Rapid Decision-Making Based on Limited Visual Input in Sports: A Review

James I. Garijo-Garde

Tufts University

Abstract:

Studies pertaining to rapid decision-making based on limited visual input are analyzed in this review paper. This topic seeks to provide a look into the intersection of visual input and the decision-making process. It starts with two studies investigating athletes performing under restrictive time conditions based on whatever visual cues they can gather before executing, one focusing on baseball and another on boxing, transitions into an analysis of how the visual processing may occur in rapid exposure scenarios, and looks at criteria for decision-making models for rapid decision-making based on limited visual input in sports. In the end, this paper will have examined the two examples, sought to justify how the athletes perceive the information they need, and laid out a model for how the decision-making process unfolds in their minds.

Introduction:

Throughout life, we are often forced to make decisions. Some decisions are easier to make than others. For example, deciding what to wear in the morning is a very easy decision compared to the famous tram dilemma of deciding whether to keep a runaway tram on its current path and kill five people or divert it and kill one person (Foot, 1967). But perhaps the most interesting examples of decisions that we humans make are the ones we make rapidly under time constraints and limited visual input. Nowhere are these decisions as frequent or under as much scrutiny as they are in sports.

Outline:

This paper has three sections followed by a conclusion.

1) *Examples of Rapid Decision-Making Based on Limited Visual Input in Sports* – this section will look at two studies of separate decision-making examples in separate sports and compare the findings.
2) *Visual Processing in Rapid-Decision-Making Situations* – this section seeks to discuss how athletes are able to make effective decisions under such limited visual stimulus. Two separate theories are applied separately to the sporting examples from section one.
3) *Decision-Making Models for Rapid Decision-Making Based on Limited Visual Input in Sports* – this section explores literature describing the types of decision-making models best suited to model sports and offers a decision-making model generalizable to both of the examples from section one.

Examples of Rapid Decision-Making Based on Limited Visual Input in Sports:

Let us look at two examples of studies examining rapid decision-making based on limited visual input in sports. The first is a study published in 2009 by Takayuki Takeuchi and Kimihiro Inomata from Chukyo University. In this study, the investigators sought to investigate the reaction times of expert and non-expert batters in baseball-like situations and the differences in points of visual fixation on the pitcher between expert and non-expert groups (Takeuchi & Inomata, 2009). In another study published in 1995, researchers Hubert Ripoll, Yves Kerlirzin, Jean-François Stein, and Bruno Reine looked into the same comparison of accuracy, reaction time, and eye movement, but in boxers.

What's interesting about the intersection of what they jointly reveal and what they dispute. Both studies support the idea that experts at a sport know where and how to get the visual information they need to execute the task accurately and efficiently (Ripoll, Kerlirzin, Stein, & Reine, 1995; Takeuchi & Inomata, 2009). But there are some key differences in the findings. Whereas Takeuchi and Inomata found that in baseball experts made more fixations than the inexperienced comparison group, Ripoll, Kerlirzin, Stein, and Reine found that boxers made less fixations. The observations relating to reaction time were also different between the two studies. In the baseball study, the experts had a faster reaction time, but in the boxing study, the expert group and the other groups had no significant differences in reaction time (Ripoll et al., 1995; Takeuchi & Inomata, 2009). To explain these differences, it is important to consider some flaws in the two studies that may have impacted the reliability of the results, but it is also feasible to offer a hypothesis that might explain these differences.

Neither of these experiments perfectly captured the decision-making process of the sport in its naturalist environment of occurrence. In boxing study, participants responded to a video recording with a joystick (Ripoll et al., 1995). While the participants obviously could not be placed in harm's way in a boxing ring, this is far from a realistic boxing environment. In the video recording, the boxer is reduced to a two-dimensional figure that cannot react appropriately to the decisions made by the study participant (Ripoll et al., 1995). With a joystick, the participant does not make motions naturally associated with the boxing decisions, further isolating realism from the experiment. The researchers also confess that the oculometer they used for the second experiment was uncomfortable for participants to wear for long periods of time, potentially distracting them from the task at hand (Ripoll et al., 1995). These limitations weaken the strength of the assertions made by the investigators.

Technical advances in the 14 years between the publication of the two studies (and the fact that baseball is not a contact sport) allowed for more realistic simulation of a sports environment in the baseball study, but this experiment was still not a perfect model of the in-game environment. For this study, eye-tracking technology could be confined to a cap worn by the subjects and, in an upgrade from a joystick, the participants were given a bat (Takeuchi & Inomata, 2009). Yet despite these improvements, the bat was plastic and weighed 710 grams – roughly 200 grams less than the minimum weight of a bat constructed to Major League Baseball specifications – and the participants pressed a button on the bat instead of swinging (Takeuchi & Inomata, 2009; Williamson, n.d.). The participants also stood behind a protective plexiglass barrier, again a removal from in-game realism made for the sake of safety (Takeuchi & Inomata, 2009). Although this is an improvement from the boxing study, this study is still not a perfect measure of the in-game experience.

Also worth discussing is the sampling of the experimental groups for the independent variables in these experiments. The boxing study makes an admirable attempt to compare not just experts and novices, but also intermediate boxers, but falls short in creating enough of a distinction between the novice and intermediate groups (Ripoll et al., 1995). Intermediates are defined as training once a week and competing at the first class level, whereas novices are defined as training for more than one year but having no experience in competition (Ripoll et al., 1995). This leaves open the possibility for novices to actually be fairly comfortable with the sport of boxing and comparable in skill-level from the intermediate group. In comparison, the baseball study used college-level athletes and novices who had no experience playing baseball, far better distinction between the levels of expertise (Takeuchi & Inomata, 2009). Both studies, however, are restricted by small sample sizes. In the baseball study, the two levels of expertise have 7 participants per group, whereas in the boxing study there are 6 participants per group (Ripoll et al., 1995; Takeuchi & Inomata, 2009). These are two relatively small sample sizes, inviting the possibility that the results are not totally in line with trends across the broader, real-world populations of each of these levels of expertise.

Combined, the lack of realism in the experiment and the small sample sizes leave the door open for data that isn’t completely applicable to decision-making under limited visual input in sports. If this possibility is set aside, however, it is possible that the differences in findings related to reaction times and the number of fixations can be attributed to the fact that these are two different sports in which the decisions are being made in different contexts. In baseball, a batter knows exactly when a ball will be thrown because he or she can see the pitcher’s windup, but in boxing, an attack could come at any moment. These two situations require very different types of visual awareness: in baseball, seeing a lot in a short time span is necessary, while in boxing, seeing a lot in a spatially large visual field is more important.

Visual Processing in Rapid-Decision-Making Situations:

In 1980, Michael I. Posner investigated the idea of shifting attention without movement of the eyes that seems to be present in expert boxers (Ripoll et al., 1995). His experimentation using the now famous Posner Cueing Task showed that participants could shift their attention around their visual field after being given a hint of where a displayed target would appear (Posner, 1980). Posner even showed that, in some tasks, eye movement is actually a detriment to attention, cutting into the time participants needed to report on the nature of a target. It is this behavior that would seem to apply to boxing: it is reasonable to assume that the expert boxers are more effective at detecting and defending rapid attacks because they are able to shift focus to different areas of their visual fields without losing response time through moving their eyes (Ripoll et al., 1995). Novices and intermediates, in contrast, may lack this discipline and lose precious time refocusing their foveas on key areas (Ripoll et al., 1995).

In a 2009 review, Christopher Summerfield and Tobias Egner discuss another element of visual perception that fits better with the situation of batting in baseball. They argue that visual expectation plays a large role in how people see in repetitive or familiar situations (Summerfield & Egner, 2009). For an experienced baseball player, batting is a very familiar process, and pitching motions generally follow very similar forms (Takeuchi & Inomata, 2009). By using the foreknowledge obtained by studying the pitcher’s arm and hand in the final phase of his delivery, batters can get a good idea of what type of pitch is going to be thrown (Takeuchi & Inomata, 2009). It is this type of anticipation that allows them to visually detect the ball faster than if they were not aware of what to expect (Summerfield & Egner, 2009). But what if a pitch is different from that expectation? Summerfield argues that unexpected stimuli will still elicit a strong response in an observer because unexpected stimuli tend to draw attention more than expected stimuli. For example, if a pitcher throws a ball in a way that would indicate it is a fastball but it is instead a curveball, a batter would quickly notice that the ball was deviating from his expectation (Summerfield & Egner, 2009). Therefore, baseball players likely use a top-down, probabilistic visual process heavily influenced by expectation when they observe a pitch (Summerfield & Egner, 2009).

Decision-Making Models for Rapid Decision-Making Based on Limited Visual Input in Sports:

Despite these apparent differences in perception, it is not unfeasible that the underlying decision-making process in these two examples is the same. In a 2006 paper, Joseph G. Johnson posits a framework for determining decision-making models in sports. In an effort to qualify these decisions, Johnson discusses common aspects of the many different decisions made across sports.

With exception, most decisions in sports are naturalistic – made by agents with a degree of familiarity with the task at hand in an environment in which the decision is naturally encountered (Johnson, 2006). For example, a point guard in basketball is well aware that he will likely have to pass the ball when he reaches the other side of the court. There is also a time element in sports. Decisions unfold as plays develop, and time pressure limits the amount of deliberation athletes can enjoy before being forced to make a decision (Johnson, 2006). With these factors in play, Johnson then begins to unpack the different conventions of cognitive modeling and how they can be best applied to decision-making in sports. Johnson writes that a dynamic model must be considered when looking at how decisions are made in sports. A dynamic model would account for the sequences of events in sports and how they influence a decision-maker's deliberations (Johnson, 2006). Johnson also stresses that it is more significant to observe the process of decision-making in athletes rather than the outcome, since the process would convey more information regarding the actual generation of the ultimate decision. Lastly, Johnson stresses that sports decisions are not deterministic, meaning that a set outcome will always come from each situation, but rather probabilistic: the idea that there is a probability for each outcome. Therefore, Johnson calls for a dynamic, probabilistic process model to be applied to sports.

One possible cognitive model for the decision-making fitting Johnson's mold is the Recognition-Primed Decision (RPD) model of rapid decision-making first proposed by Gary A. Klein in 1993. Klein studied the decision-making process of fireground commanders when deciding how to respond to fires. Klein contends that the fireground commanders' accounts of their decision-making process did not feel like decision-making to them: when interviewed, fireground commanders could describe possible alternate actions to fighting the fire they were talking about, but insisted that during the incident they did not think about this alternative and instead simply did what they thought was the best course of action. Sometimes, they would think through their idea if they had time (Klein, 1993). He maintains that following a traditional decision-tree model for weighing the pros and cons to different courses of action would cause the commanders to lose track of the firefighting task at hand (Klein, 1993). The fireground commanders' vast experience dealing with fires also seemed to allow them to merge the individual cases they had encountered throughout their career to be able to use a judgment of familiarity or prototypicality that would not be present with the retrieval of independent analogue cases (Klein, 1993).

Klein describes the RPD model as having three cases: 1) the situation is recognized and the obvious reaction is implemented, 2) the decision-maker performs some conscious evaluation of the reaction to uncover problems prior to carrying it out; 3) the evaluation reveals flaws requiring modification/rejection. Klein also asserts that there are four components to RPD decision-making: 1) understanding what goals can be reasonably accomplished, 2) increasing the salience of clues that would support different courses of action, 3) forming expectations of what should happen; 4) identifying the typical actions to take. RPD model decisions are also examples of satisficing: as soon as the decision-maker thinks of a way to achieve their goal, they pursue that option, even if "better" options may exist (Klein, 1993). Additionally, the RPD model accounts for individuals going through with a possible solution before having time to fully weigh their options (Klein, 1993).

It is case 1 that seems most likely to be conducted in fast-reaction sports like baseball and boxing. The fit is natural: a boxer or baseball player must decide what he or she seeks to achieve (hit the ball or strike the opponent), what to look for in order to make that goal happen (the ball must be in the strike zone or the opponent must be sufficiently open), what the athlete can reasonably expect to happen if they pursue their action (he or she may miss the ball or have their attack blocked if they are not successful), and what a typical action might be in that situation (swinging for an infield grounder or waiting for an opening allowing a left uppercut) (Klein, 1993, Ripoll et al., 1995, Takeuchi & Inomata, 2009). All of this must be decided in milliseconds, which is what makes the hypothesis that athletes making rapid decisions under limited visual input follow the RPD model attractive. Athletes playing tennis, for example, will tell reporters that they lunged for the ball and stretched out to get a ball in their periphery instead of weighing in their minds how to best close the distance to the ball. Athletes in these situations seem to do things instinctually the same way that fireground commanders instinctually know how to best combat a blaze.

Conclusion:

Based on the discussed examples, methods of visual perception, and decision-making models, we can make a broader conclusion relating to rapid decision-making based on limited visual input in sports. It seems reasonable to conclude that decisions following these qualifications follow the RPD model described by Klein. Athletes simply do not have time to weigh various options before committing, and often act as if the decision comes natural to them in the context. It is also worth noting that although athlete may employ different strategies for coping with limited visual input, they still share the same end result when compared to non-experts: the experts demonstrate that they know where and how to locate their eyes to maximize the effectiveness of their visual observations. Therefore, it is not unreasonable to generalize that the best athletes are both experienced at problem-solving in the contexts of their sport and disciplined to pay attention to what matters most in order for them to solve these problems at a consistently high level.

Reference List:

Foot, P. (1967). The problem of abortion and the doctrine of double effect.

Johnson, J. G. (2006). Cognitive modeling of decision making in sports. *Psychology of Sport and Exercise*, *7*(6), 631-652.

Klein, G. A. (1993). *A recognition-primed decision (RPD) model of rapid decision making* (pp. 138-147). New York: Ablex Publishing Corporation.

Posner, M. I. (1980). Orienting of attention. *Quarterly journal of experimental psychology*, *32*(1), 3-25.

Ripoll, H., Kerlirzin, Y., Stein, J. F., & Reine, B. (1995). Analysis of information processing, decision making, and visual strategies in complex problem solving sport situations. Human Movement Science, 14(3), 325-349.

Summerfield, C., & Egner, T. (2009). Expectation (and attention) in visual cognition. *Trends in cognitive sciences*, *13*(9), 403-409.

Takeuchi, T., & Inomata, K. (2009). Visual search strategies and decision making in baseball batting. Perceptual and Motor Skills, 108(3), 971-80.

Williamson, D. (n.d.). How Much Does A Bat Weigh? All You Need To Know And More! - PlayBall. Retrieved November 23, 2018, from https://www.playballbc.com/faqs/baseball/how-much-does-a-bat-weigh.