Jumping the Gun

How can a reaction be distinguished from an anticipation?

A subtle but important feature sets a true reaction apart from other types of situations in which we need to respond quickly to external events. A true reaction involves a response to an unanticipated event (or the unanticipated timing of an event). A good illustration of reacting is the sprint start or the sudden response to slam on the car brakes when a child has run into the street, as discussed in the previous story.

The goal of a sprint race is to determine who is the fastest runner. To make the sprint start as fair as possible, certain rules have been created to reduce the probability that a runner will get a head start by anticipating the starter's signal (i.e., jumping the gun). One rule charges an illegal (or false) start to a runner who has a reaction time of less than 100 milliseconds (one tenth of a second). The rule is in place because research suggests that hearing the sound of the gun and translating that information into the decision to run require time, and that time has been determined to be greater than 100 milliseconds. Therefore, the rule is that anyone with a sprint start reaction time of less than 100 milliseconds must certainly have anticipated the sound of the gun and initiated the response before the gun was fired.

The other rule that stresses the importance of reacting to and not anticipating the sound of the gun is the disqualification criterion. Prior to 2003, any sprinter who false started twice in a race was disqualified from further competition. A famous example was the British sprinter Linford Christie, whose dream of a repeat gold in the 1996 Olympics vanished when he was tagged with two false starts in the 100-meter finals. In the second of those false starts, Christie believed that he responded to the sound of the gun. However, his reaction time, as measured by the increased force applied to the block (see figure 5.1, p. 81), indicated a reaction time of less than 100 milliseconds.

With eight runners in a typical sprint race, however, the old rule allowed for up to eight false starts to the race before runners started to be ruled disqualified. After eight false starts, I'm sure the runners, the starter, and just about everyone watching the race would just like to see it finished. So the rules were changed in 2003 such that the entire field of racers was allowed only one false start. Now, after someone has committed a false start, the next person to jump the gun is disqualified. The application of this rule in 2003 World Championships is remembered well for the disqualification of

the favorite, Jon Drummond, who was so upset with the ruling that he lay down on the track and refused to leave.

Reaction times are affected by a large number of factors, especially the properties of the stimulus. For example, a recent analysis of 100-meter and 110-meter hurdle races at the 2004 Olympic Games (men's and women's races) revealed that the runners in lane 1 achieved significantly faster reaction times than the runners in the other lanes (2-8). Since lane 1was the closest to the starter, and therefore to the sound of the starter's pistol, the authors suggested that an unfair advantage was gained due to the properties of sound propagation. Another study revealed that the sound propagation effect on reaction time was magnified even more in the start of the 4x100-meter relay race, in which the distance from the starter to each of the lanes is increased dramatically compared to the sprint start race.

So, how valid is it to impose an absolute lower limit of 100 milliseconds on the start of a sprint race? Consider the following extreme example of how the stimulus properties affect reaction time in research conducted by Valls-Solé and his colleagues. They used a method in which subjects performed reaction responses to normal auditory sounds over a large number of trials. Then, on one particular trial, quite unexpectedly, an extremely loud acoustic stimulus was paired with the regular stimulus. The result was quite fascinating. Subjects produced the intended response with the precision of a regular

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reaction trial, but the response was initiated much faster, sometimes much less than 100 milliseconds faster, than the reaction times on the normal trials. Responses ranged from simple arm movements to whole-body movements (such as a sit-to-stand action). The argument the researchers offered for this result was that a motor program had been prepared voluntarily, but released involuntarily, using different neural pathways that were startled into action. My question is simply this: Is it possible for a sprinter, somehow, to be trained to be startled by the sound of the starter's gun? I am unaware of any research conducted on this question, but if this were possible, then the validity of imposing a 100-millisecond lower limit could be in question.

Regardless of the purpose of the false start rule, deciding the winner of a sprint race by including a reaction time component to the total time changes the interpretation of the skills of the winner. Instead of simply being the fastest runner, the winner of the race is the person who combines the best running *and* reacting times. For example, the medalists in the 60-meter finals at the 2006 IAAF World Indoor Championships in Moscow were Leonard Scott (6.50 sec), Andrey Yepishin (6.52 sec), and Terrence Trammell (6.54 sec). However, Trammell got off to a poor start, with a reaction time of 171 milliseconds. Scott's and Yepishin's reaction times were much faster (125 and 144 msec, respectively). Subtracting the reaction time from the final finish time reveals that, despite winning the bronze medal, Trammell had the fastest running time in the race (6.369 sec) (Scott and Yepishin were both at 6.376). So, who, rightfully, should have been crowned the world's fastest human—the fastest runner or the fastest reactor and runner?

This confusion between running fast and reacting quickly is not a problem in the sport of drag racing. The start signal for a drag race, in which pairs of cars race against each other, begins when the front wheels touch the starting line. Arriving at the starting line activates two pairs of preparation lights, followed by three amber staging lights on the so-called Christmas tree. Unlike the sprint start, in which the time between the "Set" command and the sound of the gun is varied and unpredictable, the illuminations of amber staging lights on the tree are separated by a constant amount of time (0.5 sec). The third amber light is followed very predictably by a green light. A perfect start would be a rapid acceleration of the car that is timed to begin at precisely the moment the green light appears. Essentially, this creates a reaction time of zero!

But, is it correct to call this a reaction time? Remember that a true reaction is a response made to an unpredictable external event (or unpredictable timing of the event). The sprinter who responds faster than 100 milliseconds is likely responding to her anticipation of the starter's gun. For the drag racer, the timing of the green light is perfectly predictable, and the skilled person is the one who can maximally coincide starting with its appearance. Such a skill is very different from reacting, however, because this involves primarily a temporal anticipation to a predictable external event rather than a reaction to an unpredictable event.

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SELF-DIRECTED LEARNING ACTIVITIES

1. In your own words, define and differentiate between a reaction and an anticipation.
2. Aside from the loudness of an acoustic stimulus, name two other properties of the stimulus that would influence a person's reaction time.
3. Find a recent set of results for a World Championship sprint start, and separate the reaction times from the final times. Was the winner of the race the fastest runner or the fastest combined reactor and runner?
4. Suggest a method for determining the minimum allowable reaction time in a sprint race. How would your method ensure that the sprinter reacted to, rather than anticipated, the sound of the gun?

NOTES

- I use the term *unanticipated* in this story in the sense that we don't know exactly when or where the event that we respond to will happen. For example, in the sprint race, we know that the sound of the starter's gun will be heard at some point, but we don't know exactly when.
- See this site for a demonstration of the drag race Christmas tree and a chance to test your anticipation timing:
  www.howtodragrace.com
- Try this fun little experiment: www.mathsisfun.com/games/reaction-time.html. What effect did you experience that was mentioned in the story?
- For much more on sprint start reaction times, see this site:
  www.condellpark.com/kd/reactiontime.htm

SUGGESTED READINGS

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