THESIS

THE GUN-WIELDING BIAS EMBODIMENT EFFECT UNDER STRESS

Submitted by

Nathan L Tenhundfeld

Department of Psychology

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Master's Committee:

Advisor: Jessica K. Witt

Bradley Conner
C.A.P. Smith

ABSTRACT

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Recent work has shown that the embodiment of a gun may be to blame in circumstances wherein an individual has misidentified a gun as a neutral object, such as the high-profile police shooting of Amidou Diallo. However, these embodiment effects have not been studied under stress, results of which could speak to not only applied concerns, but the nature of embodiment as well. In order to start developing an understanding as to whether embodiment is flexible, or unchanging, I utilized the Cold Pressor Task to induce stress into a paradigm published by Witt and Brockmole (2012). Results indicated that there was no difference between stress and non-stress conditions. However, my control condition (non-stress) failed to replicate the main effect previously reported, therefore prohibiting me from drawing conclusions about the nature of embodiment.

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CHAPTER 1: INTRODUCTION

There has been an unfortunate abundance of incidents in which the misidentification of a nonthreatening object as a firearm has proven deadly. Whether it be the high-profile case of Amidou Diallo, who was shot by police in 1999 while he was pulling out his wallet, or the recent shooting death of Trayvon Martin by George Zimmerman, who claimed to have seen a gun in the waistband of Trayvon's pants, the best instincts of self-preservation have recurrently turned otherwise innocuous situations deadly. One of the reasons for these fatal misperceptions may be that the victims were black. Studies have suggested that skin color increases the bias to see guns when guns are not present (Correll, Park, Judd, & Wittenbrink, 2002; Greenwald, Oakes, & Hoffman, 2003). Another possible reason is that the perceivers were holding a gun themselves. Recent research has shown that holding a gun increases the biases to see other indeterminable objects as guns (Witt & Brockmole, 2012). I will be referring to the increased bias to see guns when holding a gun as the 'gun-wielding bias effect'. By building on the framework established by Witt and Brockmole (2012), and by introducing stress into the paradigm, I hope to better understand the perceptual system's response under stress, allowing me to not only address the obvious applied concerns, but additionally to begin developing a better understanding about the nature of embodiment.

Embodiment

This gun-wielding bias effect is an example of embodied cognition. According to the embodiment theory, our cognitive processes are intertwined with the way our body interacts with the world (Wilson, 2002). One classic study involved participants judging how funny a cartoon was while holding a pen in either their teeth or their lips. Holding the pen between their teeth is an action designed to resemble smiling because it engages the same muscles as are needed for smiling; whereas holding the pen between the lips engages the same muscles as frowning. Participants found the cartoons to be funnier when they held the pen in their teeth than when they held it tightly between their lips (Strack, Martin, & Stepper, 1988).

This effect extends beyond subjective measures like humor, and into more concrete processes like memory and even affects neuroendocrine levels. Researchers found that retrieval of autobiographical memories was better when participants were in a congruent body posture (e.g., being asked to make a sport related movement while recalling a memory about that sport), than when they were in an incongruent posture (Dijkstra, Kaschak, & Zwaan, 2007). Additionally, simply altering posture, by engaging in a high-power pose or low-power pose, can alter levels of cortisol and testosterone in as few as two minutes (Carney, Cuddy, & Yap, 2010). By adopting a high-power pose (i.e. physically open), participants increased their testosterone and decreased their cortisol levels, while those with a low-power pose (i.e. physically closed off) experienced the opposite trend. Given that our body's interaction with the world can affect neuroendocrine levels, which in turn can affect behavior (which will be addressed later), this lends credence to the idea that stress induction in the present study may affect embodiment.

Another example of embodiment comes from the action-specific approach to perception, which proposes that the way in which an individual can act in their environment dictates how they perceive that environment (Witt, 2011). For example, softball players, golfers, and archers that are more successful will see the ball, hole, and targets, respectively, as larger than their less successful peers will see them (Witt & Proffitt, 2005; Witt, Linkenauger, Bakdash, & Proffitt, 2008; Lee, Lee, Carello, & Turvey, 2012). By changing an individual's capabilities, we can transform their perception. Reaching towards an otherwise out-of-reach object with a reach-extending tool makes that object appear closer (Osiurak, Morgado, & Palluel-Germain, 2012; Witt, Proffitt, & Epstein, 2005; Davoli, Brockmole, & Witt, 2011). Comparably, by wearing swimming fins, underwater objects appear closer than if you were not wearing the fins, due to an enhanced ability to more quickly and easily swim that same distance (Witt, Shuck, & Taylor, 2011). Embodiment of these tools allows for an extension of self, and an alteration of ability, which changes the way in which we perceive the world around us. This is what I believe is driving the gun-wielding bias effect. By giving participants a tool to use in a task relevant manner (i.e. a gun in order to shoot a threatening individual), it is thought that their changed perceptions are resultant of the embodiment, similar to the changes I mentioned in the reaching and swimming examples.

While there have been many demonstrations of the existence of embodiment effects, less is known about the nature of embodiment. At one extreme, these embodiment effects could be resultant of the fact that the system is being studied in a controlled, un-ecological, experimental setting, in which the participants may be privy to the experimental demands (Durgin et al., 2009). At the other extreme, embodiment effects could be an inherent and inflexible part of cognition. I propose to use stress as one way to provide insight into the nature of embodiment. If stress decreases or eliminates the gun-wielding bias effect, this would imply that the effect is flexible. Indeed, if the gun-wielding bias effect disappears altogether, this could suggest the effect is perhaps so incidental that it vanishes with any increased desire to perform better. In contrast, if stress does nothing to change the gun embodiment effect, this would be consistent with the idea that the embodiment effect is stable and inflexible, and would demonstrate that the embodiment of tools is immune to certain physiological influences.

Stress on Cognition and Attention

The terms 'stress' and 'anxiety' are used in the literature somewhat interchangeably, and typically refer to the induction of physical stress to illicit feelings of anxiety (Graydon , Linkenauger, Teachman, & Proffitt, 2012; Mogg, Mathews, Bird, & Macgregor-Morris, 1990; King, 2008). With that said, stress is known to influence cognition in a number of ways. However, the general direction of the effects remains unclear. For example, it has been shown that there is an inverted U relationship with memory, such that an increase to a certain level of stress will enhance memory, while a continued increase beyond that will have a deleterious effect (Deffenbacher, 1983). Other more recent work remains unclear in providing a consensus or rule of thumb for predicting the direction of the effect of stress on memory; substantial research has supported both claims that memory is generally enhanced and impaired under stress (Wolf, 2003).

For the present purposes, the critical research question is whether or not stress can *change* the gun-wielding bias effect. Regardless of the direction, any change in the bias would demonstrate that this particular embodiment effect is flexible, whereas resistance to change would suggest this embodiment effect is fixed and stable. Therefore, even though the literature shows conflicting effects of stress, the critical point is that stress can influence cognitive processes, including perceived ability, attentional allocation, threat detection, and perceptions.

Stress can affect people's perception of the limits of their abilities to perform an action. Anxious participants become more conservative in their perceived ability to perform reaching and grasping tasks (Graydon et al., 2012). Research involving rock climbers has shown that this decrease in perceived ability under stress mirrors the decrease in actual ability, which itself may be a function of increased muscle tension (Pijpers, Oudejans, Bakker, & Beek, 2006; Pijpers, Oudejans, Holsheimer, & Bakker, 2003).

Particularly relevant to the task of identifying objects, stress also leads to the reallocation of attentional resources. It has been suggested that stress and anxiety affect central executive functions like inhibition and the shifting of attention, both of which would clearly be disadvantageous in visual search and recognition tasks (Eysenck, Derakshan, Santos, & Calvo, 2007). Stress has been shown to significantly alter one's pattern of visual scanning. Under stress, individuals are more likely to stop scanning the entire scene before all of the alternatives have been considered, and to do the scanning in a nonsystematic fashion compared with non-stressful conditions (Keinan, Friedland, & Ben-Porath, 1987). These results suggest that an increase of stress may not be a benefit to visual processing.

Stress influences individuals to selectively attend towards threatening stimuli (Mogg et al., 1990). Given that we have a predisposition to selectively attend towards threatening stimuli, even under non-stressful conditions, these results demonstrate that stress can enhance our already heightened awareness. That said, threatening objects may capture attention beyond the direct manipulation of stress, by inducing a level of stress themselves. Work analyzing the uniqueness of guns has shown a penchant for individuals to focus on a weapon when viewing a scene longer than they do a control object (also referred to as the 'weapon focus effect') (Loftus, Loftus, & Messo, 1987). However, subsequent work has shown that this weapon focus effect can be canceled out by having an individual hold a readily usable gun, at which point this attentional bias shifts towards faces (Biggs, Brockmole, & Witt, 2013). Interestingly, this cancelation only seems to appear if there is the ability to act with the gun; having the weapon holstered does not elicit a similar bias. This suggests two things. First, actionable ability can influence attention away from threatening objects such as guns. Secondly, stress might not alter the gun embodiment effect given the selective attention away from the gun.

Individuals are quicker at detecting threatening objects. Evidence suggests that adults and children alike are quicker to detect snakes than other non-threatening plants or animals -- an effect that is enhanced when there is a greater emotional response to the threatening stimuli (LoBue & Deloache, 2008; Öhman, Flykt, & Esteves, 2001). The implication that a greater emotional response could enhance detection ability would seem to suggest a stress-related component in the efficiency of the perceptual system, which contrasts my earlier supposition that stress may have a deleterious effect. There does not always need to be an overt awareness of the threatening stimulus, however. Looming objects that were on a path in which they would either collide with the observer, or be a near miss, were presented as cues in a visual search task. Observers were not aware of whether the object was looming or a near miss, as indicated by near-chance performance on a discrimination task. Yet the looming objects captured attention, leading to performance akin to a "pop-out" effect on the visual search task (Lin, Murray and Boynton, 2009). This suggests that there is fast, subconscious processing of threatening stimuli that influences our attention, and could play a role in the present study.

Even when there is a conscious perception of threat-related objects, they do not always seem to be entirely representative of the physical realities. Evidence suggests that spiders, for instance, are seen to move quicker, as well as appear larger and closer than other non-threatening stimuli, and are more likely to be imagined as moving quicker by those who report a greater fear of them (Rinck, Reinecke, Ellwart, Heuer, & Becker, 2005; Witt & Sugovic, 2013; Riskind, Moore, & Bowley, 1995; Vasey et al., 2012; Harber, Yeung, & Iacovelli, 2011). These results indicate that physiological responses to one's own environment can affect perception, but further research is needed to better understand if this perceptual response is object dependent, or if it can be a general state that can exact the perceptual change.

Stress in Shoot/No-Shoot Paradigms

While no studies have specifically looked at the effects of stress on embodiment, some have attempted to answer how stress will change an individual's decision to shoot or not. These studies typically involve participants being shown a series of images and having to make the determination of whether or not to shoot the individual in the scene (henceforth referred to as a 'shoot/no-shoot paradigm'). Responses can be generated using anything from a keyboard, to actually tracking whether or not a participant pulls the trigger on a simulation gun. Nieuwenhuys, Savelsbergh, and Oudejans (2012) found that when given a gun to register responses with, despite no observable differences in gaze behavior, those in a high anxiety condition were more likely to wrongfully, and more quickly, shoot a subject. While these data indicated that reaction times are faster under their high anxiety condition than in the low anxiety condition (with quicker speeds when wrongfully shooting the target, than when wrongfully not shooting), the design of the experiment penalized participants in the high anxiety condition when they did not respond quickly enough. In trials for which the participant missed the target, or did not shoot fast enough, a small pellet was shot at them from a specialized cannon, hitting them in the leg and inflicting pain. While this experimental design has higher ecological validity than other studies in the paradigm (given the penalties of not shooting in time in a real life encounter), the manipulation confounds time-related penalties with negative stimulus aversion. That is to say participants may be more likely respond quicker in order to decrease the likelihood that they would be shot with the pellet, in any given trial. Because the negative stimulus was so aversive, it would be wrong, in my mind, to say that it was the stress that caused the aforementioned results, when a simple response bias explanation seems to much more accurately explain the data. Put simply, there was a penalty for responding late but no penalty for responding inaccurately. Given speed-accuracy trade-offs, it is not surprising that people shifted their responses to be faster in order to avoid the penalty, which coincided with being less accurate.

In the current studies, I manipulated stress in a way that does not inherently and directly result in a potential response bias. A common technique to induce stress is the Cold Pressor Test (also known as the Cold Pressor Task, and henceforth will be referred to as CPT) to inflict pain for studies on pain management techniques, and as a successful inducer of stress (von Baeyer, Piira, Chambers, Trapanotto, & Zeltzer, 2005; Mitchell, MacDonald, & Brodie, 2004). The CPT is a harmless procedure which involves submerging one's hand in cold water that is typically between 0°C - 7°C, for no more than a few minutes. It has been shown to increase activation of hypothalamic-pituitary-adrenal (HPA) axis, as well as levels of cortisol and adrenocorticotropic hormone (ACTH), all physiological responses to stress (Bullinger et al., 1984; McRae et al., 2006). Beyond the simple effectiveness of the CPT, it will be ideal for stress induction in the current proposed studies because of the fact that the technique will likely not elicit a response bias inherent in the induction method, as is my concern about Nieuwenhuys et al. (2012). Studies that have utilized the CPT have relied a variety of measures to assess the efficacy of the CPT, including subjective reports (Damme, Crombez, Wever, & Goubert, 2008) and physiological measures such as heart rate and systolic blood pressure (Dembroski, MacDougall, Herd, & Shields, 1979).

Another study has examined the bias in the decision to shoot black versus white 'targets', dependent on if the suspect was holding a weapon or not. Researchers found that an increase in cortisol (an indication of stress) was associated with a decrease in errors when viewing the Black 'targets' (Akinola & Mendes, 2012). However, the study required participants to respond on a keyboard, which completely neglects the gun embodiment effect mentioned above. Because participants did not hold a gun at any point, the results are uninformative with respect to the gun-wielding embodiment bias.

Statistical Measures

The current paradigm will involve a participant viewing a series of images, one at a time, wherein they will have to make the determination if they saw the subject on screen holding a gun or a shoe. They will perform this task twice, once while holding a gun, and the other while holding a neutral object. Before discussing specific hypotheses, it is important to fully orient to the statistical measures because I will discuss the hypotheses in terms of these measures. A bias score (henceforth B”) will tell us the directionality of errors made by a participant. B” is calculated by relating the probability of a hit (i.e. comparing the number of times when a participant responds that they see a gun and there actually was a gun on screen, to the number of times there was a gun total) to the probability of a false alarm (i.e. comparing the number of times when a participant responds that they see a gun on screen when it was actually a shoe, to the total number of times that a shoe was on the screen). The equation for B” is

$$B" = \frac{(H\,(1-H) - F\,(1-F)}{(H\,(1-H) + F\,(1-F)}$$

where H is the probability of a hit and F is the probability of a false alarm, just mentioned. B” will tell us what errors an individual makes, when they make errors. Scores will range from 1 (which indicates that every time they make a mistake, it is to say that there is no gun when there is in fact a gun) to -1 (which is the result of every mistake being a ‘gun’ response wherein there was no gun). B” values can fall anywhere on that continuum, and do not speak to the number of errors, only the probability that any error that was made was in a certain direction.

In addition to the B” score, I am interested in A’ which is a measure of perceptual sensitivity, or discriminability. In studies using SDT, we can think of the data as representing two separate distributions (Figure 1). The first distribution we will consider is the one for noise, which represents what we would expect the response pattern to be if there was no ability for an individual to differentiate between the stimulus and other additional factors such as neuronal activity, additional similar stimuli, etc. The second distribution would be the response patterns for noise plus the signal. The distance between the mean values of both distributions is A’, and it allows us to get a better idea of how good a participant is at discriminating the stimulus from noise (Chaudhuri, 2011).

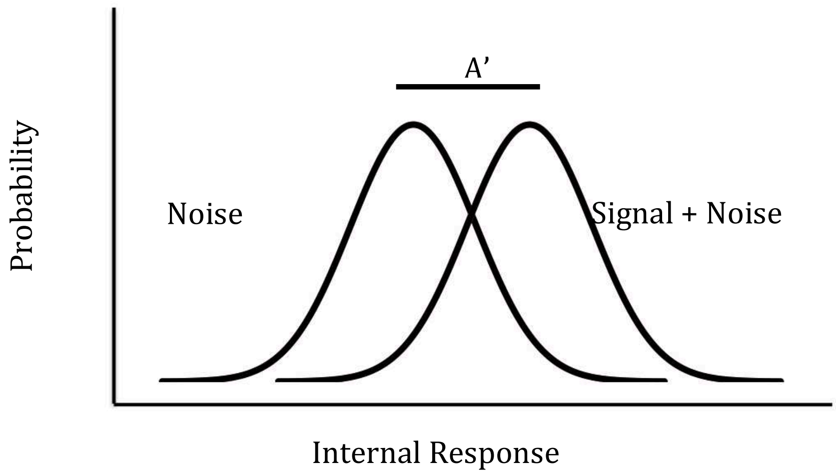

Figure 1. A representation of the two distributions that are compared in SDT.

Another way to think about this conceptually is that it represents a relationship between the probability of a hit to the probability of a false alarm; larger A’ mean you are more likely to have more hits than false alarms, where a .5 value indicates that you are unable to differentiate the stimulus from the noise. For the reasons mentioned here and above, B” and A’ will allow us to gather a more complete picture about the effects in the current study, than would simple accuracy scores.

Effect of Stress on the Gun-wielding Embodiment Bias

Henceforth, I will establish two possible patterns of results for the proposed studies. The proposed patterns will focus on the interactions between how stress affects holding a gun, versus how it affects holding a neutral object. To do this, I will analyze the differences between the held objects in the stress condition versus the non-stress condition. I will outline evidence to support both an increase and a decrease in this difference score, which should subsequently substantiate my claim that this research is needed to further our understanding about the actual effects of stress on our perceptions.

Hypothesis 1. My first hypothesis focuses on the magnitude of the gun-wielding bias effect. In other words, the focus is on the difference between the bias score when holding the gun versus the neutral objects. In the stress condition, I expect to see an increase in the difference between the two bias scores, which would occur if either the bias while holding the gun becomes more negative (indicating a greater 'gun present' bias), the bias while holding the neutral object becomes less negative, or potentially both. Support for this hypothesis is based on several fundamental assumptions. As was detailed in the study conducted by Witt & Brockmole (2012), evidence suggests that guns are not special in regards to the object embodiment that appear to bias our perceptions. By demonstrating that a similar biasing effect occurs with a shoe (an object that affords no task-relevant action) in the paradigm, the authors proposed that there is nothing unique about a gun in this specific context, and in regards to embodiment.

Despite the evidence from Witt & Brockmole (2012), I believe there are several examples of the exceptionality of guns that could play a role in changing the magnitude of the gun-wielding bias effect. Recent studies have focused on biases to report 'gun present' because of, among other things, race and priming (Correll et al., 2002; Greenwald et al., 2003; Payne, 2006). These studies have concluded that participants are quicker to accurately respond 'gun present', and are more likely to misidentify an object as a gun, if the image contains a black individual (in comparison to a white individual). Given that a similar bias does not exist with a neutral object, there must be something specific about threats that may interact with other processes in order to influence our perceptions.

The mere presence of a threatening object can change how we see our world. When participants are shown a picture of a hand holding a variety of objects, those objects associated with greater potential lethality (e.g., gun, knife, etc.) were correlated with larger size estimations of the individual holding the object (Fessler, Holbrook, & Snyder, 2012). This alteration of how we perceive the world, by the simple existence of a weapon, may interact with the induction of stress in the present study, to enhance the saliency of the gun held. Even when there is no intention to act with it, simply having a firearm in view increases aggression and the number of shocks administered by a participant, to a confederate, in a learning task (Berkowitz & LePage, 1967). These results demonstrate that guns, themselves, are linked with feelings of arousal. Given their exceptionality in the cases detailed above, the effects of stress may interact with the use of a gun in a different way than with a neutral object, thereby influencing the embodiment mechanism mentioned above, and increasing the bias, as was seen in Nieuwenhuys et al. (2012).

Beyond the direct effects that using a gun may have, research has shown us that certain stressful situations can enhance the withdrawal motivation an individual experiences (Storbeck & Stefanucci, 2014). While this withdrawal motivation may result in a 'fleeing' behavior traditionally, it is also possible that the stress induced by the CPT may be misattributed to the shoot/no-shoot task, resulting in a 'fighting' response. The growth of withdrawal motivation could produce an increase of task-relevant actions that may be consistent with real-world withdrawal. For example, an individual may choose to engage a threat they know they could not actually run from, in order to remove it. This would manifest in raising the gun to shoot in order to neutralize the threat (when the participant is holding the gun), whereas there is no similar task-relevant action afforded by holding the neutral object (Storbeck & Stefanucci, 2014). For example, experience with video games would dictate that when you see someone with a gun, you shoot in order to eliminate the threat, and prevent them from shooting you. However, because shooting is not an action afforded by the neutral object that is held, I would not expect to see an increase in the 'gun present' responses with it during a stressful situation. The increased bias when holding a gun but not when holding a neutral object would then explain an increase in the difference between the B" scores for the two conditions. The neutral object may be seen as an independent artifact that is unimportant to the task at hand, and thus, with no intention to use it, the object becomes irrelevant.

A final potential explanation for this proposed pattern of results may be that participants develop a binary classification of the task requirements under stress, in an attempt to simplify and reduce the cognitive load. The task requires the participant to indicate if they saw a gun or shoe by responding accordingly. However, this identification process may be internalized as a need to determine if what they are seeing is a gun or not (in lieu of a more complicated task of determining if it is a gun or a shoe). While it is unclear if embodiment can be categorical, a participant in this study who begins to categorically assign objects to being either a gun or not, may then be susceptible to a similar classification of objects held in the influence on their perception (i.e., if I am holding a gun, I am more likely to see the object on screen as a gun, while if I am not holding a gun, I am more likely to see the object as 'not a gun'). This categorical processing could explain an increase in the difference between scores, given that an individual may just simply respond with a bias in accordance with the classification of the object they hold.

Should I get this predicted pattern of results, it would tell us several interesting things about our perceptual system. First, it would provide us further insight into the traditional Action-Specific Perception effects that suggest we see our world in terms of our ability to act (Witt, 2011). Because of the task-relevant actions afforded by the gun, the stronger embodiment of that tool under stress would mean an individual perceives the world in a way that allows for greater use of the tool to enhance survival. Secondly, results along these lines would allow us to better understand the influence of other sensory modalities on the perceptual syntheses that we use to react in a split-second, as well as to inform more higher-order decision making processes. By this I mean that these results suggest an external influence on the perceptual understanding of the world, where it appears that actionable abilities, visual information, and internal states all work together to create one cohesive understanding of the environment. This would provide further evidence that the process of embodied cognition is not stable and fixed, but rather is flexible. Perhaps it is actually dependent on additional influencing factors, such as internal states, adding to recent work on topics such as energetics, motivation, and perception (Schnall, Zadra, & Proffitt, 2010; Cole & Balcetis, 2013). This would be exciting in that it builds upon the idea that our brains attempt to create a reality that involves input from many sources, in an effort to perceive the world in a way that will alter our decision making to best increase our chances of survival, and is not concerned with veracity.

Hypothesis 2. My second hypothesis predicts that increased stress will result in a decrease of the difference between the B" scores when holding a gun versus a neutral object. This decrease could result if the B" scores become less negative (indicating less bias to see guns) when stressed and holding the gun, if the B" scores become more negative when stressed and holding the neutral object, or both. As mentioned before, work done with police officers has found that an increase in cortisol is associated with greater accuracy in certain experimental conditions (Akinola & Mendes, 2012). Again, while this may provide support for a potential increase in accuracy in the current study, and therefore potentially a decrease in B" scores, the experimental methodology completely neglects the influence of embodiment, and so cannot be truly valid in its attempts to measure the effects of stress on perception and the identification of weapons.

As has been discussed, our ability to act (either inherent or augmented with tools) dictates how we perceive our environment (Witt, 2011; Witt & Dorsch, 2009; Witt & Proffitt, 2005; Davoli et al., 2012; Witt et al., 2005). In Witt & Brockmole (2012), this manifestation of the action-specific effect, and embodiment of tools, resulted in a greater bias to see indeterminable objects as guns, when holding a gun. Research suggests, however, that under stress/anxiety, these traditional action-specific effects disappear. In a recent study intending to look at the influence of stress on these effects, participants threw darts at a target while they were .07 m and 3.63 m above the ground. The participants in the 3.63 m condition were found to be significantly more anxious than those close to the ground, and while traditional action-specific perception effects were found amongst those in the .07 m group, those effects disappeared in the high anxiety group (Cañal-Bruland, Pijpers, & Oudejans, 2010). It was suggested that the disappearance of the effect may be due in part to the fact that as anxiety increases, so too do the distractions, which results in a redirection of attention. If stress diminishes (or extinguishes) the action-specific effects, it would follow that stress might diminish the embodiment of tools as well. By nullifying the embodiment mechanisms that are biasing perception, I might expect to see a complete regression of the B" score during the gun holding condition, towards the B" score of the neutral object holding condition.

Similarly, and as has been discussed before, stress has been shown to decrease an individual's capability for action (Graydon et al., 2012; Pijpers et al., 2006; Pijpers et al., 2003). From what I know about the reciprocal relationship between perception and action, if stress decreases one's ability to act, I would expect to see a decrease in the difference between biases to report gun present while holding the gun versus holding the neutral object, provided that the neutral object affords no task-relevant action, as the gun would. Additionally, if the stress increases the withdrawal motivation to flee, or causes participants to close up physically, as was suggested before, there may be a decrease in B" for the gun holding condition, but only a marginal effect for when the participant is holding the neutral object, given that participants are already more likely to respond by closing up (i.e., lowering the arm) in that condition (Pijpers et al., 2006; Pijpers et al., 2003).

This pattern of results would be fascinating in that it would certainly seem to be an incredible detriment to prohibit task-relevant actions in the face of stress. This would, however, provide further support for the idea that extensive firearms training is necessary for military and law enforcement officers, in order to overcome instinctual response biases. While it may seem intuitive that when faced with a threat, such as a responding to a gun, an individual would be inclined to react in the most beneficial way possible, there have been many instances in which poor training has prevented the appropriate response in such a circumstance. Grossman and Christensen (2007) detail a story in which a police officer trained repeatedly to disarm an individual by asking family and friends to hold a pistol, which he would practice quickly taking away, then subsequently return it, in order to practice again. When faced with a real-life perpetrator in an armed robbery, the officer quickly disarmed the suspect, only to instinctively give the weapon back. While not experimental in nature, this story still exemplifies the reality that instinctual responses under stress are not necessarily always going to be in the best interest of the individual performing them.

These results would also have serious implications for altering our understanding of the process of embodiment of tools, and would similarly demonstrate that embodiment is indeed flexible. If increasing stress eliminates the influences of embodiment on perception, this provides insights into the mechanisms of the process, and what components may be changing that allow for this effect to disappear. It would also have an applied benefit in that if there is a corresponding increase in accuracy, when the participant is holding the gun, then some of the initial fears behind behaviors that may enhance the bias to see and report guns (i.e., having your weapon drawn), would be mollified (Witt & Brockmole, 2012).

Effect of Stress on General Bias and Discriminability

Additionally, it is possible that there may be a main effect of stress on these biases, such that both conditions either increase or decrease. In Witt & Brockmole (2012), the changing of the pictures in the presentation from a normally dressed individual, to someone wearing a mask, seemed sufficient to increase the biases to respond 'gun present,' regardless of the object that the participant was holding. I believe one of two things may have driven this effect, both of which rely on the assumption of malevolence when someone is wearing a ski mask. First, this assumption could prime individuals to respond gun present more frequently, thereby affecting responses rather than perception. The second explanation is that the scenario may be somewhat stressful for participants; by changing the photos to one wherein the individual in the picture looks intimidating, the authors may have unintentionally introduced stress into the equation, as I hope to do here.

By introducing stress, participants' accuracy may also increase. The initial support for this idea was proposed by Yerkes & Dodson (1908), in which they showed that rats had enhanced performance in a learning task when exposed to an electrical shock. While the paper never mentions the words 'stress', 'anxiety', or 'arousal', subsequent work on those topics have built upon this proposed Yerkes-Dodson law (Deffenbacher, 1983). Work done in an attempt to further quantify this law, and relate it to human performance, has suggested that for the average individual, between 115 – 145 heartbeats per minute (bpm) is correlated with optimum visual and cognitive reaction times (Grossman & Christensen, 2007). Above approximately 145 bpm, there is a quick deterioration of visual and cognitive processing, which would theoretically decrease the accuracy of object identification and appropriate responses. While I do not believe that the current task will increase participants' bpm to anywhere near above-optimum levels, those in the stress condition may see an increase approaching the lower limits of the 115 -145 bpm sweet zone, so to speak. By increasing accuracy there may be a potential shifting of both bias scores one way or the other given the law of small numbers. The law says that smaller samples are more prone to extreme values, which could greatly expand the variability thus reducing the ability to detect the actual nature of the effect (Kahneman, 2011).

An overall main effect would be theoretically interesting given that it would seemingly demonstrate embodied cognition is a separate, parallel process that is independent of one's physiological state, and is therefore fixed and stable. This would be among the first evidence to suggest that there is not a synthesis of internal and external information to create an embodiment contingent upon certain physiological responses. The implications would be that the embodiment of tools is not subjected to temporary and plastic states, but rather remains constant in the face of varying environmental circumstances, an evolutionary adaptation that may further elucidate the way in which we process our environment and subsequently make decisions.

CHAPTER 2: EXPERIMENT 1

Method

Participants. Sixty participants were recruited through the Colorado State University participant pool, comprised of mostly entry-level psychology students. The only requirement was that the participants have normal, or corrected-to-normal, vision.

Stimuli and apparatus. Images were taken from Witt & Brockmole (2012), which depict an individual holding either a gun or a shoe in 19 different locations, such as a parking garage, a bathroom, or in a wooded area. Each image was also mirrored to give 76 unique pictures to be presented to the participants. Participants held either a Laser Shot Glock replica, or a comparably weighted tape dispenser, which served as my neutral object (see Figure 2 for a comparison). The length of the slide on the glock was approximately 19.7 cm long, and it was approximately 13.3 cm tall (from bottom of the grip to the top of the slide). The tape dispenser was approximately 8.9 cm tall and 17.8 cm long.

Figure 2. The tape dispenser and Glock replica held by the participant in Experiment 1.

The held object was used to depress a computer mouse that was attached to binder, which sat atop a table, from which participants could freely raise or lower their arm. The CPT was administered using either a bowl of ice- or lukewarm water (dependent on condition) that was approximately 10 cm deep, on the other side of the room, away from the computer. Temperatures of the water were collected using a Good Cook digital thermometer. An ePulse strapless heart rate monitor was used to ascertain heart rates.

Procedure. After providing informed consent, participants filled out a questionnaire in which they indicated their past exposure to, and experience with guns. Following the questionnaire, participants were led to the computer where they received onscreen instructions about the subsequent task. They were then given the opportunity to practice the movements required, by either raising and pointing the object at the screen to indicate 'gun present', or by lowering the object by their side to indicate 'gun absent', as instructed by an arrow on screen (the objects held first were counterbalanced). Prior to the experiment, participants were randomly assigned to either a stress or no-stress condition, which they remained in for the duration of the experiment to avoid carry-over effects. To induce stress, participants were asked to submerge their non-dominant hand into a bowl of ice water, for two minutes following the practice trials on the computer. The water was between 1-4° Celsius. Participants were asked to keep their hand still with their palm pressed against the bottom of the bowl. In an attempt to add uncertainty, and therefore potentially more stress in the stress condition specifically, participants were told that there would be several similar trials, so they should remember the instructions. Participants were told that should they become too uncomfortable at any point, they may remove their hand, but they should attempt to keep it submerged for the entire two minutes if possible. For the non-stress condition, participants submerged their hand in room-temperature water for two minutes. Measures of stress were taken using a modified version of the anxiety thermometer validated by Houtman and Bakker

(1989). The thermometer is simply a continuous scale displayed over 10 cm, ranging from 0 (feeling calm enough to fall asleep) to 10 (feeling completely overwhelmed). Participants marked on the line, following the questionnaire, and at 60 and 120 seconds after submerging their hand (or at the time they remove their hand given that it is prior to the full two minutes). A new line was used each time to avoid any sort of anchoring around prior answers. Participants' heart rates were also collected via the heart rate monitor (placed on their non-dominant arm), immediately after the practice trials, each subsequent block of shoot/no-shoot trials, and immediately following the removal of their hand from the water, as well as a baseline at the beginning of the experiment. Average heart rates for the duration of the experiment were also collected. Following the CPT, participants were brought back to the computer where they began 76 trials of the shoot/no-shoot task they were instructed on before, by using the same object used in the practice trials. All responses were coded by the experimenter who was unable to see the actual presentation the participant saw, and was required to code every response as either a gun-present response (arm raised), gun-absent response (arm lowered) or an error (change of direction, hesitation, etc.) Immediately following the 76 trials, participants' heart rate was recorded, after which they again partook in the CPT for two minutes. Following that, the experimenter exchanged the object that the participant had been holding for the other one detailed above. Participants then completed the shoot/no-shoot task once again. At the conclusion of the experiment, participants were fully debriefed and given contact information for mental health services, as a precaution.

Results

Bias scores were calculated by using B". There were fourteen participants for whom at least one bias score could not be calculated, given that no mistakes were made during the trials, therefore I excluded those data points. There were two other participants whose data was excluded due to experimenter error. A repeated-measures ANOVA with bias score as the dependent measure, held object (gun vs. tape dispenser) as a within-subjects factor, and stress group as a between-subjects factor indicated that there was no main effect for object held on B" scores $F(1, 42) = 0.10$, $p > .75$. There was no main effect of stress on the B" scores while holding the gun, $F(1, 44) = 0.01$, $p > .93$, nor while holding the tape dispenser, $F(1, 50) = 0.08$, $p > .78$. There was also no interaction between the object held and the stress condition $F(1, 42) = 0.02$, $p > .88$, (Figure 3). For hit and false alarm rates, see Table 1.

Table 1

The mean hit and false alarm ratios for each holding condition in Experiment 1, collapsed together and also separated by stress condition. The hit ratio is the number of times a participant responded gun present when there was a gun present over the total number of times there was a gun, while the false alarm ratio is the number of times the participant said gun present while there was a shoe on the screen, over the total number of times there was a shoe on screen. Standard deviations are in parentheses.

	Gun Holding Condition		Tape Dispenser Holding Condition	
	Hit Ratio	False Alarm Ratio	Hit Ratio	False Alarm Ratio
Collapsed	.98 (.03)	.08 (.08)	.98 (.02)	.08 (.06)
Stress	.98(.03)	.08 (.09)	.98 (.02)	.08 (.06)
Non-stress	.98 (.04)	.08 (.09)	.98 (.03)	.09 (.06)

The sensitivity scores (A') were not significantly different between the stress (*M* = .97, *SD* = .03) and non-stress (*M* = .97, *SD* = .02) in either the gun, *F*(1, 56) = .03, *p* > .86, or the tape dispenser holding condition (stress condition: *M* = .97, *SD* = .02, non-stress: *M* = .97, *SD* = .02), *F*(1, 56) = .60, *p* > .44. These sensitivity scores align with those reported in Witt & Brockmole (2012).

The CPT was effective in stress induction; the stress condition group gave significantly higher ratings on the anxiety thermometer (*M* = 5.93, SD = 1.43) than did the non-stress condition (*M* = 4.36, *SD* = 1.37), *F*(1, 56) = 18.18, *p* < .001. However, the non-stress condition group's anxiety scores raised significantly (*M* = 1.12, *SD* = 1.25) over their baseline *t*(28) = 4.82, *p* < .001, as did the stress condition group's scores (*M* = 2.41, *SD* = 1.77), *t*(28) = 7.33, *p* < .001. There was no difference between the two groups in their initial ratings before the experiment began, *F*(1, 56) = 0.35, p > .05. There was a significant difference between the number of seconds that those in the stress condition (*M* = 104.90, *SD* = 27.64) and those in the control condition (*M* = 120.00, *SD* = 0.00) were able to keep their hands in the water, *t*(55) = 2.89, *p* = .006. These lengths of time are comparable to other studies that have used the CPT (Snyder et al., 2005; Damme et al., 2008).

Mean heart beats per minute (bpm) for those in the warm water condition increased significantly more (*M* = 13.04 bpm, *SD* = 9.44) over the course of the study than for those in the cold water condition (*M* = 7.43 bpm, *SD* = 10.18), as determined by subtracting their base heart rate from their average heart rate across the rest of the experiment, *F*(1, 54) = 4.57, *p* = .037.

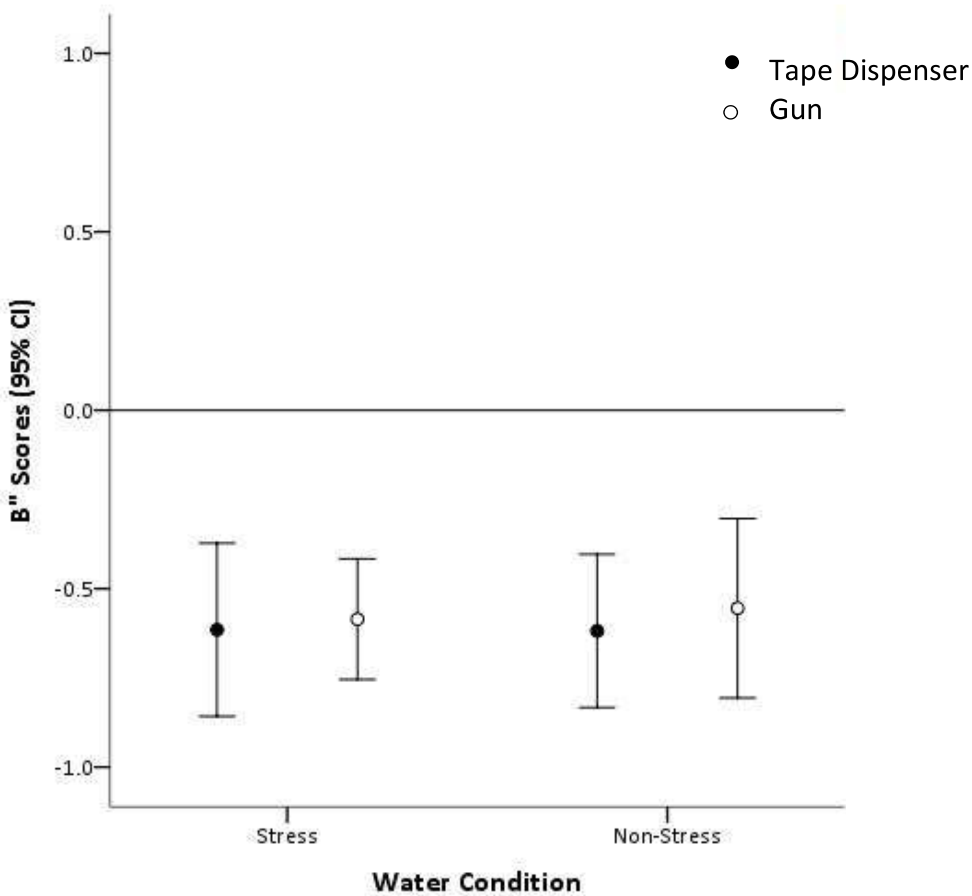

Figure 3. B" scores for the object holding condition (i.e. gun vs. tape dispenser) separated by the stress condition (i.e. cold vs. room temperature water during the CPT), in Study 1. A more negative value indicates a stronger 'gun present' bias, while a more positive value indicates a stronger 'gun absent' bias.

This is in line with other studies that show an approximately 9 bpm increase over baseline for the cold pressor task (Allen, Shelley, & Boquet, 1992). There was no difference in the initial base heart rates of the participants between the stress (M = 77.54 bpm, SD = 6.59) and non-stress (M = 76.66 bpm, SD = 5.54) conditions $F(1, 55) = .30$, $p > .58$. The average heart rate increase was significantly greater than zero for both the stress condition, $t(27) = 3.86$, $p = .001$, and the non-stress condition, $t(27) = 7.31$, $p < .001$.

Participants were significantly faster to respond to a gun on screen (*M* = 563.50 ms, *SD* = 84.02) than they were in responding to a shoe (*M* = 587.91 ms, *SD* = 86.07), $t(56) = 6.27$, $p < .000$. There was no significant difference in reaction times between the stress (*M* = 563.69 ms, *SD* = 79.38) and non-stress (*M* = 575.23 ms, *SD* = 138.43) conditions, $F(1, 56) = 0.15$, $p > .69$ (Table 2).

Table 2

Mean reaction times for participants in Experiment 1, collapsed and separated by stress conditions, for the different object holding conditions, in addition to the presentation of the gun and shoe on the screen. Standard deviations are in parentheses.

	Reaction Times			
	Gun Holding	Tape Dispenser Holding	Response to Gun	Response to Shoe
Collapsed	581.35 (88.75)	585.04 (91.11)	563.50 (84.02)	587.92 (86.07)
Stress	561.69 (85.99)	572.28 (86.86)	547.31 (78.14)	573.50 (79.12)
Non-stress	601.72 (88.46)	598.26 (95.06)	580.25 (87.97)	602.85 (91.76)

Discussion

The stress induction method was effective as shown by the difference in the anxiety thermometer ratings as well as heart rate. These results support evidence for a decrease in heart rate, when compared to a control, in studies looking at physiological responses to immersion in cold water (Schniepp, Campbell, Powell, & Pincivero, 2002). Despite the efficacy of the stress induction technique, given that I was unable to replicate the traditional main effect in the non-stress condition, I cannot make any conclusions about the null results relating to the B" scores in the stress condition. With that said, the increased rapidity with which participants responded to the gun in the pictures corroborates the exceptionality of threat detection by our perceptual system (Witt & Brockmole, 2012; LoBue & Deloache, 2008; Öhman et al., 2001).

In addition to the CPT, there were two key differences between the present study and those published by Witt and Brockmole (2012). First, the number of trials were cut in half in order to accommodate for the CPT. This may have been an issue given the way B” is calculated. If a participant has a perfect hit ratio without any false alarms, a bias score cannot be calculated; as mentioned above, this led to 14 participants missing either one or both scores, thereby not allowing us to fully compare the within subject differences. Secondly, the Glock replica replaced the Wii gun that had been used in Witt and Brockmole (2012). In order to try and determine if these changes may have had an effect on the results, I ran Experiment 2.

CHAPTER 3: EXPERIMENT 2

Because I failed to replicate the main effect in Experiment 1, I decided to rerun the experiment, changing the stimuli to mirror the structure of studies that had replicated the main effect previously. The changes are enumerated in the stimuli and procedure sections below.

Method

Participants. I ran 25 participants, recruited from the Colorado State University participant pool. Participants were compensated with class credit.

Stimuli and apparatus. Participants held either a plastic airsoft pistol (Figure 4)

Figure 4. The laser gun used for Experiment 2 with the reflective markers used for the motion tracking system.

or a spatula (Figure 5), which served as my neutral object. The spatula was chosen because it provided a flat surface on which to put the motion tracking markers. The airsoft pistol was approximately 13.3 cm tall and 19 cm long. The spatula was approximately 33 cm long with a 12.7 cm long handle.

Figure 5. The spatula used for Experiment 2 with the reflective markers used for the motion tracking system.

Responses were coded using a Vicon Nexus 2.0 motion capture system. Infrared markers were placed on both objects. Participants stood approximately 1 meter from the display that measured approximately 58 cm across. Images were 30.5 cm across and 15.9 cm tall. All trials were started by depressing a mouse that was 90 cm off the ground. All other stimuli remained the same.

Procedure. The instructions remained the same for participants (i.e. respond up or down accordingly), but the participants were not subjected to the CPT. This study simply served to determine if the fact that I was relying on half as many trials could have been contributing to the lack of significant results.

Data Analysis. Data were collected by the Vicon system which yielded X, Y, and Z coordinates for every marker, every 10 milliseconds. In order to process the data, I used programming language in R to code movements. The script established a baseline for where the participant would start each trial, as well as a threshold for up and down movements (set to 20% of the average distance deviation from the baseline). By comparing the motion capture data to the time-stamped stimuli presentation data from the software used to display images (E-prime), I was able to ascertain the length of each trial. If a participant moved above the up or below the down threshold and then returned to baseline within that time frame, the trial was coded accordingly. If the participant went either above or below the threshold and then quickly changed direction and crossed the other threshold, it was coded as a reversal. Finally, if the movement did not exceed the threshold during the time frame, it was coded as no movement. I corroborated the coding done in R by examining the graphs for each trial to ensure that there were no mistakes.

Results

B’’ scores were calculated for each condition. A paired-samples T test indicated no significant difference in the bias scores between the gun (*M* = -0.27, *SD* = 0.64) and spatula (*M* = -0.45, *SD* = 0.51) holding conditions; $t(24) = 1.35$, $p > .18$. There was no significant difference between accuracy scores between the gun (*M* = 90.70% correct, *SD* = 8.87) and spatula (*M* = 92.72% correct, *SD* = 4.69) holding conditions either; $t(24) = 1.22$, $p > .23$.

Discussion

Given that I set up the experiment in a way that should have otherwise served as a pure replication, the fact that I had non-significant results indicates that it is likely the fewer number of trials that could be contributing to the non-significant results in Experiment 1, thus, I ran Experiment 3.

CHAPTER 4: EXPERIMENT 3

Method

Participants. I ran 69 participants, recruited from the Colorado State University participant pool, and from flyers posted around campus. Participants were either compensated with class credit, or $15 for their participation.

Stimuli and apparatus. The setup was the same as in Experiment 2 in regards to the objects held and the motion capture system set up. I added in the CPT from Experiment 1.

Procedure. The procedure remained the same as in my first experiment, with the exception of doubling the number of trials. In order to double the trials, each stimulus was shown an additional time. I excluded one picture (and therefore its mirror) because of performance associated with it during the first two studies, which, in addition to doubling the number of times each picture was presented, lead to 148 trials per holding condition.

Results

All trials wherein the reaction time was less than 50 ms or larger than 1500 ms were excluded. Analysis found once again that there was no main effect for object held on B” scores, $F(1, 57) = 1.06$, $p > .30$. There was also no significant interaction between object held and the stress condition (Figure 6), $F(1, 57) = 0.49$, $p > .48$.

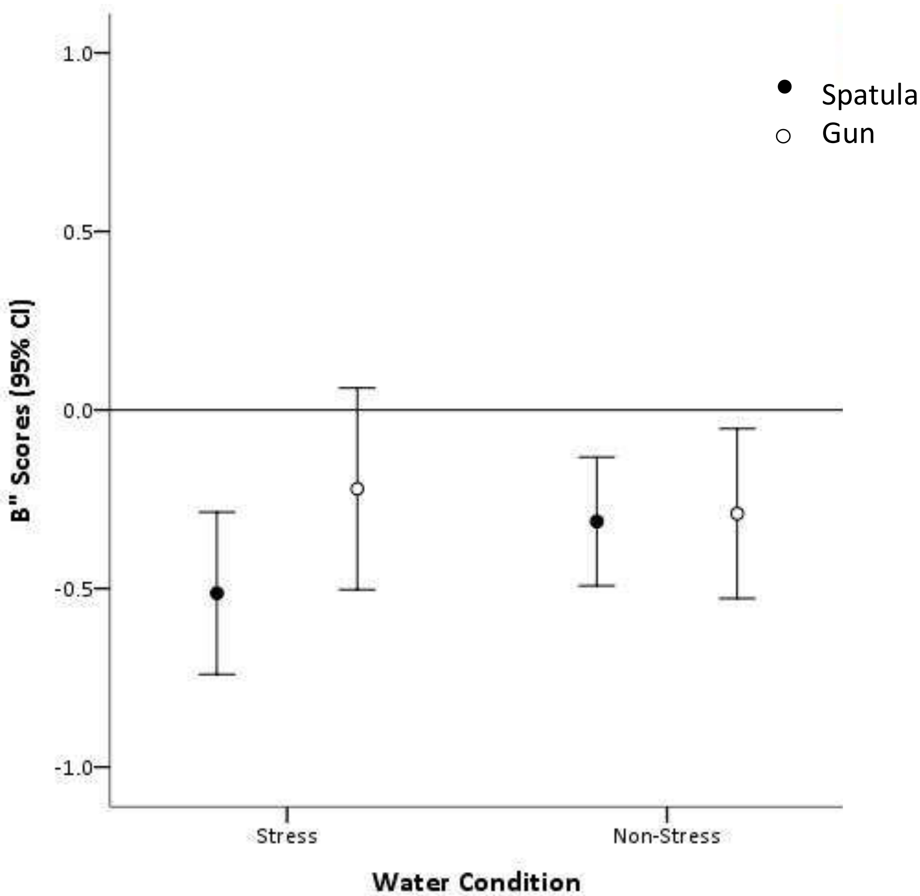

Figure 6. B" scores for the object holding condition (i.e. gun vs. spatula) separated by the stress condition (i.e. cold vs. room temperature water during the CPT), in Experiment 3. A more negative value indicates a stronger 'gun present' bias, while a more positive value indicates a stronger 'gun absent' bias.

The warm water condition, which served to replicate the findings of Witt and Brockmole (2012), yielded no significant difference between the bias scores in the difference object holding conditions, $t(29) = 0.27$, $p > .79$. See Table 3 for hit and false alarm ratios.

Table 3

The mean hit and false alarm ratios for each holding condition in Experiment 3, collapsed and separated by stress condition. The hit ratio is the number of times a participant responded gun present when there was a gun present over the total number of times there was a gun, while the false alarm ratio is the number of times the participant said gun present while there was a shoe on the screen, over the total number of times there was a shoe on screen. Standard deviations are in parentheses.

	Gun Holding Condition		Spatula Holding Condition	
	Hit Ratio	False Alarm Ratio	Hit Ratio	False Alarm Ratio
Collapsed	.97 (.08)	.06 (.07)	.97 (.07)	.06 (.07)
Stress	.95 (.12)	.07 (.09)	.98 (.03)	.05 (.04)
Non-stress	.97 (.02)	.04 (.04)	.96 (.08)	.07 (.08)

A' sensitivity scores were not significantly different when holding the spatula under stress (M = .98, SD = .01) than they were in the non-stress condition (M = .97, SD = .07), $F(1, 52) = 1.01$, $p > .32$, nor were the A' scores significantly different when holding the gun under stress (M = .96, SD = .09) than they were in the non-stress condition (M = .98, SD = .01), $F(1, 52) = 1.48$, $p > .23$. There was no significant main effect for object held on accuracy, $F(1, 52) = 0.89$, $p > .35$. The interaction between object held and stress condition was also not significant (Figure 7), $F(1, 52) = 3.72$, $p = .059$.

A one-way ANOVA indicated that there were no significant differences in heart rate increases over the baseline established at the beginning of the experiment, between stress conditions, $F(1, 51) = 0.65$, $p > .42$. Both the stress ($t(21) = 3.90$, $p < .001$) and the non-stress conditions ($t(30) = 4.40$, $p < .000$) increased significantly over the baseline (stress: M = 7.23

bpm, *SD* = 8.68, non-stress: *M* = 9.68 bpm, *SD* = 12.24), again, in line with past research on CPT (Allen et al., 1992). There was a difference in the

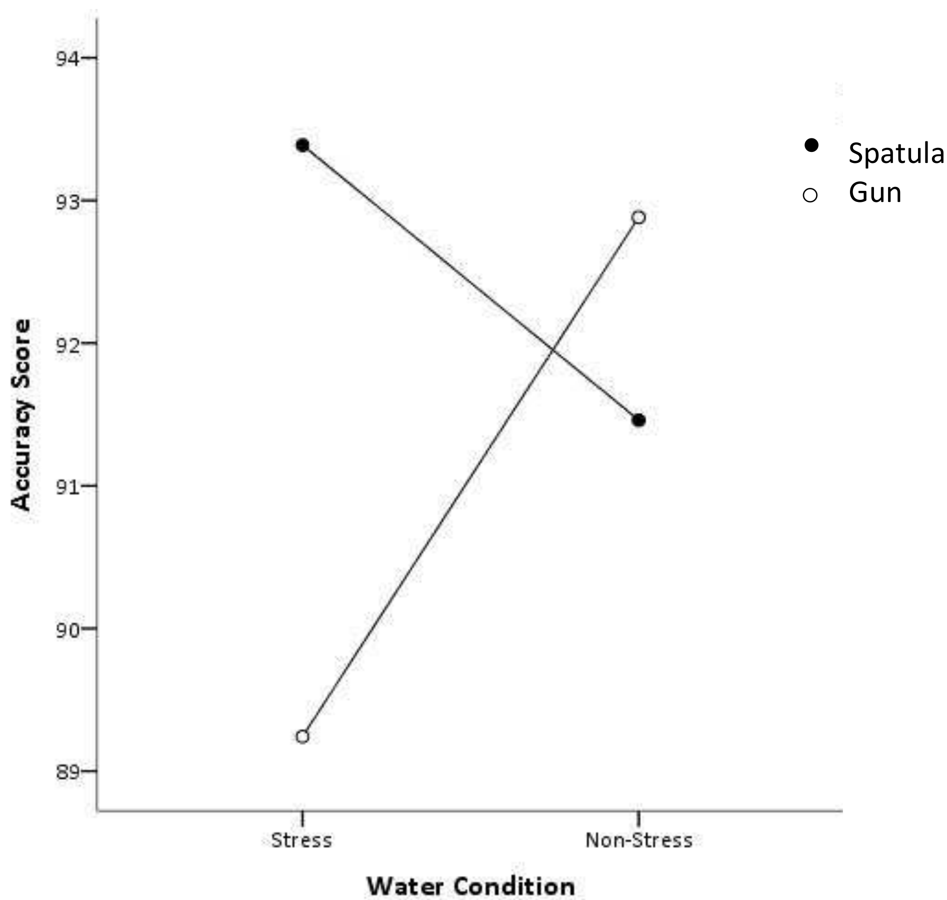

Figure 7. Interaction between the accuracy scores of the object holding condition (i.e. gun vs. spatula) separated by the stress condition (i.e. cold vs. room temperature water during the CPT).

anxiety thermometers between conditions, with those in the cold water condition giving a significantly higher rating (*M* = 5.62, *SD* = 2.21) than did those in the warm water condition (*M* = 4.35, *SD* = 1.48), *F*(1, 53) = 6.43, *p* = .014. The cold water condition had an increase in average thermometer rating (*M* = 1.45, *SD* = 2.58) above baseline, *t*(23) = 2.76, *p* = .011, as did the warm water condition (*M* = 0.90, *SD* = 1.65), *t*(30) = 3.05, *p* = .005. There was a significant difference between the number of seconds that those in the stress condition (*M* = 109.81, *SD* = 25.33) and those in the control condition (*M* = 120.00, *SD* = 0.00) were able to keep their hands in the water, $t(53) = 2.25$, $p = .029$.

There were no significant differences in reaction times between stress conditions when holding the gun, $F(1, 52) = 1.52$, $p > .22$, or when holding the spatula, $F(1, 52) = 2.82$, $p = .099$. There was a main effect for reaction times in responding to a gun (*M* = 616.59 ms, *SD* = 92.96) versus responding to a shoe (*M* = 632.32 ms, *SD* = 88.63), collapsed across stress conditions, $t(53) = 3.66$, $p = .001$. See Table 4 for additional reaction times.

Table 4

Mean reaction times for participants in Experiment 3, collapsed and separated by stress conditions, for the different object holding conditions, in addition to the presentation of the gun and shoe on the screen. Standard deviations are in parentheses.

	Reaction Times			
	Gun Holding	Spatula Holding	Response to Gun	Response to Shoe
Collapsed	610.81 (99.91)	618.14 (97.33)	616.59 (92.96)	632.32 (88.63)
Stress	629.47 (99.49)	642.59 (100.80)	639.29 (94.61)	653.62 (92.72)
Non-stress	595.88 (99.37)	598.59 (91.46)	598.43 (89.02)	615.27 (82.83)

Discussion

Once again I failed to replicate the main finding of Witt and Brockmole (2012), which means I am unable to determine the effects that stress has on the embodiment of guns. While the gun I used in the present study was not the Wii gun used in the initial study, our lab had used the current gun successfully in other pilot studies, which gave us good reason to believe it would be effective. While there was no difference between the HR increases (over baseline) between the two stress conditions, there was a significant difference between the thermometer ratings, which would indicate that the CPT was effective at inducing stress, once again. Analyses of reaction times once again support previous findings on increased speed in reaction to threat (Witt & Brockmole, 2012).

CHAPTER 5: GENERAL DISCUSSION

There are several possible explanations for my lack of significant results. First and foremost, could simply be the small effect size. Witt and Brockmole (2012) reported a significance of $p = .03$ with the stimuli I used in the current study, a value that indicates the effect has about a .58 probability of replicating the significant effect (Boos & Stefanski, 2011). An additionally compounding issue revolves around the law of small numbers, which says that smaller samples are more prone to extreme values (Kahneman, 2011). Given that participants are very good at this task, and the measure of bias relies on errors, of which there are relatively few, the calculated B" scores are prone to more extreme values. These extreme values can lead to more variability in my samples, thereby leaving us with less of an ability to detect this bias. However, while not reported above, analyses indicated that the same pattern of results emerged when doing a median split on A' scores and analyzing only those with lower A' scores (i.e. only those with more errors), potentially ruling out this explanation.

Another possible reason is that the lack of significant results may be attributable to an overall increase in arousal, regardless of the stress condition. While there was a significant difference between groups on the heart rates in Study 1 and anxiety ratings in both studies, all groups had significant increases over baseline, indicating a higher level of physiological arousal than their resting level. While this may be due, in part, to a higher level of activity during the study, it also could be due to the fact that even the room temperature water was cool enough to raise this arousal. Given that water conducts heat 25 times faster than air, submerging one's hand in room temperature water could result in it feeling cool enough to raise arousal levels (Cole & Becker, 2004). The increased level of arousal also may have something to do with the images themselves. As mentioned before, when Witt and Brockmole (2012) changed the images to an individual in a mask, B" scores shifted towards saying 'gun present' more frequently. That shift may represent a stress response to the pictures given that assumption of malevolence, which may be potentially born out in the present data.

In comparison of the B" values for Study 1, to those published in Witt and Brockmole (2012), it appears as though the value for the gun holding condition is similar, but the neutral object holding condition is substantially more negative (manifesting around the values I expected to see for the gun). It is not entirely clear why the values of the neutral object resemble those of the gun. One hypothesis could be that participants were somehow primed to treat the neutral objects as a gun. Perhaps the spatula in my second study elicited comparisons to a gun given a similar arching profile. That said, Witt and Brockmole (2012) found no effect for priming, thus it is unlikely that would be driving the shift I see here. Another possible explanation could be that there is somewhat of a floor effect wherein the abovementioned potential enhancement of arousal could be skewing everything towards saying 'gun present' more often, as was shown in the stimuli switch documented in Witt and Brockmole (2012). One way to test this would be to return to stimuli like those used in Correll et al. (2002) that depicted individuals in regular clothes, eliciting B" scores more towards the middle of the range. With that said, I saw a similar pattern of results in my second study with B" values more towards the middle of the continuum, leading me to believe that this may not be a fruitful explanation.

There are a couple limitations in the present study that future studies should aim to address. First, real time heart rate tracking should be considered in order to better correlate changes in the level of arousal over time throughout the CPT and shoot/no-shoot task. Additionally, in order to better mimic the stress of a real life situation, a consequential system should be developed that is similar to, yet less likely to bias responses than, the one used by Nieuwenhuys et al. (2012). As is mentioned above, participants are so good at this task that it may also make sense to develop stimuli that are more visually ambiguous in order to start teasing out these biases. Finally, any subsequent study should work on teasing out what component of the non-stress condition of the CPT may have eliminated the traditional effect (i.e. was it in fact the water raising arousal levels, or could it have been something else, such as the additional time to mentally rehearse the task, etc.)

While I did not find the traditional embodiment effects of the gun, I did find that there does not appear to be a complete elimination under stress of the bias to misidentify neutral objects as guns, while holding a gun. While I should caution against drawing any strong conclusions here, given various other external factors that could have led to these results, it is a potentially important applied conclusion to consider that may continue to support the accounts of those who have claimed to see a gun when none was present. Additionally, this pattern of data might suggest that embodiment is flexible, however more research would be required to tease apart whether I unintentionally induced stress in the control condition which drove the effect, or if I simply was unable to replicate a small effect. Finally, I have provided further evidence that the CPT is an effective method of stress induction and can be easily implemented in nearly any setting.

Understanding behaviors and perceptions related to the decision to shoot or not, under stress, are critically important and the failings of the current study should not deter future research on the topic. The debate on gun control is as feverous as it is commonplace. Quoting Supreme Court Justice Antonin Scalia, “Undoubtedly some think that the Second Amendment is outmoded in a society where our standing army is the pride of our Nation, where well-trained police forces provide personal security, and where gun violence is a serious problem… but what is not debatable is that it is not the role of this Court to pronounce the Second Amendment extinct.” (District of Columbia v. Heller, 2008). To the extent that guns will remain a staple in America, it is the obligation of researchers to better understand the consequences of firearm use in order to inform training and policy. By examining this construct through the lens of embodiment, I can develop a greater understanding about the nature of perception and cognitive processes which instruct the fragile decision of whether or not to shoot, that an individual may have to make in a fraction of a second.

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