4. PERFORMANCE AND PERCEPTION

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Use of a computer-controlled firearms training simulator in perception response time experiments

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This paper describes the use of a custom-configured computer-controlled firearms training simulator to measure perception response (reaction) time (RT) to a stimulus in which the degree of threat presented is a manipulable variable across trials. The computer records the number of frames of videotape traversed between the point of presentation of the threat in the video stimulus and the point at which the subject responds by drawing the firearm. For the purposes of data analysis, these frame-count measures are converted to RT measurements. Example data are presented that capture perception RT at both the *draw*-stimulus and the *fire*-stimulus points in situations for which either only one threat or more than one threat exists. Other elements, such as degree of threat and accuracy of response, provide additional data.

Several simulation devices are currently available for use in training for occupations in which a firearm is a critical tool. Currently, firearms simulators are used by military, police, armed security, and law-enforcement training schools, both in the U.S. and in several foreign countries. In an earlier paper (Seymour, Stahl, Levine, Ingram, & Smith, 1994), we described modifications of such simulators for use in basic research. Three systems that represented the leading edge of current technology in this area were compared.

Recent developments in technology have allowed for the use in training situations of increasingly sophisticated

equipment designed to present dilemmas to the users of lethal weapons. A continuing obstacle to training for faster reaction time and greater accuracy in firing the weapon, however, has been the separate need to train for better judgment. The system described in the present paper is the Judgment Under Stress Training (JUST) simulator, which has been extensively modified for research. It is a computer-controlled, multimedia, life-sized video projection system designed to bridge these three dimensions of human performance—reaction time, accuracy, and judgment—in situations of threat. This apparatus—a custom-configured firearms training simulator similar to those currently used in training applications—is being used in a series of experiments that measure perception response (reaction) time (RT) to a stimulus, where the degree of threat that is presented in the stimulus with which the subject is confronted is a manipulable variable across trials. Within each trial, there are three stimulus points that define the RT experiment. These stimuli are also variable across trials.

This research was supported in part by Grant DAAL 03-92-G-0382 from the U.S. Army Research Office to G.O.S. and J.M.S., and by Undergraduate Honors Research Fellowship 5T34MH16573-14 from NIMH-COR to D.R. Correspondence concerning this article should be sent to G. O. Seymour, Center of Excellence for Research on Training (CERT), Morris Brown College, 643 M. L. King, Jr. Drive, Atlanta, GA 30314.

Alexander and Lunenfeld (1975) describe the four basic elements of all RTs: detection, identification, decision, and response. Most simple RTs involve a known stimulus and a clearly described response. Choice RT involves both detection and identification, and may also introduce a decision process (see Luce, 1986, for a review). Current developments in the use of technological equipment in reacting to stimuli that pose high degrees of risk to the operators of such equipment have led to a resurgence of interest in RTs in which all four elements are present. Hence, aircraft simulators to train pilots, driving simulators to measure the degree of recovery in stroke patients, and firearms simulators to measure the judgment of police officers are highly dependent on measures of RT that capture the mental processes present in each element.

Such measures differ from measurements of ordinary detection RT and from choice RT in that they include measurement of the time required to perceive an object or stimulus to which a response must be made, where the appearance of the object or stimulus is an emergent phenomenon (i.e., not an on/off occurrence), as well as measurement of the time required to complete the physical response (Rogers & Fisk, 1990). Taken together, these provide a measurement of the time for perception reaction, and as such, they have formed the topic of discussion and research in obstacle avoidance (Barrett, Kobayashi, & Fox, 1982).

Using the modified JUST system, the measurement of perception RT is accomplished by setting up the computer to record the number of frames of videotape traversed between the point of presentation of the threat in the video stimulus (which is determined by the experimenter) and the point at which the subject responds by drawing the firearm. The computer records the point of threat frame using a predetermined marking on the video tape which is read by the frame counter in the computer. When the subject responds by drawing the firearm from the holster, a draw sensor located 1 in. from the bottom of the holster identifies the movement of the firearm, closing an electronic circuit activating a signal to a sensor box, which then transmits the information to the computer to record the frame at which the circuit was activated. This sensor is activated on an all-or-none basis when the firearm is withdrawn from the holster. For the purposes of data analysis, these frame-count measures are converted to RT measurements that are multiples of 33.3 msec, as there are always 30 frames per sec. These measurements are designated *draw* RT since they record the perception RT required to respond to the *draw* stimulus, once that stimulus is perceived.

In the current research program, there is a dimension of situational complexity that begins to approach the question of visual-search strategy. This research was concerned with the possibility that the ability to perceive a threat might be influenced by whether one source of threat or more than one source of threat existed. Fifty-eight male and female trained police officers participated in tests using the JUST system. Following a standard introduction to the research apparatus, the subjects were given a practice test followed by eight tests on scenarios differing in the degree of threat

(high vs. low) and the number of persons presenting the threat (single vs. multiple). Two RTs were recorded for each police officer for each scenario—a *draw* RT and a *fire* RT. No scenarios were repeated.

For purposes of illustration, we are presenting data from two of the high-threat scenarios—one with a single-threat stimulus, and another with multiple-threat stimuli. The appropriate response for both scenarios was to give a verbal command to drop the weapon while drawing the firearm and then to shoot. To set the scene prior to the test, the following instructions were read:

High-threat/single-stimulus scenario. You are a uniformed law-enforcement officer. You approach an officer down with another man hunched over him.

High-threat/multiple-stimulus scenario. You are a uniformed law-enforcement officer. You enter a bar to investigate the nature of a disturbance that was called in. Ask for the manager.

Figure 1 shows the *draw* RT in the high-threat scenarios for single stimuli and multiple stimuli, by gender of

A) High threat/single stimulus:

B) High threat/multiple stimuli:

Figure 1. A. The *draw* time in high-threat scenarios for single stimuli, by gender of respondents. B. The *draw* time in high-threat scenarios for multiple stimuli, by gender of respondents.

respondents. Some of these RTs are so short that they could not reasonably be reactive to the stimulus itself. In addition, when the police officers were given the instruction to respond to an "officer-down" situation (i.e., one in which an officer was injured), 41% drew their weapon in response to the pretest instructions, even before the actual threat stimulus was presented. Drawing the weapon before the threat stimulus is visible is consistent with the training that police officers receive regarding how to act when an officer is down, as well as with data of Bjorklund (1992) and others showing the importance of warning information provided by the instructions given to subjects as part of their preparation for the task.

These same officers, when given instructions to investigate a disturbance in a bar, did not exhibit the *draw* RT until the threat was presented in the scenario. While these results preclude drawing conclusions about the effect of the number of threat stimuli on *draw* RT, they support the notion that police officers respond to the simulated shooting situations as they would do in real life. This suggests that, with refinements in our research protocol, the firearms training simulator can produce RT data with a high degree of generalizability to the real-life training needs of police officers.

In addition to timing the individual responses to the stimulus for drawing the firearm (*draw* RT), this research apparatus permits the identification of a point at which firing the weapon provided in the simulator would be the appropriate response to a perceived threat. The weapon is a real firearm (a 9-mm Barretta) retrofitted with a light-emitting diode to allow an infrared light beam to be fired and to prevent the discharge of live rounds. Each time the weapon is fired, the infrared light emitted is recorded. This allows for a second measure of perception RT in response to the next point of threat. Since pulling the trigger of the firearm causes the infrared light beam to be emitted, this measurement is coded as a separate data point by the computer, as the point at which reaction to the *fire* stimulus is completed. This measure of perception RT may also be influenced by whether there was one stimulus or whether there were more than one, and these trials are therefore designated accordingly. Figure 2 shows the *fire* RT in high-threat scenarios with single and multiple stimuli, by gender of respondent. The *fire* RT is exceptionally short for the officer-down scenario. This was due to the fact that many of the subjects entered the scenario with the firearm drawn in response to the pretest instructions.

Subsequent measurements identifying the accuracy with which subjects fire the firearm are also recorded by the computer, using a pin-point camera to capture the location of the emitted beam on a grid. The computer overlays the information received from the pin-point camera with specific point coordinates (cross-hairs) on the base grid underlying each videotape frame. Because all of these data are captured by the computer program without having to affect the videotape presentation, each subject's performance on each trial can be reviewed and replayed at any time. The current set of studies captures perception RT at both the *draw*-stimulus and *fire*-stimulus points.

A) High threat/single stimulus:

B) High threat/multiple stimuli:

Figure 2. A. The *fire* time in high-threat scenarios for single stimuli, by gender of respondents. B. The *fire* time in high-threat scenarios for multiple stimuli, by gender of respondents.

The differences in the stimulus presentations lie in the immediacy of the threat posed directly to the subject, within the context of scenarios to which they have been trained to respond (as if they were indeed personal-threat situations). Therefore, the demand characteristics of the simulation are enhanced at the later (*fire*-stimulus) point. It was hypothesized that such high-threat circumstances would produce greater vigilance, and that the consequent perception RT would therefore be reduced.

Such methodology and technology are also uniquely suited to moving from the examination of "pure" RT to examining the judgment dimension. This is done by devising a judgment score which takes account of those elements of performance that show, first, adequate perception of threat, then a judgment as to the type of response needed, and, finally, a response that accomplishes the goal of removing the threat (Triggs & Harris, 1982, as cited in Olson, 1989). The data on such performance are stored in an ASCII data file for ease of subsequent data analysis. This last point is important, as the most accurate and appropriate data-analytic techniques may well be those described as *fuzzy-set statistics*. More work in assessing the adequacy of such analytic techniques needs to be done, and part of the labo-

ratory's research plan for the next two years is, indeed, to accomplish this.

In summary, this paper has described a new approach to RT research which, because it adapts police firearms training equipment to data-collection requirements, has the potential for producing research data that has direct applicability to training needs.

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(Manuscript received November 29, 1994;
revision accepted for publication March 6, 1995.)