Preventing Penalties and Batting Baseballs

How do athletes use temporal and spatial anticipation?

The goalkeeper in soccer is responsible for defending a goal that is enormous: 8 yards (7.3 m) wide and 2.6 yards (2.4 m) high. In a penalty kick situation, the player who is taking the shot has a free kick of the ball from a distance of only 12 yards (11 m) from the goal line. The closeness of the player taking the kick to a goal of such size makes it seem as though stopping the ball is virtually impossible. And yet, skilled goalkeepers are successful at stopping about one out of every four penalty kicks. How do they do it?

Unlike in the situations discussed in the preceding stories, reacting after the ball has been kicked is unlikely to be a successful strategy in soccer, given the time it would take to respond appropriately (reaction time) and then move into position to stop the ball. If the goalkeeper were to react to the direction in which the player has struck the ball, successfully defending the goal would be unlikely, if not impossible. Instead, the goalkeeper must anticipate the spot to which the ball will be kicked and begin moving toward that spot before the kicker actually strikes the ball. This type of anticipation is similar to the temporal anticipation seen in the drag race start (i.e., an action is made that uses predictable information provided by some external event). For the drag racer, the Christmas tree provided information that facilitated temporal anticipation (see “Jumping the Gun”). Although temporal anticipation is of some importance for the soccer goalkeeper, the more critical matter is being at a certain spot in front of the goal to block the shot when the ball arrives. This requires spatial anticipation; the goalkeeper needs to predict where the ball will be kicked.

How does the goalkeeper know where to dive before the ball is struck? If the goalkeeper knows something about the kicker’s history or tendencies in penalty kicks, then an educated guess might be better than nothing at all. However, researchers have found that skilled goalkeepers use more than memory and guesswork to make these spatial anticipations. They see specific information as the kicker approaches the ball, despite the kicker’s attempt to disguise that information. Studies by researcher Geert Savelsbergh and his colleagues used eye movement recordings to reveal that expert goalkeepers rely on visual cues provided by the kicker to anticipate where the ball will go. The cues detected by experts are more dependable and revealing than the cues used by novice or less skilled goalkeepers. As the kicker starts the initial approach to the ball, the expert goalkeeper tends to focus on the kicker's face, perhaps with the hope that the direction of gaze might give away the intended location of the shot. As the kicker comes closer to the ball, the skilled goalkeeper switches the focus of visual gaze to the kicker's lower body. In contrast, novices tend to be much less focused in their visual search and often look at the upper torso during the entire kick.

The information about the probable intended location of the shot, extracted during the run-up and before ball contact, allows the skilled goalkeeper to predict with some reliability where to dive to block the ball. Of course, this does not guarantee that the goalkeeper will actually stop the ball once there, but at least she has a better chance for success than she would have if she waited until the kick or merely guessed.

Extracting information to predict an object's temporal occurrence is critical for the drag racer, and information that predicts an object's spatial occurrence is of utmost importance to the soccer goalkeeper. Having to pick up on both sources of information is perhaps why professional baseball players are rewarded with multimillion-dollar contracts for achieving success in only a third of their trips to the plate!

A few numbers about baseball batting reveal why the task is considered so difficult to perform well. Although the pitcher starts his windup just over 60 feet (18 m) from the batter, by the time he finally releases the ball, the pitcher's hand may be only 55 feet (16.8 m) or so away from the plate. It is not uncommon for major-league pitchers to throw over 90 miles per hour (145 km/h), and some have been clocked at over 100 miles per hour (161 km/h). Although these numbers sound impressive, they are even more astounding when expressed in time. A relatively pedestrian 80-miles-per-hour (129 km/h) fastball takes just over half a second to reach the plate (517 msec), and a 100-miles-per-hour fastball leaves the pitcher's hand and arrives at the plate in just over four tenths of a second (413 msec). Hubbard and Seng's early research with college baseball batters found that they needed about 160 milliseconds to get the bat from the first motion of the swing into the hitting zone (above the plate). So, given all of these time constraints, how long does a batter have to make the decision of whether or not to swing at the pitch?

Let's assume for the moment that a batter will decide to swing at a pitch that is in the strike zone, and will decide not to swing at a pitch that is out of the strike zone. And let's also assume, for now, that the batter is reacting to the information contained in the ball flight. So, after the batter has reacted with a decision to swing, he must factor in the time it will take for the bat to arrive in the hitting zone (160 msec). Simple subtraction tells us that for an 80-miles-per-hour (129 km/h) pitch, the average batter has 517 − 160 = 357 milliseconds to decide whether or not to swing the bat. For the 100-miles-per-hour (161 km/h) pitch, that decision time is reduced to about 253 milliseconds. In all, that seems like a lot of time to make the decision (consider that a sprinter typically reacts to the sound of the starter's gun in 150 msec or so).

But, there are some complications here. First, the batter is not responding to a sound but rather to something he is seeing, and reaction times to visual information are typically slower than reaction times to sound. Second, coinciding the spatial aim of the bat requires that the batter accurately predict where the ball will be when it arrives in the area near the plate. Therefore, the longer the batter gets to see the flight of the ball, the better the prediction should be. And that is assuming that the flight of the ball is predictable. Pitchers have an arsenal of skills to increase the difficulty of predicting where the ball will be as it crosses the plate. The last thing major-league pitchers want to do is throw a ball that goes straight. Instead, they use various finger grips and throwing motions to change the ball's direction during its flight. And to complicate things even more for the batter, the savvy pitcher changes speed from pitch to pitch, thereby increasing the temporal anticipation complexity of hitting.

So, what strategies does a batter use to improve the likelihood of colliding the bat with the ball? Like expert soccer goalkeepers, skilled baseball batters search for cues from the pitcher, before the ball is released, that might tip them off about the nature of the pitch. Being able to visually detect these tip-off cues is mandatory for achieving some measure of success (and money). For example, the location of the ball in the pitcher's hand can give the batter some indication of the type of pitch being thrown. A ball tucked between the index and middle fingers could be a tip-off that the pitcher is going to throw a split-fingered fastball. If the ball is held deep in the palm of the hand, or grasped between the thumb and index finger, then a slower-than-normal pitch (called a changeup) is likely on the way. Of course, the pitcher will try to hide this information by keeping the throwing hand out of sight from the batter for as long as possible. So, the skilled batter must try to pick up this information as early as possible during the pitch.

As with the soccer goalkeeper, if the batter must react to the ball as it arrives near the plate, then the odds of success are very poor. But these odds improve dramatically when the batter can use temporal and spatial anticipation. Perhaps this explains why baseball players frequently remark, after a particularly good day of batting, that they were "seeing the ball well today."

Self-Directed Learning Activities

1. Define *spatial anticipation* and *temporal anticipation* in your own words.
2. Given the numbers presented in the story for the durations to deliver pitches of different speeds and bat swing times, calculate how much time a batter would have to make a decision for a 90-miles-per-hour (145 km/h) fastball and a 140-millisecond bat swing duration.

From T.D. Lee, 2011, *Motor control in everyday actions* (Champaign, IL: Human Kinetics).

3. Do some research if needed and identify two types of occlusion methods that have been used in research to examine the nature of perceptual expertise in sport.
4. Pick a sport task, other than goalkeeping and batting, in which spatial and temporal anticipation serve an important role, and speculate on the nature of advanced search clues used by skilled athletes.

Notes

- Here is a pitching speed calculator:
  www.tinyurl.com/pitchspeed
- When I pitched for the Dundas Chiefs senior baseball team, my 68-miles-per-hour (109 km/h) fastball took about six tenths of a second to arrive at the plate. Batters could yawn during my pitches and still have plenty of time to hit the ball . . . and hit it hard . . . to places far, far away.

Suggested Readings

Hubbard, A.W., & Seng, C.N. (1954). Visual movements of batters. *Research Quarterly, 25,* 42-57.

Savelsbergh, G.J.P., Williams, A.M., Van der Kamp, J., & Ward, P. (2002). Visual search, anticipation and expertise in soccer goalkeepers. *Journal of Sports Sciences, 20,* 279-287.

Schmidt, R.A., & Lee, T.D. (2011). Central contributions to motor control. In *Motor control and learning: A behavioral emphasis* (5th ed., pp. 177-222) Champaign, IL: Human Kinetics.