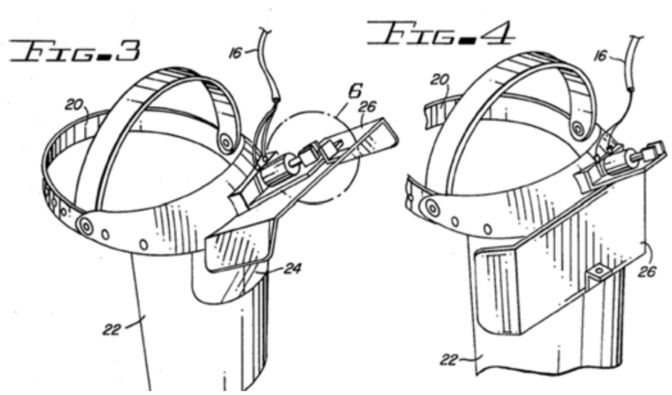

Figure 4. Visual Interruption System (patent illustration)

Figure 5. Occlusion Spectacles
(courtesy Translucent Technologies)

The baseball players participating in Burroughs' study first received video-occlusion training in a laboratory setting. They then moved to a baseball field where a pitcher threw full-speed pitches and VIS was used to occlude the batters' vision after a short amount of ball flight. VIS used the landing of the pitcher's front foot on a force pad to send an electronic signal to a hinged visor that would snap down, blocking the batter's vision. Batters identified the type of occluded pitch or predicted the location of the pitch, just as they had when watching occluded video clips of pitches in the laboratory. The study demonstrated near transfer of learning gains made in a video-occlusion task to an analogous *in situ* occlusion task. Occlusion spectacles (Figure 5) have been used in a similar way by researchers conducting video-occlusion testing and training in cricket (Müller & Abernethy, 2012).

Having participants or trainees perform a simplified version of the full psychomotor performance task represents a different type of transfer. For example, Scott, Scott, and Howe (1998) used video-occlusion to train tennis players to recognize types of serves. They then had the players perform a return-of-serve task on court with a "live" server. Players scored increasing points for making contact with the serve, returning the serve over the net, or returning the serve into the server's court. The researchers' assumption was that a higher score indicated that trainees were successfully applying the skill of picking up early cues that they had practiced during video-occlusion training. Researchers have sometimes combined *in situ* occlusion tasks (as Burroughs) and on-court/field representative tasks (as Scott, Scott, & Howe) approaches by, for example, having cricket batters not only identify but also attempt to strike bowled balls while having their vision cut off with occlusion spectacles (Müller & Abernethy, 2006).

Far Transfer of Occlusion Training

The transfer of perceptual-cognitive training gains to psychomotor performance of the full skill in match situations can be thought of as far transfer. As in all areas of training, transfer to performance can be very challenging to measure. However, a benefit of investigating baseball batting is that performance is systematically measured by established statistics. Fadde (2006) used laboratory-based video-occlusion methods (see Figure 1) in a training program intended to improve the pitch recognition skill of college baseball batters. Batters on the same college baseball team were randomly assigned to occlusion training and control groups.

During the team's winter practice sessions at an indoor facility, players in the training group left the practice field to complete individual 15-minute video-occlusion training sessions. Upon completing video-occlusion sessions, players returned to team practice that often included situational batting against full-speed pitching. The actual treatment, therefore, was a combination of video-occlusion training and "live" batting in the context of organized team practice.

The effectiveness of the pitch recognition training program was determined by comparing the batting statistics of players in the training and control groups during the team's 18-game pre-conference schedule. Batters in the training group had higher Batting Average, On-Base Percentage, and Slugging Percentage – the batting statistics generally considered to represent batting skill (Weinberg, 2014). Rank correlation of batters was used to determine statistical significance of the differences between training and control groups, which was statistically significant on the measure of batting average ($p<.05$).

Limitations of Occlusion Training Studies

Training-based research studies are usually experimental in design, attempting to isolate and validate the effectiveness of training methods. These studies purposefully limit the duration and context of experimental training interventions in order to strengthen experimental control. The internal validity that is maximized by controlled experimental designs, however, limits the external validity of the studies. Wider adoption of occlusion methods for training high-performance athletes depends upon the implementation and study of perceptual-cognitive training programs in authentic settings with high-level performers.

METHOD: OCCLUSION TRAINING IN A NATURAL SETTING

The study described here implemented and evaluated a training program that used occlusion principles to train the perceptual-cognitive skill of pitch recognition. The ability of expert batters to pick up early cues in the pitcher's delivery and early ball flight is not only well established by sports science research as a differentiating skill of expert batters (Paull & Glencross, 1997) but is also recognized as a valuable skill by many college and professional baseball teams. However, it has not generally been considered to be "coachable" (White, 2014, June 4). This study investigates whether occlusion training methods, when incorporated into the routine practice activities of a NCAA Division I college baseball team, would transfer to improved batting performance.

Integrating Computer and Batting Cage Pitch Recognition Drills

The pitch recognition training program involved players individually using a computer application (see Figure 2) created by *AxonSports* that presented temporal occlusion drills in a format that combined drill-and-practice methodology with dynamic testing in which the occlusion point of video pitches was automatically shortened as players achieved target scores. Players could choose to work on Pitch Type or Pitch Location drills and could choose among three video pitchers.

The pitch recognition training program also included several "live" batting cage drills that added a layer of pitch recognition to traditional batting drills. For instance, rather than simply hitting the ball off a tee, batters would watch a teammate or coach deliver a mock pitch from behind a protective screen and hit the ball off the tee only when they recognized the mock pitch as a designated type of pitch (e.g., fastball, curveball, changeup). As shown in Figure 6, the net occluded the pitch very much as the computer program did by editing to black.

Figure 6. Net Occlusion Drill

Another "live" drill was similar to the *in situ* near-transfer tasks used in occlusion training research (e.g., Burroughs, 1984). Instead of measuring transfer, however, this drill was intended to facilitate transfer by replicating the computer occlusion drills with live pitchers. While the team's pitchers were practicing pitching in the bullpen (a designated area at baseball fields where pitchers warm up), the batters would *stand in*. That is, a batter would take a normal position in the batter's box but would not swing his bat. In traditional stand-in drills, batters are tasked with tracking the pitch into the catcher's mitt.

Figure 7. Bullpen Stand-In Pitch Recognition Drill

The *Stand-In Pitch Recognition* drill interjected occlusion into this routine drill by instructing batters to call the type of pitch out loud before the ball hit the catcher's mitt. Batters also predicted whether or not a pitch would be in the strike zone, calling out "Yes" to indicate the pitch would be a strike and "No" to predict the pitch would not be a strike. With a typical pitch reaching the catcher in less than 500 milliseconds, the requirement that batters verbalize their pitch call enforced early recognition – a variation termed *attention occlusion*.

RESULTS

The effectiveness of the Pitch Recognition Training Program was measured in terms of batting performance in conference games. Official NCAA batting statistics were used. In this case study all of the batters on the team were trained and the team's mean batting statistics were compared between the 2013 and 2014 seasons. As summarized in Table 1, the trained team showed consistent and substantial improvement from the 2013 season to the 2014 season. While it is not possible to attribute the team's batting performance gains to the pitch recognition training program, both the coaches and the researcher wanted to know whether the observed improvements were "beyond the reasonable expectation of a good team getting better." To address this question the participating team's batting statistics were compared with those of a comparable conference team that had similar batting statistics in the 2013 season but did not receive pitch recognition training. Like the trained team, the nop-training team returned 8 out of 9 batters in its starting lineup from 2013 for the 2014 season.

Table 1 displays the teams' batting statistics in 2013 to 2014. Batting average, on-base percentage, and slugging percentage are considered to be a basic profile of batting performance (Weinberg, 2014). Base-on-balls (BB), strikeouts (K), and BB/K ratio are considered to represent "good eye" or plate discipline (Panas, 2010). Runs-per-Game is highlighted in Table 1 as the most basic measure of team batting performance. Base-on-Balls/Strikeouts (BB/K) ratio is highlighted as the statistic most closely associated with plate discipline. For contextual purposes (not specific to this study), general benchmarks of excellence for these statistics include: Batting Average (.300), On-base Percentage (.380), Slugging Percentage (.450), and BB/K (.50). The measure of Strikeouts is reverse scored because fewer strikeouts represent better batting performance.

As can be seen in Table 1, the no training team showed modest improvement in most team batting statistics from 2013 to 2014, as would be expected from a team returning most of the starting players from the previous year. However, the training teams' batting statistics showed consistent and often substantial improvements from 2013 to 2014, well beyond expectations for a good team returning most of its starting lineup.

Table 1. NCAA Batting Performance Statistics for Training and No Training Teams

	Training Team			**No Training Team**		
	2013	**2014**	**Change**	**2013**	**2014**	**Change**
Runs Per Game	5.8	8.6	**48%**	6.6	6.8	**3%**
Batting Average	.286	.326	14%	.290	.304	5%
On-base Percentage	.372	.407	9%	.372	.383	3%
Slugging Percentage	.390	.468	20%	.413	.464	12%
Home Runs	11	25	127%	17	27	59%
Base-on-Balls	108	140	30%	127	124	(2%)
Strikeouts (K)	217	182	16%	189	200	(6%)
BB/K Ratio	.50	.77	**54%**	.67	.62	**(7%)**

To test whether the differences between the two teams went beyond face-value and were statistically significant, I compared the changes in both teams' ranking among conference teams for 2013 and 2014 batting statistics. As in Fadde's 2006 study, statistical significance was determined by comparing the ranking of the training and no training teams' within the conference and applying the Mann-Whitney *u*-test of rank correlation, scaled for small *n*. Figure 8 displays Rank data. With eleven teams competing in the conference, the top rank-based score is designated as "11" and the bottom rank is designated as "1" on the graph.

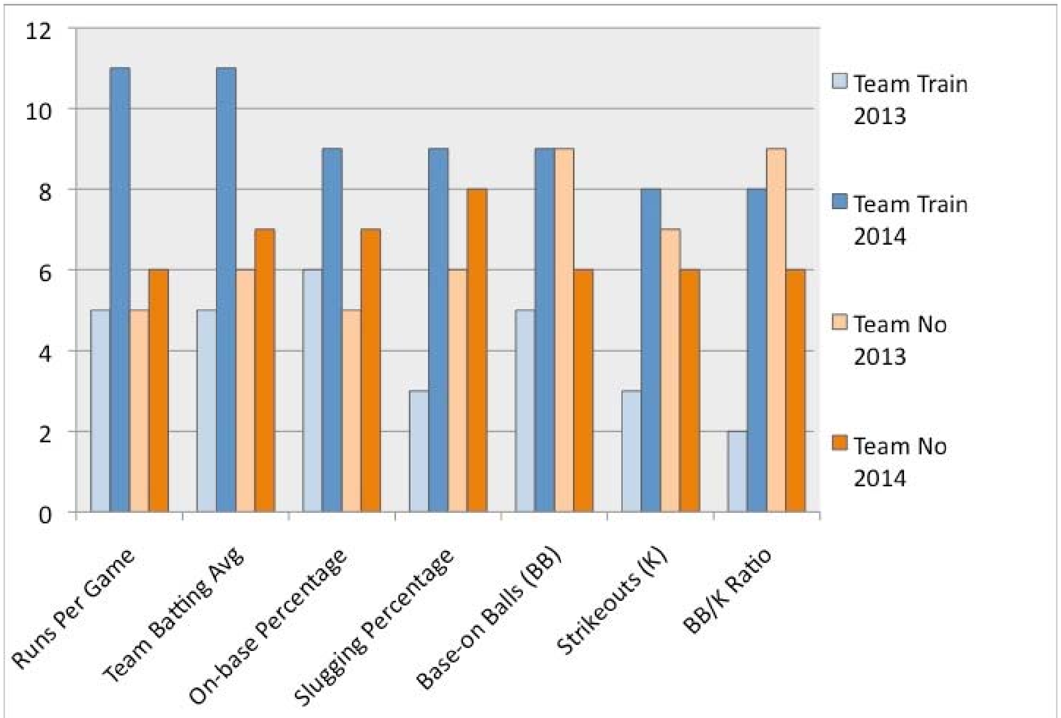

Figure 8: Ranking of Training and No Training Teams' Batting in Conference (11=best; 1=worst)

Applying a one-tailed analysis with alpha of $p<.01$, the season-to-season change for pooled rankings in the batting statistics of the team receiving pitch recognition training is significant ($p=.0005$) while the change in pooled batting statistics of the comparison team is non-significant ($p=.4364$).

DISCUSSION

Occlusion methods originally developed by sports science researchers to verify and locate the sources of expert advantage in perceptual-cognitive skills have been shown, through time-limited experimental implmentations, to be effective training methods. However, occlusion methods had not previously been systematically applied to the training of high-performance athletes. This case study addressed this need by implementing an occlusion-based pitch recognition training program that targeted already high performing athletes. The training program used temporal occlusion embodied in a video-simulation on a laptop computer and also incorporated occlusion principles into "live" drills that essentially simulated the computer simulation.

The attention occlusion method of calling the pitch out loud before it hits the catcher's mitt, which was developed for the training program in this study, is now being used for training pitch recognition in at least one major league baseball organization (White, 2014, June 4), and the study has implications for targeted, part-task, occlusion-based training of the recognition component of high-speed decision-making (Fadde, 2009) in sports and a variety of other performance domains.

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