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Scared Stiff: The Influence of Anxiety on the Perception of Action Capabilities

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Abstract

Influences on the perception of affordances (i.e., opportunities for actions) have been primarily studied by manipulating the functional morphology of the body. However, affordances are not just determined by the functional morphology of the perceiver, but also by the physiological state of the perceiver. States of anxiety have been shown to lead to marked changes in individuals' physiological state and their behavior. To assess the influence of emotional state on affordance perception, the perception of action capabilities in near space was examined after participants completed an anxiety provoking task. Anxiety was induced immediately prior to tasks that assessed participants' perceived reaching ability in Experiment1, grasping ability in Experiment 2, and the ability to pass their hands through apertures in Experiment 3. Results indicated that those participants that experienced changes in anxiety underestimated their reaching, grasping, and passing ability compared to non-anxious participants. In other words, anxious participants were more conservative in their estimations of their action capabilities. These results suggest that anxiety influences the perception for affordances in near space and are consistent with the notion that anxiety induces withdrawal behaviors.

Keywords

affordance perception; visual perception; anxious arousal

Most objects and surfaces in the environment provide individuals with opportunities for action. These action capabilities are called affordances. Affordances are defined as "what it [the environment] offers the animal, what it provides or furnishes, either for good or ill" (Gibson, 1979). For example, solid ground affords walking for people, but not fish; whereas, the sky affords flying for birds, but not people. In order to perceive affordances for our own bodies in a given environment, we must compare visual information specifying the environment to information pertaining to our body and its action capabilities. Affordances are discovered by perceiving the consequences of movement within the environment (see Adolph, 1997, for a review). Gibson (1979) believed the purpose of visual perception is to inform and guide these actions through perceiving these visuo-motor relationships. Evolution has guided the acquisition and use of this information, so that we can effectively perceive our environment in a way that is adaptive for successful actions.

There is a wealth of empirical studies that have shown that individuals are very good at determining their own capabilities in various environmental contexts. This requires that

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individuals compare the optical information specifying the relevant spatial aspects of the environment to their body's abilities to allow for successful interactions within their environment (Warren, 1984). For example, to determine whether they can successfully jump across a crevasse, perceivers must compare the maximum extent over which they can jump to the optical information specifying the length of the crevasse. Specifically, in near space (reachable space), individuals are capable of perceiving their action capabilities for actions ranging from reaching to grasping to passing their hands through an aperture with only a small margin of error (Bootsma, Bakker, van Snippenberg, and Tdlohreg, 1992; Carello Grosofsky, Reichel, & Solomon, 1989; Linkenauger, Witt, Bakdash, Stefanucci, & Proffitt, 2009a; Linkenauger, Witt, & Proffitt, in press; Ishak, Adolph, & Lin, 2008; Rochat & Wraga, 1997). For example, research on the perception of reachability has shown that individuals are accurate at estimating how far they can reach, albeit with a ~10% overestimation tendency (Bootsma, et al., 1992; Carello, et al., 1989; Linkenauger, et al., 2009; Rochat & Wraga, 1997). While the origins of these overestimations are not entirely clear, there is some empirical support that they are a consequence of experimental constraints that are not typically present in natural reaching settings (e.g., restricting arm reach by preventing the individual from leaning forward by moving the shoulder or torso) (Fisher, 2000; Rochat & Wraga, 1997). Likewise, participants were consistently accurate in perceiving the size of an object that they could grasp with their hand, with a slight tendency to overestimate (Linkenauger, Witt, Bakdash, Stefanucci, & Proffitt, 2009a; Linkenauger, Witt, & Proffitt, 2011). Participants have also been successful at determining the minimum sized aperture through which their hand can fit (Ishak, Adolph, & Lin, 2008). Overall, these studies suggest that people are adept at relating visual information to their action capabilities in a manner that promotes the effective selection and execution of actions.

Because our bodies, and thus action capabilities, are constantly changing, it is necessary for us to adapt to changes in the relationship between visual information specifying extents and our action capabilities over such extents. Previous research has clearly demonstrated that individuals are very successful at detecting changes in affordances in relation to changes in their body and environment (Proffitt & Linkenauger, in press). For example, when providing an individual with a tool to expand their reach, they can adjust their perceived reachability to extend to those objects that were previously unreachable (Witt, Proffitt, & Epstein, 2005). Similarly, individuals are capable of accurately altering their perception of reaching ability based on changes in their center of gravity, posture, and type of grasp to be employed (Carello, Grosofsky, Reichel, & Solomon, 1989; Robinovitch; 1998; Linkenauger, Witt, Stefanucci, Bakdash, & Proffitt, 2009; Rochat & Wraga, 1997). Additionally, individuals are also able to make adjustments in determining affordance thresholds for reaching through an aperture, even as hand size is adjusted using hand-enlarging prostheses (Ishak, Adolph, & Lin, 2008). Overall, these studies show that people are able to perceive how their action capabilities change following manipulations that alter their effective morphology.

Most of the research on perceiving affordances has demonstrated adaptations to changes in the morphological structure of the body. However, our bodies' action capabilities can be influenced by other phenotypic changes aside from structural and postural differences. The physiological experiences associated with emotional changes, such as anxiety, have yet to be thoroughly examined to determine their effect on perception of affordances. In the current studies, we used an established physiological stressor to manipulate anxiety levels in order to determine how this change may influence the perception of action capabilities.

Although not a direct change to the morphological structure of the body, anxiety can drastically alter our physiological state in any given instance. Anxiety leads to physiological changes through the release of several hormones, such as cortisol, which alter the functioning of the autonomic nervous system through the suppression of the immune and digestive systems, while also constricting blood vessels, accelerating heart rate and respiration, and dilating the pupils (e.g., Hamilton, 1989; Levenson, 1992; Romero & Butler, 2007). In relation to environmental interactions, anxiety initiates withdrawal behaviors and the desire to avoid potentially threatening scenarios (Davidson, 1992, 1998; Shankman & Klein, 2003). In situations of high anxiety, there can be an overactivation of the withdrawal system (Shankman & Klein), whereby anxiety levels may become maladaptive. Rather than inducing a fight-or-flight response that can help cope with threatening stimuli, anxiety may lead to less efficient movements within one's surroundings (Beuter & Duda, 1985; Beuter, Duda, & Widule, 1989; Weinberg, 1978; Weinberg & Hunt, 1976). Put simply, anxiety can make it harder to effectively interact in a given environment.

Anxiety has also been shown to interact with both cognitive and perceptual processes. Previous research has shown that extreme fear (e.g., in phobic situations) is associated with perceptual distortions of feared stimuli, such as snakes, spiders, and heights (Rachman & Cuk, 1992; Teachman, Stefanucci, Clerkin, Cody, & Proffitt, 2008). Fearful individuals drastically overestimate high heights, especially when reminded of the costs of interacting in the dangerous environment (e.g., imagining falling from a height: Clerkin, Cody, Stefanucci, Proffitt, & Teachman, 2009; Stefanucci & Proffitt, 2009; Stefanucci, Proffitt, Clore, & Parekh, 2008), suggesting that extreme fears really can cause the environment to be seen differently. Similarly, researchers have found that explicit awareness of the slant of a hill is affected by the fear associated with a potentially dangerous action that could be performed on the hill (i.e., skateboarding down a steep incline; Stefanucci et al., 2008). These studies clearly show that anxiety, and likely its associated physiological responses, influence the perception of our surroundings.

In support of this notion, previous research has shown that placing individuals in contexts that provoke arousal can influence their judgments of their action capabilities. Specifically, individuals were asked to judge their ability to reach on either a low or high height on a climbing wall. At higher heights, individual's judgments of their reaching capability were lower (Nieuwenhuys, Pijpers, Oudejans, & Bakker, 2008). Specifically, individuals anticipated that they could not reach as far at higher heights, likely because of the more threatening consequences of overestimating their reach in dangerous contexts. However, because the anxiety was induced by the actual action that the individuals anticipated performing (i.e., reaching when high off the ground), it is unclear whether the anxious state itself (independent from the specific action required) can influence the perception of action capabilities, or whether the anxiety must be tied to the intended action (as was the case for the reaching and height estimation studies described previously). This question is important because we know that mood and emotional states can affect numerous aspects of cognitive processing, for example visual perception, even when the emotion is not directly linked to the cognitive task (e.g., the effect of mood when visually perceiving slants; see Reiner, Stefanucci, Proffitt & Clore, 2010), but we do not know if the same general emotion effect occurs when estimating opportunities for action To address this question, in these experiments, we tested whether anxiety would decrease participants' perceived action capabilities even in situations that are unrelated to the anxiety provoking stimulus.

In Experiment 1, we investigated whether manipulating anxiety levels could have an effect on an individual's perception of their reaching capabilities. We found that when individuals were more anxious, they underestimated their perceived reach more than calm individuals. A similar result was found in Experiment 2 where anxious participants underestimated their grasping abilities more than calm individuals. In Experiment 3, we found a relationship between self-reported change in anxiety and the perception of one's ability to pass their hand through differently sized apertures. Together, these experiments demonstrate that anxiety influences the perception of those action capabilities in near space.

Experiment 1: Anxiety and the Perception of Reaching Ability

The purpose of this study was to investigate anxiety's influence on the perception of the ability to reach. Anxiety was manipulated using a restricted breathing task. Presumably, if anxiety influences perceived reaching ability, there will be a change in perceived reaching capabilities between anxious and non-anxious individuals.

Method

Participants—Thirty-six undergraduate, right-handed students (28 females) at the University of Virginia participated in this study in exchange for course credit in an introductory psychology course. All participants had normal or corrected-to-normal vision.

Stimuli and Apparatus—Participants sat in front of a square table measuring 91.5 cm × 91.5 and 74.5 cm tall. On the side of the table across from the participant there were stickers placed at 30° and 15° to the left, at the center, and 15° and 30° to the right (axis stickers). An origin sticker was placed on the table directly in front of the participants' torso. Reaching judgments were made relative to a poker chip that was moved towards and away from the participants on the indicated diagonals specified by one of the stickers on the other side of the table and the origin sticker. Coffee straws, 1 mm in diameter, were used in the breathing task for the anxiety condition.

Procedure—Participants were randomly assigned to either the anxiety or control conditions[1]. Participants in both conditions were instructed to perform a breathing task. During the breathing task, participants completed a subjective anxiety measure where they were asked to report their level of anxiety several times using a 0–100 scale (0-calm enough to fall asleep, 100-feeling as if they may have a panic attack). Anxiety was reported at multiple occasions, including before the instructions for the breathing task were given (as a baseline measure), and, following task completion, participants reported the highest level of anxiety they experienced during the breathing task.

The breathing task for those in the control condition consisted of participants breathing normally for the duration of the two minutes. The breathing task in the anxiety condition consisted of participants placing a 1 mm-diameter coffee stirrer straw between their lips, holding the straw with one hand and plugging their nose with the other hand. They were instructed to breathe in and out solely through the straw for two minutes. This manipulation has been shown in past research to induce mild to moderate levels of anxiety and physiological sensations, making it a frequently-used anxiety provocation in anxiety research (e.g., Hofmann, Bufka, & Barlow, 1999; Schmidt & Trakowski, 2004; Teachman & Gordon, 2009; Teachman, Marker, & Clerkin, 2010; Teachman, Smith-Janik, & Saporito, 2007). This procedure does not involve any serious harm or risk to participants (in fact, it derives from the widely used Panic Control Treatment manual by Barlow & Craske, 1994), but several studies have shown that this straw breathing task can result in changes on subjective anxiety measures, physiological changes in heart rate and other self-reported bodily sensations, as well as changes in threat-related cognitions (e.g., Gordon, 2008; Steinman & Teachman, 2010). Notably, participants were told they were welcome to stop at any point during the procedure if it became too uncomfortable. In this set of experiments, the self report measure of anxiety on the 0–100 scale was used to evaluate the effectiveness of this state anxiety manipulation.

[1]Three participants with a previous or current history of asthma were placed in the control condition due to concern that the breathing task might affect their asthma.

After the breathing task was completed and participants' present anxiety level was reported, participants were placed at a hand's length away from the table, and the back of their clothing was clipped to the chair so that their shoulders were held back against the seat. Participants were told to estimate their reach with their hands in their lap and their back against the chair (i.e., not leaning forward). This was done so that all participants estimated reaching in the same way and from the same position. Next, a poker chip was either moved towards or away from the participants on the diagonals specified by one of the axis stickers and the origin sticker. Participants were to indicate to the experimenter when they believed the poker chip to be just within the reach of their dominant hand on that specific diagonal without leaning forward. They were instructed to ask the experimenter to make minor adjustments to the poker chip's position if necessary in order to estimate their reachability as accurately as possible. Participants were instructed to keep their hands in their lap and not reach or move their arms over the table to prevent them receiving any feedback on their reaching capabilities.

The poker chip was moved both towards and away from the participant from all five different diagonals for a total of ten trials. When moving the chip away from the participant, the chip's movement began at the origin sticker and moved toward one of the axis stickers. When moving the chip towards the participant, the chip's movement started at one of the axis stickers and moved towards the origin sticker. The five axis stickers were placed 30° contralateral to the dominant hand, 15° contralateral, directly in front, 15° ipsilateral, and 30° ipsilateral from the origin sticker and participant; see Figure 1. The order of the trials was randomized for each participant. After each estimated reaching trial, the distance from the center of the poker chip to the origin mark in front of the participant was measured. This was done while the participant's eyes were closed to prevent the provision of feedback on their estimated reaching distance. After completing all of the perceived reaching trials, actual reachability was measured. Specifically, participants placed the poker chip as far away as they could reach in each direction, while keeping to the posture constraints indicated at the beginning of the study. The distance between the center of the poker chip and the origin sticker was then measured for each of these five diagonals.

Results and Discussion

Two participants were excluded from the subsequent analyses. One individual was removed due to the fact that he indicated that his anxiety level actually decreased markedly during the anxiety manipulation; he reported being a swimmer who was taught to relax his body when holding his breath. The other individual was removed due to failure to comply with the task instructions. This participant reached across the table during the perceived reaching task, which would provide the individual with feedback for reaching estimates.

Change in anxiety was calculated by subtracting individuals' baseline anxiety estimates from their test anxiety measurements. Therefore, a positive value would suggest that individuals were less anxious following the breathing task, and a negative value would suggest that individuals were more anxious following the breathing task. As a manipulation check, to assess that those in the anxiety group were made more anxious following the straw breathing task than those in the control group, a univariate analysis of variance (ANOVA) was conducted with anxiety condition as a between subjects variable and the change in anxiety as a within subjects variable. The straw breathing condition, $M = -17.83$, $SE = 3.47$, had a significantly higher increase in anxiety following the breathing task than the control condition, $M = 2.89$, $SE = 3.47$, $F(1, 35) = 17.84$, $p < .001$, $\eta_p^2 = .34$.

Reachability accuracy was measured by calculating the ratio of estimated reachability to actual reachability. A repeated-measures ANOVA was conducted using reachability ratios as the dependent variable, with the diagonal (30° contralateral, 15° contralateral, center, 15°

ipsilateral, and 30° ipsilateral) and movement direction (towards and away) as within-subjects factors. The anxiety condition was the between-subjects factor. As predicted, there was a significant difference between the anxiety conditions, such that individuals in the high anxiety condition (*M*=1.12, *SE*=.03) overestimated less than individuals in the control condition (*M*=1.21, *SE*=.03), $F(1,32)= 4.42$, $p=.04$, $\eta_p^2=.12$; see Figure 2. The main effect for diagonal direction was also significant with ipsilateral estimates being overestimated more than contralateral estimates, $F(4, 128)= 28.46$, $p<.001$, $\eta_p^2=.47$. This result is not surprising as it has been found in other reaching studies (Fischer, 2004, Linkenauger et al., 2009; Rochat & Wraga, 1997). There was also a significant effect of hysteresis, which is the direction of movement in relation to an individual's body (in this case, whether the chip was moved towards or away from the participant), such that people overestimated more when the poker chip was moved toward them (*M*= 1.20, *SE*=.02) than when it was moved away (*M*=1.13, *SE*=.03), $F(1, 32)= 17.51$, $p<.001$, $\eta_p^2=.35$. This finding has also been previously reported (Fischer, 2000). In addition, there was a significant interaction between reaching direction and hysteresis, $F(4, 128) = 7.40$, $p<.001$, $\eta_p^2= .19$, indicating that some directions were more affected by hysteresis than others.

To examine individual differences, we looked within the full sample (i.e., combining both groups) to assess the relationship between change in subjective anxiety level and reaching ratios (estimated reaching/actual reaching). We found a significant correlation between the change in self-reported anxiety from baseline to test and mean reaching ratio; specifically, a greater increase in anxiety was associated with lower perceived reachability, $r= -.31$, $p=.04$, one-tailed; see Figure 3.

It is important to note that both conditions overestimated their reaching ability. This finding is by no means new (Carello et al. 1989; Fisher, 2000; Linkenauger et al, 2009; Rochat & Wraga, 1997). As a result, one might interpret the reduced estimates by the anxious group as an indication that anxiety makes individuals more accurate. However, many of the overestimation effects are thought to be due to experimentally necessary, but unnatural, restrictions on the reaching degrees of freedom of participants, (i.e., the participant maintaining a seated position with back against the chair rather than being able to lean forward with their torso and shoulders), as well as other variables associated with assessing reachability in a empirically controlled setting (e.g., not allowing torso rotations for contra- and ipsilateral reaches; increase in the amount of time to make the reaching decision; differences in texture of surface over which individuals reach, etc.; Carello et al., 1989; Coello & Iwanow, 2006; Gabbard & Ammar, 2007; Fisher, 2000). It has been suggested that this is due to individual's inability to mentally take into account experimental restrictions when making these action judgments (Fisher, 2000). In fact, imposing fewer restrictions on degrees of freedom during a perceived reaching ability task nearly eliminates this standard overestimation finding (Carello et al., 1989; Fisher, 2000). Therefore, it is likely that people are not actually overestimating their reach; they are instead estimating their reach with more degrees of freedom than are available in the unusually restricted experimental setting. Thus, we do not interpret the findings in terms of accuracy; rather, we focus on the relative estimates across conditions and the finding that anxious individuals estimated a shorter reach than individuals in the control condition.

The results from Experiment 1showed that perceived reachability can be influenced by anxiety. This suggests that increased levels of anxiety lead to a corresponding decrease in estimated reaching capabilities. Our findings are consistent with earlier findings that suggest anxiety influences motor performance (Wann, 1997), and show that anxiety's influence can be extended to the perception of the affordances for reaching.

Experiment 2: Anxiety and the Perception of Grasping Ability

This study was designed to investigate the effect anxiety has on the perception of grasping ability in order to extend our investigation of the effects of a task-independent emotional state on perceived action capabilities. As seen in the previous study, there was a decrease in perceived reachability after an anxiety manipulation. We thus expected a similar underestimation of perceived graspability following the anxiety-inducing breathing task.

Method

Participants—Thirty undergraduate, right-handed students (17 females) at the University of Virginia participated in this study in exchange for course credit in an introductory psychology course. All participants had normal or corrected-to-normal vision.

Stimuli and Apparatus—Participants were seated at the same table as used in Experiment 1. They were asked to make grasping estimations using a set of sixteen square blocks made from 1.5 cm thick foam board. The widths of these blocks ranged from 4 cm to 24 cm. Each block had parallel lines (3 cm in length) in the center of opposing sides to indicate where the participant was to imagine placing their fingers when grasping; see Figure 4.

Procedure—Participants were randomly assigned to either the anxiety or control condition. Participants then completed the same breathing task procedure as in Experiment 1. Immediately afterward, all participants were seated at the table and instructed that they would be estimating whether they could use their dominant hand to grasp blocks that were placed in front of them. Grasping was defined to the participants as being able to place their thumb on one of the black lines, extending their hand over the block and placing one of their fingers on the other black line, and successfully lifting the block off the table. Once the participants understood the type of grasp they would be employing, they were instructed to close their eyes while the experimenter placed one of the sixteen blocks on the table with the black lines perpendicular to the individual. When the participants opened their eyes, they were to indicate whether they thought they would be able to grasp the block with their dominant hand. This was done for all sixteen blocks, which were presented in random order. Following all estimations, participants attempted to overtly grasp the largest of the blocks they could with their dominant hand to determine actual graspability.

Results and Discussion

Change in anxiety was calculated by subtracting individuals' self-reported baseline anxiety score from their test score. Again, as expected, the manipulation check indicated that the anxious condition ($M = -12.80$, $SE = 2.25$) had a significantly greater increase in anxiety following the breathing task than the control condition ($M = .60$, $SE = 2.25$), $F(1, 29) = 16.23$, $p < .001$, $\eta_p^2 = .37$.

Graspability ratios were calculated by dividing perceived graspability (as defined by the largest block they estimated grasping) by actual graspability (as defined by the largest block the participant would actually grasp). The ratios are a measure of accuracy; if participants overestimated their grasping ability, their graspability ratio would be over 1, and if they underestimated, their ratio would be under 1. One participant's data were removed from the analysis due to their graspability ratio being 3 standard deviations below the mean. A univariate ANOVA was conducted with anxiety condition as the between subjects variable and graspability ratios as the dependent variable. As predicted, the main effect of anxiety condition was significant, $F(1,28) = 4.5$, $p = .04$, $\eta_p^2 = .14$, with anxious individuals overestimating their action capabilities ($M = 1.02$, $SE = .03$) less than non-anxious individuals (*M*= 1.10, *SE*= .03); see Figure 5. In this experiment, when looking at individual differences within the full sample, we found no significant correlation between the change in self-reported anxiety and grasping ratios; however, the relationship indicated a small effect size, $r = -.19$, $p = .16$, one-tailed, in the same direction as reported in Experiment 1. It seems likely that the lack of a significant correlation in this case was a result of the smaller sample size, less sensitivity in the graspability measure than in the reachability measure, and fewer estimates per individual in the graspability versus reachability design.

The results from this study suggest that affordances, beyond just reaching, can be influenced by an individual's subjective anxiety state. Inducing anxiety led to a corresponding decrease in perceived grasping ability, further supporting the finding from Experiment 1 that a task-independent emotional state can influence perceived action capabilities.

Experiment 3: Anxiety and the Perception of Reaching through Apertures

The purpose of this experiment was to determine how anxiety influences perception of the size of an aperture a participant's hand can fit through to further extend the range of perceived action capabilities examined. This study used the same breathing task to manipulate anxiety as used in the earlier experiments. Given that an underestimation in action capabilities was seen in the previous studies, we expected that anxiety would also decrease perceived abilities related to aperture passability.

Method

Participants—Thirty-one undergraduate, right-handed students (20 females) at the University of Virginia participated in this study in exchange for course credit in an introductory psychology course. All participants had normal or corrected-to-normal vision.

Stimuli and Apparatus—An apparatus to create a manipulable aperture was constructed. A square hole was created between 2 pieces of foamboard attached to a wooden frame; see Figure 6. The size of the hole was manipulated by moving the top piece of foamboard upwards to increase hole size or downwards to decrease hole size. The maximum size the aperture could extend was an area of 324 cm^2; the aperture could decrease all of the way down to 0 cm^2.

Procedure—Participants were randomly assigned to either the anxiety or control condition. Participants completed the same breathing task procedure as in Experiments 1 and 2. Participants were seated at the same table as in Experiments 1 and 2, and were told to keep their hands in their lap until otherwise instructed. The apparatus was placed on the table in front of participants, and they were told to indicate when they could just fit their dominant hand through the hole without touching the sides of the foamboard. For two trials, subjects were presented with the largest sized hole, and the experimenter slowly decreased the size of the hole until participants indicated that they could just fit their hand through. For two other trials, participants made the same judgment, except that they were first presented with the smallest sized hole and the experimenter slowly increased the size of the hole. Following all four estimates, the maximum size hole that participants could actually fit their hands through was determined.

Results and Discussion

Change in anxiety was again calculated by subtracting individuals' baseline anxiety score from their test score. Surprisingly, in this study, the straw breathing condition ($M = -4.73$, $SE = 3.36$) *did not* have a significantly higher increase in anxiety following the breathing task than the control condition ($M = 2.28$, $SE = 3.25$), $F(1, 30) = 2.25$, $p = .15$, $\eta_p^2 = .07$.

Aperture accuracy was determined by averaging the two estimates for each movement direction and dividing that value by the participant's actual passable aperture. That provided us with two ratios for each participant: one ratio when the estimates were made when the size of the aperture was decreasing and the other when the size of the aperture was increasing. A repeated-measures ANOVA was performed on the ratios with movement direction (increasing and decreasing) as a within-subjects variable and anxiety condition (straw breathing and control) as a between-subjects variable, and aperture ratios as the dependent measure. Consistent with the lack of difference in change in anxiety between the conditions, there was also no significant difference in the aperture ratios between the straw breathing ($M = 1.09$, $SE = .04$) and control conditions ($M = 1.14$, $SE = .04$), $F(1,29) = 1.01$, $p = .32$, η_p^2=.03. As found in previous studies, there was an effect of hysteresis, with participants overestimating the size of the passable aperture more when the aperture was moving inwards ($M = 1.17$, $SE = .03$) than outwards ($M = 1.06$, $SE = .02$), $F(1, 29) = 39.28$, $p <.001$, $\eta_p^2 = .58$.

The failure to find a difference in this affordance task seems likely attributable to the ineffectiveness of the straw breathing task in inducing anxiety in this group of participants. It is not clear why the breathing task was not as effective in this experiment; the same research assistants implemented the same procedure as in Experiment 2. Thus, it seemed plausible that our random sample contained several people that were simply not made anxious by straw breathing. This led us to examine individual differences to see if those who were made anxious made more cautious affordance estimates as in Experiment 1. As expected, when looking within the full sample, a significant correlation was found between increases in anxiety from baseline to test with overestimations in the size of the passable aperture, $r = -.36$, $p = .02$, one-tailed; see Figure 7. This correlation corresponds to our previous findings, suggesting that increases in anxiety are related to decreases in estimates of action capabilities. When the group as a whole was not influenced by the manipulation, no change in affordance perception occurred. However, the extent of individual increase in anxiety level was related to greater underestimations in their anticipated action capabilities.

General Discussion

The goal of these studies was to determine the influence of anxiety on perceiving affordances; specifically those in near space. The results demonstrate that anxiety influences the perception of affordances for reaching and grasping, and is associated with affordances for aperture passability. Individuals were more conservative in their judgments of their action capabilities for these affordances in near space after a change in self-reported anxiety. These results were observed both in group differences induced by anxiety manipulations (for Experiments 1 and 2), as well as in individual differences in self-reported anxiety ratings (for Experiments 1 and 3).

Anxiety is associated with several physiological changes and behavioral tendencies that could result in the reduction of perceived action capabilities. It is well documented in the literature that anxiety leads to physiological changes in the autonomic nervous system (e.g., Levenson, 1992; Romero & Butler, 2007). While the initial activation of anxiety may lead to extraordinary physical capabilities, such as lifting a car when under severe threat, this surge of hormones eventually leaves the body exhausted of resources. Interestingly, many individuals experience freeze responses following anxious episodes, typically referred to as General Inhibition Syndrome (GIS; Selye, 1974). GIS is often precipitated by excessive stress that leaves an individual in need of a period of recovery. The purpose of the GIS response would be for an individual to either freeze or hide when faced with threatening stimuli, and thus restore or conserve energy (Hamilton, 1989). Similarly, the intense physiological responses experienced during high levels of anxiety are typically followed by fatigue, muscle tension and weakness, hyperventilation, and increased attention to internal bodily states (Selye, 1974).

These physiological changes occur in parallel with anxiety-linked behavioral changes (e.g., Cannon, 1917; Selye, 1974). The fight-or-flight response was first documented by Cannon (1929), who theorized that anxious individuals experience a series of physiological changes under distress to prepare themselves to fight or flee a threatening stimulus. Due to the anxiety symptoms associated with the breathing task employed in the current experiments, we suspect that anxious individuals experienced a desire to flee or withdraw from their environment (notably, avoidance is often referred to as the hallmark of pathological anxiety; see Barlow, 2002). Thus, participants in the anxiety condition likely felt vulnerable and thus, may have perceived that they were less able or willing to act on their environment, which reduced their perception of their action capabilities.

Previous research has found that anxious climbers are more conservative in estimating their relevant action capabilities (Pijpers, Oudejans, & Bakker, 2005; Pijpers, Oudejans, Bakker, & Beek, 2006). Anxiety was related to a decrease in both perceived and actual vertical reaching height when ascending a climbing wall (Pijpers, et al., 2006). The researchers also found that anxious individuals made more exploratory movements and climbed over a longer period of time. These individuals were also more hesitant, grasping for longer periods and moving to new positions more slowly (Pijpers et al., 2005). Similar to the results in our study, anxiety was found to correlate with reduced perceived reaching length. However, unlike our studies, the Pijpers findings also suggest that anxiety led to a decrease in performance, such that the climbers made shorter and less accurate reaches. It is important to note that their manipulation of anxiety is directly linked with the danger associated with the reaching task, rather than the subjective and physiological experience of anxiety independent of the task demands. For example, it is highly likely that participants were more reserved in their estimated reaching ability and actual movements at greater heights above ground due to the danger associated with these heights, rather than the general effect of anxiety unrelated to the affordance task. Similarly, the effect on actual reachability in Pijpers and colleagues' work may be interpreted as a reluctance to fully extend one's arm when in a precarious and potentially dangerous position. Thus, while Pijpers' study provides interesting results investigating the manipulation of anxiety directly related to an affordance task, it is difficult to determine whether their findings are due to the experience of anxiety in general or to anxiety associated with the specific task. Our results add to the previous literature by showing that a manipulation of anxiety that is independent of the affordance task can influence perceived affordances in that task. This suggests that just as a change in affect or emotional state can affect performance on seemingly unrelated cognitive tasks, like judgment and memory (see Storbeck & Clore, 2008), changes in anxiety appear to have far reaching effects on unrelated perceptual estimates (see also Riener et al., 2010).

Anxiety leads individuals to make more conservative estimations of their action capabilities. This corresponds to previous research done on performance in high stress situations, such as sporting events. Wann (1997) found that anxiety can have detrimental effects on players' performance during a sporting event. During such events, players must act on an object accurately and efficiently in order to achieve success. Wann's findings are consistent with the results from our studies, suggesting that anxiety can decrease an actor's perception of his or her action capabilities performed in near space, likely leading to more conservative behavior where the actor's full action capabilities are not employed or realized. While in potentially dangerous situations, such as climbing, conservative actions may have their benefits. However, in activities such as sports, underestimating one's own capabilities can be detrimental.

The results from this set of experiments extend our knowledge of anxiety's effect on our perceptions. While these results demonstrate that anxiety can influence affordance perception, they also suggest a more general interpretation that the physiological state of the body must be taken into account in a theory of affordances, at least for those in near space. It is important to note that anxiety responses are multifaceted, including physiological, cognitive, subjective emotional, and behavioral changes, indicating that anxiety can be expressed in many ways (Barlow, 2002; Bradley & Lang, 2000; Lang, 1978; Lang, Cuthbert & Bradley, 1998). Therefore, future experiments that assess multiple aspects of the anxiety response, beyond just the measure of change in subjective anxiety utilized in the current studies, will be important. This will help determine the specific mechanisms underlying anxiety's effects on action capabilities; we expect the role of arousal will be particularly helpful to assess. Examining these effects among clinical populations to see the effects of more severe anxiety will also be helpful.

Finally, we recognize that our ability to make direct comparisons across the action capability measures is limited by the differences in measurement procedures. However, these differences were required to validly measure reaching versus grasping versus aperture passability. We prioritized using previously validated paradigms in each case (Carello et al., 1989; Ishak, Adolph, & Lin, 2008; Linkenauger et al., 2009). Although it would have been ideal to use more similar procedures for each experiment, it is difficult to fluidly increase the diameter of a block in the same way as it is to change a reaching distance or the size of an aperture.

In summary, these experiments were conducted to determine whether anxiety influences the perception of affordances in near space. Our results showed that anxiety influences the perception of action capabilities, and thereby, makes anxious individuals more conservative. We argue that this effect is likely explained by feelings of vulnerability and changes in physiology and avoidance motivation that induce anxious individuals to withdraw from or freeze in their environment in an attempt to reduce perceived danger and associated arousal. As a result of the changes in anxiety, participants likely perceive themselves to be less capable and more vulnerable, and consequently, judge their action capabilities to be diminished relative to when they are not anxious.

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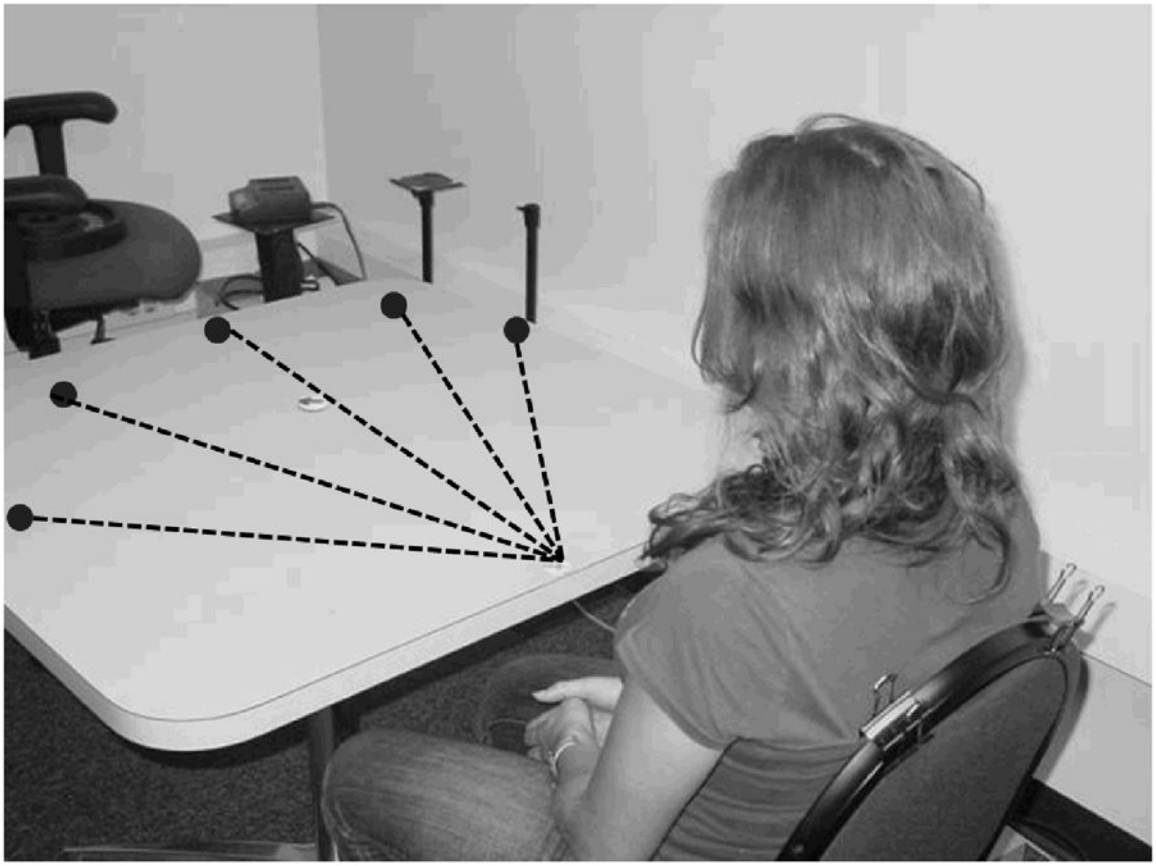

Figure 1.
A diagram of the experimental set-up for Experiment 1. The dashed lines represent 5 different directions of the trajectories. Note that the participant is prohibited from leaning forward by clipping their shirt to the back of the chair.

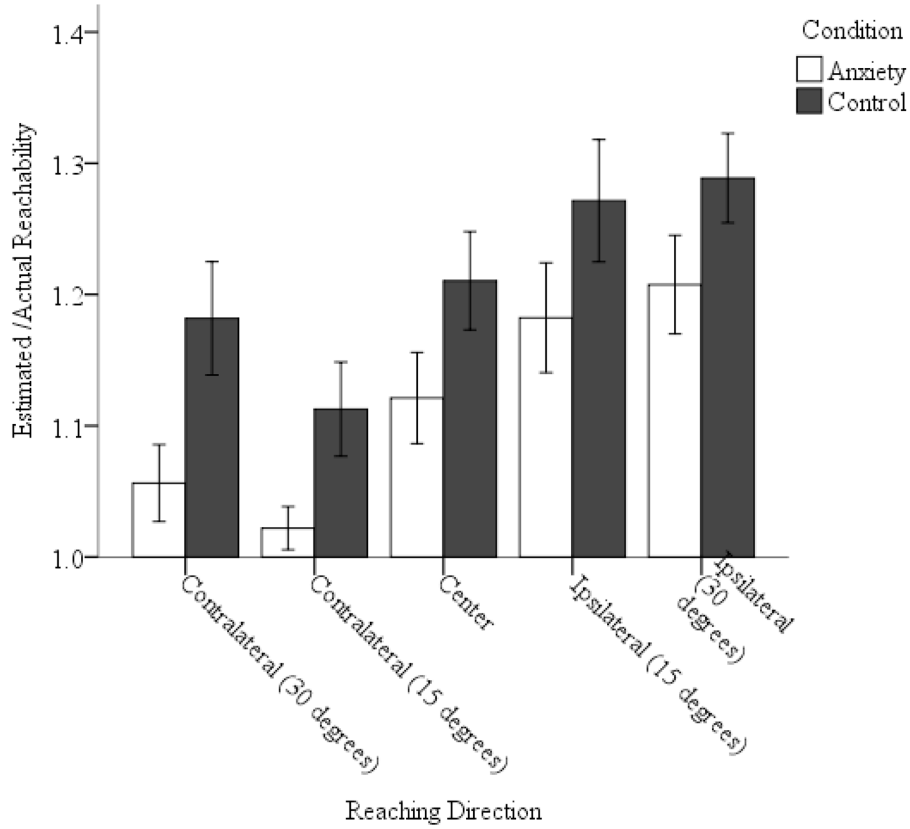

Figure 2.
The ratio of estimated to actual reachability in both the anxiety and control conditions for each reaching direction. Error bars represent +/− 1 SE from the mean.

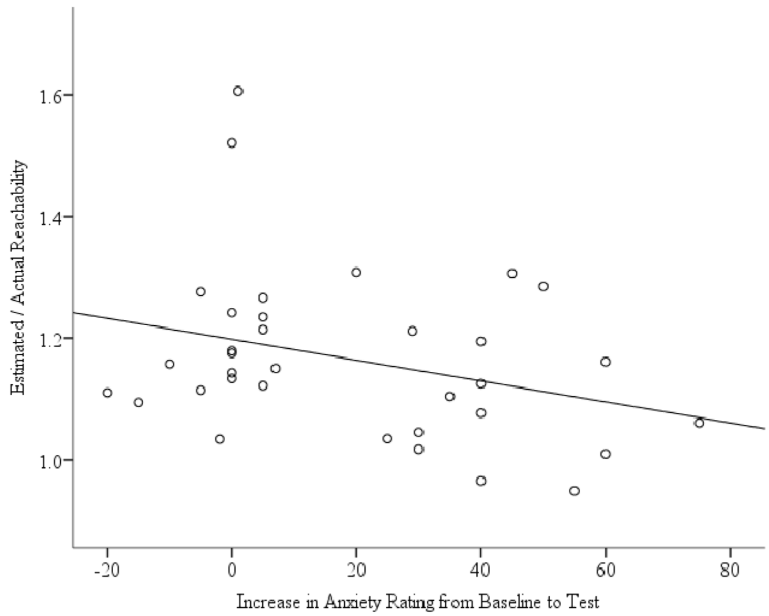

Figure 3.
The relationship between mean reachability and the difference in self-reported anxiety between baseline and test. Greater change in self-reported anxiety was associated with smaller mean reachability estimates.

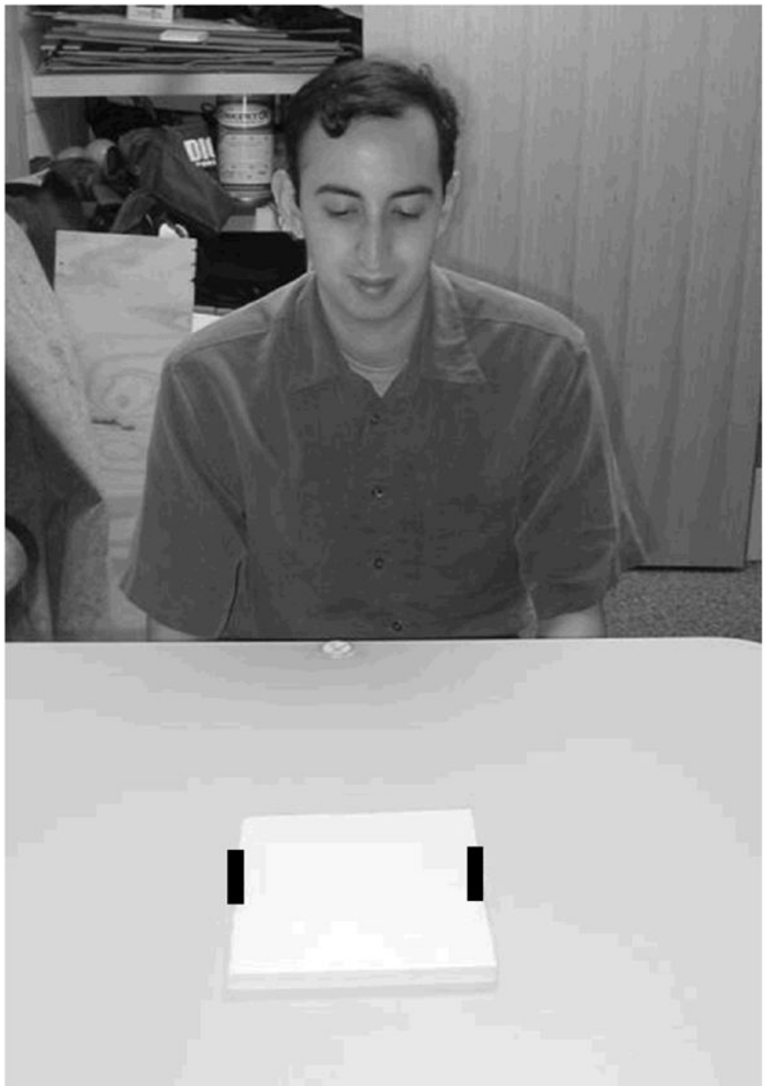

Figure 4.

A diagram of the experimental set-up for Experiment 2. The black lines on the block are where participants were told to estimate placing their fingers during the grasping ability estimates.

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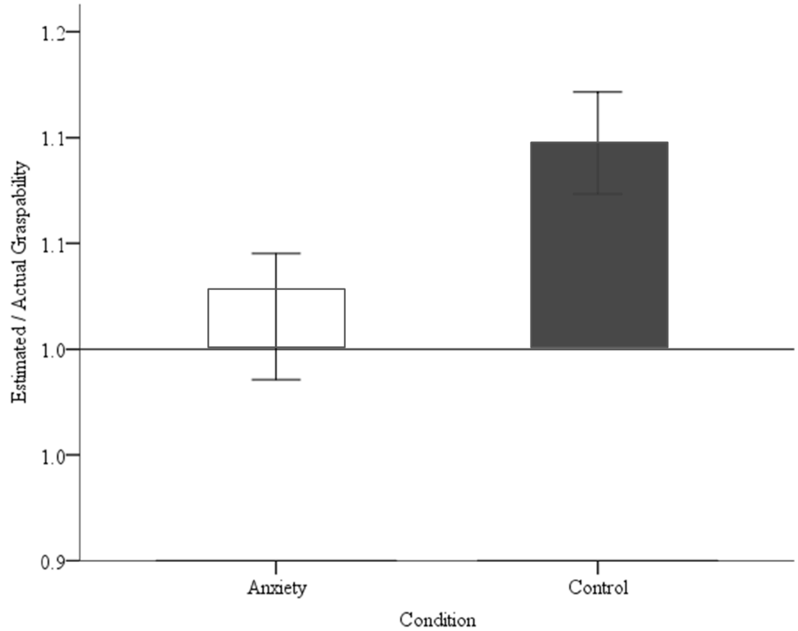

Figure 5.
Grasping ratios in the anxiety and control conditions. Error bars represent +/− 1 SE of the mean.

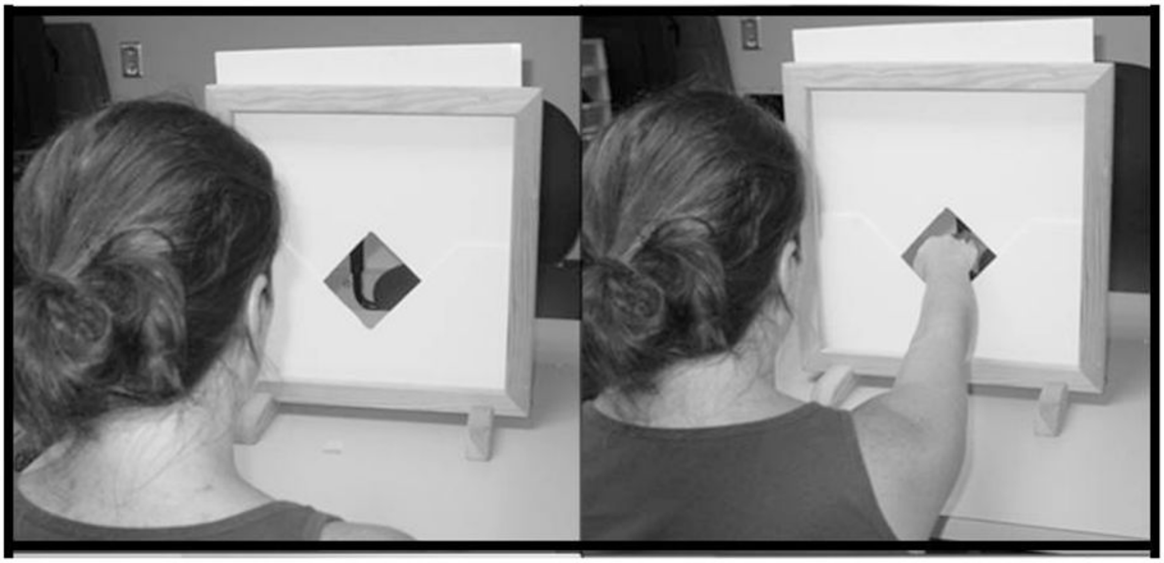

Figure 6.
Apparatus used in the aperture fitting task.

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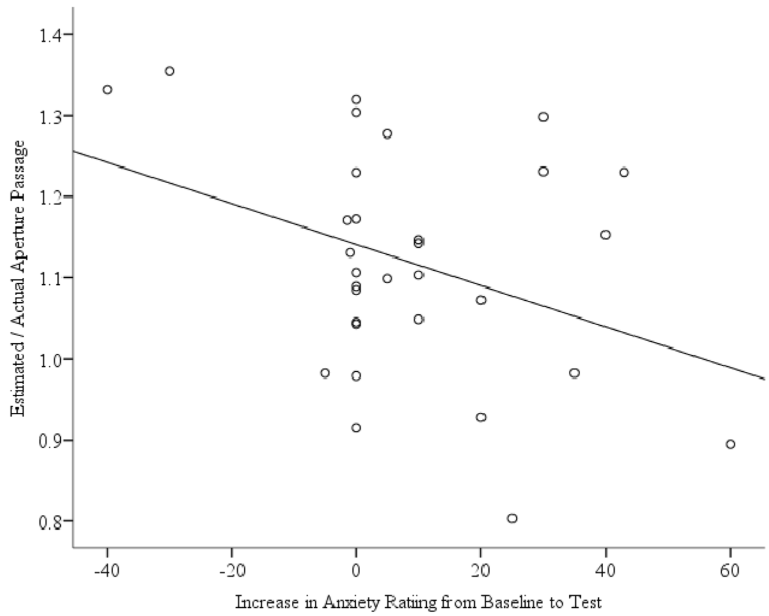

Figure 7.
Relation between change in anxiety from baseline to test and overestimations in the size of the aperture through which individuals could pass their hand.