Friendly Fire and the Proportion of Friends to Foes

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Losses of inhibitory control may be partly responsible for some friendly fire incidents. The Sustained Attention to Response Task (SART; Robertson, Manly, Andrade, Baddeley, & Yiend, 1997) may provide an appropriate empirical model for this. The current investigation aimed to provide an ecologically valid application of the SART to a small arms simulation and examine the effect of different proportions of enemy to friendly confederates. Seven university students engaged in a small arms simulation where they cleared a building floor using a near-infrared emitter gun, tasked with firing at confederates representing enemies and withholding fire to confederates representing friends. All participants completed three conditions which were differentiated by the proportion of enemies to friends present. As hypothesized, participants failed to withhold responses more often when the proportion of foes was higher, suggesting that a prepotent motor response routine had developed. This effect appeared to be disproportionately more substantial in the high foe condition relative to the others. Participants also subjectively reported higher levels of on-task focus as foe proportions increased, suggesting that they found this more mentally demanding. Future research could examine closer the nature of the performance reductions associated with high proportions of foes, as it appears that this is more complex than a simple linear relationship.

INTRODUCTION

Friendly fire, otherwise known as fratricide, is estimated to account for between 10 and 24 percent of all allied force casualties (Schraagen, te Brake, de Leeuw, & Field, 2010). The likelihood of friendly fire incidents has partly been increased by technological advancements leading to weapons with improved accuracy and faster rates of fire. It is possible that losses of inhibitory control are a contributing factor (Greitzer & Andrews, 2008; Wilson, Head, & Helton, 2013).

The Sustained Attention to Response Task (SART; Robertson, Manly, Andrade, Baddeley, & Yiend, 1997) may provide an appropriate, although simplified, empirical model in the laboratory for some battlefield environments (Helton, Weil, Middlemiss, & Sawers, 2010; Helton & Kemp, 2011). This task requires participants to overtly respond to frequently occurring neutral stimuli and withhold responses to rarely occurring target stimuli. Typically the stimuli are the numbers 1 – 9, with 3 being the target and the remaining numbers being the neutral stimuli. The high probability of Go stimuli induces the self-organization of a feed-forward ballistic motor routine, which requires significant effort to inhibit when appropriate for the low probability No-Go target stimuli (Helton, 2009; Head & Helton, 2013a; Head & Helton, 2013b; Stevenson, Helton, & Russell, 2011).

Recently, Wilson et al. (2013) investigated whether the SART could be used to model small arms friendly fire incidents. Wilson and colleagues conducted a small arms simulation experiment where participants armed with a near-infrared emitter gun (similar to allied forces MILES gear) were confronted with a confederate acting as either a friend or a foe. The confederate moved in and out of a doorway at short consistent intervals, with the participant positioned several meters down a hallway facing the doorway. The participant's task was to fire when the confederate represented a foe and to withhold their fire when the confederate represented a friend. When the relative probabilities of the friends and foes emulated the original computer SART (Go probability of 0.89; No-Go probability of 0.11), participants had a high commission error rate. Additionally, there was a significant negative correlation between commission errors and response time indicating a speed-accuracy trade-off which is typically found in the SART (Helton, 2009; Head & Helton, 2013a).

These findings showed that participants struggled to withhold pulling the trigger to rarely-occurring friendly stimuli when the majority of stimuli were foes. This suggested that in a real battlefield situation where many of the partakers are enemy soldiers and a small amount are allies, soldiers may find it difficult to prevent themselves from pulling the trigger when they encounter an allied soldier. However in the Wilson et al. experiment, the participant was stationary for the duration of the experiment, and the person they were confronted with appeared in the same location at the same time intervals for each trial. While this paradigm allowed for greater control, it perhaps lacked some ecological validity. Furthermore, while they investigated the effect of High Go conditions relative to Low Go conditions, there was never any mixture of the two, e.g., a Medium Go condition.

In the current investigation we aimed to address the ecological validity by using a slightly more realistic paradigm. Participants were tasked with room clearing

which required them to physically search multiple rooms in a single building floor. Additionally, confederates (neutral and target stimuli) consisted of multiple people stationed in different places. This closer mimicked a real battlefield situation.

In the current investigation we manipulated the ratio of enemy to friendly confederate: a high enemy condition (89% foes); a low enemy condition (11% foes) and an even enemy-friendly condition (50% foes). It was expected that the ratio of enemy to friendly confederates would have a differential effect on error rate. More specifically, we predicted that a higher amount of Go targets presented would likely encourage the development of a pre-potent motor response routine which would be difficult for participants to actively inhibit. In other words, conditions with higher rates of enemy relative to friendly confederates should have resulted in more failures to withhold pulling the trigger to the incorrect confederate. Additionally, it was predicted that participants would find the conditions more mentally demanding as the proportion of enemies increased, as reflected in the questionnaire responses.

METHOD

Participants

Participants were 8 undergraduate students (5 females and 3 males) from the University of Canterbury. Their participation was a course requirement. They ranged in age from 21 to 46 years, with a mean age of 25.3 years.

Materials

Participants were instructed to clear rooms on a single floor, by firing at foes but avoiding firing at friends. The participants were armed with a Steradian SX-7 emitter gun (see Figure 1).

The task utilized several rooms and hallways on a single floor of a building (see Figure 2). Positioned around this floor were 9 confederates acting as stimuli for the tasks. These people were stationed in 9 separate zones, which were marked out by chalk on the floor's carpet. The zones were approximately 5 square meters each and were large enough for the people to move around in with some freedom in order to take a variety of positions. These people were armed with Steradian SX-7 laser (near-infrared emitter) guns.

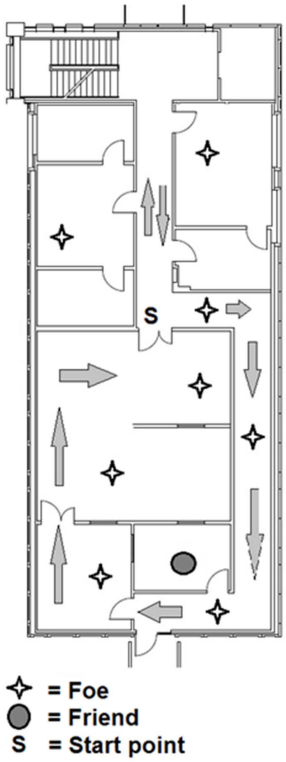
There were three conditions. One was a high foe condition which was essentially a High Go condition, with 89% of the targets being Go stimuli (foes), just like the computer-based SART. A second condition was a low foe condition which was a reversal of the SART condition. Here, 89% of targets were No-Go stimuli. This replicates a Low Go detection task. A third condition had equal probability 50/50 of Go and No-Go stimuli.

The visual cue signaling whether a person was a friend or foe was the presence of a hat upon their head. Go stimuli wore hats whereas No-Go stimuli did not. The hats varied in shape and color to ensure additional realism of modern asymmetrical conflicts. The confederates each possessed a personalized list identifying whether they were to have their hat on or off for each individual trial. This list was created quasi-randomly, with the constraints being that over each condition the proportion of Go stimuli to No-Go stimuli had to meet the required amount, and for the High Go condition there were never less than 7 Go stimuli for a particular circuit and never less than 7 No-Go stimuli for a circuit in the Low Go condition. Participants wore a GoPro Hero 2 camera upon their head to record each task. The video footage was later analyzed to identify when the participant fired their emitter gun.

The NASA-TLX questionnaire (Hart & Staveland, 1988) was used to gauge subjective workload.

Figure 1. *Steradian SX-7 laser gun*

Figure 2. *Example floor plan of task area (showing High Go condition).*



Procedure

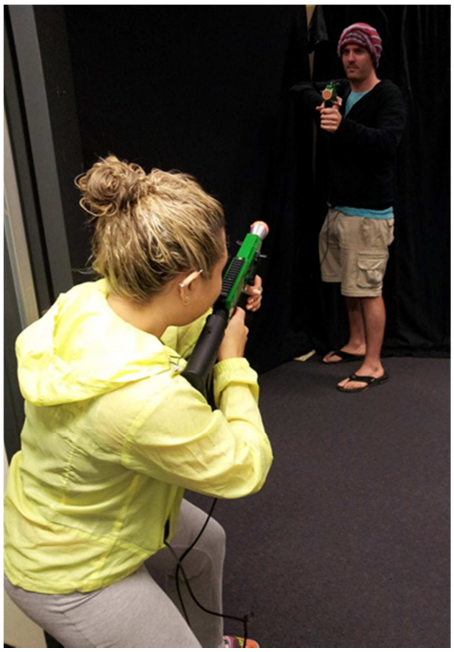
Participants completed all three conditions. The experimenter prompted the participant when they were to begin each task. Participants were instructed to move swiftly throughout the floor, clearing each zone as they went (see Figure 3). The order in which they cleared the 9 zones was pre-determined and fixed for the experiment. Participants were told to be as quick and accurate as possible when they had engaged a person, firing at Go (foe) stimuli and withholding their fire to No-Go (friend) stimuli. Each confederate was instructed to have their gun raised and pointed at the participant when the participant entered their zone and to hold for 1 second before themselves firing on the participants.

For each condition they completed 4 full circuits of the floor without stopping. There was a break of approximately 2 minutes between each condition. In this time the participant completed the workload questionnaire and also had time to recuperate in case they were physically tired from their effort in the previous condition. During this break the confederates were free to swap zones with other confederates.

Participants completed the NASA-TLX immediately after each set of trials, for a total of 3 times. They also filled out a self-report measure of task concentration, task related thoughts and task unrelated thoughts (items on a 0-100 scale like the NASA-TLX).

The order in which participants completed the conditions was counter-balanced.

Figure 3. *Example of a participant clearing an area*



RESULTS

One participant's results were excluded due to being an extreme outlier, thus results were taken from 7 participants. Main effects for condition were tested using one-way repeated measures ANOVAs. Polynomial contrasts were performed to investigate the nature of trends.

Behavioral measures. There was a significant main effect of foe proportion for accuracy (Figure 4), $F(2,12) = 6.10$, $p = .02$, $\eta^2_p = .50$. As the proportion of foes increased, errors of commission increased also. There was a significant quadratic trend in the relationship, $F(1, 6) = 9.2$, $p = .05$, $\eta^2_p = .61$.

Due to the nature of the task, we were unable to accurately and reliably measure response time in the fashion that is typical for the SART, which is the time taken for a response to stimuli, trial by trial. For a measure of time, we instead measured the time taken for participants to complete each circuit (course time), which consisted of 9 trials each. There were no significant differences for course time over conditions (Figure 5), $F(2, 12) = 1.19$, $p > .05$, $\eta^2_p = .17$. There was however a slight trend apparent with time appearing to increase in a linear fashion across the conditions, although a polynomial contrast was not statistically significant for a linear trend, $F(1, 6) = 2.52$, $p = .16$, $\eta^2_p = .30$.

Figure 4. *Errors of commission across conditions*

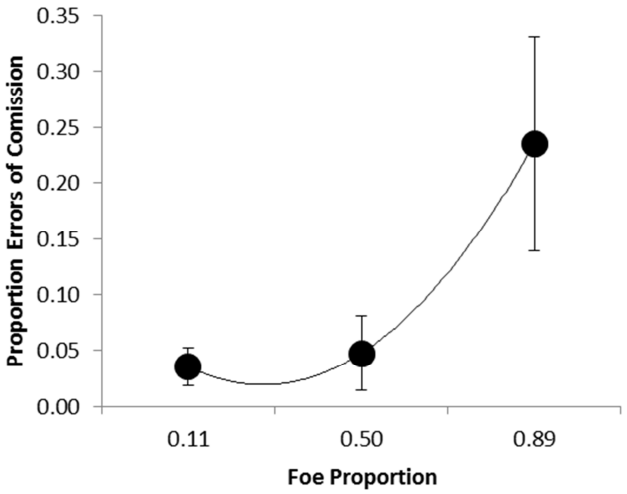


Figure 5. *Course time across conditions*

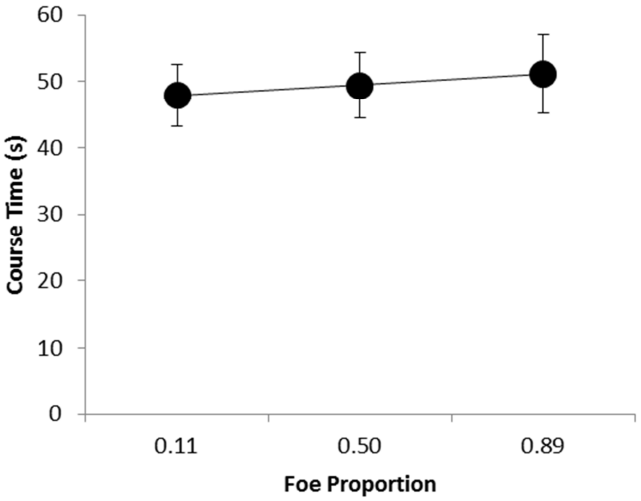
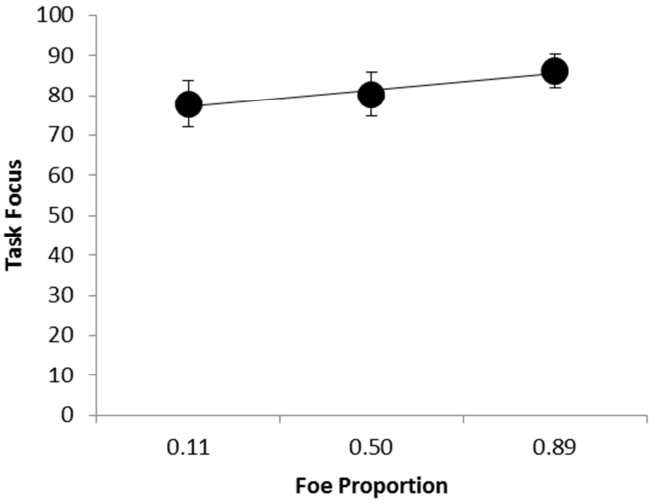


Figure 6. *Task focus across conditions*



Subjective measures. One participant failed to complete over half of the questionnaire items and was thus excluded from the subjective data analyses, leaving results from 6 participants. There were no significant main effects of condition on any of the typical questionnaire metrics, $p > .05$. A metric was created to measure the level of task focus participants experienced during the task. This was calculated by averaging three items: thinking about the task; thinking about other things than the task; and concentration. Thinking about things other than the task was reverse scored. A higher score on this composite indicates a person is "on-task" or focused. There was a significant main effect of condition for this task focus measure (Figure 6), $F(2, 10) = 3.98$, $p = .05$, $\eta^2_p = .44$. There was a significant linear trend in the relationship, $F(1, 5) = 6.3$, $p = .05$, $\eta^2_p = .56$.

DISCUSSION

The current experiment investigated whether the proportion of friends relative to foes within a battlefield scenario could have an effect on the likelihood of friendly fire incidents. More specifically, we investigated whether environments with a higher proportion of foes to friends increase the probability of a soldier accidentally firing at a friend.

As hypothesized, participants made significantly more errors of commission in the high foe condition. A polynomial contrast revealed a significant quadratic relationship here. No significant differences between conditions were found for the average time taken by participants to complete a circuit. The questionnaire results revealed that participants' task focus appeared to increase as the proportion of enemies became higher. A polynomial contrast revealed a significant linear trend. No significant main effects were found, however, with the global workload score of the NASA-TLX.

The finding that a higher proportion of enemies was associated with more failures to withhold is consistent with much literature on the SART as well as Wilson and colleagues' (2013) findings. The greater amount of firing appears to have caused a prepotent motor response routine to develop, thus making it difficult for participants to withhold fire to the rarely-occurring friends. Interestingly, this effect appeared to occur in an exponential rather than a linear fashion. There may be a 'breaking point' where the foe proportion surpasses a certain level and the prepotent motor ballistic routine develops causing performance to decline. Future research should more closely examine the functional relationship between friend-foe probability and commission errors.

Participants may have experienced more on-task focus as foe proportion increased due to an increased

demand on concentration. This result is in line with prior findings that High Go, Low No-Go tasks are mentally challenging. The self-report results are consistent with the finding that in the high foe condition participants struggled to withhold firing and thus made more mistakes. The participants were aware of the challenge posed by High Go probability.

While there were no significant differences in time over conditions, there was a slight trend suggesting that as the foe proportion increased, participants slowed down. The large effect size supports this observation, despite statistical insignificance. Perhaps this result is related to the above finding that participants reported more focus as foe proportion increased. The heightened concentration may be associated with a slowing of the physical pace around the course. Alternatively, the fact that this condition required more shooting (more motor movement) may be responsible for this result.

Due to the intricate and time-consuming nature of the task only 8 participants were recruited, and only data from 7 were subsequently included, resulting in a small sample size. A larger sample may have revealed more results that were statistically significant. Despite this, effect sizes were relatively large in the current study, supporting the interpretation of the reported findings.

Future research could look closer at the proportion of enemies relative to friends where commission error rates begin to occur markedly. It may be that there is a ratio where performance begins to deteriorate rapidly, rather than it doing so in a predictable linear fashion. Indeed the present results show little difference between low foe probability (11%) and moderate foe probability (50%). The real difference in commission errors was for the high foe probability condition (89%). Improved knowledge of this functional relationship between friend-foe proportions and the likelihood of commission errors (fratricide or friendly fire) could assist military personnel in both identifying environments which are particularly high-risk for friendly fire incidents and in the future unraveling the cause of the functional relationship itself. Other studies should also look to use professional soldiers in their research, as there could be differences in the nature of their performance relative to the unskilled civilians utilized here.

REFERENCES

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.

Head, J., & Helton, W.S. (2013a). Practice does not make perfect in a modified sustained attention to response task. *Experimental Brain Research, 232*(2), 565-573.

Head, J., & Helton, W.S. (2013b). Perceptual decoupling or motor decoupling? *Consciousness and Cognition, 22*(3), 323-333.

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., & 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.

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.

Schraagen, J. M. C., te Brake, G. M., de Leeuw, M., & Field, J. (2010). *Cognitive aspects of friendly fire incidents.* Soesterberg: TNO Defence, Security and Safety.

Stevenson, H., Russell, P. N., & Helton, W. S. (2011). Search asymmetry, sustained attention, and response inhibition. *Brain and Cognition, 77*(2), 215-222.

Wilson, K., Head, J., & Helton, W. S. (2013, September). Friendly fire in a simulated firearms task. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 57, No. 1, pp. 1244-1248). SAGE Publications.