

REPORT DOCUMENTATION PAGE			Form Approved OMB NO. 0704-0188		
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1. REPORT DATE (DD-MM-YYYY) 30-07-2014		2. REPORT TYPE Final Report		3. DATES COVERED (From - To) 1-Oct-2013 - 30-Jun-2014	
4. TITLE AND SUBTITLE Final Report: STIR: Assessing and Training Response Inhibition Abilities			5a. CONTRACT NUMBER W911NF-13-1-0480		
			5b. GRANT NUMBER		
			5c. PROGRAM ELEMENT NUMBER 611102		
6. AUTHORS Adam T. Biggs, Stephen R. Mitroff			5d. PROJECT NUMBER		
			5e. TASK NUMBER		
			5f. WORK UNIT NUMBER		
7. PERFORMING ORGANIZATION NAMES AND ADDRESSES Duke University 2200 W Main St Ste 710 Durham, NC 27705 -4677			8. PERFORMING ORGANIZATION REPORT NUMBER		
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS (ES) U.S. Army Research Office P.O. Box 12211 Research Triangle Park, NC 27709-2211			10. SPONSOR/MONITOR'S ACRONYM(S) ARO		
			11. SPONSOR/MONITOR'S REPORT NUMBER(S) 64423-LS-II.1		
12. DISTRIBUTION AVAILABILITY STATEMENT Approved for Public Release; Distribution Unlimited					
13. SUPPLEMENTARY NOTES The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision, unless so designated by other documentation.					
14. ABSTRACT Shooting a firearm involves a complex series of actions, and each action depends on a distinct cognitive process (e. g., finding targets involves visual search, aiming involves perceptual judgments of distance and motion). Examining these action-cognition links provides a valuable tool for revealing how cognitive mechanisms interact with one another in addition to offering new avenues for enhancing shooting performance and safety. The present study established a direct relationship between a critical shooting error, civilian casualties, and a particular cognitive ability: response inhibition. Response inhibition abilities significantly correlated with civilian casualties.					
15. SUBJECT TERMS Civilian casualties, response inhibition, cognitive training					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT UU	15. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON Adam T. Biggs
a. REPORT UU	b. ABSTRACT UU	c. THIS PAGE UU			19b. TELEPHONE NUMBER 919-668-6144

Report Title

Final Report: STIR: Assessing and Training Response Inhibition Abilities

ABSTRACT

Shooting a firearm involves a complex series of actions, and each action depends on a distinct cognitive process (e.g., finding targets involves visual search, aiming involves perceptual judgments of distance and motion). Examining these action-cognition links provides a valuable tool for revealing how cognitive mechanisms interact with one another in addition to offering new avenues for enhancing shooting performance and safety. The present study established a direct relationship between a critical shooting error, civilian casualties, and a particular cognitive ability, response inhibition. Response inhibition abilities significantly correlated with civilian casualties in a shooting simulation, and response inhibition training—but not a control form of cognition training—reduced civilian casualties. Survey and behavioral measures revealed that civilian casualties were not related to motor impulsivity (i.e., an itchy trigger finger), but rather to an individual's ability to withhold an initiated response (i.e., an itchy brain). This study demonstrated successful response inhibition training and “far transfer”^{1,2} learning, where individuals improved on a task only conceptually related to the training. Likewise, the study demonstrated the rich potential of developing specific forms of cognitive training to improve shooting performance for military and law enforcement personnel.

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(a) Papers published in peer-reviewed journals (N/A for none)

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TOTAL:

Number of Papers published in peer-reviewed journals:

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(c) Presentations

Number of Presentations: 0.00

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Graduate Students

<u>NAME</u>	<u>PERCENT SUPPORTED</u>
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Names of Post Doctorates

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Names of Faculty Supported

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Stephen Mitroff	0.00	
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The number of undergraduates funded by this agreement who graduated during this period with a degree in science, mathematics, engineering, or technology fields:..... 0.00

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Sub Contractors (DD882)

Inventions (DD882)

Scientific Progress

Technology Transfer

(1) Foreword (optional): not provided

(2) Table of Contents (if report is more than 10 pages): less than 10 pages

(3) List of Appendixes, Illustrations, and Tables (if applicable):

Figure 1: Shooting performance at pre-test and post-test for each training condition for civilian casualties (left graph) and intended targets hit (right graph). Dark gray bars represent pre-test scores and light gray bars indicate post-test scores.

Figure 2: Change in civilian casualties (pre-test minus post-test) as compared to an individual's ADHD score on the Jasper-Goldberg Adult ADD/ADHD Questionnaire separated by training condition. Larger ADHD score represents increased self-reported symptoms associated with ADHD.

(4) Statement of the problem studied:

Shooting a firearm involves a complex series of actions, and each action depends on a distinct cognitive process (e.g., finding targets involves visual search, aiming involves perceptual judgments of distance and motion). Examining these action-cognition links provides a valuable tool for revealing how cognitive mechanisms interact with one another in addition to offering new avenues for enhancing shooting performance and safety. The present study established a direct relationship between a critical shooting error, civilian casualties, and a particular cognitive ability, response inhibition. Response inhibition abilities significantly correlated with civilian casualties in a shooting simulation, and response inhibition training—but not a control form of cognition training—reduced civilian casualties. Survey and behavioral measures revealed that civilian casualties were not related to motor impulsivity (i.e., an itchy trigger finger), but rather to an individual's ability to withhold an initiated response (i.e., an itchy brain). This study demonstrated successful response inhibition training and “far transfer”^{1,2} learning, where individuals improved on a task only conceptually related to the training. Likewise, the study demonstrated the rich potential of developing specific forms of cognitive training to improve shooting performance for military and law enforcement personnel.

(5) Summary of the most important results:

The act of shooting a firearm involves an impressively complex cascade of actions, and each action can be linked to a specific cognitive ability. For example, finding appropriate targets involves visual search, determining whether someone is friend or foe involves decision-making processes, taking aim involves perceptual estimations of distance and motion, and pulling the trigger (or withholding the shot) involves response execution (or inhibition). Given this intricate series of cognitive functions, shooting behaviors provide an excellent opportunity to examine the links between action and cognition.

There are two primary research endeavors that can be informed by examining the action-cognition links of the shooting process. First, much can be gleaned about how individual cognitive mechanisms interact if studied through the preceding and following processes involved in shooting behaviors. This point is especially relevant when considering that successful shooting behaviors require success at each step of the cognitive process. Second, these action-cognition links can be leveraged to inform cognitive training methods. Training effects can broadly take

two forms: (1) “near transfer”—when two situations are highly similar in context and execution, or (2) “far transfer”—when two situations are only conceptually similar. Near transfer would be, for example, learning a song on one piano and then playing it on another piano, and far transfer would be replaying the song on a guitar instead of a piano. Far transfer requires an abstract application of the core learning principle^{1,2}, and viable examples are often hard to find and/or assess. If exposure to non-shooting activities can improve shooting performance, this would offer a prime example of far transfer.

The current study focused on one specific relationship between shooting performance and cognition—civilian casualties and response inhibition. Civilian casualties occur when a shooter hits a non-combatant with weapons fire^{3,4}. These incidents can have dramatic psychological, economical, and practical implications, and therefore every effort should be made to minimize their occurrences. The current project looks to understand and reduce civilian casualties by studying them in relation to the cognitive ability of response inhibition—the ability to stop from performing an already initiated behavior⁵⁻⁹. Most everyone has experienced successful and failed response inhibition; take for instance when you start the motion to hit the “send” button on an email, and then you suddenly realize that it is addressed to the wrong person. Sometimes you successfully abort the button-press behavior (i.e., successful response inhibition), but sometimes you do not (i.e., failed response inhibition). Initiated responses can be successfully withheld, even with very brief time windows between the decision to respond and the response inhibition signal¹⁰⁻¹², yet this can be cognitively challenging. When applying the logic of response inhibition to the act of shooting a firearm, consider the situation where a shooter takes aim at a target and initiates the process to fire the weapon—but then realizes that the target is a civilian. The shooter must rely upon response inhibition skills to successfully inhibit a trigger pull upon identifying the person as a non-target.

Exploring this particular relationship between shooting and cognition—and others like it—can also offer highly practical benefits. First, the action-cognition links between shooting and cognitive abilities would help identify those individuals best suited for performing specific shooting tasks—or conversely, individuals who are most likely to make particular types of errors. For example, if the proposed relationship between civilian casualties and response inhibition is established, the individuals most likely to inflict civilian casualties could be identified before being sent into combat. Second, if specific cognitive abilities can predict specific aspects of shooting performance, then individualized training could be developed to help a particular person avoid an error to which he or she is predisposed. Civilian casualties could then be reduced if shooters underwent the appropriate cognitive training. These combined efforts could have substantial potential for military and law enforcement efforts in performance, training, and evaluation. Such new training methods are particularly important in light of recent evidence that deliberate practice alone may not be as influential for performance in professional tasks as once believed¹³.

The present study included three components: a large baseline cohort of participants to establish potential relationships between attentional abilities and civilian casualties, a response inhibition training (RIT) group to assess the efficacy of training, and an active control training group (visual search training; VST) to eliminate methodological concerns involving placebo effects^{14,15}. Baseline measurements included shooting performance, cognitive abilities, and self-report surveys to examine whether civilian casualties were related to individual differences in response inhibition, attentional deficits, or impulsivity. The key dependent variable was civilian casualties within a simulated shooting environment¹⁶ containing a mix of both intended targets

(i.e., hostiles) and unintended targets (i.e., civilians). Training participants completed a 5-day training protocol either designed to reduce civilian casualties (RIT) or designed to enhance a cognitive ability conceptually unrelated to civilian casualties (VST).

Baseline Differences. Performance on a Stop Signal Reaction Time (SSRT) task, which measured an individual's ability to withhold an initiated response, was significantly related to the number of civilian casualties at baseline ($r(85)=.26, p<.05$) with poorer performance on the SSRT task related to increased civilian casualties. Two attention-related self-report scales were significantly related to the number of civilian casualties at baseline: increased civilian casualties were related to higher ADHD score¹⁷, $r(84)=.21, p<.05$, and greater attentional impulsivity^{18,19}, $r(82)=.24, p<.05$. Civilian casualties were not related to self-reported motor impulsivity^{18,19}, $r(83)=.12, p=.27$, nor the total number of shots fired in the simulated shooting task¹⁶—a behavioral measure of motor impulsivity, $r(86)=.08, p=.44$.

Training Effects. Civilian casualties were significantly reduced from pre-test to post-test for the RIT group, but not for the VST group, $F(1,55)=4.10, p<.05, \eta_p^2=.07$ (Figure 1). This reduction could not be explained by a group difference in civilian casualties at pre-test, $t(55)=0.69, p=.49$, nor by a reduction in the number of intended targets hit as RIT participants improved more than VST participants in intended targets performance, $F(1,55)=4.10, p<.05, \eta_p^2=.07$. RIT participants also improved their ability to inhibit an initiated response on the SSRT task from pre-test to post-test ($t(27)=2.25, p<.05$), whereas the VST group showed no change ($t(27)=0.92, p=.36$). Finally, increased self-reported ADHD symptoms¹⁷ were associated with a larger reduction in civilian casualties from pre-test to post-test for the RIT group, but not the VST group (Figure 2).

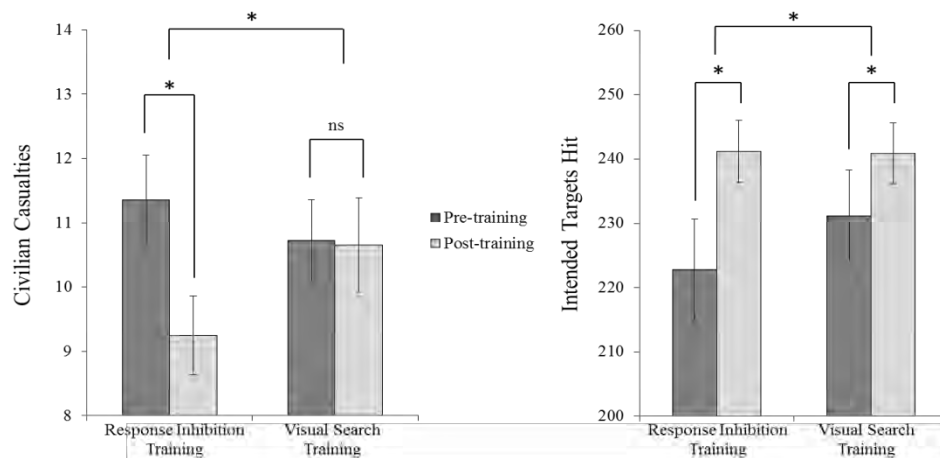


Figure 1. Shooting performance at pre-test and post-test for each training condition for civilian casualties (left graph) and intended targets hit (right graph). Dark gray bars represent pre-test scores and light gray bars indicate post-test scores.

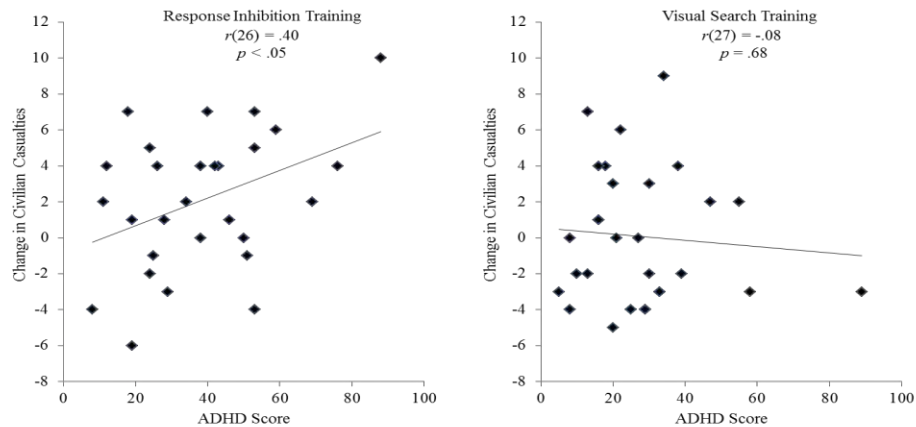


Figure 2. Change in civilian casualties (pre-test minus post-test) as compared to an individual's ADHD score on the Jasper-Goldberg Adult ADD/ADHD Questionnaire separated by training condition. Larger ADHD score represents increased self-reported symptoms associated with ADHD.

Conclusions. The current study revealed important links between civilian casualties in a simulated shooting environment and the cognitive ability of response inhibition. First, individuals with poor inhibitory control and high attentional impulsivity were more likely to inflict civilian casualties during the shooting scenarios. Second, a lack of a relationship between civilian casualties and motor impulsivity highlights the cognitive underpinning—an itchy brain caused civilian casualties more so than an itchy trigger finger. Finally, civilian casualties were significantly reduced via response inhibition training (compared to a conceptually unrelated cognitive training group), and individuals who self-reported high levels of ADHD symptoms benefited most from the training. This latter point indicates that not only do some people benefit more from training than others, but also that such individuals could be identified prior to training.

From an academic perspective, the training results are a prime demonstration of “far transfer” in cognitive learning^{1,2}. RIT sessions involved computer-based SSRT and go/no-go tasks that were clearly different from the shooting scenarios, yet RIT participants significantly improved on their ability to avoid shooting civilians. In contrast to previous results^{20,21}, the current findings offer exciting evidence of generalized response inhibition training that expands upon previous successful “near transfer” response inhibition training efforts—such as treating alcohol addictions by enhancing inhibitory signals for alcohol-specific stimuli^{22,23}.

Practically, the current study provides promise for improving shooting performance for a range of individuals, including military and law enforcement personnel. The relationship between response inhibition abilities and civilian casualties provides a means of identifying those individuals most likely to inflict civilian casualties. Furthermore, successful training efforts could reduce the likelihood of these casualties occurring in the field. Similar efforts can yield further targeted training regimens so that the most effective training can be implemented for any given scenario; for example, some shooters (e.g., competitive sports shooters) might want to specifically enhance their ability to pick up potential targets through visual search, whereas other shooters (e.g., military and law enforcement personnel) might want to specifically enhance their ability to avoid hitting unintended targets—thereby reducing civilian casualties or friendly fire incidents²⁴.

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(7) Appendixes

None