The Point of No Return

Is there a point in time after which an initiated motor program cannot be stopped?

Steve Williams has caddied for Tiger Woods for many years, and on occasion, his actions have caused some controversy. In one instance, Williams went into a crowd of people who were watching Tiger hit a shot to take a camera away from a photographer who had snapped a picture in the middle of one of Tiger's swings. Such a disruption would normally be infuriating to a professional golfer, but Tiger calmly stopped his downswing, backed away from the shot, and started over again. How did he do that?

What Tiger demonstrated is something that we actually see fairly often in sports other than golf. In baseball batting, for example, the decision to swing is based on the perceived "hit-ability" of a pitch, which is gathered from the flow of information about the oncoming ball flight (see "Preventing Penalties and Batting Baseballs" in chapter 5). Sometimes the visual information received early in the pitch would indicate that the ball is very hit-able, so the batter initiates a swing. But later visual information tells the batter that the earlier decision was wrong and that now would be a good time to change that decision and not swing.

The checked swing in baseball (see figure 7.4*a*) is an illustration of a successful reversal in the decision to act. Like Tiger, the batter initiated the trigger to swing but then initiated a second "stop swing" signal that was effective in arresting the swing before it was too late. The rules of baseball, however, define very clearly when the batter has been successful in checking a swing. If that internal signal to stop the swing is not sent soon enough, the bat will cross the plate and the umpire will rule that the batter has swung at the pitch (see figure 7.4*b*). The batter's success in checking the swing before the bat crosses the top of the plate is very likely a matter of time: the second signal (to stop the swing) must be sent very soon after the first signal (to start the swing) to have any chance of inhibiting it.

The Tiger Woods example and the checked swing in baseball raise a number of fascinating questions about motor control. Is there a point of no return once an action has been started? Is there a point in time after which the full execution of the action can no longer be stopped? If so, is there something in particular about the nature of the action or the person who is performing the action that makes it unstoppable?

Before we can begin to answer questions about how a batter might stop a baseball swing, let's review a couple of findings about what might underlie

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the swing in the first place. For this, we call upon the concept of a motor program and what role it might play in the initiation of an action.

One clue about the role of a motor program in movement initiation comes from experiments on the subjective estimate of time. In this research the subjects' task was to simply watch the second hand of an analog clock sweep around the clockface and to press a button at any time. Immediately after pressing the button, the subjects estimated the point on the clockface where the clock hand had been when they pressed the button. Even given this very simple task, most subjects believed that the clock hand position was at an earlier point than it actually was when they pressed the button. Why did they make this consistent error bias in such a simple, voluntary task?

One leading argument is that this subjective error reflects the dissociation between the initiation of the motor program and the action resulting from initiating the motor program. The error occurs because the subject misattributes the command to release the motor program to the actual start of the movement itself. Hence, the belief is that the point on the clock when the button was pressed is actually the point on the clock when the motor program to press the button was sent to the muscles.

In an earlier story ("Antilock Brakes" in chapter 5) I discussed the research of Franklin Henry, who found evidence for the existence of motor programs that underlie the control of more complex, rapid actions. In his work Henry found that the time delay in initiating a motor program was directly related to the complexity of the action to be performed and, theoretically, directly related to the complexity of the motor program underlying it. Given this finding, it is quite reasonable to suspect that there should be an even longer delay before the initiation of a movement that is under the control of a more complex motor program (such as a baseball swing) than before a simple button press.

The point of all this is that initiating an action takes time because of the underlying neural activity that must occur before a movement can actually begin. For the result of a movement to occur at a specific point in time (such as hitting a baseball), the temporal delays in getting the action started must be anticipated and factored into the timing of the entire action, as well as the time that it takes for the movement to be completed.

Now consider how much time is needed to stop a motor program after it has been initiated. One clue to answer that question came from some research by Arthur Slater-Hammel many years ago, which in some ways mimicked the checked swing situation. Participants in his study were asked to perform an anticipation task by lifting a finger from a button when a rapidly rotating sweeping hand reached the 10 o'clock position (not unlike the anticipation timing required to swing a bat and hit a pitched ball as it crosses the plate). As suggested before, the subjects couldn't wait until the sweeping hand actually reached the 10 o'clock position before issuing

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the command to lift the finger because of the delays in the initiation and execution of the motor program, as well as in making the movement itself. The command to start the motor program needed to be sent well in advance of the coincident point.

This being a simple task, Slater-Hammel's subjects quickly figured it out and were stopping the sweep hand at close to the 10 o'clock position. A critical point in the experiment occurred, however, when Slater-Hammel introduced a catch trial into the sequence of normal trials, in which the clock automatically stopped on its own, prior to the 10 o'clock position. The participants were instructed that whenever a catch trial occurred, they were to try to stop themselves from lifting their finger. Essentially, this is the same as the checked swing in baseball (if the batter sees that the pitch is out of the strike zone, he must stop himself from completing the initiated swing). For these catch trials, the important measure of performance was whether or not the subjects were successful in inhibiting their response. Again, this is similar to the baseball situation because success would be measured in terms of whether or not the batter successfully checked the swing (see figure 7.4).

Slater-Hammel found that his participants were successful in preventing their finger from releasing the button only if the clock hand stopped more than 200 milliseconds before the 10 o'clock position. For positions less than 160 milliseconds or so from 10 o'clock position, the participants could not stop themselves from lifting their finger. It was as if the control of the finger had been turned over to the motor program responsible for its execution, and once the program had been initiated, the participant no longer had control over the finger's action.

The implications of these results are complicated by the fact that the baseball swing is a much more complex action than the simple finger lift in Slater-Hammel's study. The finger lift is very much a ballistic action, and the motor program to initiate it is probably also very simple. The baseball swing, on the other hand, has a longer movement time and more complex motor program underlying it, which produces some advantages and disadvantages. The bad news is that the swing would need to be initiated well before a comparable finger lift because of the added movement time involved in getting the bat into the hitting area and the added initiation time involved in recruiting a more complex motor program. The good news is that this additional delay would also provide more time for the batter to change the decision to swing. As a result, the checked swing in baseball is not an either–or situation, and we sometimes see the batter check the swing before the bat starts to move, sometimes just before it crosses the plate, or sometimes not until after the bat has crossed the plate.

Numerous lines of evidence suggest that motor programs exist and that they play an important role in the control and alteration of intended actions. But, is there a point of no return—a point in time when the action cannot be modified at all? One more finding, provided by Gordon Logan, helps to answer this question. Logan asked skilled typists to type prose in a normal way, but to stop typing whenever an auditory signal was presented. He found that the typists could stop very quickly when they heard the signal, suggesting that a point of no return does not exist. However, there was one exception: the typists could not stop typing the word *the* before the entire word (including the space after the word) had been typed. One interpretation of this result was that a highly overlearned motor program for *the_* had been developed in these typists, the full execution of which was nearly impossible to inhibit once it had been initiated. For *the_*, initiation of the uninterruptible motor program represented a point of no return.

So, what we have is a rather complex set of findings. On the one hand, a highly overlearned motor program for typing seems to control the execution of an entire coordinated action once initiated. On the other hand, complex movements such as the golf and the baseball swing seem to be modifiable well after they have begun. For highly skilled typists, the development of a motor program for typing the word *the* appears to have developed with practice. For highly skilled baseball players and golfers, the ability to modify a well-learned action may be a consequence of learning, too. The reasons for these discrepancies are not well understood and remain an impetus for future research.

Self-Directed Learning Activities

1. Explain the point of no return in your own words.
2. Suggest another highly overlearned word or phrase that might represent an unmodifiable motor program in skilled typists.
3. A checked swing in baseball occurs when a batter cancels a previously initiated motor program. Suggest a different activity in which the motor program is not canceled, but instead is replaced with a different motor program.
4. Suggest a methodology for studying the time to check the swing in baseball using the methods Slater-Hammel used.

Notes

- Important biomechanical influences are involved in successfully checking the baseball swing, such as arresting the angular momentum and torque in the swing.

Suggested Readings

Gray, R. (2009). A model of motor inhibition for a complex skill: Baseball batting. *Journal of Experimental Psychology: Applied, 15,* 91-105.

Logan, G.D. (1982). On the ability to inhibit complex movements: A stop-signal study of typewriting. *Journal of Experimental Psychology: Human Perception and Performance, 8,* 778-792.

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.

Slater-Hammel, A.T. (1960). Reliability, accuracy and refractoriness of a transit reaction. *Research Quarterly, 31,* 217-228.