Friendly Fire in a Simulated Firearms Task

Kyle Wilson, James Head, and William S. Helton
University of Canterbury
Christchurch New Zealand

Factors such as poor visibility, lack of situation awareness and bad communication have been shown to contribute to friendly fire incidents. However, to the authors' knowledge, an individual's ability to inhibit their motor response of shooting when a non-target is presented has not been investigated. This phenomenon has been modeled empirically using the Sustained Attention to Response Task (SART; Robertson, Manly, Andrade, Baddeley, & Yiend, 1997) computer task. The SART is generally a high Go/low No-Go detection task whereby participants respond to numerous neutral stimuli and withhold to rare targets. In the current investigation, we further investigate the SART using a simulated small arms scenario to test whether lack of motor response inhibition can be modeled in a more ecologically valid environment. Additionally, we were interested in how error rates were impacted in low Go/high No-Go versions of the task. Thirteen university students completed a computer and simulated small arms scenario in a SART and low Go condition. Both the computer and small arms scenario revealed similar speed-accuracy trade-offs indicating participants' inability to halt their pre-potent responses to targets even in a more ecologically valid environment. The SART may be used in future studies to model friendly fire scenarios.

INTRODUCTION

Blue on blue, friendly fire or the more commonly used colloquial term "fratricide" has been defined as "the employment of friendly weapons and munitions with the intent to kill the enemy or destroy his equipment or facilities, which results in unforeseen and unintentional death or injury to friendly personnel" (Department of the Army, 1992). Friendly fire has a long history. For example, in the French and Indian wars of 1758 two separate British detachments mistakenly fired upon each other due to poor visibility which resulted in casualties (Doton, 1996). Friendly fire can occur amongst modern day war fighters for multiple reasons, such as losses of situational awareness, higher fire rates of modern firearms, difficult environmental conditions (e.g., nighttime operations), and cognitive factors. Indeed, with technological advancements fratricide rates have actually steadily increased since the Second World War (Rasmussen, 2007). Some research has focused on technological countermeasures, although problems arise when reliability is less than perfect with these systems, which is often the case (Dzindolet, Pierce, Beck, Dawe, & Anderson, 2001; Kogler, 2003; Parasuraman & Riley, 1997).

The introduction of new weapons with higher rates of fire and improved accuracy has increased the likelihood of friendly fire incidents; however, it is not clear whether losses of inhibitory control are a contributing factor (Greitzer & Andrews, 2008). Fast paced engagements may lead to a potential problem of soldiers being unable to withhold a pre-potent fire response. For example, if a soldier is engaged in a fire fight in a cluttered environment where the warfighter is confronted by many enemy combatants (targets) embedded within relatively few non-combatants and comrades (neutrals) a soldier may have difficulty inhibiting their response to shoot when a comrade or non-combatant appears. Indeed, Helton and colleagues (Helton, Weil, Middlemiss, & Sawers, 2010; Helton & Kemp, 2011) have suggested that this process may already be modeled empirically in the psychological laboratory with the Sustained Attention to Response Task (SART, Robertson, Manly, Andrade, Baddeley, & Yiend, 1997).

The SART is a Go/No-Go response task whereby participants respond to numerous Go stimuli while withholding to rare No-Go stimuli. The Go stimuli occur 89% of the time and the No-Go stimuli occur 11% of the time. Performance on the task is measured by errors of omission (inappropriately withholding to a Go stimulus), errors of commission (failing to withhold a response to a No-Go stimulus), and response time to Go stimuli. The primary measures of interest on the SART are errors of commission. The ubiquitous findings of the SART are negative correlations between response time to Go stimuli and errors of commission indicating a speed-accuracy trade-off (Helton, 2009). The speed-accuracy trade-off of the SART has been attributed to a self-organizing feed forward ballistic motor response program (Helton et al., 2010). When several Go stimuli occur in a rapid sequence the Go motor response becomes pre-potent and requires active control to inhibit. When an infrequent No-Go stimulus appears, participants are often physically unable to inhibit the motor response routine in time and thus make an inappropriate response (error of commission).

The SART has never been examined in a more realistic firearm simulation using actual moving humans as Go and No-Go stimuli. In the current investigation we further examine whether the speed-accuracy trade-off process modeled in the SART occurs in a more ecologically realistic small-arms engagement scenario. Unlike previous studies with the SART using computers with simple number or word stimuli, we wanted to see whether the feed forward motor ballistic routine occurs when participants have to physically shoot a person who may actively shoot back (Go stimuli) or not (No-Go stimuli). In addition, to this question, we also reversed the response paradigm of the SART to mimic low Go, high No-Go stimuli tasks more commonly used in the traditional target detection or vigilance literature, the Traditionally Formatted Task (TFT, Helton, 2009). In the TFT the Go stimuli occur

11% of the time, whereas the No-Go stimuli occur 89% of the time. Participants completed both tasks (SART and TFT) using both our small-arms simulation version and the computer task version used in typical SART studies. We also had participants complete the NASA-TLX questionnaire (Hart & Staveland, 1988) designed to assess workload.

We expected more errors of commission (inappropriately responding to No-Go stimuli) to be made in the SART than in the TFT for both the small-arms and computer versions. Secondly, a speed-accuracy trade-off will be evident in both the small-arms and computer version of the SART; that is, participants who respond faster to the Go stimuli will make more inappropriate responses to the No-Go stimuli. We expected the NASA-TLX global workload rating to be higher for the SART version than the TFT version of both tasks, because unlike the TFT, the SART requires response inhibition in addition to target identification.

METHOD

Participants

Participants were thirteen adults (7 men and 6 women) with limited firearm experience. They were compensated with $20 NZD vouchers. All participants had normal or corrected-to-normal vision based on sensory interview questions. Participants ranged in age between 18 and 45 years (M = 26.15, SD = 8.6).

Materials

There were two different Go versus No-Go stimuli relative probabilities for the task, the SART (high Go) and the TFT (low Go), and two different scenarios of the two tasks (small arms simulation with live humans and computer with numeral stimuli). There were thus four tasks in total. Participants completed all four tasks: a computer SART, a computer TFT, a firearm SART, and a firearm TFT. Participants were told to respond as quickly and accurately as possible for all tasks. Stimuli presentation and recordings of reaction times and accuracy were performed by personal computers running E-prime 2.0 software (Psychology Software Tools, Pittsburgh, PA).

Computer Tasks. Participants were seated 50 cm in front of a computer (377 mm x 303 mm, 75 Hz refresh rate) mounted at eye level. The participants' head movements were not restrained. The computer SART was nearly an exact replica of that by Robertson et al. (1997) except that instead of pressing a key to respond, participants pulled the trigger on a modified Steradian SX-7 "laser" gun instead (see Figure 1). This was for the purpose of keeping the actual physical response consistent with the firearm tasks. The gun was not pointed at the screen or anywhere in particular; participants were told to rest it comfortably on their laps. The SART and TFT were each 4.3 min long and consisted of 225 trials. Digits were all the same font but varied in size randomly. The font sizes were 48, 72, 94, 100 and 120, with height varying between 12 and 29 mm.

For the SART, participants were to respond to frequently occurring Go stimuli and withhold to No-Go stimuli. Go stimuli probability was .89; No-Go stimuli probability was .11. The TFT was perceptually identical to the SART except Go stimuli occurred with a probability of .11, and No-Go stimuli more frequently with a probability of .89. In the SART the Go stimuli were the numbers 1-9, excluding the number 3 which served as the No-Go stimulus. This was the reverse for the TFT, where the number 3 was the Go stimulus and the numbers 1-9 (excluding 3) were the No-Go stimuli.

Gun Tasks. The laser gun was a Steradian SX-7 laser gun (see Figure 1) weighing 1.3 kg (2.8 lb) and made primarily of machined metal. In order to measure trigger-pulls and reaction time, the gun was modified. Attached to the gun's trigger was a micro switch (unobtrusively within the gun), which was wired to an electrical circuit board. This enabled the recording of responses in E-prime.

The gun tasks involved the participant being stationed in a hallway, standing or leaning at a 'leaner' structure 1240 mm high. The leaner had a flat top/surface on which a pillow was placed which gave a similar feel to a sandbag as well as helping participants to remain comfortable. At the end of the hallway there was a small .5 m-wide doorway, a distance of 5.8 m from the edge of the leaner (participant side). A research assistant, also carrying a SX-7 gun, was dressed in a black balaclava, a black baseball cap, and a black shirt, and was based in this area. An opaque black cloth was put up in the doorway, obscuring the entire section from the floor to a height of 1.2 m up the doorway. This was to ensure the foot movement of the research assistant did not appear first. The black balaclava was worn so the participant was not distracted by visual cues from facial expressions. This also forced them to concentrate on the cap direction which was the primary cue for Go and No-Go stimuli. This was chosen as it simulated the battlefield where aspects of the uniform indicate which force a soldier is aligned. Adjacent to the doorway and on the side not visible to the participant was another research assistant, who monitored visual cues on a computer detailing which way the cap was to face for each subsequent trial. In between doorway appearances, when the balaclava-clad research assistant was out of view of the participant, was when the other research assistant was able to quickly turn the cap around if required, out of sight of the participant.

There were 180 trials for each of the gun tasks. Due to the physically demanding nature of the task (with a real person moving), trials took 4 sec each. The total time for each task was 12 min. As with the comparative computer tasks, in the gun SART there was a probability of .11 for a No-Go stimulus to appear, and a probability of .89 for a Go stimulus to appear. For the gun TFT this probability was reversed.

Figure 1. Modified Steradian SX-7 Laser Gun

Questionnaires. The NASA-TLX (Hart & Staveland, 1988) was used to subjectively assess workload.

Procedure

Participants completed all four tasks (computer SART, computer TFT, firearm SART, and firearm TFT). The order of the tasks was counterbalanced in a nested design. Following each of the four tasks participants immediately filled out the questionnaire. All participants were tested individually. Participants surrendered their wristwatches and cell phones. No feedback was given to participants on their performance until the end of the experiment.

Computer Tasks. Each trial a single digit, selected by random from the numbers 1-9 (inclusive) was visually presented on the computer screen for 250 ms. This was followed by a 900 ms mask, which was a ring (29 mm in diameter) with a diagonal cross in the middle spanning from one side to the other (see Figure 2).

Gun Tasks. Participants were instructed that they would be trying to shoot a person appearing intermittently in a doorway. Some of the time the person would be a 'friendly,' as in someone on their side or team. Other times the person would be the enemy, from an opposing force. This was to be signaled by the direction of the cap which the person was wearing. Forward-facing signified a member of the same force; backwards-facing signified a member of the opposing force. The person was also armed with a SX-7 gun, and participants were told the person would be aiming at them too regardless of which way the cap was facing. This was to give participants more incentive to act quickly and accurately (see Figure 3). Participants were informed that their accuracy – in terms of where they were pointing the gun – was not overly important; if they pulled the trigger, they effectively shot the target. A new trial began every 4 sec. The balaclava-clad research assistant would be visible in the doorway for approximately 1.5 sec. In order for this to be consistent, a 1.5 sec burst of white noise played over the research assistant's earphones. The beginning of the sound signaled the research assistant to step out, and the end of the noise signaled a step back in. In order for this movement to be consistent, the research assistant was careful to move out in the same manner each trial. Only one step was necessary to make the transition from beside the doorway into a visible position inside the doorway. Reaction times in the firearm tasks were measured from the onset of the white noise and would therefore have a slight lag due to the research assistant's need to move into view.

Figure 2. Example of the computer task set-up.

Figure 3. Example of the gun task setup

RESULTS

To explore the differences between conditions paired sample t-tests were conducted between the SART and the TFT (see Table 1.) These indicated that participants made significantly more errors of commission (EC) in the SART than the TFT in both the computer tasks and the firearm tasks. Further, reaction times (RT) were significantly faster in the SART than the TFT, again for both the computer tasks and firearm tasks. Errors of omission (EO) were not significantly different between the SART and TFT in either the computer tasks or firearm tasks. Dependence among means was corrected for and correlations between the pairs were factored in (see Morris & DeShon, 2002).

Table 1. Paired t-tests between conditions with mean and standard deviation

Condition	SART	TFT	t	d
Firearm - EC	.33 (.17)	.01 (.01)	7.02*	3.88
Firearm - EO	.01 (.01)	.01 (.02)	1.07	.47
Firearm - RT	1110 (62.95)	1247 (63.64)	8.31*	2.31
Firearm - GW	55.32 (20.98)	46.35 (18.00)	3.36*	0.98
Computer - EC	.55 (.18)	.02 (.01)	11.29*	5.35
Computer - EO	.00 (.01)	.000 (.01)	.31	.25
Computer - RT	324 (50.94)	398 (32.77)	5.23*	1.52
Computer - GW	57.18 (18.09)	33.14 (18.00)	5.22*	1.45

Note. Proportion of Errors of Commission (EC), Proportion of Errors of Omission (EO), Reaction Time (RT), NASA-TLX global workload (GW).
* $p < 0.01$.

Correlation analyses demonstrated a significant relationship between reaction time and errors of commission. Participants with faster reaction times tended to make more errors of commission, for both the computer task (Figure 4), $r = -.78$, $p < .05$, and the firearm task (Figure 5), $r = -.64$, $p < .05$.

Figure 4. Correlation between Errors of Commission and Reaction Time on Computer Task

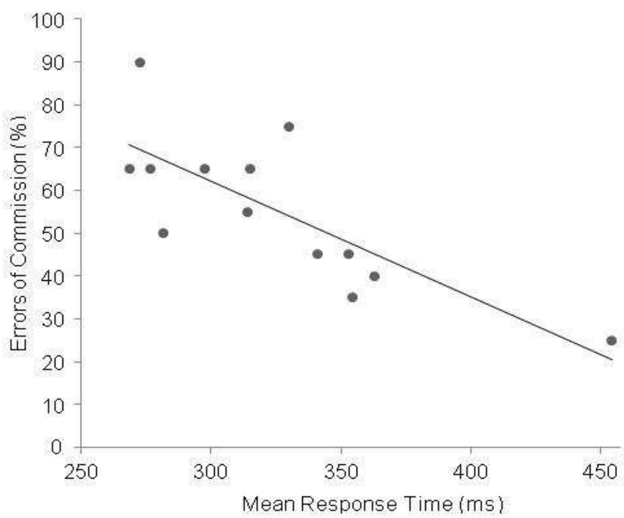
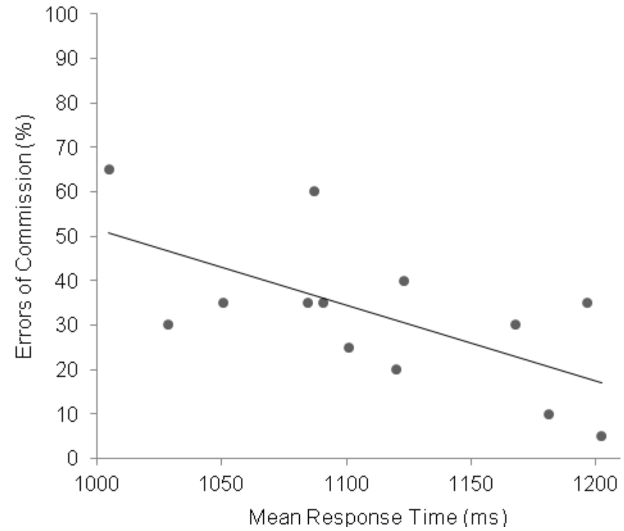


Figure 5. Correlation between Errors of Commission and Reaction Time on Firearm Task



DISCUSSION

In the current investigation the SART and TFT were used in a computer and simulated small-arms engagement to determine whether the speed-accuracy process of the SART could be relevant in some settings where friendly fire could occur. We further performed the same types of tasks in lower Go rate versions for comparison (TFT; Helton, 2009). Each participant completed both formats of the task (SART and TFT) in both the computer-based and firearm-based version, along with the NASA-TLX questionnaire after each of the four tasks.

The behavioral results revealed that participants made substantially more errors of commission in the SART than the TFT. There was also strong evidence of a speed-accuracy trade-off, with those participants responding faster in both versions of the SART also tending to make more errors of commission. This was the case for both the computer tasks and firearm tasks, although the relationship was slightly weaker in the firearm version, presumably due to either less accuracy in measuring response time (as the movement of the research assistant could not be perfectly the same across trials), the slower event rate of the task (necessary to be physically possible), or both.

As we expected the NASA-TLX global workload ratings were higher for the SART version than the TFT version in both the computer and firearm tasks. These findings are in line with the perspective of Helton and colleagues (2010) that the SART places additional response inhibition demands on individuals which do not occur in perceptually equivalent low Go tasks (TFT).

The current findings are consistent with findings often observed with high Go, low No-Go tasks such as the SART, showing that the classic speed-accuracy trade-off occurs in a more ecologically valid scenario as well. It suggests that the feed forward ballistic routine may occur in some battlefield scenarios where soldiers are responding to frequently occurring targets amongst rarely occurring ‘neutrals,’ e.g., comrades or civilians. Whether this is the case in more realistic scenarios remains to be seen as the participants in the present experiment were not trained soldiers and the firearm task, while closer to a battlefield scenario than a computer task with numbers, was still far from a battlefield in consequences. The findings do, however, suggest further research along these lines should be conducted.

These findings may have implications for firearm scenarios. It appears that the pre-potent motor response in a high Go/low No-Go task is difficult to inhibit. Whether training and technological countermeasures can assist in helping the soldier in this setting remains an open question and demands further research. The findings also suggest the SART may indeed, as Helton and colleagues suggested (Helton & Kemp, 2011) be a useful tool in future research involving accidental shootings. This could perhaps also include civilian hunting accidents and law enforcement.

REFERENCES

Department of the Army. (1992). Fratricide: Reducing Self-Inflicted Losses, Newsletter No. 92-4, p. 3. Fort Leavenworth, KS: Center for Army Lessons Learned, U.S. Army Combined Arms Command.

Doton, L. (1996). Integrating technology to reduce fratricide. Acquisition review quarterly (Winter issue), 1-18.

Dzindolet, M., Pierce, L., Beck, H., Dawe, L., & Anderson, W. (2001). Predicting misuse and disuse of combat identification systems. Military Psychology, 13, 147-164.

Gadsen, J., & Outteridge, C. (2006). What value analysis: the historical record of fratricide. In 23rd International Symposium on Military Operational Research, 29 August – 1 September.

Greitzer, F. L., & Andrews, D. H. (2008). Training strategies to mitigate expectancy-induced response bias in combat identification: A research agenda. Human Factors in Combat ID Workshop, 127.

Hart, S. G., & Staveland, L. E. (1988). Development of a multi-dimensional workload scale: Results of empirical and theoretical research. In Hancock P.A., Meshkati N. (Eds.), Human mental workload (pp. 139–183). Amsterdam: North-Holland.

Helton, W.S. (2009) Impulsive responding and the sustained attention to response task. Journal of Clinical and Experimental Neuropsychology, 31, 39-47.

Helton, W. S., Kern, R. P., & Walker, D. R. (2009). Speed-Accuracy Tradeoffs and the Role of Emotional Stimuli on the Sustained Attention to Response Task (SART). In Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 53(17), 1052-1056.

Helton, W. S., & Kemp, S. (2011). What basic–applied issue? Theoretical Issues in Ergonomics Science, 12(5), 397-407.

Helton, W.S., Weil, L., Middlemiss, A., & Sawers, A. (2010). Global interference and spatial uncertainty in the Sustained Attention to Response Task (SART). Consciousness and Cognition, 19, 77–85.

Kogler, T. M. (2003). The effects of degraded vision and automatic combat identification reliability on infantry friendly fire engagements (Unpublished master’s thesis, Virginia Polytechnic Institute and State University).

Morris, S. B., & DeShon, R. P. (2002). Combining effect size estimates in meta-analysis with repeated measures and independent-groups designs. Psychological Methods, 7(1), 105.

Parasuraman, R., & Riley, V. (1997). Humans and automation: Use, misuse, disuse, abuse. Human Factors, 39, 230-253.

Rasmussen, R. E. (2007). The wrong target: The problem of mistargeting resulting in fratricide and civilian casualties. National Defense University of Norfolk VA Joint Advanced Warfighting School.

Robertson, I. H., Manly, T., Andrade, J., Baddeley, B. T., & Yiend, J. (1997). 'Oops!': performance correlates of everyday attentional failures in traumatic brain injured and normal subjects. Neuropsychologia, 35(6), 747.

Steinweg, K. K. 1995. Dealing realistically with fratricide. Parameter, Spring, 4-29.