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Time to START Shooting? Time to STOP Shooting? THE TEMPE STUDY

By Dr. Bill Lewinski and Dr. Bill Hudson

The concepts addressed in this study are critical for officers to understand, especially those who are consulted by prosecuting attorneys or go before grand juries as firearms experts. Research on reaction time began in 1820 by astronomers and was first published by psychologists in 1864. Since that time, researchers have published thousands of articles and textbooks on the topic. An interesting question is—why hasn't this treasure trove of knowledge made its way into a more scientific understanding of officer-involved shootings? For instance, many department policies require an officer to immediately stop firing when the threat ceases. An important question is—what is immediate? Most departments intuitively understand that immediate means “as soon as reasonably possible” and will cut the officer some slack—others will not. Most will not apply the principles of perception, processing and reaction to the understanding of immediate.

To understand the significance of this study, we must remember that officers in this country are currently charged with homicide for being less than half of a second out of policy or out of what a prosecutor deems appropriate. Less than one half of a second too late on stopping a trigger pull! If we are going to be involved in judgments of an officer's behavior based on what he did in a fraction of a second, it is important to understand the limits of human reaction time and apply these limits in a scientific fashion to officer-involved shootings.

The legal foundation for decision-making relies upon many elements, including a concept called “the rational man.” The rational man has no reaction time, but responds instantly to any change, no matter how slight, in the most complex situation. The rational man is not human. He is not even a computer. In the Tempe Study, we presented the stimulus to shoot and stop shooting by means of light patterns on a stimulus board. We understood that the stimulus board, if run by the main computer, would have a reporting delay that differed from computer to computer. In the interest of a high level of accuracy, a computer was installed into the stimulus board, which controlled the stimulus lights, received the data, and transferred the data to another computer for analysis and storage. This cut our delay time in recording, down to less than one half of a millisecond. Even computers take time to register input, process and respond.

The essence of the Tempe Study was to understand how principles of perception, processing and reacting apply to officer-involved shootings. Hopefully this effort will lead to a better understanding of the human parameters of the concept of “immediate” in lethal force encounters and explore the human elements in the lethal force equation. In this study 102 officers

from Tempe, Arizona Police Department were tested on five separate experiments. This article will give the results of only two of the experiments. The remaining three experiments are still being sorted and analyzed and will be presented in later articles.

History and Principles

An analysis of the human components of reaction time tells us that a number of well-studied principles are in operation in every officer-involved shooting. These principles are connected to perception (the act of seeing and understanding a stimulus,) processing (the act of making sense of what is seen and making decisions on it) and then reaction (the act of responding to what is seen and processed.) Several of these principles were selected for this study.

Basic Reaction Time—Most studies on reaction time in law enforcement are done using a simple auditory stimulus, such as a buzzer. The traditional scientific research informs us that a reaction to a visual stimulus is slower than a reaction to an auditory stimulus and the more complex the visual stimulus is, the slower is the reaction. There are a variety of reasons for this, but this first experiment was designed to find out the time of a reaction to simple visual stimuli while pulling the trigger of a handgun.

Impact of Split Attention on Trigger Pull Reaction—The reader is likely aware of the significant media attention on the ability to react to driving emergencies while eating and driving, using the cell phone and driving, disciplining children and driving, etc. Similarly, officers in lethal force encounters are seldom doing only one thing. Just like drivers, many are multi tasking and working with a varied degree of split attention. They are moving, pointing, ducking, seeking cover, shooting, processing, reacting emotionally, etc. The question that was researched is—does multitasking effect the officer's reaction time, both in the starting of the trigger pull reaction as well as the termination of the trigger pull reaction?

Over 150 years of research tells us how these principles should apply to officer-involved shootings. For instance, the first publication ever on human reaction time addressed the issue of index finger (trigger finger) response time to a stimulus—the question answered in the Tempe Study is not only do these principles apply, but what is the actual time element involved in the response? For example, does 150 years of research on index or trigger finger reaction have any application to a law enforcement officer's trigger pull reaction. The

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results of this research will answer questions such as this.

Reader—be cautioned—the research is done in a controlled laboratory situation. The stimuli are simply lights. They are unaffected by issues of race, sex, economic status, street experience or the emotional status of the officer etc. The researchers were only interested in measuring reaction to a very neutral situation—in essence to establish simple base rates of reaction time. The officers were encouraged to react as quickly as they could. Almost all appeared to comply. A small number appeared to have difficulty completely complying, especially when they were instructed to pull the trigger as quickly as they could. A small number of officers insisted on a slow, controlled, trigger pull reaction while they stared at the light. Because these officers did not split their attention, their reaction times to terminate the trigger pull response was much quicker than the officers who “really got into” pulling the trigger. This is exactly what the scientific literature says would happen. Simply put, it says that the more occupied or preoccupied someone is at the time the stimulus changes, the longer it will take that person to notice and respond to the change.

Equipment

The first piece of equipment was a stimulus board. The board consisted of a black metal box with a pattern of clusters of lights on the face. There were 9 clusters of lights in a 3 by 3 pattern. Each cluster in turn had three lights in them (red, yellow and green.) The lights were instant on/off, light emitting diodes. Depending upon the pattern and sequence of lights presented, the eye and brain were forced to cope with a variety of problems. The stimulus board had a separate computer in it that was programmed to run the board and present the information to the master computer for data storage and analysis. The computer inside the stimulus board had software written for it that allowed us to create the light patterns necessary for the research

The second piece of equipment was the instrument used to measure the officer's trigger pull response. This instrument was a training gun developed by Glock. This pistol had a trigger pull at just under 10 pounds, a slightly longer trigger pull than a regular Glock and had a trigger reset that was based on a mechanical spring operation rather than a bullet explosion. Everything else was based on a standard 9mm Glock, including the frame, length of trigger, sights, etc. This training gun was outfitted with an external frame that contained a resistor that allowed the researcher to break the trigger pull distance into 120 separate units. The computer then monitored the trigger pull every 10 milliseconds. Simply put, nothing happened to that trigger that we weren't aware of. The third piece of equipment was a master computer which recorded the pattern of lights presented on the stimulus board, and combined this with the trigger information provided from the Glock. This information was then transformed by the computer into trigger pull plots or graphs.

Experiment #1

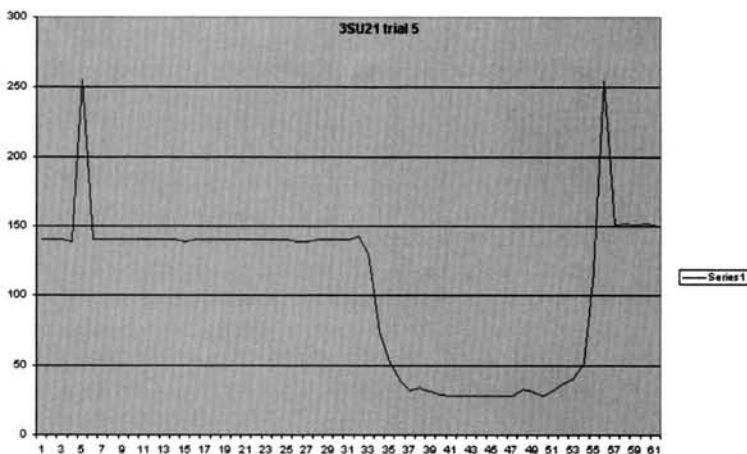
- Reaction Time to a Visual Stimulus

This experiment was the most simple and was used to test the reaction time to a visual stimulus as well as familiarize the

officers with the equipment. Most of the reaction tests in law enforcement have been done using a trigger pull response to an auditory stimulus. The basic research tells us that vision is more complicated than hearing and subsequently the visual reaction time is slightly slower than the auditory reaction time. The officers were instructed to pay attention to the clusters of lights in the upper left hand quadrant of the stimulus board. They were to pull the trigger once, as quickly as they could when a specific green light came on in this area.

The average trigger pull reaction time to a simple light stimulus was 31/100ths of a second. Because of the equipment, we were able to break the reaction time up into two separate components. The act of seeing the green light, processing that information and sending a message to the finger, on average took 25/100ths of a second. The average time for the mechanical action of actually pulling the trigger was 6/100ths of a second. This was the time it took to move the trigger from its normal resting position to a position at the rear of the trigger guard.

The following is an example of a trigger pull plot from experiment number one. It illustrates the onset of the stimulus, the perception, processing time and psycho/neurological reaction time right up until the start of the trigger pull response. It then illustrates the trigger pull time and pattern as well as the recovery time and pattern.



The two peaks in the upper part of the plot are the marks that indicate the start and the stop of the stimulus light. The officers were to react to the onset of the light or the first peak on the left. The flat line extending from that peak is the perception, processing time up to the very start of the trigger pull. The valley that follows the straight line is the actual trigger pull. The left side of the valley is the trigger being pulled backward. The bottom of the valley is the trigger being held against the frame. The right side of the valley is the trigger being released.

The basic information from this reaction time study has implications for understanding officer-involved shootings. For instance, given the trigger pull time of 6/100ths of a second, is it possible for an officer to see a change in the circumstance and stop pulling the trigger once the trigger starts to move? The answer from this experiment is definitely NO. Now the officer may be slowly pulling the slack out of the trigger and if that is

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the case, then he might be able to stop, but if the officer was reacting as quickly as he could to pull that trigger, there is not a human being on the face of the earth that could react quickly enough to interrupt the trigger pull motion. If the officer were to stop it at all, the decision to stop would have to start early in the processing time. The processing time is the “time expensive element” of the trigger pull. In this experiment, the processing time for reacting to nothing but a light coming on was four times longer than the physical trigger pull time. It is very clear from other parts of this research, that depending upon the complexity of the visual picture or scenario that the officer is reacting to, his processing time for even a quick reaction could start at half a second and get longer from there.

Experiment #2

- Time to Stop Pulling the Trigger

In this experiment, the officers were instructed that the researcher was measuring the officer’s ability to rapidly pull the trigger. When the light came on the officer was to immediately and repeatedly pull the trigger as quickly as he could, but he had to stop immediately when the light went off. To emphasize this, the officers were also intentionally misinformed that any trigger pulls after the light went off would count against their overall score and so they had to be very careful to stop the trigger pull immediately after the light went off.

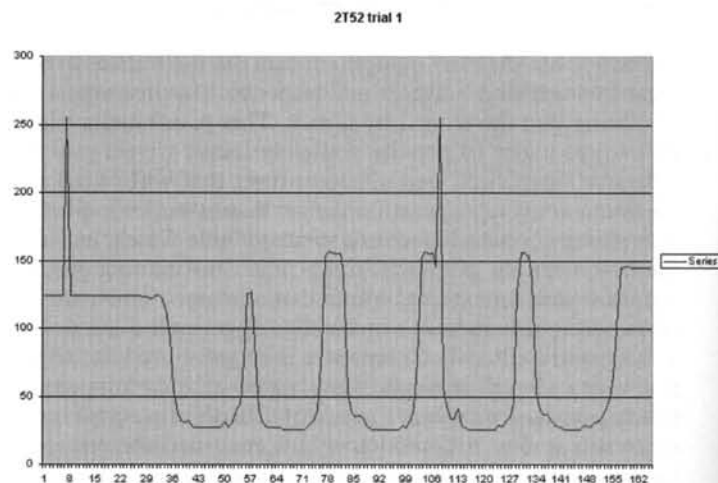
The officers in the study were misled. The rapid trigger pull was not what the researchers were interested in measuring. In essence, an officer who is pulling a trigger as quickly as he can with a handgun that is just slightly different than his regular weapon has to focus intently to make the trigger on the test instrument work quickly. This essentially forced the officer, in a very simple and minimal way, to split his attention from looking at the stimulus to looking at the stimulus and shooting. This minimal multitasking had a truly profound impact on the officer’s ability to immediately react to changes in the stimulus.

Research on reaction time logically states that it should take someone at least as long to stop an action as it does to start an action. This is reasonable, with the exception that the stopping reaction time is to some degree very dependent upon many things, including when the person begins to see the change in the stimulus or threat, and what the person is doing at the time, in both his brain and his body. For instance if an officer is just starting a trigger pull when the stimulus changes, is that different than having the stimulus start to change in the middle of the trigger pull, or at the end of the trigger pull? This argument may seem trivial, but given the time it takes to complete a trigger pull cycle and the time it takes to see, process and react to a change, this question in and of itself could account for the difference between one and two rounds pulled after the stimulus goes off or the threat ceases.

Also involved in this reaction time is attention and motivation. In this experiment, for instance, the extent to which the officers were motivated to pull the trigger as quickly as they could and split their attention, the longer the delay to see a change in the stimulus and react to that change. The less motivated the person was to pull the trigger as quickly as he could, the easier and quicker he was able to react to the change in the stimulus.

Training or experience also has an effect. For instance, in this experiment the trigger pulls or shots fired after the stimulus went off were double the amount, the first couple of times the officers were tested versus later tests. In later tests the officers as a group, did not split their attention as much and were able to anticipate the change in the stimulus light and stop shooting quicker. In essence, this defeated the purpose of this experiment. Subsequently the data from the first trials of this experiment are the most significant if we wanted to study the impact of multitasking or on trigger pull reaction. If we just wanted to study termination of a response, then the later trials in this experiment would be helpful to examine. Remember, the stimulus light came on at an irregular time and stayed on for an irregular time, so the officer could not anticipate either the start or the stop of the stimulus. This experiment is very important because, among other things, it tells us the stopping reaction time in a series of triggers pulls and may be the first study of its type ever done with law enforcement.

The analysis on the data from experiment number two indicates that the start time on the trigger pull in this experiment is the same as the starting reaction time in experiment number one. The scientific literature says that a stop reaction time where a person is actively engaged in doing something and then has to react to a new stimulus is approximately one-half of a second or a little less. In the first couple of tests in this experiment, the ones that most effectively caused the officers to multitask, the officers stopped pulling the trigger in 35/100ths of a second. The main body of officers, 68%, stopped pulling the trigger between 1/10th and 6/10ths of a second. The more effectively the officers multitasked, the closer they were to the 5/10ths to 6/10ths of a second.



Graph 2 is read the same as graph one – the first spike in the upper part of the graph is the onset of the stimulus light. The light stayed on until the second spike on the upper part of the graph, just to the right of the center. In this graph, the officer pulled the trigger three times when the light was on for one second. These are the three valleys in between the two spikes. The light then went off (second spike) just as the officer was starting a fourth trigger pull. The officer then pulled one more

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time before stopping. The grid at the bottom of the plot is in 100ths of a second. You should note that although the officer had only two trigger pulls after the stimulus went off, those two trigger pulls took a half a second to finish.

In law enforcement, these times have to be translated into trigger pulls to be fully appreciated. In this simple experiment, in which the officer was reacting only to a light going off, the time to termination of a trigger pull response, when the officer was engaged in a chain of trigger pulls, was at least two and sometimes three trigger pulls or more. In the street, the officer engaged in a highly threatening lethal force encounter is also likely to be doing many activities simultaneously or sequentially that will impact on the termination of his trigger pull response. These factors may be the type of weapon used, the poundage and length of the trigger pull, the skill of the officer, the emotional distress of the officer, the visual focus and attention of the officer (tunnel vision and a funnel of concentration that may cause the officer not to even notice a change in the threatening stimulus,) the officer's shift in attention to look for cover, the officer's expectation that the threatening action will continue when in fact it doesn't or it changes in some vital quality, etc.

In essence, this experiment in a laboratory setting gives us the minimal amount of time it takes the average officer to start

pulling the trigger and to stop pulling the trigger under ideal conditions. These numbers define the minimal limits of the term "immediate" when we are making reference to the performance of the human machine. The authors wish to thank Tempe, Arizona Police Department for their outstanding cooperation and hospitality, especially Sgt. Craig Stapp, Commander Brenda Vanamburg and Commander John Dorsey. Thanks also need to go to graduate assistants Darwin David and Ross Loven from the Electrical and Computer Engineering Department at Minnesota State University, Mankato. ☆

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