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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

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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 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 attempt to promote changes in control strategies (80%, 50%, and 20% weapon present conditions). Our prediction is that working memory will be a predictor of shooting behavior across all conditions, but that it may be more important for regulating shooting behavior under conditions that promote reliance on reactive control strategies. A secondary goal is to investigate how WMC and the proportion of "shoot" to "don't shoot" trials influence signal detection parameters of sensitivity and decision criteria.

Method

Participants

Participants were 186 introductory psychology students recruited from the undergraduate research pool at Arizona State University. Participants' WMC score was calculated as a composite of their performance across Operation, Symmetry, and Reading span. One participant failed to complete the complex-span tasks and was removed from the analyses.

Materials

Working memory capacity (WMC) tasks.

Operation Span (Ospan). In this task participants solved a series of math operations while simultaneously trying to remember a set of unrelated letters. At encoding, participants first solved a math operation and after solving the operation they were presented with a letter for 1 s. Immediately after the letter was presented, the next math operation was presented and after it was solved the participants were presented with the next letter. Participants were presented with a single letter at a time on each trial and the trials composed list-lengths of 3–7. There were 3 repetitions of each list length and the order of list-length varied randomly. At recall, participants were presented with an array of letters on the screen and their task was to click on the letters from the current set in the correct order that they were presented in during encoding (see Unsworth, Heitz, & Engle, 2005 for more details). After recall, participants began the next list. For all of the span measures, items were scored if the item is correct and in the correct position so with list lengths ranging from 3 to 7 a participant's maximum possible score on the Ospan task is 75.

Reading Span (Rspan). Participants were required to read sentences while trying to remember the same set of unrelated letters as in the Ospan task. For this task, participants read a sentence and determined whether the sentence made sense or not (e.g., "The prosecutor's dish was lost because it was not based on fact"). Half of the sentences made sense while the other half did not. Nonsense sentences were made by simply changing one word (e.g., "dish" from "case") from an otherwise normal sentence. Participants read the sentence and indicated whether it made sense or not. After participants gave their response, they were presented with a letter for 1 s. At recall, participants were presented with an array of letters, and letters from the current set were recalled in the correct order by clicking on the appropriate letters. There were three repetitions of each list-length with list-length ranging from 3 to 7. The same scoring procedure as Ospan was used.

Symmetry Span (Symspan). In this task, participants recalled sequences of red spatial locations within a matrix while simultaneously performing a symmetry-judgment task. In the symmetry-judgment task, participants were shown an 8×8 matrix with some squares filled in black. Participants decided whether the design was symmetrical about its vertical axis. The pattern was symmetrical half of the time. Immediately after determining whether the pattern was symmetrical, participants were presented with a 4×4 matrix with one of the cells at a certain spatial location filled in red for 650 ms. At recall, participants were presented with the 4×4 matrix and they attempted to recall the sequence of red-square locations in the preceding displays, in the order in which they appeared by clicking on the cells of an empty matrix. There were three repetitions of each list-length with list-length ranging from 2 to 5. The same scoring procedure as Ospan was used.

Negative photograph assessment. Based on previous studies examining WMC and shooting behavior, we decided that participants should encounter threatening and arousing information before conducting the shooting task. Importantly, we did not manipulate the content of the exposure to threatening and arousing information because we were not interested in whether affect induction would influence shooting behavior. All participants rated a series of photographs from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008). More specifically, thirty pictures were chosen from the database that depicted murder scenarios. The IAPS pictures have normative statistics for valence (emotional content) and arousal (physiological response). Participants rated these pictures for valence and arousal to ensure that they attended to the stimuli (i.e., we were able to match the normative data to the participants' ratings).

Computer-based shooting task. The materials and procedure for the computer-based shooting task closely resembled those found in Kleider and Parrott (2009; see also Correll et al., 2002).[1] More specifically, participants saw a series of photographs of scenes presented at a rate of 2000 ms per scene. In some of the scenes there was an individual inserted and these trials only lasted 700 ms to encourage a quick decision to either shoot or don't shoot. Participants made shoot or don't shoot decisions to two different sets of photographs based on whether the inserted individual in each picture had a weapon or not. Participants were instructed to press a key on the keyboard (f versus j) to acknowledge their decision to shoot or not shoot. After each picture there was a 3000 ms inter-trial interval. In each block of 20 trials, there was a different proportion of trials where shoot was the correct decision (80% versus 50% versus 20% weapon present trials). These blocks consisted of 20 trials each and they were counterbalanced between subjects. The dependent measures were the proportions of hits (individuals with weapons being shot) and false alarms (individuals without weapons being shot), which were submitted to a signal detection analysis to derive independent estimates of sensitivity (d') and criterion (c).

Design

The current study used a one factor within-subjects ANOVA design with three levels of the independent variable (Weapon Present Trials: 80%, 50% versus 20%) to evaluate the computer-based shooting task. Also, an Analysis of Covariance was used where participants WMC composite score was entered as a covariate in the model to assess the degree to which individual differences in working memory were differentially related to sensitivity and criteria setting in the three Proportion Shoot conditions.[2] WMC and the proportion of shoot trials served as the independent variables. The dependent measures were sensitivity and bias derived from the signal detection analysis of the hit and false alarm rates from the computer-based shooting task.

Procedure

Participants completed three complex span tasks to assess their WMC. Participants were then shown photographs designed to induce negative affective states in the viewer and were then asked to assess their subjective affect and level of arousal. Importantly, we have no quantifiable measure of the impact of the rating phase so this issue will not be discussed further. Upon completion of this part of the experiment, participants moved on to a computerized shooting task in which they had to make speeded shoot/don't-shoot decisions in response to individuals presented on the computer screen.

Results

Complex-Span Tasks

Participants' performance in the Ospan (M = 57.74, SD = 13.96), Rspan (M = 52.43, SD = 13.55), and Symspan (M = 21.15, SD = 8.67) was similar to previously reported research (Redick et al., 2015). The complex-span tasks were also correlated ($r_{Ospan.Rspan} = .55$, $r_{Ospan.Sspan} = .45$, and $r_{Rspan.Sspan} = .38$). Therefore, we summed the dependent measures from the three tasks and created a z-transformed composite score. When possible, multiple measures of working memory are desirable to mitigate task specific variance driving relations with outcome measures (Conway et al., 2005).

Computer Task

The experimental design was a one-factor ANOVA design with 3 levels (20/80 shoot/don't shoot, 50/50 shoot/don't shoot, 80/20 shoot/don't shoot) with working memory span score (composite of the three complex span tasks) entered as a covariate in this model.[2] Follow-up t-tests were assessed with a Bonferonni corrected alpha value. Signal detection theory (SDT) parameters, sensitivity and criteria, were modeled using each participant's hit and false alarm rates from the shoot/don't shoot task (Stanislaw & Todorov, 1999).

We originally hypothesized that WMC would influence shooting behavior in the 80%-shoot and 20%-shoot conditions because previous trials reinforce the "shoot" or "don't shoot" behavior leading to more incorrect shoot decisions. However, WMC should not be needed in the 50%-shoot condition. In this condition, previous trials are not diagnostic of future trials since trials in which a weapon is present are occurring equally as often as trials in which a weapon is not present (i.e., each trial demands a more proactive strategy). There was a main effect of condition on d' (sensitivity), $F(2,182) = 11.56, p < .05, \eta_p^2 = .11$. Participants were more sensitive to the gun present versus absent differences between different proportion shoot conditions ($M_{80} = 1.30$ & $SD_{80} = 1.91$, $M_{50} = 1.30$ & $SD_{50} = 1.05$, and $M_{20} = 1.86$ & $SD_{20} = 1.50$, for the 80%, 50%, and 20% shoot conditions, respectively). Oddly, this effect was driven primarily by participants in the 20% shoot condition. Performance in the 20% shoot condition was significantly better than performance in the 50% and 80% shoot conditions, both $t(184) = 4.62$, $p < .01$ and $t(184) = 3.68$, $p < .01$. There was also a main effect of WMC on d', $F(1,184) = 4.21$, $p < .05$, $\eta_p^2 = .022$. To investigate the nature of this effect we examined participants in the upper and lower quartiles of the working memory distribution. Overall, individuals with high WMC (M = 1.68, SE = .11) were more sensitive to shoot versus don't shoot trials than individuals with low WMC (M = 1.16, SE = .11). No interaction was found between condition and WMC on d', $F(2,182) = .372$, $p = .690$, $\eta_p^2 = .004$ (see Fig. 1).

To examine decision criteria in the computer-based shooting task we also derived measures of criterion (c) from the signal detection analysis. There was a main effect of condition on c (criterion), $F(2,183) = 64.66$, $p < .05$, $\eta_p^2 = .415$. This result was expected based on previous research demonstrating that

[1] We thank Joshua Correll for sharing the pictures he developed for the shoot/don't shoot task.

[2] Entering WMC as a covariate in this analysis allows for the assessment of an interaction between shooting proportion and working memory capacity on the dependent variables of interest (i.e., does the effect of changing environmental base rate of shoot trials on d' and c differ as a function of working memory). This analysis makes use of the entire range of working memory capacity data and to facilitate interpretation of significant main effects and interactions one can plot effects from the upper and lower quartile of the continuous working memory distribution (Aiken, West, & Reno, 1991).

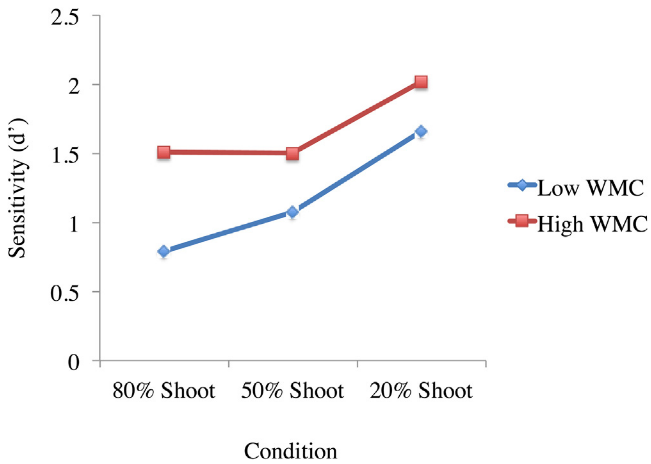

Figure 1. Sensitivity (d') as a function of working memory (upper and lower 25% of the overall distribution of scores) and condition (80% Shoot, 50% Shoot, & 20% Shoot).

participants change criterion based on their assessment of the proportion of trials in which the signal (in this case a weapon) is present (Macmillan & Creelman, 1991). Furthermore, criterion differed in all three conditions ($M_{80} = -.88$ & $SD_{80} = .88$, $M_{50} = -.24$ & $SD_{50} = .55$, and $M_{20} = .00$ & $SD_{20} = .85$), 80% versus 50% shoot $t(184) = 9.54$, $p < .01$, 80% versus 20% shoot $t(184) = 10.81$, $p < .01$, and 50% versus 20% shoot $t(184) = 3.55$, $p < .01$, respectively. Participants became more liberal in their bias (made more shoot decisions to both targets and lures) when there were more shoot trials. There was no main effect of WMC on c, $F(2,183) = 1.36$, $p = .244$, $\eta_p^2 = .007$. However, a significant interaction was found between condition and WMC on c (see Fig. 2, $F(2,182) = 3.55$, $p < .05$, $\eta_p^2 = .038$). In the 50%-shoot and 80%-shoot conditions, high and low working memory span individuals used the same criterion when deciding whether or not to shoot. However, in the 20%-shoot condition where shoot trials occurred infrequently, low WMC individuals failed to adjust their decision criterion in a similar manner to high

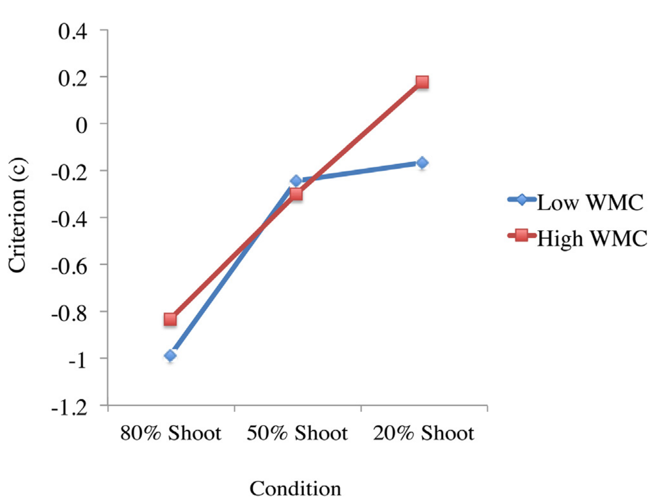

Figure 2. Criterion (c) as a function of working memory (upper and lower 25% of the overall distribution of scores) and condition (80% Shoot, 50% Shoot, & 20% Shoot).

WMC individuals, $t(90) = 2.06$, $p < .05$. That is, low WMC individuals were more liberal than high WMC individuals in their shooting decisions when "shoot" trials were infrequent.

Discussion

The present study provides evidence that WMC and the proportion of shoot to don't-shoot decisions influence shooting behavior outcomes. In the computer-based version of the shooting task, sensitivity to detecting weapons unexpectedly differed as a function of the proportion of shoot trials, whereas bias expectedly differed across all levels of shoot decision base rate (80%, 50%, and 20%). WMC was differentially related to sensitivity and criterion. That is, working memory is needed to maintain task focus in order to identify weapons in the shooting task, but it was not needed to adjust criterion in all cases. Along these lines, there was an interaction between WMC and the proportion of shoot trials on criterion setting in mostly don't shoot conditions, suggesting that WMC is only relevant to criterion adjustment in conditions under which the environment is continually reinforcing a not shooting beavior.

According to the dual-mechanisms of control framework (Braver, 2012), continuous reinforcement of the decision to shoot or not shoot should lead to changes in reliance on proactive versus reactive control strategies and shifts of behavior should be related to WMC as assessed by the complex-span tasks. Interestingly, the environmental base-rates of shoot and not shoot trials essentially mirrored each other in the 80% and 20% shoot conditions. However, participants' reliance on maintaining context seemed to shift depending on whether participants were mostly making shoot versus not shoot decisions in a manner inconsistent with information theory. Moreover, the low WMC participants were generally less effective at detecting weapons and they did not adjust their decision criteria in a manner similar to high WMC participants. Adopting and relying on control strategies may be related to both a history of reinforcement as well as the contextual circumstances surrounding the decision maker (i.e., it seems that deciding to shoot is somewhat different than deciding not to shoot). Future research should further examine how WMC is sensitive to changes in context maintenance as a function of reinforcement history and external factors to the participant.

Previous research into the relationship between WMC and shooting behavior found that low working memory participants had higher rates of false alarms and misses (Kleider & Parrott, 2009; Kleider et al., 2010). The current results extend these findings in a variety of ways. Hit and false alarm rates analyzed in previous research could arise from a variety of cognitive processes. The current work sought to examine the underlying basis for participant shooting decisions using a well-established theory of signal detection, which allowed us to separate the influence of sensitivity and bias on hit and false alarm rates in the computer task. In the current study we found that working memory is globally related to sensitivity (d') when decision-making in the shooting simulation regardless of the prevalence of shooting decisions that are being made. Presumably, low WMC participants fail to discriminate shoot versus not shoot trials due to lapses of goal maintenance across all conditions. Along these lines, Kleider and colleagues have suggested that working memory is important for avoiding emotionally intrusive thoughts leading to aberrant shooting behavior.

Interestingly, working memory is only necessary for adjusting criteria to shoot and regulating emotion under conditions where the environment prompts not shooting. High WMC participants adjusted their criteria to be near ideal under conditions of infrequent shooting (i.e., $c = 0$). This result is interesting because it suggests that high WMC participants were more careful about making shooting errors in this context where an error is perceived to have more impact (i.e., most people are unarmed and therefore it is important to adjust criteria to be maximally effective and avoid shooting unarmed people). In this condition, low WMC participants maintained a more liberal threshold for evidence of a weapon and erroneously made more false alarms. These results suggest important future directions for investigating the role of working memory in criterion setting in many areas of applied research.

The current results also point to new directions of exploration regarding individual differences in hot cognition and emotion regulation in shooting environments. As demonstrated by the Stroop task, working memory is only necessary when the environment presents conflicting task demands (Engle, 2002; Kane & Engle, 2003). Intrusive thoughts resulting from stress and negative emotions should not matter if the environment is either completely consistent with the task goal (shoot 0% or 100%) or completely random (shoot 50%): in those conditions one would not expect errors because there is no habitual response for working memory to override. Only under conditions of infrequent shooting are individual differences in working memory predictive of adjusting criterion in order to make a correct decision. Therefore, future research should examine individual differences in shooting behavior across under acute stress in conditions of high and low prevalence of shoot decisions.

Practical Application

One practical implication of the current results is that police officers and military soldiers with higher working memory capacity are perhaps less likely to get shot on the job and can effectively neutralize a target more often than police officers with lower working memory. Moreover, individual differences in working memory was also related to adjusting decision strategies in terms of criterion setting as environmental contingencies shift from high prevalence to low prevalence decisions. High working memory participants adjusted criterion in a more consistent manner regarding changes in environmental shooting frequency than low working memory participants. Along with previous results reported by Kleider who examined the role of working memory in shooting behavior in a large sample of police officers, the current results point to a potentially useful cognitive ability measure that can be used for personnel selection. Future research should examine whether verbal working memory, spatial working memory, or a combination of both are best predictors of quick decision making in naturalistic environments.

Conclusion

Working memory is an important predictor of many real-world behaviors that people perform on a daily basis. Its role in these experiences, however, is subtle and varies according to the task and the environmental context in which that behavior is performed. With regard to shooting behavior, working memory is needed to detect the presence of weapons and adjust bias, but these differences are not apparent in all circumstances. Future research should further examine the link between individual differences in hot cognition arising from matching and mismatching internal variables (working memory, attention, emotional control, etc.) and external variables (environmental support, context, group composition, etc.).

References

Aiken, L. S., West, S. G., & Reno, R. R. (1991). *Multiple regression: Testing and interpreting interactions*. Sage.

Barrett, L. F., Tugade, M. M., & Engle, R. W. (2004). Individual differences in working memory capacity and dual-process theories of the mind. *Psychological Bulletin*, *130*(4), 553–573.

Braver, T. S. (2012). The variable nature of cognitive control: A dual mechanisms framework. *Trends in Cognitive Sciences*, *16*(2), 106–113.

Braver, T. S., Gray, J. R., & Burgess, G. C. (2007). Explaining the many varieties of working memory variation: Dual mechanisms of cognitive control. In A. R. A. Conway, C. Jarrold, M. J. Kane, A. Miyake, & J. N. Towse (Eds.), *Variation in working memory*. Oxford University Press.

Conway, A. R. A., Kane, M. J., Bunting, M. F., Hambrick, D. Z., Wilhelm, O., & Engle, R. W. (2005). Working memory span tasks: A methodological review and user's guide. *Psychonomic Bulletin & Review*, *12*(5), 769–786.

Correll, J., Park, B., Judd, C. M., Wittenbrink, B., Sadler, M. S., & Keesee, T. (2007). Across the thin blue line: Police officers and racial bias in the decision to shoot. *Journal of Personality and Social Psychology*, *92*(6), 1006–1023.

Correll, J., Park, B., Judd, C. M., & Wittenbring, B. (2002). The police officer's dilemma: Using ethnicity to disambiguate potentially threatening individuals. *Journal of Personality and Social Psychology*, *83*(6), 1314–1329.

Engle, R. W. (2002). Working memory capacity as executive attention. *Current Directions in Psychological Science*, *11*(1), 19–23.

Engle, R. W., Tuholski, S. W., Laughlin, J. E., & Conway, A. R. A. (1999). Working memory, short term memory, and general-fluid intelligence: A latent-variable approach. *Journal of Experimental Psychology: General*, *128*(3), 309–331.

Hepburn, L., Miller, M., & Hemenway, D. (2007). The U.S. Gun Stock: Results from the 2004 National Firearms Survey. *Injury Prevention*, *13*, 15–19.

Kane, M. J., & Engle, R. W. (2003). Working-memory capacity and the control of attention: The contributions of goal neglect, response competition, and task set to Stroop interference. *Journal of Experimental Psychology: General*, *132*(1), 47–70.

Kane, M. J., Bleckley, M. K., Conway, A. R. A., & Engle, R. W. (2001). A controlled attention view of working memory capacity. *Journal of Experimental Psychology: General*, *130*(2), 169–183.

Kleider, H. M., & Parrott, D. J. (2009). Aggressive shooting behavior: How working memory and threat influence shoot decisions. *Journal of Research in Personality*, *43*(3), 494–497.

Kleider, H. M., Parrott, D. J., & King, T. Z. (2010). Shooting behaviour: How working memory and negative emotionality influence police officer shoot decisions. *Applied Cognitive Psychology*, *24*, 707–717.

Klein, K., & Boals, A. (2001). The relationship of life event stress and working memory capacity. *Applied Cognitive Psychology*, *15*(5), 565–579.

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (2008). *International affective picture system (IAPS): Affective ratings of pictures and instruction manual*. Gainesville, FL: Technical Report A-8, University of Florida.

Macmillan, N. A., & Creelman, C. D. (1991). *Detection theory: A user's guide*. Cambridge: Cambridge University Press.

Redick, T. S. (2014). Cognitive control in context: Working memory capacity and proactive control. *Acta Psychologica*, *145*, 1–9.

Redick, T. S., Broadway, J. M., Meier, M. E., Kuriakose, P. S., Unsworth, N., Kane, M. J., et al. (2015). Measuring working memory capacity with automated complex span tasks. *European Journal of Psychological Assessment*,

Spillers, G., Brewer, G., & Unsworth, N. (2011). Working memory and information processing. In N. Seel (Ed.), *Encyclopedia of the sciences of learning*. Springer Science+Business Media, LLC.

Stanislaw, H., & Todorov, N. (1999). Calculation of signal detection theory measures. *Behavior Research Methods, Instruments & Computers*, *31*(1), 137–149.

Unkelbach, C., Forgas, J., & Denson, T. (2008). The turban effect: The influence of Muslim headgear and induced affect on aggressive responses in the shooter bias paradigm. *Journal of Experimental Social Psychology*, *44*(5), 1409–1413.

Unsworth, N., & Engle, R. W. (2007). The nature of individual differences in working memory capacity: Active maintenance in primary memory and controlled search from secondary memory. *Psychological Review*, *114*(1), 104.

Unsworth, N., Fukuda, K., Awh, E., & Vogel, E. K. (2014). Working memory and fluid intelligence: Capacity, attention control, and secondary memory. *Cognitive Psychology*, *71*, 1–26.

Unsworth, N., Heitz, R. P., & Engle, R. W. (2005). Working memory capacity in hot and cold cognition. In R. W. Engle, G. Sedek, U. Hecker, & D. N. McIntosh (Eds.), *Cognitive limitations in aging and psychopathology: Attention, working memory, and executive functions*. NY: Oxford University Press.

Unsworth, N., Heitz, R. P., Schrock, J. C., & Engle, R. W. (2005). An automated version of the operation span task. *Behavior Research Methods*, *37*, 498–505.

Unsworth, N., Schrock, J. C., & Engle, R. W. (2004). Working memory capacity and the antisaccade task: Individual differences in voluntary saccade control. *Journal of Experimental Psychology, Learning, Memory, and Cognition*, *30*(6), 1302–1321.

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