Breaking the Perception-Action Link: Simulation Training of the Perceptual Decision-Making Component of a Complex Psychomotor Skill

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Summary

Problem

Experts in many sports skills are able to recognize situations, select an appropriate response, and execute the response in time frames that challenge simple human reaction time – while paradoxically appearing to have "all the time in the world" (McLeod & Jenkins, 1991). The cognitive component of such reactive skills can be termed *perceptual decision-making* (PDM), meaning extremely rapid decision-making based primarily on visual perception. PDM is involved in reactive sports skills such as return-of-serve in tennis, blocking shots-on-goal in hockey and soccer, and hitting a pitched baseball or softball.

This study involved using a laptop computer program to train the PDM skill of *pitch recognition* in college softball players. Implications are drawn for simulation training of perceptual decision-making in non-sports areas such as use-of-force by police and military personnel, emergency response, security, and vehicle operation.

Simulation theory suggests that high-fidelity simulations are most appropriate for learners that are high in initial ability (Alessi & Trollip, 2001). The classic example is pilot training in which extremely realistic flight simulators are used. The high cost of designing, building, and operating high-fidelity simulators is justified by the even higher cost of training in actual aircraft.

However, a body of research in sports science suggests that the essence of expert performance in reactive skills lies in the perceptual decision-making processes more than in psychomotor actions. The ability to execute the appropriate physical movement is a requirement of competent performance rather than an attribute of expertise. A smaller body of sports science research has demonstrated the effectiveness of video-based simulation training of PDM skills (Williams & Ward, 2003).

The implications of the sports-based research for the larger contexts of expertise and simulation training is that training focused on PDM may provide a means of accessing an elusive aspect of expert performance that is often considered to come only from instinct or massed experience. In addition, training that targets the cognitive domain separate from motor execution can be accomplished with lower fidelity, lower cost methods. The question is whether a perception-action link that is broken for training purposes can be re-coupled in performance of the full psychomotor skill. Addressing the question invokes and informs theories of technology, instruction, cognition, and learning.

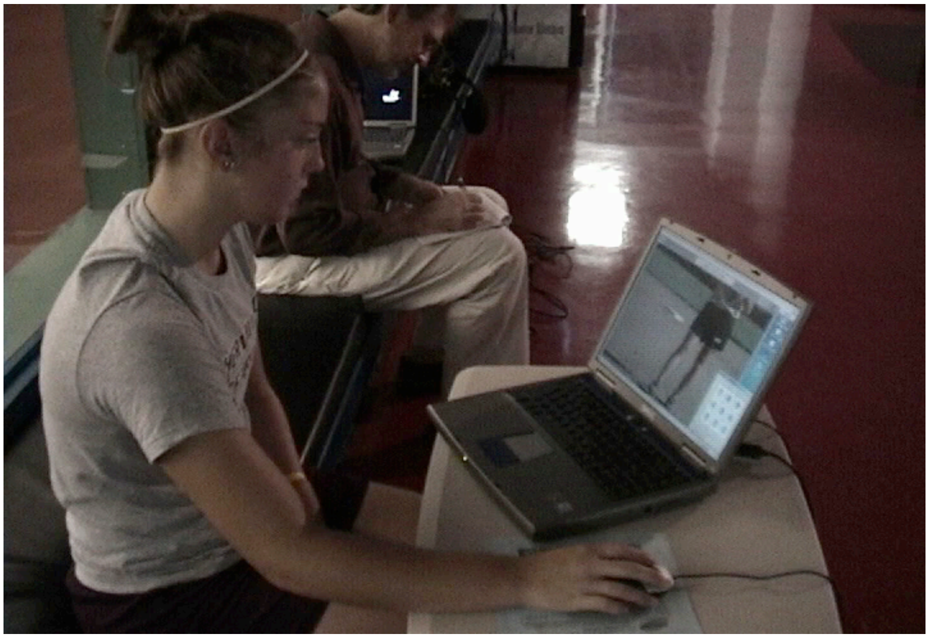
Theoretical Framework

Efforts to build a general theory of expertise (Ericsson, et al., 1993) have drawn on cognitive information processing (CIP) models associated with research in content areas such as chess (Simon & Chase, 1973). In recent years, sports science researchers have come to adopt the CIP model and focused on perceptual and decision-making skills as differentiating expert performers (Chamberlain & Coehlo, 1993). General expertise researchers now look at sports research as a “test bed” for investigating expert learning and behavior (Starkes & Ericsson, 2003).

Researchers debate CIP versus ecological models for describing and training expert performance (Bootsma & Hardy, 1997). At the heart of the debate are contrasting views of perception-action linkage. Training implications of the two theoretical perspectives are substantial. The CIP model suggests that targeted, part-task training of the perceptual decision-making aspect may be adequate or even optimal for developing expert reactive skills. The ecological approach supports the use of whole-task, realistic (high-fidelity) training contexts such as flight simulators. The theoretical perspective that best supports effective and efficient instruction can argue for being the more useful cognitive model of expertise.

Among theories of instruction, the 4C/ID-model (van Merriënboer, et al., 2002) says that complex cognitive skills include *non-recurrent* (novel, effortful) and *recurrent* (routine) constituent skills. Perceptual decision-making represents recurrent skills that involve rule automation. Through repeated and varied practice, declarative knowledge advances to procedural knowledge that "primes" rapid motor responses (Anderson, 1993). The 4C/ID-Model emphasizes the value of *part-task* practice in building automatic recognition. These views suggest that *drill-and-practice* is an appropriate instructional method for strengthening perceptual decision-making skills to expert level. That is the intent of the computer-assisted instruction program called *Interactive Video-Softball* (IAV-SB) that was used in this training-based research implementation to improve the pitch recognition ability of college softball players.

Training Method



College softball player engaging IAV-SB training session.

The IAV-SB computer program selects and randomly sequences pitches as drill-and-practice items, displays the pitch on a laptop computer screen, takes learner input via keyboard or mouse, gives immediate and corrective feedback, provides a running score, gives summary drill feedback, and provides guidance to the learner in creating drills. In a typical 15-minute IAV-SB session a learner completes five or six drills while encountering up to 200 pitches. The learner selects the type of drill (Type, Location, or Zone Hitting), the video pitcher (two right-handed pitchers and one left-handed pitcher), the types of pitches (e.g., riseball, curveball, changeup), and the level of difficulty (based on amount of ball flight shown).

Research Method

Earlier studies have established that video-based simulation training of PDM skills is effective in laboratory situations. However, Williams and Ward (2003) conclude a review of PDM training-based research studies by noting "if this area of study is to make a significant contribution . . . then scientists, practitioners, and coaches must work together to develop, implement, and evaluate appropriate training interventions (pg. 247)." This training-based research study, then, was *situated* with an NCAA Division I softball team at a mid-size midwestern university. Six players, selected by the coach, participated in ten 15-minute IAV-SB training sessions during the team's six-week off-season practice period. The participants, all females between 18 and 22 years of age, were selected from team members who volunteered for video training. Participants were trained during regular practice sessions so that no additional practice time was added.

As is often the case with field research, this study involved numerous compromises in research design, such a small number of participants and non-random selection of participants. Four of the six participants completed the IAV-SB training program but did not play enough in the seasons before or after IAV-SB training to generate adequate statistics for judging in-game batting performance. One participant became ill and withdrew from IAV-SB training. The remaining participant was a senior who had played regularly since her freshman season. The coach profiled her as "a good hitter, but inconsistent." This player was the only participant who completed the IAV-SB training program *and* had sufficient playing time to generate meaningful game batting statistics.

Data Sources

A number of aspects of the IAV-SB training implementation were analyzed. Survey data was gathered and a de-briefing session was conducted to collect participants' suggestions for improving the training. Videotapes of training sessions were analyzed in terms of the participants' self-regulated learning strategies. The participants' choices of drills and achievement scores were collected by the computer program and analyzed.

However, the singular focus of this paper is the central question "does pitch recognition training effect batting performance?" The primary data source for addressing this question was batting statistics from the players' career prior to the 2005 season and batting statistics from the 2005 season, which followed the off-season practice period that included IAV-SB training. Game batting statistics were previously used as a dependent measure of performance in a study that involved training pitch recognition with college baseball players (Fadde, 2002).

The statistics used were generated by the Sports Information Department of the participating university. The statistics of *batting average* (BA), *slugging percentage* (SLG), and *on-base percentage* (OB) were analyzed along with an *on-base plus slugging percentage* (OPS) measure that is often used to represent all-around hitting ability.

Results and Conclusions

Although only one of the players participating in IAV-SB training produced adequate game batting statistics to use as pre/post-test performance data, this player was representative of a type and level of player who would be expected to benefit from PDM training. The coach's profile of the player and her career statistics over three seasons indicated that the player had the physical *ability* to bat at a high level. However, her performance had been inconsistent. She embodied the gap between highly skilled and expert levels of performance. Arguably, the expert-novice research paradigm is more meaningfully applied to *individual* performers as they progress toward expertise than it is to describing groups identified as expert or novice based on level of competition (e.g., major league versus minor league baseball players).

As shown in Table 1, the IAV-SB trained player made substantial improvements in game batting statistics from her pre-2005 career to the 2005 season. Her game batting statistics are compared to a composite of three teammates who are similar in profile. All four players were described by the coach as "power" hitters and usually batted in the 3-4-5-6 positions in the 2005 team batting order. They faced the same opponent pitchers under similar conditions.

Table 1. Batting statistics.

	BA	SLG	OBP
Participant			
2002/03/04	.218	.346	.318
2005	.284	.613	.347
Change	.066 (30%)	.267 (77%)	.029 (9%)
Comparison Group			
2002/03/04	.242	.440	.351
2005	.276	.483	.381
Change	.034 (14%)	.043 (10%)	.030 (9%)

All four players showed improvement in the 2005 season. This is to be expected as players mature and gain experience. However, the improvement of the comparison players was around 10 percent on most measures while the improvement of the IAV-SB trained player was in the 30 percent range and up to 77 percent on the measure of slugging percentage. The improvement in slugging percentage is largely because the IAV-SB trained player doubled her career home runs in the 2005 season. Her 14 home runs in 2005 tied the single season record (set by one of the comparison players, also in the 2005 season). After hitting a pair of home runs in a game, the participant commented that she was "seeing the ball better this season" (Antoine, 2005). Whether this player's improvement in game batting performance can be attributed to IAV-SB training is an open question; no claims of causality are made.

This study is limited in the scope of the training implementation and of the generalizability of the research findings. However, it does contribute to the modeling of expert cognition, developing simulation theory, and designing instructional technology by demonstrating that a lower fidelity approach can be effective if it is highly targeted. The results have implications for training in areas outside of sports, such as use-of-force training for military and police, emergency response, and vehicle operation.

References

Anderson, J. R. (1993). *Rules of the mind*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Antoine, L. (2005). #20 softball shuts out #16 Missouri 3-0 to open NCAA regional tournament. *http://www.collegesports.com/printable/schools/silu/sports/w-softbl/*. Accessed May 23, 2005.

Alessi, S., & Trollip, S. (2001). *Multimedia for learning: Methods and development*. Boston: Allyn and Bacon.

Bootsma, R., & Hardy, L. (1997). Perception and action in sport: Half-time comments on the match. *Journal of Sports Sciences*, *15*, 641-642.

Chamberlain, C., & Coehlo, A. (1993). The perceptual side of action: Decision-making in sport. In J. L. Starkes and F. Allard (Eds.), *Cognitive issues in motor expertise*. Amsterdam: North Holland.

Ericsson, K., Krampe, R., & Tesch-Romer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological Review*, *100*(3), 363-406.

Fadde, P. (2002). Interactive video training of perceptual decision-making in the sport of baseball. Purdue University, Thesis 48355PhD

Macedonia, M. (2004). Games, simulation, and the military education dilemma. http://www.educause.edu/ir/library/pdf/ffpiu018.pdf. Accessed March 4, 2004.

McLeod, P., & Jenkins, S. (1991). Timing accuracy and decision time in high-speed ball games. *International Journal of Sport Psychology*, *22*, 270-295.

Simon, H., & Chase, W. (1973). Skill in chess. *American Scientist*, *61*, 394-403.

van Merriënboer, J. J. G., Clark, R. E., & de Croock, M. B. M. (2002). Blueprints for complex learning: The 4C/ID-model. *Educational Technology Research & Development*, *50*(2), 39-64.

Williams, A. M., & Ward, P. (2003). Perceptual expertise: development in sport. In J. L. Starkes and K. A. Ericsson (Eds.), *Expert performance in sports: Advances in research on sport expertise*. Champaign, Illinois: Human Kinetics.