Individual Differences in Working Memory Capacity and Shooting Behavior

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Previous research on the relation between working memory capacity (WMC) and shooting behavior suggests that individuals with low working memory spans are more prone to shooting errors than are individuals with high working memory spans. The present study investigated how WMC interacts with the proportion of "shoot" to "don't shoot" decisions to affect overall shooting performance. Participants were 186 undergraduate students who completed a series of complex span tasks, rated a series of negative photographs for valence and arousal, and then completed a computerized shooting task in which participants were shooting on 20%, 50%, or 80% of the trials. Results indicated that participants with high working memory spans outperformed participants with low working memory spans in all conditions. Participants also exhibited a greater tendency to inappropriately shoot as the proportion of shoot decisions increased. These results suggest that WMC and the proportion of shoot trials interact to affect shooting behavior.

Keywords: Working memory capacity, Shooting behavior, Individual differences

According to a national firearms survey, there are approximately 283 million guns in the hands of American civilians (Hepburn, Miller, & Hemenway, 2007). Considering this, and the fact that guns are critical for police officers and military personnel to be able to perform their jobs, it is important to research the factors that influence the decision to shoot when gun-wielding people find themselves in threatening situations. These factors can be context-specific and situational (e.g., high-crime environment), or they can be individual factors that pertain to the shooter himself (e.g., individual differences in working memory). Individual factors that may be relevant in shooting situations include cognitive processes such as reactions to stress, behavioral inhibition, and the control of attention, all of which have been empirically demonstrated to have a relation with working memory (Engle, 2002; Klein & Boals, 2001; Unsworth, Heitz, & Engle, 2005). The goal of the current study is to examine the role of working memory capacity (WMC) in shooting behavior across changes in situational factors such as the prevalence of shooting decisions.

Working memory is a limited capacity adaptive system for maintaining task-relevant information in an active and accessible state for the purpose of completing complex cognitive and behavioral tasks (Spillers, Brewer, & Unsworth, 2011). Individual differences in WMC should be predictive of behavior in situations where controlled attention is needed to resolve competing task demands in contexts laden with environmental distractors and/or internal interference from prepotent, automatic tendencies (Barrett, Tugade, & Engle, 2004; Unsworth, Heitz, Schrock, & Engle, 2005; Unsworth, Schrock, & Engle, 2004). In other words, WMC is most relevant in situations in which automatic response tendencies are counterproductive to the current goal. As such, people with higher working memory spans should outperform those with lower working memory spans in these situations because they have better attentional control necessary to inhibit automatic responses and do what is needed to complete the task at hand.

WMC is often measured using complex span tasks. Such tasks require that task-relevant information be actively maintained in the face of distracting information (Conway et al., 2005). Complex span tasks pair the presentation of to-be-remembered target stimuli with the presentation of an attention-demanding, secondary processing task (Conway et al., 2005). Performance on these complex span tasks has repeatedly been correlated with higher-order cognition, which suggests that WMC is an important individual differences measure. Engle, Tuholski, Laughlin, and Conway (1999) found that working memory, not short-term memory, correlated with measures of general fluid intelligence (*g*F). One major factor driving this relation between working memory and higher-order cognition is attention control (Engle, 2002; Kane, Bleckley, Conway, & Engle, 2001; Unsworth & Engle, 2007; Unsworth, Fukuda, Awh, & Vogel, 2014).

The Stroop paradigm has been adopted to explore the relation between WMC and attention control (Kane & Engle, 2003), as successful completion of the task depends upon inhibiting a

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habitual response. In the Stroop task, participants are shown color words and are asked to name the color of the ink in which each word is written. The color word and ink color can either be overlapping (e.g., the word 'red' written in red ink) or not overlapping (e.g., the word 'red' written in green ink). WMC should correlate with performance on the Stroop task because executive attention is required to maintain the goal of naming the color of the ink when reading the word elicits a stronger, automatic response to say the word. Research suggests that the magnitude of Stroop interference (overlapping minus non-overlapping response times) increases with the number of overlapping trials in the design.

Kane and Engle (2003) found no differences between high and low WMC individuals in the number of errors made when overlapping stimuli comprised either 0% or 50% of the trials. When overlapping stimuli accounted for 75% of the trials, however, people with low WMC made twice as many errors as people with high WMC. Goal maintenance should be easiest in 0% overlapping conditions because participants must remember the task goal ("Say the ink color, not the word) for every trial. Goal maintenance becomes more difficult when overlapping conditions make up 75% of all of the trials because non-overlapping trials are now rare and a history of overlapping trials reinforces using less trial-to-trial active maintenance processes to avoid inappropriately reading the word. While both high and low WMC individuals experienced impaired performance when the proportion of overlapping trials was increased, it makes sense that individuals with low working memory spans experienced greater impairment because they lack the executive attention necessary to maintain the task goal of saying the ink color in the face of a stronger, automatic response tendency to say the word. In the current study we manipulated the proportion of "shoot" trials in a computer-based shooting simulation similarly to the Kane and Engle's (2003) proportion overlapping Stroop manipulation.

The dual-mechanisms of control framework provides a theoretical basis for understanding trial-to-trial fluctuations in executive attention in the Stroop task (Braver, Gray, & Burgess, 2007, chap. 4). In this framework, proactive control refers to actively maintaining information (e.g., task instructions, previous stimuli, cues, etc.) to actively bias perception and action systems to facilitate goal completion (Braver et al., 2007). In contrast, reactive control refers to transient activation of bottom-up, late-correction processes that reduce interference after it occurs. Increases in the proportion of overlapping color-word trials Stroop task encourages changes from a proactive strategy to reactive strategy (Braver, 2012). In situations where trials reinforce a behavior (e.g., the overlapping Stroop trials in Kane & Engle, 2003) proactive strategies diminish and response bias develops to reflect the greater prevalence of some events compared to others. WMC correlates with the maintenance of proactive control as this ability reflects the efficacy with which goal maintenance can be achieved across a period of time (Redick, 2014). WMC has also been linked to shooting behavior in contexts where trial-to-trial history gives no information about the prevalence of the decision to shoot.

Shooting behavior can be measured through the use of a computer-based simulated shooting task in which participants must make speeded "shoot" or "don't shoot" decisions in response to presented targets that are either armed or unarmed. Participants are typically awarded points on the basis of their performance in order to partially recreate real-life shooting situations, with 'hits' earning the highest reward and 'misses' resulting in the greatest penalty. To date, most of the research utilizing shoot/don't shoot tasks has focused on how the awareness of cultural stereotypes and personal racial prejudices influence the decision to shoot (Correll, Park, Judd, & Wittenbring, 2002; Correll et al., 2007; Unkelbach, Forgas, & Denson, 2008). Following recent incidents in which police officers mistakenly shot and killed unarmed citizens, accounting for environmental and cognitive factors underlying shooting decisions is an important goal for researchers in this area.

Kleider and Parrott (2009) were the first to investigate the link between WMC and shooting decisions using this task. Participants completed a series of questionnaires assessing their tendencies to exhibit negative affect and aggressive behavior, performed a single complex-span task (operation span), and then engaged in a computer-shooting task similar to that used in the Correll et al. (2002) study. To manipulate affect, the researchers showed participants an FBI training video that depicted a police officer performing a routine traffic stop that ended with a police officer being shot or ended without violence. Then in the subsequent shooting task participants with lower WMC exhibited more aggressive shooting behavior and were thus more likely to shoot unarmed targets. Moreover, Kleider and colleagues (2009) found that high levels of negative affect did not have any effect on aggressive shooting behavior. In a follow-up study, Kleider, Parrott, and King (2010) administered a negative affect induction and simulated shooting task to a sample of police officers. As in the previous study, officers with lower WMC exhibited a greater likelihood to shoot unarmed targets and a failure to shoot armed targets. In contrast to their previous study, an interaction was reported between negative affect and WMC, such that shooting errors were only evident among individuals that expressed negative affect from viewing the threatening video. These results are inconsistent with Kleider and Parrott (2009) original study and suggest the presence of moderating variables that influence shooting behavior.

The Current Study

The current study examined shooting behavior as function of WMC across changes in overlapping versus non-overlapping trials similar to Kane and Engle's (2003) Stroop task. As described previously research on the Stroop effect has illustrated that error rates on non-overlapping trials increase as the number of overlapping trials increases (Kane & Engle, 2003), and this effect is exacerbated for low WMC individuals. In most versions of the shooting task previous trials are not diagnostic of the prevalence of shooting decisions. This means that the proportion of trials where a weapon is present and participants must make a shoot decision is typically set at 50% which places higher demands on the usage of proactive control strategies. A primary goal of the current study is to examine shooting behavior in conditions that vary the prevalence of shooting decisions and

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