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The Effects of Stress on Distance Perception

Monica Rosen
University of Central Florida

THE EFFECTS OF STRESS ON DISTANCE PERCEPTION

by

MONICA L. ROSEN

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ABSTRACT

Although there has been a great deal of research on binocular distance perception (Foley, 1980; Gogel, 1977), a number of questions remain unexplored. One such question involves how our ability to perceive distances is influenced by fitness and stress (internal and external). Previous research has shown that kinesthetic stress (via backpack weight) influences a person's ability to accurately guess distances (Proffitt, Bhalla, Gossweiler, & Midgett, 2003). This research did not only attempt to replicate previous work, but also extend it by exploring potential interactions between fitness level and mental stress on distance perception, a combination that is often encountered by soldiers, firefighters, and rescue workers. Mental stress was measured using the State Anxiety Inventory test (Spielberger, Reheiser, & Sydeman, 1995) and cardiovascular fitness was measured using MET scores (Jurca et al., 2005). Physical stress was manipulated by asking participants to estimate distances and then walk blindly to the target while carrying a backpack weighing 20% of their weight. We were unable to replicate Proffitt. We did however find a positive correlation between cardiovascular fitness and error in the second block of the blind walking task for the heavy backpack condition, $r(22) = -.45$, $p = 0.03$.

DEDICATION

This is dedicated to Julian Rosen, whom without his support and drive I may have never taken up such a strong passion for education and research.

ACKOWLEDGMENTS

My genuine thanks goes to Dr. Mark Neider and Dr. Daniel McConnell for their guidance in this research. Dr. Neider supported this crazy idea of mine and Dr. McConnell taught me about the finer details of action and perception. Furthermore, special thanks is given to Joanna Lewis, Adam Emfield, Pooja Patel, Jen Pesarchick, Kirsten Orlandella, and many other patient and hardworking research assistants that helped with this project.

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INTRODUCTION

Soldiers, firefighters, and rescue workers work in some of the most physically and mentally demanding careers. For instance, a soldier in the US Army Infantry School typically carries 48lbs for a fighting load, 72lbs for an approach march load, and 145lb for an average low-intensity operation (Patton, Kaszuba, Mello, & Reynolds, 1990). Most recently, it has been noted that the average combat gear for a US Marine weighs in at 137lb (Williams, 2009). In addition, rescue workers, firefighters, and soldiers are more likely to encounter much more state and trait anxiety than a normal individual because of the dangerous demands made on them in their career field. State anxiety is the nervousness or fear an individual feels in a particular situation, which is temporary. However, trait anxiety refers to the worrisome feelings one might feel from everyday stress and is considered more related to the person's personality (Spielberger, 1985).

According to the National Center for Post-Traumatic Stress Disorder, (PTSD) 11-20% of Iraq and Afghanistan war veterans suffer from PTSD, an anxiety disorder associated with the aftereffects of trauma and extreme stress (U.S. Department of Veterans Affairs, 2007). Where general anxiety disorder is often thought of as a manifestation of trait anxiety and specific phobias are manifestations of state anxiety, PTSD leans towards being considered a state anxiety, because certain stimuli can trigger an episode. However, a person with abnormally high levels of trait anxiety does tend to be more prone to developing PTSD when exposed to a highly stressful event (La Greca, Silverman, & Wasserstein, 1998).

The mental stress associated with life threatening situations and trauma have been known to cause cognitive impairments (Walter, Palmieri, & Gunstad, 2010). For example, clinical research has shown that stress, can impair visio-spatial ability (Morgan, Doran, Steffian, Hazlett & Southwick, 2006; Taverniers, Van Ruysseveldt, Smeets, & von Grumbkow, 2010). Traverniers et al. (2010) conducted a between groups study of soldiers in which one group was subjected to a high stress situation, a simulated prisoner of war scenario, and the other group was not. Soon afterwards they tested the two groups on a variety of cognitive tasks. The group exposed to the high-intensity stress showed significantly impaired responses on the cognitive tasks compared to those in the control group. Morgan et al. (2006) found similar results in their experiment when they demonstrated how stress can influence cognitive deficits in soldiers by conducting a between group experiment with special operation warfighters. The participants were randomly assigned to a pre-stress, stress, or post-stress group and completed a Rey Ostereith Complex Figure (ROCF) task (Rey & Osterrieth, 1993). They found that the stressed group had significantly impaired results compared to the other two groups and from these findings they argued that such results could suggest potential operational and battlefield errors.

Additional, research has suggested that cardiovascular fitness also affects many cognitive functions (Etnier et al., 2006; Hillman, Erickson, & Kramer, 2008). In fact, it has been noted that those individuals with heart failure and diminished cardiovascular activity have a decrease in cognitive functioning (Garcia et al., 2013). In contrast, individuals that engaged in cardiovascular fitness showed improved cognitive functioning (Colcombe, & Kramer, 2003). It seems reasonable then to speculate that individuals that possess higher levels of cardiovascular fitness may also perform better on cognitive tasks when physically encumbered than those with lower level scores. If cognitive functions, such as spatial ability, can be influenced by both anxiety and physical fitness then what about distance perception?

Terminology of Distance Perception

For one to understand how visual perception is altered by stress though, it is first imperative to understand some of the more basic mechanisms of visual perception and the common terminology used in the field. It is essential to begin by differentiating between the two types of distance judgments that we make. *Absolute distance* is the perception of the distance between the observer and the object; *relative distance* is the perception of distance between two objects (Foley, 1980; Loomis, Da Silva, Philbeck, & Fukusima, 1996). Relative distance is much more accurate than absolute distance (Foley, 1980). Absolute distance and relative distance share many of the same cues, which are used by the visual system to process distance, depth, and motion, yet they also possess a few individual cues. Visual cues can be split into two categories; binocular, those that require two eyes to be processed, and monocular, those that only require one eye. Due to its relevance to this study, we will briefly discuss only the cues associated with absolute distances and skip over those related to relative distance.

Monocular Cues

The known monocular cues for depth and distance perception are relative and familiar size (Hochberg & McAlister, 1955), texture gradient (Bajcsy, & Lieberman, 1976), aerial perspective (Egusa, 1983), accommodation and convergence (Fincham, & Walton, 1957; Grant, 1942; Leibowitz, & Moore, 1966; Owens & Liebowitz, 1980), occlusion (Finkel, & Sajda, 1992), linear perspective (O'leary & Wallach, 1980) angular declination (Ooi & He, 2001;

Philbeck & Loomis, 1997), and light and shadow (Mamassian, Knill, & Kersten, 1998; Ramachandran, 1988).

Relative size is used to tell us how far objects are from one another based on the notion that objects appear smaller when they are further away, whereas familiar size assumes the size of an object from experience with that object, so the observer can then assume how large the object ought to appear in relation to the above stated notion. Texture gradients are cues that are based on the understanding that texture appears finer the closer it is to the observer. On a related note, aerial perspective relies on the fact that objects further away from the observer appear hazier due to particles in the air. The brain also takes into consideration the information of the muscle changes in the eye as the lens becomes thinner and thicker while focusing on near and far objects. Accommodation is the thickening of the lens and comes from looking at objects nearer to the observer, while convergence is the thinning of the lens and comes from focusing on objects further away. If one object appears to cover another object the covered object will be assumed to be further away from the observer and this is referred to as occlusion. Cues of linear perspective state that parallel lines that are further away from the observer appear to converge. Angular declination is simply the height of the eyes and it is important because of the angles it creates when judging egocentric distances of objects on the ground. If the observer is aware of where the light is coming from shading can be a useful cue for depth.

Recent studies have attempted to tease these cues apart and measure the subcomponents of each such as the role of object orientation (Lewis & McBeath, 2004), where the shadowing is placed on an object (Shirai & Yamaguchi, 2004), and whether there is a cast shadow around the object (Imura, Shirai, Tomonaga, Yamaguchi, & Yagi, 2008).

Binocular Cues

Binocular disparity or stereopsis is a cue responsible for our ability to see in depth and relies on the notion that our eyes are set slightly apart from one another, so we therefore see two slightly different images of the environment (Regan & Beverly, 1979). When these images fuse together in the brain we perceive them as being one image, but are then able to perceive the objects in our environment in rich depth. In addition to being an important monocular cue, accommodation and convergence are often also thought of as an important binocular cue because our two lenses thicken and thin simultaneously (Regan & Hamstra, 1993).

Embodiment Argument

Some argue that the vision research ought to not lose sight of the importance of embodiment or that cognition develops from the relationship between mind, body, and environment (Clark, 1998). Therefore, to understand one part of cognition such as, visual perception, we must also understand how it relates to action with the world that we visually perceive. From an evolutionary prospective it makes sense that our vision evolved in order to act and react to other moving things in the world. Therefore, there are some additional visual cues that have come from this field, action-oriented cues.

Action-oriented Cues

Since many people make judgments of distances while interacting with the environment, it is also central to discuss how visual perception and action relate. ‘Idiothetic information’ is a source of information that is used for navigating in one’s environment from internal bodily states, such as motor and vestibular signals (Tversky, 2000). Action-oriented perception has been a popular area of research (Bingham & Pagano, 1998; Goodale & Humphrey, 1998), particularly in the context of understanding the interaction between athletic ability and performance (Bach & Tipper, 2006; Williams, Davids, & Williams, 1999). We know from professional athletes that people can train at and improve their performance on reacting to their environment (Abernethy, 1998). *Action space* is a term that has recently been used to refer to the ability to perceive distances and depth of objects moving in space and the ability to act or react upon them (Goodale, & Milner, 1992). Familiar size, angular declination, absolute motion parallax (motion based cue) are, so far, the only cues yet identified that require absolute distance within a range of *action space* (Loomis and Knapp, 2003). With this in mind, some researchers have suggested the necessity of using an action-based task such as, blind walking, (in addition to a verbal response task) in order to generate a more accurate judgment from participants in experiments that explore distance perception (Bingham & Pagano, 1998; Philbeck, Loomis, & Beall, 1997). *Optic flow* is the apparent motion an observer visually perceives because the body is moving in space (Gibson, 1950) and it is used to control human walking (Warren, Kay, Zosh, Duchon, & Sahuc, 2001).

Furthermore, recent studies have also shown how a person's judgment of their performance can also affect their perceptual abilities, for instance golfers report golf holes to be larger when they are hitting more puts (Witt, Linkenauger, Bakdash, & Proffitt, 2008) and swimmers judge distances to targets in water to be closer when they are wearing flippers (Witt, Schuck, & Taylor, 2011). But how does what we know about our own physical aptitude affect our ability to perceive our environment?

Previous Research

Proffitt, Bhalla, Gossweiler, and Midgett (1995), have shown that estimating the slope of a hill is based on a person's physiological potential (fitness level, age, and health). Furthermore, a physical stressor can alter our cognitive ability, in particular, a heavy backpack can change a person's ability to perceive geographical slants accurately (Bhalla & Proffitt, 1999). Later it was indicated that a backpack's weight can also influence a person's ability to perceive flat distances (Proffitt, Stefanucci, Banton, & Epstein, 2003). Overall, these studies suggests that the more weight a person carries the more likely they are to overestimate the distance to a set target.

However, there has been much debate about these findings. Some argue that methodology failed to capture the true effect of the backpack because of psychosocial issues in the experiment (Durgin, Baird, Greenburg, Russell, Shausghnessy, 2009). Durgin and colleagues. (2009 & 2012) argue that by not giving a cover story about the purpose of the backpack participants are subject to bias results that favor the experimenter's hypothesis. Furthermore, some researchers failed to replicate these findings (Hutchinson & Loomis 2006a, 2006b, Proffitt, Stefanucci, Banton, & Epstein, 2006a, 2006b, Woods, Philbeck, Danoff, 2009).

Hutchinson and Loomis (2006) used a similar design to Proffitt and colleagues with a few differences. They added two additional task types; an action-based task (blind walking) and a size estimation task of the target being viewed. They also tested whether reduced viewing cues had an effect on distance and size estimations. They were unable to find an effect from the backpack manipulation, but did find effects from the reduced visual cues manipulation. It is unclear as to why Hutchison and Loomis were unable to replicate Proffitt and colleagues backpack experiment.

Similarly, Woods and colleagues (2009) were also unable to replicate Proffitt (2003). They suggest several reasons for these inconsistent findings, one being that these findings could be effects that occur under restricted conditions and another being that anticipated effort is probably not the only influence in altering distance judgments.

Hypothesis

The current study looked at how a heavy backpack, cardiovascular fitness, and anxiety might influence both verbal and blind walking judgments of distance. The research was intended to build on previous findings and implement several new objectives. The first objective was to attempt to understand the discrepancies found between Proffitt et al. (2003), Hutchinson and Loomis (2006), and Woods et al. (2009). Earlier it was mentioned that Proffitt and colleagues (2003) claimed physiological potential combined with a physical stressor could be the reason for perceptual error, but Woods et al. (2009) concluded that anticipated effort cannot be the only factor. This leads us to the second objective, what about *actual* physiological potential?

No one has yet looked at actual physiological potential, so perhaps these measurements might shed some insight into the relationship between physical effort and distance perception. The second objective, therefore, was to measure actual physiological potential. By doing this we were also able to make inferences on the embodiment argument. In general, we expected fitter participants to make less error than less fit participants. As mentioned previously, fitness has been related to improved cognitive functioning, so our reasoning was that perhaps improved 'idiothetic information' can be extended to both task types in distance judging.

The third objective was to extend further into the embodiment question by looking at potential relationships between anxiety and error in distance judging; if anxiety can alter cognitive functioning as previously noted, then this might extend to distance perception. Furthermore, if there was any relationship between cardiovascular fitness and distance perception and mental anxiety and distance perception, we speculated that we might be able to characterize how they interact with one another in these two distance judging tasks. Therefore, this experiment looked at how internal stress (anxiety) and external stress (backpack weight) might affect the ability to perceive distances and then whether actual physical potential is related. If physiological potential really is a determining factor for distance perception then running a correlation and multiple regression between a person's physical fitness and mental stress to their error should show some trend.

Lastly, we were interested in knowing the relationship between the accuracy of verbal and blind walking tasks of judging distances. In other words, were participants better or worst in one task compared to the other? If they were, in which circumstances were they better or worse? Additionally, would we find more or less error over time, between blocks?

Our participants were randomly assigned to either the experimental group (received heavy backpack) or the control group (received an empty backpack). Anxiety was measured via a State Trait of Anxiety Inventory (STAI) test (Spielberger, Reheiser, & Sydeman, 1995) and cardiovascular fitness was inferred by a Metabolic Equivalent of Task (MET) score (Jurca et al., 2005). The participant then completed six judgments twice between 10 and 60 feet. These twelve distances were broken up into two blocks and were randomized. They also completed four practice trials in the beginning with feedback. The participant's task for each trial was to give a verbal response and perform an action-based task (blindly walk) to how far they believe the distance was to a set target.

Unlike, what was reported by Proffitt (2003) or Huchinson & Loomis (2006), we decided to add a demand characteristic by using a deceptive story about the purpose of the backpack. A recent study has shown that participants that were not given a cover story about why they must wear a backpack during the distance judging experiment were more likely to have biased results because the experimenter's hypothesis was transparent (Durgin, Baird, Greenburg, Russell, Shausghnessy, & Waymouth, 2009; Durgin, Klein, Spiegel, Strawser, & Williams, 2012). Durgin and colleagues (2009 & 2012) ran a slope estimating experiment in which they told one group (the naïve group) that they wore a heavy backpack because it contained muscle measuring equipment, while another group (standard) was told nothing about the reason for wearing the backpack and then a third group (no backpack) did not wear a backpack and was thus not given a cover up story. They found in a survey administered after the experiment that those in the standard backpack group were able to guess the purpose of the backpack when asked what they thought its purpose was. Lastly, they found no difference between the naïve and no backpack group, but a significant difference between the standard group and the naïve group. Those in the backpack condition overestimated distances significantly more than either the naïve or no-backpack group. In an interview afterwards, the standard group reported that they believed the backpack was supposed to affect their distance judgments and the naïve group did not because the majority had believed the cover up story.

METHODS

Participants

This experiment recruited 48 undergraduate students (29 women and 19 men with a mean age of 19) using the SONA system at the University of Central Florida. Similar studies used a sample size of 24, but we chose a larger sample size to capture a broader distribution of low, medium, and high cardiovascular fitness levels found in the general population. The SONA system allows undergraduate students enrolled in a psychology course to earn extra credit or to fulfill a class requirement. All students were screened for stereopsis, color blindness, and normal or corrected to normal vision. Participants read and agreed to consent forms. All procedures were approved by the University of Central Florida Institutional Review Board (See Appendix A).

Apparatus

Measurements

Participants used a desktop computer to input demographic information and filled out form Y of the self-reported, four point likert scaled STAI test. STAI was used to calculate current state of anxiety (Appendix B). A scale with a wireless display that projects weight information was used to measure participant's weight. The wireless remote display ensured that participants that were sensitive towards such information were not influenced by being able to see it. A measuring tape attached to the wall was used to take height. A Biopak MP150 was used to take a five minute ECG reading from which the mean resting heart rate will be derived. Height, weight, and resting heart rate measurements were three components of a formula used to calculate cardiovascular fitness (i.e. a MET score) for each participant. The MET was calculated by a formula (See Appendix B) and is a measurement that is highly correlated to V02Max (Jurca et al, 1998), but does not require the participant to physically exert themselves. The Stereo-*Fly test, a Snellen chart,* and *Ishihara plates* were used to test stereoscopic vision, far and near vision, and any color deficiency.

Experimental Task

Coding sheets were implemented to record participant's vision screening and participants' task responses. Golf tees were used to mark the participants starting point and the different distance trials that the participant will run through. These tees were placed prior to the participant's arrival in a spindle layout (Figure 2).

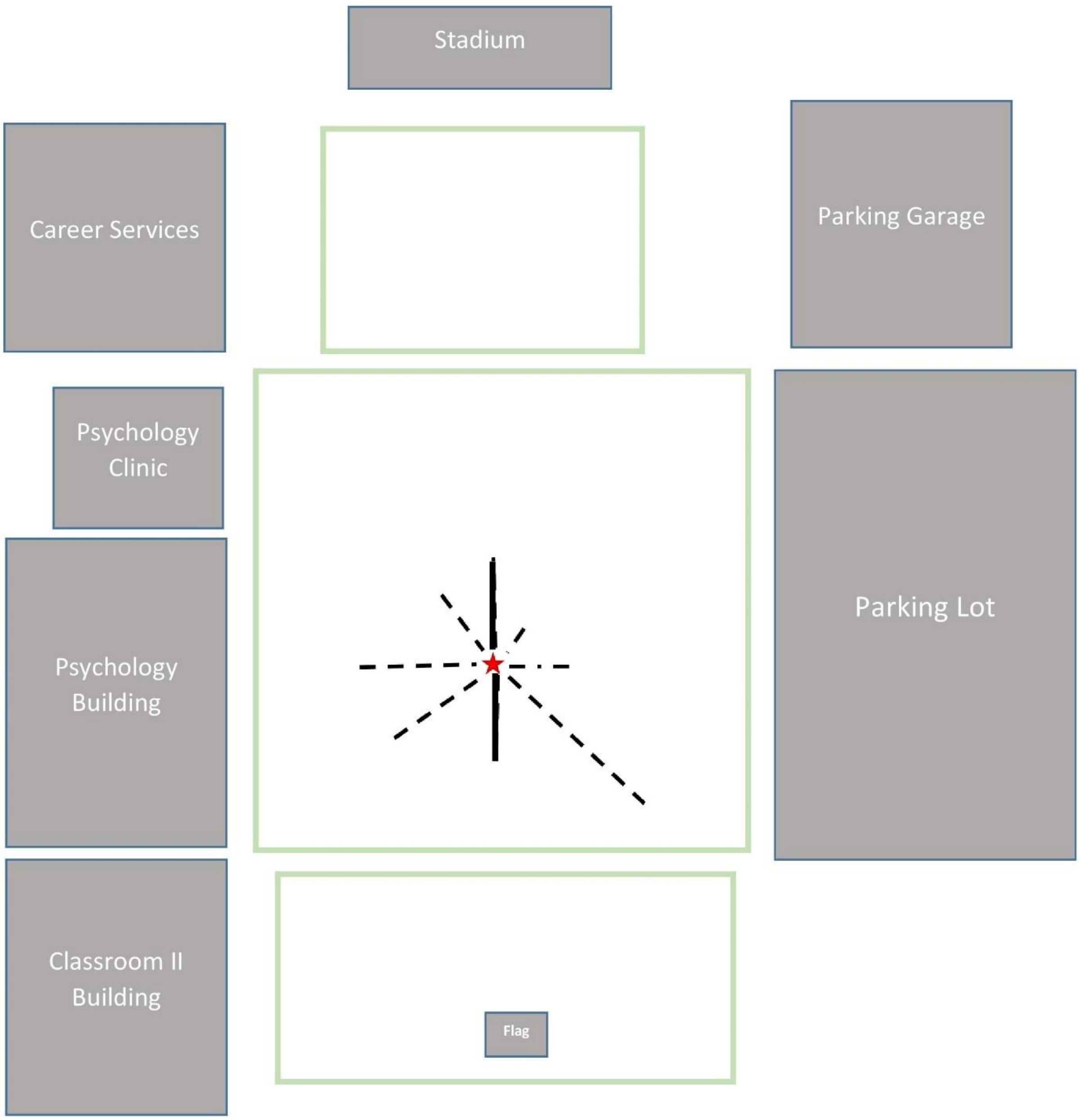


Figure 1 An example of the layout from a bird's eye view (not scaled to size).

The tees were made flush with the ground and the participant was not able to see them while standing at the starting position. An orange frisbee was be used to indicate the ‘target’ for which the participant will judge their distances to. The participant’s walking distance was measured using a tape measure. A hiking backpack with hip and chest straps was worn by all participants beginning soon after the practice trials. If the participant was assigned to the experimental group, prefilled yoga sandbags were be placed in the backpack based on the participant’s weight out of site of the participant (See Table 1).

Table 1 Criteria used to determine backpack weight

Participant Weight	Backpack Weight	Participant Weight	Backpack Weight
lb	kg	lb	kg
100-120	45.36-54.43	20	9.07
121-150	54.59-68.04	25	11.34
151-180	68.49-81.65	30	13.61
181-210	82.10-95.26	35	15.88

Source: (Bhalla & Proffitt, 1999)

A blindfold was used to blind the participants for the walking task and the setting of the target. Over-the- ear Sony noise canceling headphones playing white noise were used to control for auditory cues while the experimenter was placing the target and during the blind walking task.

Procedure

Pre-Experimental Measurements

The participant was greeted and asked to read the consent form. They were then screened for near and far vision acuity, color blindness, and stereoscopic perception. Afterwards, they were escorted to the desktop computer and asked to first fill out the demographics sheet, which also contained the single self-assessment question, needed for the MET formula, already embedded in it (See Appendix B). Second, the participant completed a computerized version of the STAI. When the participant was finished they had their height recorded. Participants were then connected to the ECG and had their resting heart rate calculated for five minutes. Afterwards, the participant had their weight measured and recorded. If the participant was assigned to the experimental group, prefilled yoga sandbags were placed in the backpack. This was done discreetly and out of the view of the participant. The experimenter then carried the backpack and materials while escorting the participant to the starting point located at Memory Mall (a flat field located directly outside of the laboratory) (Figure 2).

Tasks

The experimenter read the instructions to the participant, which outlined the tasks the participant was asked to perform, and then instructed him or her to perform four practice trials for both tasks (verbal and blind-walking) without carrying the backpack. The four practice trial distances are 5’, 10’, 25’, and 50’ and were performed in this order. These distances were chosen because it allowed participants a broad range of distance judgments based on the experimental trials. Feedback during the practice trials was given to ensure that the participant understand the unit of measurement and that they were calibrated before the manipulation was introduced

(Bingham & Pagano, 1998). The participant wore a blindfold and noise cancelling headphones with white noise playing while the experimenter set the target over the predetermined distance marked by the golf tees. The experimenter then returned to the participant and stood parallel to him or her and instructed the participant to remove the blindfold and headphones.

The first task the participant was asked to perform was to give his or her verbal response for how far he or she believed the distance appeared to be to the center of the target. The second task was to perform an action-based task, which was to blindly walk to the where the target was. Participants were reminded that after they put the headphones and blindfold back on that the experimenter would remove the target and then tap the participant on the shoulder when they can begin their walk. The participant was also instructed to not feel obliged to necessarily match their blind walking distance to their verbal report, but to attempt to use their memory for where they last saw the target. They were also told that they, the experimenter, were going to be following closely behind them to insure their safety and that when they believed they were standing exactly at the location to where they thought that the target was they were to stand perfectly still and say “here”. Furthermore, the participants were asked to please not remove the blindfold and headphones till they were tapped on the shoulder again.

After the practice trials were finished the participant was asked to wear the backpack and conduct two blocks of six trials each with no feedback using both types of tasks. The six trials of distance were 10’, 20’, 30’, 40’, 50’, and 60’. These distances were similar to the distances used by Proffitt (2003) and Hutchison & Loomis (2006), but we also included two additional distances that were further, 50’ and 60’. Both blocks were randomized.

RESULTS

Verbal Mean Signed Errors

A one-way mixed ANOVA was run with the between-subjects component being the manipulation of condition (with a heavy backpack or empty backpack) and the within-subject component being distance (10', 20', 30', 40', 50', and 60') and block (block 1 and block 2). The dependent variable was participant's verbally reported distances to the target. We considered the mean signed error in inches. There was a main effect of distance, F (5, 42) = 14.433, p < .001). However, there was no main effect of block, F (1, 46) = 1.671, p = .203), nor any interaction effect between distance and block, F (5, 42) = 1.24, p = .216, block and condition, F (1, 47) = .001, p = .982, or distance and condition, F (5, 42), = .637, p = .672, or distance, block, and condition F (5, 42) = .692, p = .630. Lastly, there was no main effect of condition between participants F (1, 46) = .036, p = .851. We can only conclude that participant's make more error as the distances get further, but not that they differ over block or condition. However, there is an interaction of condition, block, and distance trending for the further distances (50' and 60') as seen in figure 4a & 4b.

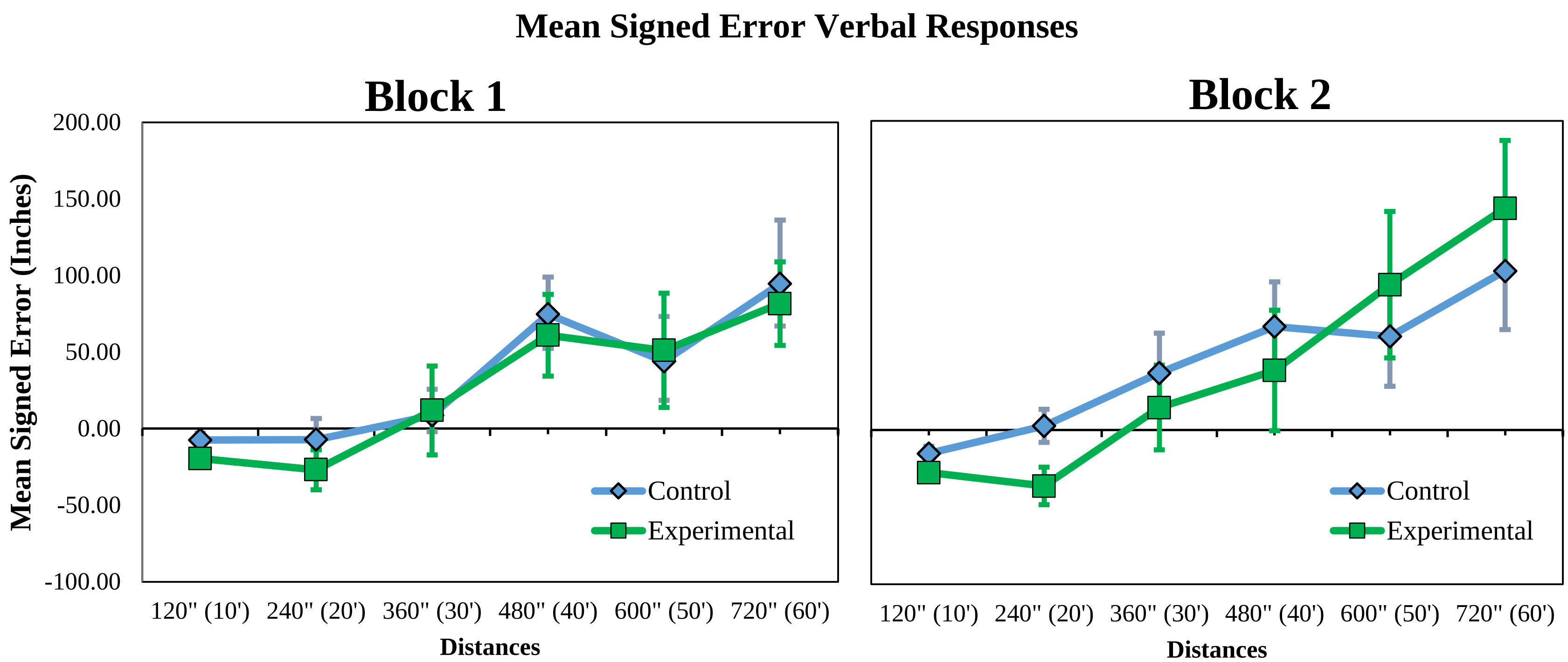


Figure 2a & 2b Verbal Mean Signed Error

Blind Walking Mean Signed Errors

A one-way mixed ANOVA was run with the between-subjects component being the manipulation of condition (with a heavy backpack or empty backpack) and the within-subject component being distance (10’, 20’, 30’, 40’, 50’, and 60’) and block (block 1 and block 2). The dependent variable was participant’s blind walking distance response to the target. We considered the mean signed error in inches. There was a main effect of distance, F (5, 42) = 6.229, p < .0001), and interaction between block and distance, F (5, 42) = 2.595, p = 0.026). However, there no interaction between block and condition, F (1, 46) = 003, p = .958, distance and condition, F (5, 42) = .454, p = .81, nor distance, condition, and block, F (5, 42) = .328, p = .896. There was no significant effect of condition between participants, F (1, 46) = .424, p = .518. These data are similar to the verbal task type data in that the only real difference is that participants make more error as the distances get further, except now block has an effect. Nevertheless, there was also a trending interaction of condition, block, and distance for the further distances (50’ and 60’) as seen in figure 5a & 5b.

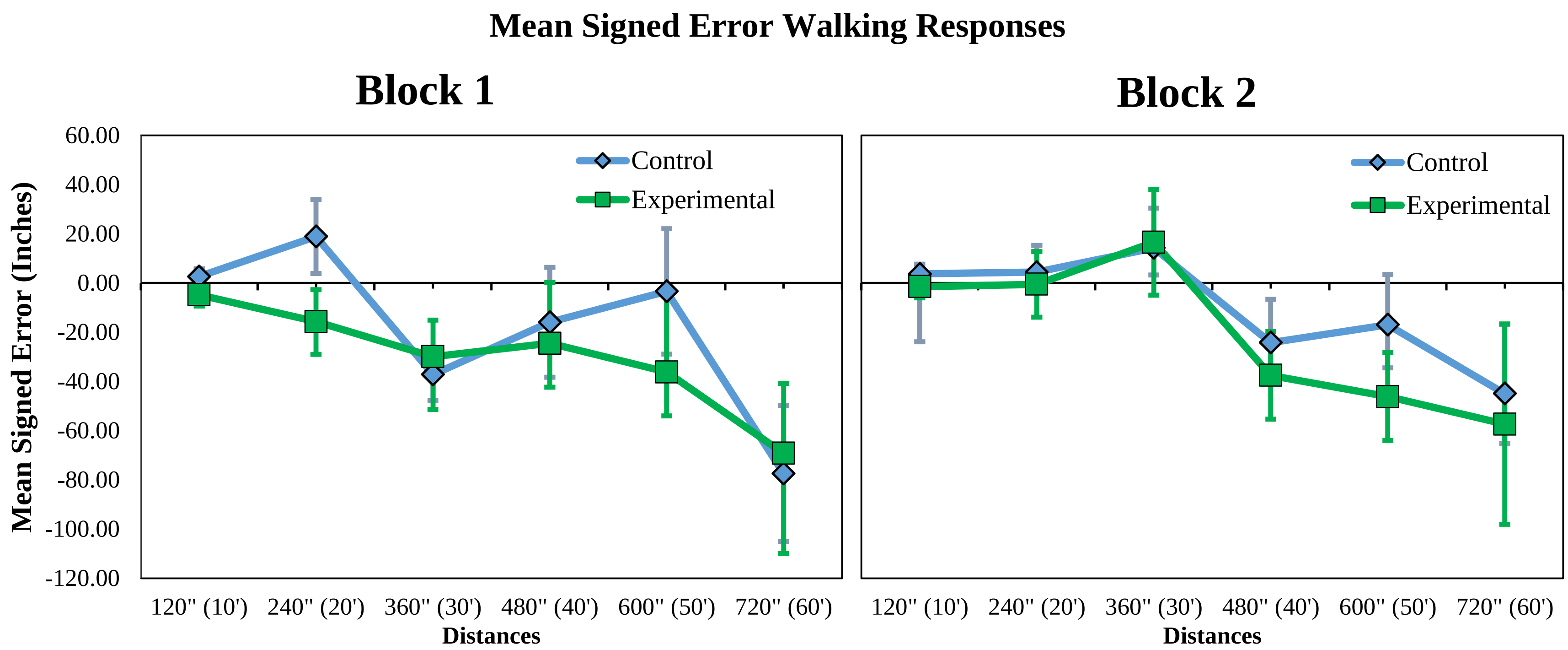


Figure 3a & 3b Mean Signed Blind Walking Error

MANOVA: Both Task Types

Figures 4 and 5 show what appears to be very different types of error being made. These two task types ought to be measuring, conceptually, the same variable- distance judgment, but we notice very different reports; participants overestimate in the verbal task and underestimate in the blind walking task. We therefore, also decided to run a mixed-design MANOVA with all independent variables remaining constant to look for potential effects of task type. As before we considered the mean signed error in inches. There was a main effect of task type in the mean signed error, F (1, 46) = 15.625, $p < .001$), and an interaction between task type and distance, F(5, 42) = 25.079, p < .001). However, there was no interaction between task type and condition, F (1, 46) = 0.048, p = .828), block and task type, F (1, 46) = 0.116, p = .735) , task type, block, and condition, F (1, 46) = 0.001, p = .973), task type, distance, and condition, F (5, 42) = 0.742, p = .593), block, task type, and distance, F (5, 42) = 1.605, p = .16), nor block, task type, distance, and condition, F(5, 42) = 1.022, p = .405).

Correlations between Blocks & Task Types

Experimental Group: Collapsed Over Condition

Results between the experimental and control groups correlations from block one to block two for each task type were very similar in previously reported data, shown in the above mentioned ANOVAs. They showed that there was no significant difference between conditions for either task type, so we therefore also decided to run a correlation collapsed over condition to look for more explanation

Verbal

There was a strong positive correlation between block one verbal scores and block two verbal scores, $r(46) = .77$, $p < 0.001$. Thus, how much verbal distance judging error a participant made in their first block, could strongly predict how much error they would make in their second block.

Blind Walking Task

Surprisingly, though there was no correlation between the block one blind walking scores and block two blind walking scores, $r(46) = .09$, $p = 0.27$. How much blind walking distance judging error a participant made in their first block could not serve as predictive tool for how much error they would make in their second block (See Figures 6a & 6b).

Response Correlations Between Blocks

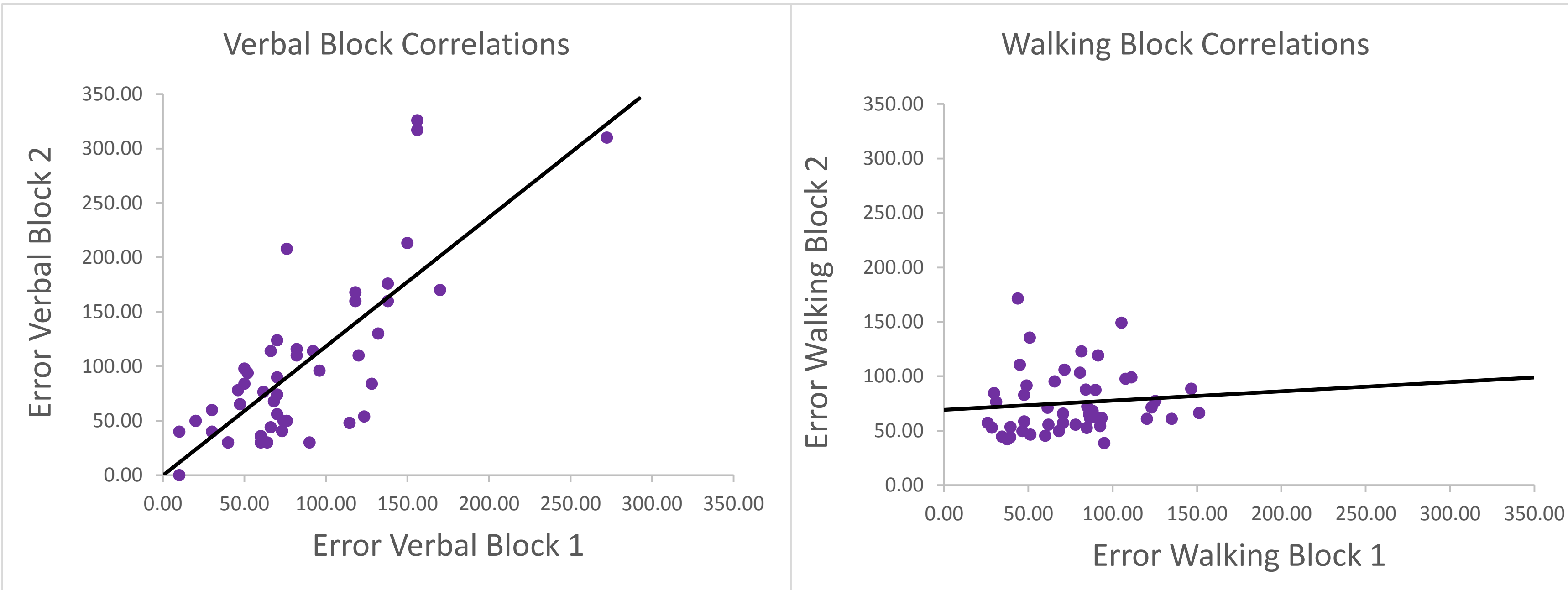


Figure 4a & 4b: Collapsed Over Condition Correlations between Blocks 1 & 2

Fitness and Anxiety Correlations

Normalizing MET Scores

The correlations that were run between MET scores and the other variables were based on the participant's MET z-score. This method was used instead of using the raw MET scores because the distribution of men and women's raw MET scores were vastly different; women (M = 11.18, SD = 1.71) and men (M = 14.68, SD = 1.33) (See Figure 7a & 7b). In order to normalize the data we correlated our variables to the appropriate z-score that each participant's raw score corresponded to.

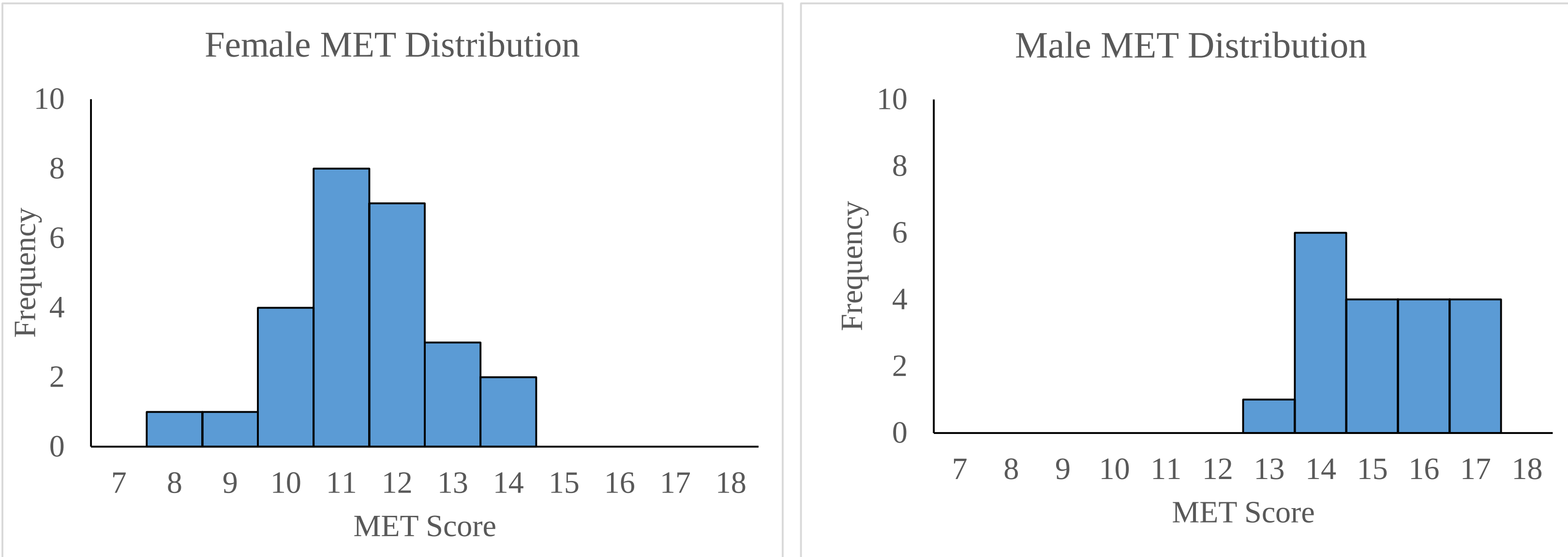


Figure 5a & 5b Distribution of Women & Men's MET scores

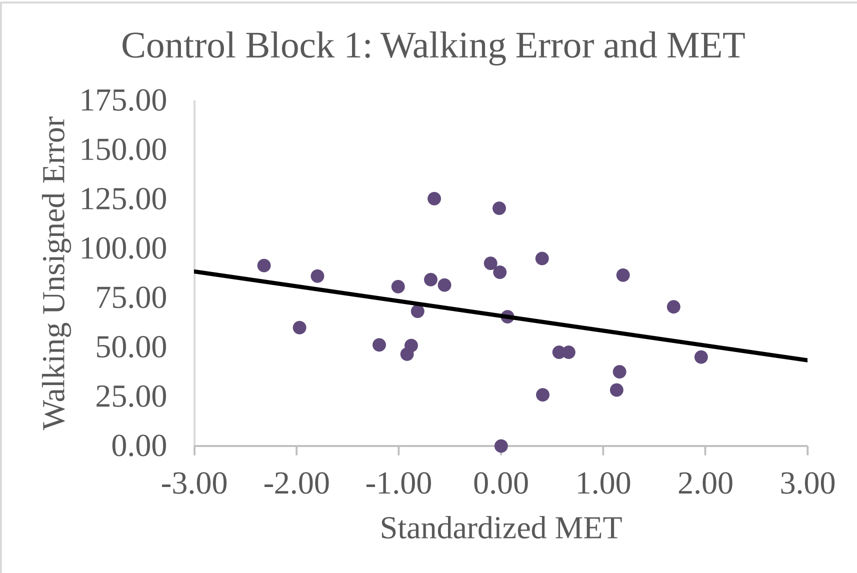
Control Group Correlations of MET Z Scores and Unsigned Error

Verbal Task

There was no correlation between the control group's MET z score and unsigned error in block one of the verbal task, $r(22) = .03$, $p = 0.44$. There was also no correlation between the control group's MET z-score in block two of the verbal task, $r(22) = -.07$, $p = 0.38$. MET, therefore, does not seem to appear to be a predictive mechanism for detecting the amount of verbal error a control participant would make for judging distances.

Blind Walking Task

There was a small negative correlation between the control groups MET z-score and unsigned error in block one of the blind walking task, $r(22) = -.31$, $p =0.07$. However, this relationship shrank by block two and wasn't significant, $r(22) = -1.9$, $p = 0.19$ (See figure 8a & 8b). Data from block 1 indicates a possible trend in that MET scores may serve as a possible predictive factor for the amount of blind walking error a control participant makes. This may be potentially indicating effects of fatigue.



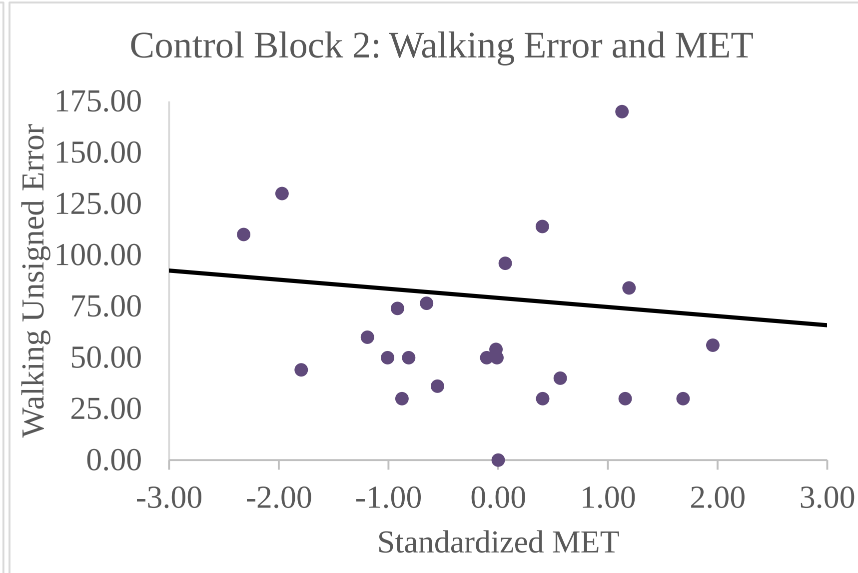


Figure 6a & 6b Control Group Correlations of MET Scores and Unsigned Error

Control Group Correlations of STAI scores and Unsigned Error

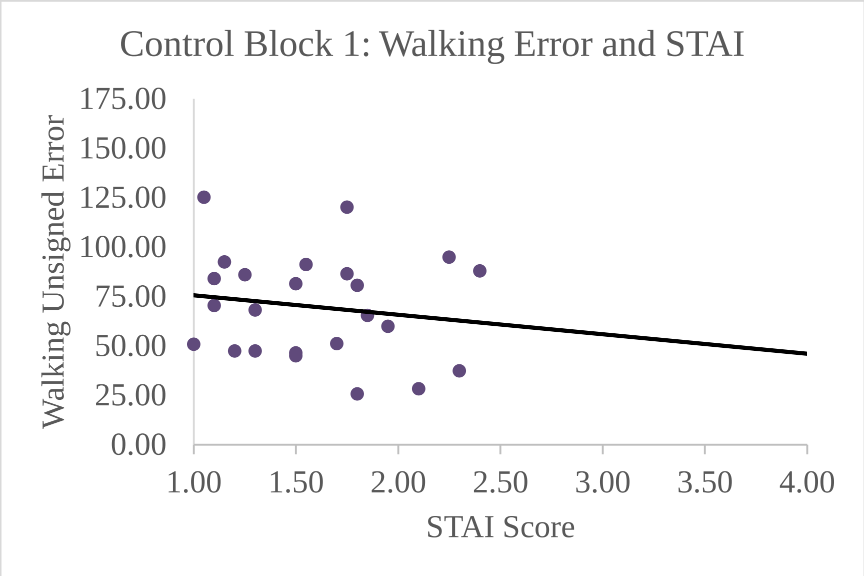
The STAI tests scores are computed by taking the participant's average score for each answer. This average score can range from one (little to no anxiety) to four (strong anxiety). No single participant scored higher than two and half, which causes us to have a restrictive data range as seen in the figures below.

Verbal Task

There was a very small, positive correlation between the control group's STAI scores and their mean unsigned error in the verbal task in block one, $r(22) = .17$, $p = 0.22$, however these were not significant. There was no correlation between the control group's STAI scores and their mean unsigned error in the verbal task in block two, $r(22) = -.08$, $p = 0.35$. There is a trend suggesting that control participants have higher error in the verbal distance judging task as their anxiety increases, however these data are not significant.

Blind Walking Task

There was a very small, negative, linear relationship between the control group's STAI scores and their mean unsigned error in the blind walking task in block one, $r(22) = -.15$, $p = 0.24$, but these data were not significant. However, a stronger negative linear relationship appeared by block two between the control group's STAI scores and their mean unsigned error in the blind walking task, $r(22) = -.34$, $p = 0.05$. (See figure 9a & 9b). It appears that over time control participant's anxiety scores tend to have a stronger predictive factor for less error for the blind walking distance judging task.



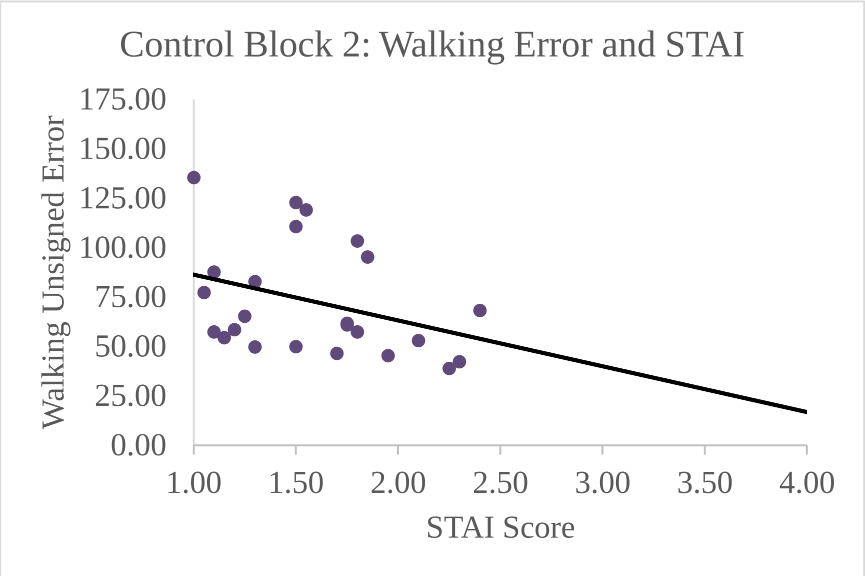


Figure 7a & 7b Control Group Correlations of STAI scores and Unsigned Error

Control Group Multiple Regression: MET, STAI, & Unsigned Error

Verbal Task

A multiple regression was run between the control group's mean unsigned error and their STAI and MET z scores to check for interactions between these two factors. There was no linear regression in block one, $r(22) = 0.17$, $p = 0.748$ nor in block two, $r(22) = 0.098$, $p = 0.90$. For the control participant's, fitness and anxiety together do not interact to create a stronger predictive power for verbal distance error.

Blind Walking Task

A multiple regression was run between the control group's mean unsigned error and their STAI and MET z scores. There was a small, linear relationship in block one, $r(22) = .32$, $p = 0.314$ and block two $r(22) = 0.37$, $p = 0.217$, however these data were not significant. For the control participant's, fitness and anxiety together do not interact to create stronger predictive power for blind walking distance error, however it should be noted that because of certain trends perhaps this is a result of restrictive values in STAI scores.

Experimental Group Correlations of MET Scores and Unsigned Error

Verbal Task

There was a very small positive correlation between the experimental group's MET z scores and their mean unsigned error in the verbal task in block one, $r(22) = .256$, $p = 0.11$, however, these were not significant. There was also a very small positive correlation between the experimental group's MET z scores and their mean unsigned error in the verbal task in block two, $r(22) = -.10$, $p = 0.32$ that also was not significant. Therefore, there is not a significant finding that there is any predictive power for participants who carry a heavy backpack's cardio fitness level and their error in the verbal distance judging task.

Blind Walking Task

There was a very small negative correlation between the experimental group's MET z scores and their mean unsigned error in the blind walking task in block one, $r(22) = .18$, $p = 0.20$. There was a moderately negative correlation between the experimental group's MET z scores and their mean unsigned error in the blind walking task in block two, $r(22) = -.4$, $p = 0.03$ (See Figure 10a & 10b). There is a lack of significance in our data to show that there is any predictive power for participants who carry a heavy backpack's cardio fitness level and their error in the first block of the blind distance judging task but there is sufficient evidence that their cardio fitness levels can predict lower error by the second block.

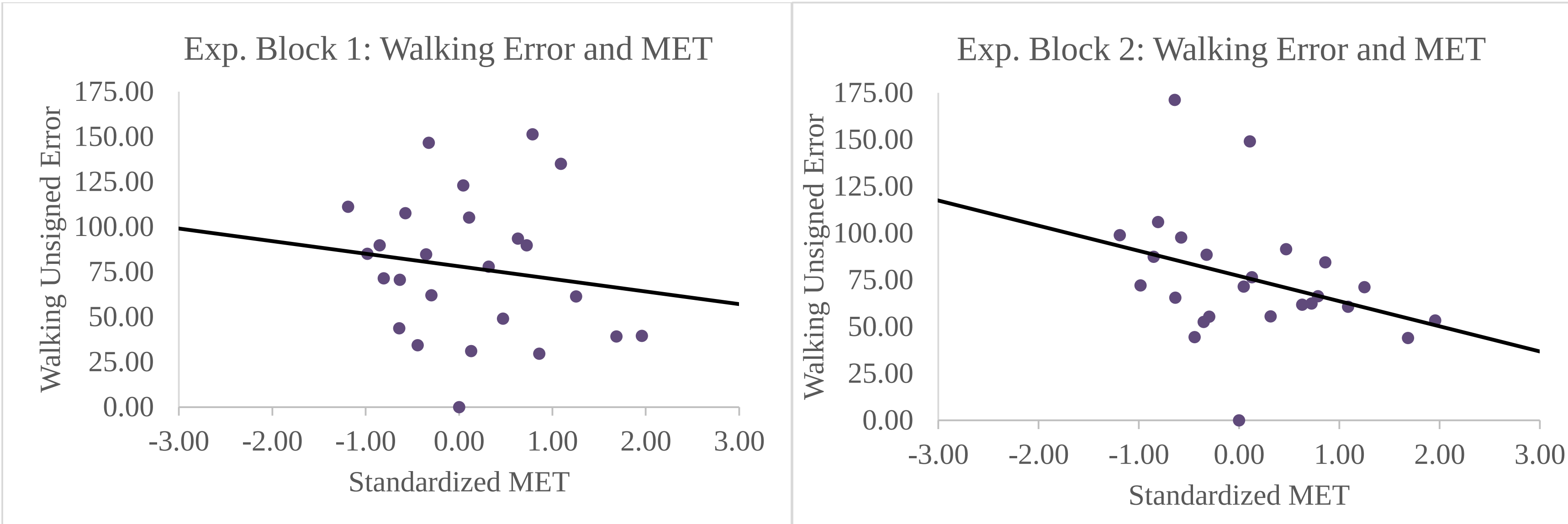


Figure 8a & 8b Experimental Group Correlations of MET Scores and Unsigned Error

Experimental Group Correlations of STAI scores and Unsigned Error

Verbal Task

There was a small positive correlation between the experimental group's STAI scores and their mean unsigned error in the verbal task in block one, $r(22) = .27$, $p = 0.10$. There was a very small positive correlation between the experimental group's STAI scores and their mean unsigned error in the verbal task in block two, $r(22) = .15$, $p = 0.24$. There is are no significant findings that participants who carry heavy backpack's anxiety scores have any predictive power on how much distance judging error they will make in the verbal task. There is, however, a trend that these participants may be making more verbal error as their anxiety increases but the lack of significance data could be related to the restrictive STAI values.

Blind Walking Task

There was a very small positive correlation between the experimental group's MET scores and their mean unsigned error in the blind walking task in block one, $r(22) = .191$, $p = 0.19$. There was a very small positive correlation between the experimental group's STAI scores and their mean unsigned error in the blind walking task in block two, $r(22) = -.19$, $p = 0.19$. These results are similar to the results found for the experimental group's verbal responses. There is again no significant findings that participants who carry heavy backpack's anxiety scores have any predictive power on how much distance judging error they will make in the blind walking task. There is, however, a small trend that these participants may be making more blind walking error as their anxiety increases but lack significance in our could be related to the restrictive STAI values.

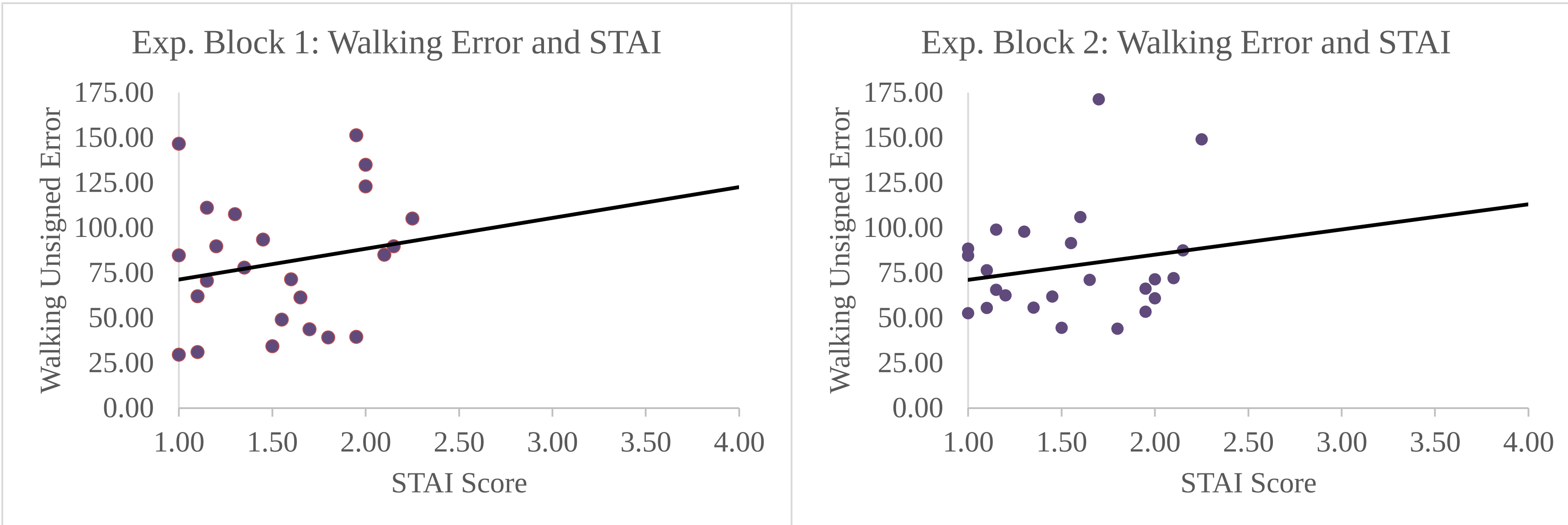


Figure 9a & 9b Experimental Group Correlations of STAI scores and Unsigned Error

Experimental Group Multiple Regression: MET, STAI, & Unsigned Error

Verbal Task

A multiple regression was looked at for the experimental group's mean unsigned error in verbal task and the STAI and MET z scores. In block one there was a small linear relationship r(22) = 0.342, p = 0.27, but these data not significant. In block two there was no linear relationship r(22) = 0.170, p = 0.074.

For the participants who carried heavy backpacks, fitness and anxiety together do not interact to create stronger predictive power for verbal distance error. However, there is a trend for these factors to interact for the verbal distance judging error in the first block and again lack of significance could be related to the restrictive values found in the STAI scores.

Blind Walking Task

A multiple regression was analyzed for the experimental group's mean unsigned error in the blind walking task and STAI and MET z scores. In block one there was a small linear relationship, r(22) = 0.291, p = 0.39, that is not signficant. In block two, there was a moderate linear relationship r(22) = .48. Running an ANOVA we can see that this regression model is a good fit for the data, $F(2, 23) = 3.087$, $p = 0.067$.

For the participants who carried heavy backpacks, fitness and anxiety together do not interact to create stronger predictive power for blind walking distance error at first but by the second block they do. According to the coefficient table, for every increase in MET z score there is a decrease in error by 15.8 inches, t = -2.287, p = 0.033, however for an every increase in STAI score there is an increase in error by 20.4 inches, t = 1.39, p = .18. The driving force is in the MET z score and not in the STAI score, however this could also be related to the restrictive values of STAI.

CONCLUSION

Failure to Replicate Proffitt et al. (2003)

We were not able to find an effect of the backpack weight on distance judgments therefore, failed to replicate Proffitt and colleagues (2003). Out data suggest that a heavy backpack does not necessarily make participants overestimate distances in a verbal response task. However, our data do indicate a possible trend towards replicating at the further distances, though Proffitt and colleagues did not look at distances further than 42' whereas we looked at distances up to 60'. In other words, the heavy backpack condition seems to overestimate distances at the 40, 50, and 60 foot distances though these findings are not significant (perhaps due to power issues or the increasing variability and decreasing precision at the very far distances beyond action space.)

Our results are consistent with others, in that we too were unable to replicate Proffitt's (2003) findings when it comes heavy backpacks making participants overestimate distances verbally. The only changes we made to our methodology was the addition of an explanation (a false one) informing participants to why they were asked to carry the backpack, the use of additional distances (which were measured in feet instead of meters), and the addition of an action-oriented task type. Furthermore, we took cardiovascular fitness and anxiety measurements. These minor changes to the methodology may have affected participants to not verbally respond with a heavy backpack as they did in Proffitt et al.'s (2003) experiment, but this seems unlikely. It could be, as others have stated, that their results are more sensitive to the condition in which they were run (Woods et al., 2009).

Action-Oriented Task

In addition, to attempting to replicate Proffitt's (2003) experiment, like Hutchinson & Loomis (2006) we too wanted to look at how an action-oriented task might be affected by the heavy backpack. We were unable to find an effect of the backpack on the blind walking task. Figures 8a and 8b do, however, show a potential trend that participants carrying heavy backpacks may underestimate more for certain distances than those who carried empty backpacks. Underestimating distances in an action-oriented task, in general, has been a common finding (Fukusima, Loomis, & Da Silva, 1997; Rieser, Ashmead, Talor, & Youngquist, 1990; Li, Phillips, Durgin, 2011; Commins, McCormack, Callinan, Fitzgerald, Molloy, & Young, 2013; Bian & Andersen, 2013). In addition, the effect that error becomes greater for further distances is also not a new discovery (Commins et al., 2013; Corlett, Patla, & Williams 1985, Fukusim et al., 1997, Loomis, Da Silva, Fujita, & Fukusima 1992, Rieser et al., 1990; Thomson, 1983). One study suggested that younger participants were more likely to underestimate in an action-oriented task than older participates and seeing that our sample has a mean age of 19 this may be the reason why (Bian & Andersen, 2013)

However, when we compared the results from the verbal task to the blind walking task we notice a strong difference in direction for error; participants on average overestimated in the verbal task but underestimated the same distance in the blind walking task. As, Bingham and Pagano (1998) had suggested, verbal and action measures may not be measuring the same thing after all. These results lead us to our next major comparison.

Comparing Task Types

When we ran our MANOVA to look at potential effects of task type we saw significant differences between these task types. We then decided to run a correlation between block one and block two of the unsigned (absolute value) of the mean error made when it was collapsed over distance for the two different task types. We found that the error made for the verbal task was consistent over block, but this was not the case for the blind walking task. This may suggest that these two task types are processed differently in the brain and that a blind walking task is more subjective to changes over time, i.e., fatigue. This would be consistent with the literature on 'idiothetic information', which likely influences distance judgment for non-visual input (Chance, Gaunet, Beall, & Loomis, 1998; Tversky, 2000). If this is the case then measuring a participant's cardiovascular fitness levels may show changes in error too, because varying levels of cardio fitness project different physical signals. This could be evidence for embodiment, in that changes to the body are more apparent in an action-based task.

Fitness Measurements

Our data show that cardiovascular fitness was positively correlated with the amount of error made. The relationship between cardiovascular fitness scores and error were most readily apparent in the experimental condition's second block of the blind walking task or in other words, when these factors were in demand because of potential effects of fatigue. Consistent with the 'idothetic information' idea, when participants carry heavy backpacks and have better cardiovascular fitness they are less likely to make errors in a blind walking task. In other words, a person with higher cardiovascular fitness has a higher threshold for being effected by the signals from fatigue information coming from the muscles and joints that typically inform the person of distance traveled. However, the experimental group's verbal responses in the second block were not correlated just as the control groups wasn't. Therefore it appears that 'idothetic information' does not affect verbal responses for distance judging.

In addition, some researchers have found that a weight feels heavier over time, as fatigue kicks in. (McCloskey, Ebeling, & Goodwin, 1974 and Burges & Jones, 1997). This may explain why participants with higher cardiovascular fitness, which supports endurance, are less likely to be affected by fatigue. This could also be support for Proffitt's (1998) proposal of an energy expenditure for other cognitive responses. If cognition can change from internal physical signals in the body, can it also change from mental ones?

Another explanation for these findings may be related to the participant's expertise type. In other words, some individuals that rely on visual perceptual expertise, such as golfers and surveyors, versus those individuals that rely more heavily on physical expertise, such as hikers and soldiers, vary on their accuracy in the verbal and action-oriented tasks for judging distances (See Table 2).

Table 2 Predicted Performance between Expertise Type and Task Type

Distance Judging Task Type

Expertise Type	Verbal	Action oriented
Visual	Better	Poorer
Physical	Poorer	Better

However, questions about a participants expertise in these areas were not taken, thus it may be beneficial to add such a questionnaire in future experiments.

STAI Measurements

For this experiment we implemented the State Test of Anxiety Inventory to correlate anxiety with distance estimates. However, after the data were collected it was noted that no participant scored in the mid to high range for anxiety. This is unsurprising given that we collected our sample from a normal population and the average person should not test high on anxiety. However, the restricted values could be the reason for the absence of significant correlations, as there apparent trends for potential predictive powers that STAI scores had on distance judging. Nevertheless, because none of our anxiety data were significant we cannot draw any particular relationships, we can only suggest certain trends as indicated by the scatter plots, and the need to recruit from a population with STAI scores would be necessary.

Yerkes-Dodson Model

Yerkes-Dodson Model

An established theory of performance based off of stress is the Yerkes-Dodson Curve, which suggests that too little stress hinders performance as does too much stress and that optimal performance is when stress is moderate (Yerkes & Dodson, 1908). By making certain assumptions from significant and trending data, we might suggest that individuals with the highest fitness scores and the lowest anxiety scores have the least amount of error and

Table 3 Predicted Performance between STAI and MET

Fitness Scores (MET) / Anxiety Scores (STAI)

	Low	**High**
Low	---	Best Accuracy
High	Poorest Accuracy	---

individuals with the lowest fitness scores and the highest anxiety scores have the most error (See Table 3).

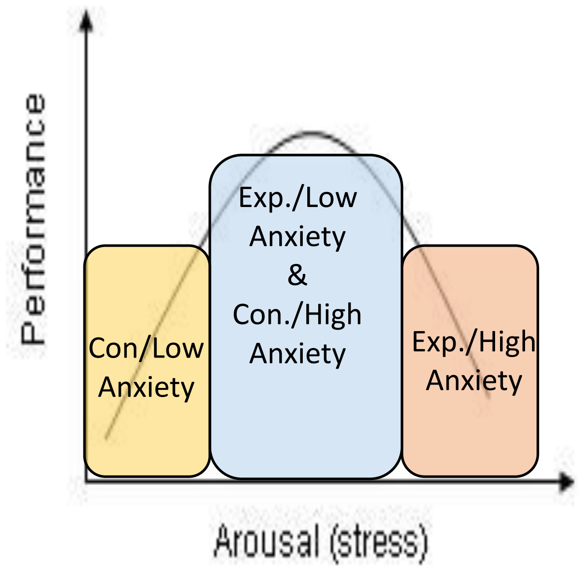


Figure 10 Yerkes-Dodson Model

Such results would be consistent with the Yerkes and Dodson curve of motivation (See Figure 12). However, to confirm this, a new study would need to be made to recruit from a population with higher STAI scores.

Possible Flaws

Other types of fitness (besides cardio)

This study used the MET measurements provided by Jurca et al. (2005) to measure cardiovascular fitness levels, which as mentioned, is highly correlated with VO2 Max, but this measurement does not take into consideration other types of fitness like strength. It may have been interesting to look at strength as a possible covariate with error/accuracy for distance judgments along with cardio fitness.

Implement an Interview

Though there did seem to be a relationship between cardiovascular fitness and error for distance judging it may have been interesting to note whether there was a difference between the type of fitness expertise that one possess; physical or visual. Furthermore, the types of physical fitness that person engages in may shed light on differences, for instance whether one played sports versus one that participates in fitness building at a gym. According to a to-down approach we might speculate that athletes, whom had high MET scores and have more experience with guessing distances in an interactive setting with the environment, may have different results compared to those individuals that only possess high MET scores because they exercise on cardio machines and therefore lack experience with building on their distance judging skills.

Implications for future research

Training Task

This relates to my concern about having not implemented an interview about the participant's fitness history. If there are some top-down components in play, we might assume that a training task might improve participants distance judging tasks. For instance, we know that athletes can improve performance after practice (Abernethy, 1996) Furthermore, it may be interesting to some participants in only of the tasks but test accuracy for both task types to see whether improvement only happens in the task type that was trained or in both. This may strengthen the argument that verbal and action-oriented tasks are processed differently.

Manipulate Fitness

If cardio fitness is related to accuracy one could, in theory, train participants over time in cardio to improve their fitness scores and then their error in judging distances in an action-oriented task should also improve over time. Furthermore, one could divide participants into a condition that improved cardio only using cardio machines and another group that improved by engaging in a sport of some sort to look at effects of certain types of fitness training.

Recruit from a Mid-High Anxiety Population

We were unable to make confident inferences from the data drawn from our anxiety results because of restricted data values. Out of our 48 participants no single person scored higher than a 2.5 on a 1-4 anxiety scale (1 being little to no anxiety and 4 being high anxiety). Therefore, to check for true relationships between distance judging and anxiety the next step would be to recruit from a population that would have an average score at the mid to high ranges on a reputable anxiety test.

Neuroimaging

Neuroimaging has revealed many insights into cognitive functioning and anxiety. It may be worthwhile to look at the relationship between distance judging and anxiety by implementing certain devices that can show changes in brain activity from the potential interaction between a physical stressor (heavy backpack) and high anxiety on making distance judgments. One such device would be an fNIR. An fNIR is similar to an fMRI in that is can view change in activity in the brain over time, except that the fNIR is a portable device that looks at activity of the prefrontal cortex. In relation to the proposed study, this would be ideal because the prefrontal cortex is related to many functions of cognition, including decision making (judgments) (Frith & Dolan, 1996). We can also observe differences in the PFC between those with high levels of anxiety and stress and those with low to no anxiety and stress (Eitken & Wagner, 2007).

Since changes in PFC activity can be observed in those engaged in a cognitive tasks and those undergoing high levels of stress, we theoretically should be able see potential overlap and interactions between stress (physical and mental) and distance judging.

Furthermore, if action oriented tasks really are processed differently than verbal tasks in estimating distances than these differences may or may not also be observed by implementing neuroimaging.

In conclusion, the hope that we have for the results found in this study is that it will lend more insight into how stress, both physical, like a heavy backpack, and mental, like PTSD, can affect certain important cognitive functions such as, estimating distances. It is the long term goal for this research and research that extends from it to be implemented in the creation of resources that will help to minimize error for those individuals that work in high stress careers in which making accurate distance judgments could mean life or death for others.

APPENDIX A IRB APPROVAL FORM

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Approval of Human Research

From: **UCF Institutional Review Board #1**
FWA00000351, IRB00001138

To: **Mark Neider** and Co-PI: **Monica Rosen**

Date: **March 21, 2013**

Dear Researcher:

On 3/21/2013 the IRB approved the following human participant research until 3/20/2014 inclusive:

Type of Review:	Submission Correction for UCF Initial Review Submission Form Expedited Review Category # 4 & 7
Project Title:	Analyzing Distance Perception
Investigator:	Mark Neider
IRB Number:	SBE-13-09199
Funding Agency:	
Grant Title:	
Research ID:	N/A

The scientific merit of the research was considered during the IRB review. The Continuing Review Application must be submitted 30days prior to the expiration date for studies that were previously expedited, and 60 days prior to the expiration date for research that was previously reviewed at a convened meeting. Do not make changes to the study (i.e., protocol, methodology, consent form, personnel, site, etc.) before obtaining IRB approval. A Modification Form **cannot** be used to extend the approval period of a study. All forms may be completed and submitted online at https://iris.research.ucf.edu .

If continuing review approval is not granted before the expiration date of 3/20/2014, approval of this research expires on that date. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

Use of the approved, stamped consent document(s) is required. The new form supersedes all previous versions, which are now invalid for further use. Only approved investigators (or other approved key study personnel) may solicit consent for research participation. Participants or their representatives must receive a copy of the consent form(s).

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

On behalf of Sophia Dziegielewski, Ph.D., L.C.S.W., UCF IRB Chair, this letter is signed by:

Signature applied by Patria Davis on 03/21/2013 11:19:08 AM EST

IRB Coordinator

Page 1 of 1

APPENDIX B. SELF-EVALUATION QUESTIONAIRE STAI FORM Y-1
(Spielberger, Reheiser, & Sydeman 2005)

Participant Number: ________________________

DIRECTIONS A number of statements which people have used to describe themselves are given below. Read each statement then circle the appropriate number to the right of the statement to indicate how you feel right now, that is, at this present moment. There are no right or wrong answers. Do no spend too much time on any one statement but give the answer which seems to describe your present feelings best.	Somewhat	Moderately So	Very Much So	Very Much So
1. **I feel calm**	1	2	3	4
2. **I feel secure**	1	2	3	4
3. **I feel tense**	1	2	3	4
4. **I feel strained**	1	2	3	4
5. **I feel at ease**	1	2	3	4
6. **I feel upset**	1	2	3	4
7. **I am presently worrying over possible misfortunes**	1	2	3	4
8. **I feel satisfied**	1	2	3	4
9. **I feel frightened**	1	2	3	4
10. **I feel comfortable**	1	2	3	4
11. **I feel self-confident**	1	2	3	4
12. **I feel nervous**	1	2	3	4
13. **I am jittery**	1	2	3	4
14. **I feel indecisive**	1	2	3	4
15. **I am relaxed**	1	2	3	4
16. **I feel content**	1	2	3	4
17. **I am worried**	1	2	3	4
18. **I feel confused**	1	2	3	4
19. **I feel steady**	1	2	3	4
20. **I feel pleasant**	1	2	3	4

APPENDIX C. MET CALUCULATION (Jurca et al., 2005)

STEP 1

<u>Physical activity score</u>: Choose <u>one</u> activity category that best describes your usual pattern of daily physical activities, including activities related to house and family care, transportation, occupation, exercise and wellness, and leisure or recreational purposes.

Level 1: Inactive or little activity other than usual daily activities

Level 2: Regularly (≥ 5 d/wk) participate in physical activities requiring low levels of exertion that result in slight increases in breathing and heart rate for at least 10 minutes at a time.

Level 3: Participate in aerobic exercises such as brisk walking, jogging or running, cycling, swimming, or vigorous sports at a comfortable pace or other activities requiring similar levels of exertion for 20 to 60 minutes per week.

Level 4: Participate in aerobic exercises such as brisk walking, jogging, or running at a comfortable pace, or other activities requiring similar levels of exertion for 1 to 3 hours per week.

Level 5: Participate in aerobic exercises such as brisk walking, jogging, or running at a comfortable pace, or other activities requiring similar levels of exertion for over 3 hours per week.

STEP 2
<u>Estimate MET level of cardiorespiratory fitness</u>

Enter 0 for women or 1 for men	_____x 2.77	=	______
			minus
Enter age in years	_____x 0.10	=	______
			minus
Enter body mass index[1]	_____x 0.17	=	______
			minus
Enter resting heart rate	_____x 0.03	=	______
			plus
Enter physical activity score from step 1	_____ x 1.00	=	______
			plus
Constant			<u>18.07 .</u>
Estimated MET value		=	______

<u>Clinical relevance of selected maximal MET levels of cardiorespiratory fitness[2]</u>

1 MET	Resting metabolic rate; sitting quietly in a chair
<3 METSs	Severely limited functional capacity; a criteria for placement on a heart transplant list
3-5 METs	Poor prognosis I coronary patients; highly deconditioned individual
10 METs	Good prognosis in coronary patients on medical therapy; approximate capacity expected in regularly active middle-ages men and women
13 METs	Excellent prognosis regardless of disease status
18 METs	Elite endurance athletes
20 METs	World-class athletes

[1] Body mass index=(weight in lbs x 703)/(height in inches) or (weight in kilograms)/(height in meters)
[2] Adapted from the American Heart Associate. (CITE)

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