

2009

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### Recommended Citation

Clerkin, E. M., Cody, M. W., Stefanucci, J. K., Proffitt, D. R., & Teachman, B. A. (2009). Imagery and fear influence height perception. *Journal of anxiety disorders*, 23(3), 381-386.

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## Imagery and fear influence height perception

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### ARTICLE INFO

#### Article history:

Received 1 May 2008

Received in revised form 30 November 2008

Accepted 3 December 2008

#### Keywords:

Imagery

Visual perception

Height fear

Acrophobia

### ABSTRACT

The current study tested whether height overestimation is related to height fear and influenced by images of falling. To assess perceptual biases, participants high ( $n = 65$ ) versus low ( $n = 64$ ) in height fear estimated the vertical extents of two balconies using a visual matching task. On one of the balconies, participants engaged in an imagery exercise designed to enhance the subjective sense that they were acting in a dangerous environment by picturing themselves falling. As expected, we found that individuals overestimated the balcony's height more after they imagined themselves falling, particularly if they were already afraid of heights. These findings suggest that height fear may serve as a vulnerability factor that leads to perceptual biases when triggered by a stressor (in this case, images of falling).

Published by Elsevier Ltd.

Clinicians have long recognized the seeming perceptual distortions that many fearful clients exhibit. For an individual with a phobia, a small garden snake may achieve epic proportions, a harmless spider might appear to scurry at breakneck speeds, and a neutral expression can suddenly “look” like a menacing scowl. Drawing from these anecdotal claims, our goal with the current study was to examine the relationship between visual perception and height fear. Moreover, we sought to investigate one of the mechanisms that may underlie perceptual biases—imagery that enhances fears of interacting in a “dangerous” environment.

The idea that biases in visual perception might be associated with pathological anxiety has received some prior empirical support. For instance, Riskind, Kelly, Moore, Harman, & Gaines (1992) found that spider fearful (versus non-fearful) individuals reported relatively faster forward motion of a spider while viewing a video of a spider crawling toward them (but not of a rabbit moving forward). Similarly, Rachman & Cuk (1992) found that fearful (relative to non-fearful) individuals verbally reported greater estimates of a snake's flickering tongue movements and a spider's jumping movements, and that these biases were diminished following fear reduction. While these types of studies provide intriguing clues as to the ways in which fear may alter visual perception, their reliance on hypothetical interactions with the feared object and/or verbal report makes it difficult to determine the extent to which the observed biases were primarily

cognitive, perceptual, or both. It is possible, for instance, that reports of greater movement in these studies were simply due to distortions in judgment or other cognitive biases, as opposed to biased visual perception.

To help address this issue, researchers have begun to utilize measures that minimize cognitive influences in order to more directly investigate perceptual biases in psychopathology. For instance, Stefanucci, Proffitt, Clore, & Parekh (2008) asked participants to estimate the slant of a hill while they stood either on a skateboard or on a wooden box of the same height. Researchers found that individuals who reported fear while standing on the skateboard perceived the hill as steeper, relative to individuals who stood on the box and were unafraid. Furthermore, in a precursor to the current study, we demonstrated that individuals high (versus low) in acrophobia (height fear) symptoms overestimated the vertical extent of a balcony (Teachman, Stefanucci, Clerkin, Cody, & Proffitt, 2008). Moreover, such perceptual distortion remained even when controlling for cognitive biases. Accordingly, we concluded that emotional states, such as fear, may be related to what people see at a perceptual level.

This research grew out of work in the field of visual perception examining the extent to which non-visual factors influence perception. For example, in a series of studies examining spatial layout, researchers demonstrated that expectations, intent, and effort are implicated in visual perception (see Proffitt, 2006). In fact, research suggests that if one is wearing a heavy backpack while looking at a hill, the slope will appear steeper (e.g., Bhalla & Proffitt, 1999). According to Proffitt (2006), this is because visual perception “promotes survival by making us aware of both the opportunities and costs associated with action” (p. 111). In other words, when the metabolic costs of ascending a hill become more

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pronounced (i.e., carrying a heavy backpack while climbing), it is adaptive to “see” the slope as steeper.

Similarly, fear can play an adaptive role in one’s functioning. There is good reason to feel fearful, for instance, if one encounters a truly dangerous situation because it promotes avoidance and other safety behaviors. In the present study, our goal was to increase the apparent danger in a height-relevant situation to determine whether this would affect visual perception. Specifically, we manipulated imagery of falling based on prior research that imagery can effectively enhance perceived threat (Sherman, Cialdini, Schwartzman, & Reynolds, 1985). We chose to focus on fears of falling because of the obvious risk of injury (or worse) that falling confers, and because it is a common fear among acrophobic patients (Menzies & Clark, 1995). Thus, manipulating imagery of falling seemed like a logical means to enhance the perceived costs associated with being in a high place, particularly among height fearful individuals.

To examine the effect of falling imagery on perceptual biases, we asked individuals who were high versus low in acrophobic symptoms to estimate the vertical extents of two balconies. On one of the balconies, participants were asked to engage in a brief guided imagery exercise designed to heighten the subjective sense that they were acting in a dangerous environment by picturing themselves falling. Following Proffitt (2006), we hypothesized that amplifying the immediate danger of being on the balcony through imagery (thus enhancing the perceived cost of acting near its edge; e.g., falling) would lead participants to overestimate the balcony’s apparent vertical extent. We also expected individuals high (versus low) in height fear to perceive the balcony as higher (based on Teachman et al., 2008) because height fearful individuals presumably exaggerate the costs of being on the balcony.

## 1. Method<sup>1</sup>

### 1.1. Participants

Participants were recruited from undergraduate psychology or other classes and were offered course credit or payment for completing the study. Additionally, some participants were community volunteers who responded to newspaper advertisements seeking individuals who were either very afraid or not at all afraid of heights. Participation was completely voluntary, and this study was approved by the University of Virginia Institutional Review Board.

All interested individuals completed a screening measure: the anxiety subscale from the Acrophobia Questionnaire (AQ—Anxiety; Cohen, 1977), which has a mean of 27.10 and standard deviation of 17.32 in a student sample (Cohen, 1977). In the present study, individuals who scored greater than or less than one standard deviation from the prior student sample mean (i.e., 45 and above or 9 and below) were invited to participate. This recruitment strategy yielded a total sample of 129 participants ( $n = 65$  high fear, 78% female;  $n = 64$  low fear, 70% female). Mean age was 20 years ( $S.D. = 7.95$ ). For the high fear group, race was reported as 66% Caucasian, 6% Black or African American, 18% Asian, 2% Native American or Pacific Islander, 3% bi- or multiracial, and 5% other. Ethnicity in the high fear group was reported as 88% not Hispanic/Latino, 9% Hispanic/Latino, and 3% declined to answer. For the low fear group, race was reported as 91% Caucasian, 0% Black or African

American, 2% Asian, 0% Native American or Pacific Islander, 3% bi- or multiracial, 3% other, and 2% declined to answer. Ethnicity in the low fear group was reported as not 91% Hispanic/Latino, 8% Hispanic/Latino, and 2% declined to answer.

### 1.2. Height exposures

Two balconies were used for the height estimates, one at 26 ft (7.92 m) and the other at 33 ft (10.06 m) from the ground. Both were enclosed by ledges approximately 3 ft (0.91 m) high. Balcony order for the exposures was counterbalanced, but participants always received the imagery manipulation on the second balcony so that this manipulation would not influence the other balcony estimation.

### 1.3. Measures

#### 1.3.1. Height fear

To verify the validity of the fear group classification, participants completed the full Acrophobia Questionnaire (AQ; Cohen, 1977) at the conclusion of the study. The AQ is a 40-item measure of height phobia with anxiety and avoidance subscales. On the day of testing, Cronbach’s alpha for the anxiety and avoidance subscales was .96 and .89, respectively. While standing on both balconies, participants also completed a measure of anxious cognitions, the Agoraphobic Cognitions Questionnaire (ACQ; Chambless, Caputo, Bright, & Gallagher, 1984). This questionnaire was modified slightly to reflect anxious thoughts related to heights (e.g., “I am going to fall,” “The railing will not protect me”). Note that for ease of discussion, the ACQ will be discussed primarily as a measure of costs; however, it is important to clarify that this type of cognitive bias is likely composed of an interaction between the probability of a negative event, such as falling, occurring and the associated costs (Beck, Emery, & Greenberg, 1985).

In addition, participants reported their anxiety-related bodily sensations on both balconies, using a modified Body Sensations Questionnaire (BSQ; Chambless et al., 1984). Both the ACQ and the BSQ have been shown to have good internal consistency and test–retest reliability (Chambless et al., 1984). Cronbach’s alpha for the ACQ on both balconies was .89, while alpha for the BSQ was .93 on the first balcony and .94 on the second. Finally, participants rated their subjective fear on a 0–100 verbal analogue Subjective Units of Distress Scale (where 0 is *not at all afraid* and 100 is *panicked*; SUDS; Wolpe, 1990) several times throughout the experiment.

#### 1.3.2. Manipulation check

Participants were asked to rate the vividness of their mental imagery on a 0–100 verbal analogue scale after completing the tasks on both balconies (where higher numbers indicate increasingly vivid images of the self-falling off the balcony).

#### 1.3.3. Visual perception

For the height estimation task, participants were asked to look at a target disk on the ground beneath the balcony. They then estimated the height of the balcony by positioning an experimenter the same distance away from them horizontally along the balcony as they were vertically from the target on the ground. The experimenter recorded the distance, and the ratio of overestimation was computed (the participant’s estimate divided by the actual height of the balcony) so that the height estimates across the two different balconies (26 and 33 ft) would be on the same metric. For instance, an estimate of 30 ft given for the 26-ft balcony would result in an overestimation ratio of 1.15. The height estimate was our primary measure of perceptual bias, but in order to provide a converging and less direct measure of height estimation, a subsample of participants also estimated the size of the target disk by instructing the

<sup>1</sup> Only those materials relevant to the current hypotheses are listed here. For a more complete description, please contact the first author. For instance, participants also completed a measure of attentional bias (the dot-probe task), a measure of implicit bias (the Implicit Association Test), and a measure of behavioral avoidance. All participants completed the same procedures. The main exception to this was that the target on one of the balconies was missing for a subsection of participants ( $n = 10$ ); thus, these participants did not complete the size estimation task.

**Table 1**  
Descriptive statistics for 'traditional' height fear measures.

	Full sample		High height fear		Low height fear	
	M	S.D.	M	S.D.	M	S.D.
	N = 129		N = 65		N = 64	
Acrophobia Questionnaire—Anxiety	35.45	25.43	56.97	15.20	13.59	10.77
Acrophobia Questionnaire—Avoidance	6.72	6.42	11.2	5.86	2.17	2.68
Anxious Cognitions Questionnaire—No Imagery Balcony	3.53	5.64	6.4	6.74	0.61	1.18
Anxious Cognitions Questionnaire—Imagery Balcony	4.32	6.24	7.81	7.18	0.89	1.75
Bodily Sensations Questionnaire—No Imagery Balcony	4.65	7.24	8.25	8.69	1.00	1.68
Bodily Sensations Questionnaire—Imagery Balcony	5.74	8.24	10.06	9.69	1.43	2.28

experimenter to adjust a tape measure (held up with the blank side facing the participants) until it matched the diameter of the target. This measure was included because the apparent size of the target should be related to estimates of apparent distance (here, height) following the size–distance invariance hypothesis (i.e., the frequently found relation between apparent size and distance; Epstein, 1973). Two different sized targets were used, a 16-in. (40.64 cm) target<sup>2</sup> for the smaller (26-ft) balcony, and a 20-in. (50.80 cm) target for the larger (33-ft) balcony. Again, the ratio of size overestimation was computed by dividing the participant's estimate by the actual diameter of the target. For both the height estimation and size estimation tasks, participants were encouraged to look back and forth between the experimenter and the target as often as they needed.

#### 1.4. Procedure

Following informed consent, participants were taken onto the first balcony (either the 26- or 33-ft one; this was counter-balanced) and instructed to look over the ledge while reporting their initial fear level using the SUDS rating of 0–100. They then completed the height estimation task followed by the target disk size estimation task. While still on the balcony, participants were instructed to complete the ACQ and BSQ in counterbalanced order, using a clipboard that was positioned on the ledge (so that participants had to stand close to the edge of the balcony, facing outward). Administration of the questionnaires while on the balcony was considered important to enhance the sense that participants were still interacting in the height environment while making their ratings. They then were asked to rate the extent they imagined themselves falling off the balcony, on a scale of 0 (*no image at all*) to 100 (*a vivid image of self-falling*). Finally, participants were asked to report their peak level of fear during the balcony task using the SUDS rating.

Following the first balcony exposure, participants were taken to the second balcony and again asked to look over the ledge and report their initial fear level. Next, participants were asked to close their eyes while the experimenter read a brief imagery induction script. Participants were instructed to imagine themselves leaning out far over the edge of the balcony and losing their balance. They were led to form an image of themselves falling to the ground, using multiple senses and relating the imagery to real memories of falling. After generating the image, participants were instructed to hold it in their minds and replay it over and over for 30 s. After imagery manipulation, participants again reported their state fear level using the 0–100 SUDS ratings and completed the height

estimation, size estimation, ACQ, BSQ, imagery rating, and peak SUDS rating, following the same procedure as on the first balcony.

After completing tasks on both balconies, participants were brought back inside and given the AQ and measures of cognitive and avoidance biases that are not reported here (see footnote 1). Finally, an exit interview was conducted to check for knowledge of the hypotheses and suspicion of deception before participants were fully debriefed.

## 2. Results

### 2.1. Sample characteristics

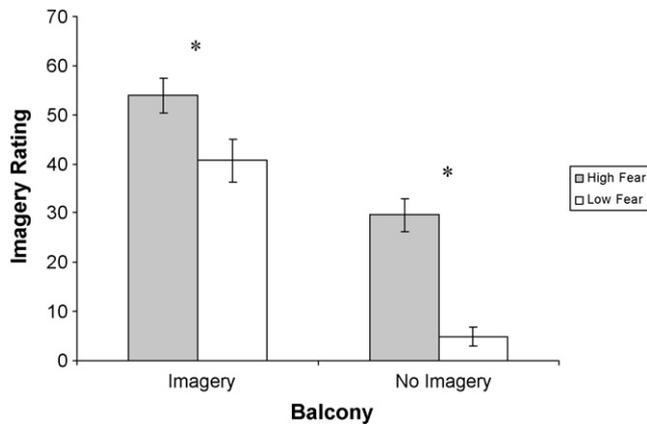
Independent samples *t*-tests indicated that fear groups differed on anxiety and avoidance tied to height fear in the expected direction (AQ—Anxiety and Avoidance:  $t_{111.60} = 18.81$ ,  $p < .001$ ,  $d = 3.31$ ). The high fear group reported greater anxiety and avoidance than the low fear group. Across both balconies, individuals high (versus low) in height fear also reported greater anxious cognitions (ACQ—No Imagery Balcony:  $t_{67.96} = 6.82$ ,  $p < .001$ ,  $d = 1.20$ ; ACQ—Imagery Balcony:  $t_{69.20} = 7.43$ ,  $p < .001$ ,  $d = 1.32$ ) and fear of bodily sensations (BSQ—No Imagery Balcony:  $t_{68.85} = 6.59$ ,  $p < .001$ ,  $d = 1.16$ ; BSQ—Imagery Balcony:  $t_{68.87} = 6.88$ ,  $p < .001$ ,  $d = 1.23$ ). Together, these findings confirm validity of the fear group classification (see Table 1). Note, distributions for self-report measures of state height fear (e.g., ACQ, Imagery ratings, BSQ, and Peak SUDS) were highly skewed so results with these measures should be interpreted with some caution [skew was not a significant problem for the primary perceptual bias outcome measures (i.e., height overestimation) or trait height fear measure (AQ—Anxiety and Avoidance)]. Additionally, degrees of freedom for the independent samples *t*-tests were corrected for unequal variances when applicable (based off of a Levene's test for equality of variances); hence, the degrees of freedom vary across tests.

Chi-square tests revealed that there were no significant group differences in gender ( $\chi^2 = 1.13$ ,  $p > .10$ ). Unexpectedly, there was a significant group difference in race ( $\chi^2 = 14.08$ ,  $p = .001$ ), so this variable was used as a covariate in subsequent analyses (comparing Caucasian, Asian, and all other races). There was also a non-significant trend for an age difference across the groups ( $t_{65.17} = 1.98$ ,  $p = .052$ ,  $d = 0.35$ ), which was driven by four individuals in the high fear group who were much older than the other participants ( $R = 57$ – $76$  years old) [note: when excluding these four people, there was no significant between-groups difference in age ( $t_{114.19} = .13$ ,  $p > .10$ ,  $d = -.02$ )].

### 2.2. Imagery manipulation and perceived costs

To evaluate whether imagery manipulation was effective at inducing a vivid image of the participant falling over the balcony's ledge, imagery ratings were compared across balconies. We conducted a repeated measures Analysis of Covariance (ANCOVA), with one between-subjects factor (Height Status) and one within-

<sup>2</sup> A different target of unknown size had been used for the first half of the participants on the smaller balcony. Due to experimenter error, this target was lost, and a 16-in. target was made to replace it. The size estimation analyses for the smaller balcony reported below only include the data for the participants who viewed the new target, because a number of participants had missing data for the lost target.



**Fig. 1.** Group differences in falling imagery ratings. *Note:* Group mean (and S.E. bars) for falling imagery ratings while on the balconies. Higher scores indicate more vivid imagery. In this figure, the asterisks reflect a significant main effect of Height Status.

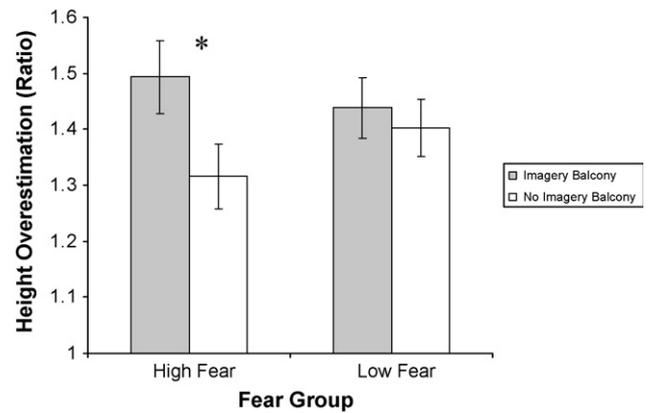
subjects factor (Balcony: Imagery versus No Imagery). As expected, individuals reported a more vivid image of themselves falling after the imagery induction ( $F_{(1,124)} = 143.20$ ,  $p < .001$ ,  $\eta_p^2 = .54$ ), indicating that the manipulation was successful. There was also a significant main effect for Height Status ( $F_{(1,124)} = 20.76$ ,  $p < .001$ ,  $\eta_p^2 = .14$ ), and a significant interaction between Height Status and Balcony ( $F_{(1,124)} = 5.69$ ,  $p = .02$ ,  $\eta_p^2 = .04$ ). As expected, analysis of simple effects within each fear group indicated that both groups reported a more vivid image of themselves falling in the Imagery condition, relative to the No Imagery condition (High Fear:  $F_{(1,62)} = 62.09$ ,  $p < .001$ ,  $\eta_p^2 = .50$ ; Low Fear:  $F_{(1,61)} = 84.81$ ,  $p < .001$ ,  $\eta_p^2 = .58$ ). Additionally, individuals high (versus low) in height fear reported more vivid images of themselves falling off both balconies (Imagery Balcony:  $F_{(1,124)} = 5.05$ ,  $p = .03$ ,  $\eta_p^2 = .04$ ; No Imagery Balcony:  $F_{(1,124)} = 41.94$ ,  $p < .001$ ,  $\eta_p^2 = .25$ ), and this group difference appeared to be larger for the No Imagery balcony. See Fig. 1.

Next, given our goal of enhancing the perceived dangerousness of the situation, we examined whether anxious cognitions tied to heights (on the ACQ) were exacerbated as a function of the imagery manipulation. Again, we conducted a repeated-measures ANCOVA, with one between-subjects factor (Height Status) and one within-subjects factor (Balcony: Imagery versus No Imagery). In line with expectations, participants were more likely to overestimate the costs of being on the balcony following the imagery induction ( $F_{(1,123)} = 9.31$ ,  $p = .003$ ,  $\eta_p^2 = .07$ ). Additionally, there was a significant main effect for Height Status ( $F_{(1,123)} = 54.66$ ,  $p < .001$ ,  $\eta_p^2 = .31$ ), and a significant interaction between Height Status and Balcony ( $F_{(1,123)} = 5.83$ ,  $p = .02$ ,  $\eta_p^2 = .05$ ). Follow-up tests to examine the source of the interaction revealed that individuals high in height fear reported more anxious cognitions than individuals low in height fear across both balconies (Imagery Balcony:  $F_{(1,125)} = 53.65$ ,  $p < .001$ ,  $\eta_p^2 = .26$ ; No Imagery Balcony:  $F_{(1,123)} = 54.54$ ,  $p < .001$ ,  $\eta_p^2 = .31$ ). Additionally, analysis of simple effects within each fear group indicated that the high fear group reported more anxious cognitions in the Imagery condition, relative to the No Imagery condition (High Fear:  $F_{(1,61)} = 8.11$ ,  $p = .006$ ,  $\eta_p^2 = .12$ ). Within the low fear group, there was no significant effect for Balcony ( $F_{(1,61)} = 2.19$ ,  $p > .10$ ,  $\eta_p^2 = .04$ ). These results suggest that imagery enhanced the perceived costs of being on the balcony, especially for individuals who were afraid of heights.

### 2.3. Visual perception as a function of imagery

#### 2.3.1. Height overestimation

To examine the relationship between height fear, imagery, and visual perception, we evaluated height estimations on both



**Fig. 2.** Group differences in height overestimation (visual matching) as a function of the imagery manipulation. *Note:* Group mean (and SE bars) for height overestimation (visual matching) of the balconies. Higher scores indicate greater perceptual distortion (1.0 would indicate an accurate estimate). In this figure, the asterisk reflects a significant effect of Balcony (Imagery or No Imagery) within the high fear group.

balconies. Regardless of fear status, we predicted that the falling imagery condition would lead to greater perceptual distortion. In addition, consistent with our earlier findings (Teachman et al., 2008), we expected that individuals would be more likely to overestimate the vertical extent of the balcony if they were afraid of heights<sup>3</sup>.

To test these hypotheses, we first conducted a repeated-measures ANCOVA, with one between-subjects factor (Height Status) and one within-subjects factor (Balcony: Imagery versus No Imagery). As expected, there was a significant main effect for Balcony, with individuals overestimating the vertical extent of the balcony more following the imagery induction (versus No Imagery;  $F_{(1,121)} = 9.96$ ,  $p = .002$ ,  $\eta_p^2 = .08$ ). However, contrary to expectations, there was no significant main effect for Height Status ( $F_{(1,121)} = .09$ ,  $p > .10$ ,  $\eta_p^2 = .001$ ). Finally, there was a significant Balcony by Height Status interaction ( $F_{(1,121)} = 4.16$ ,  $p = .04$ ,  $\eta_p^2 = .03$ ). Follow-up tests revealed that within the high fear group, there was a significant effect for Balcony ( $F_{(1,59)} = 11.24$ ,  $p = .001$ ,  $\eta_p^2 = .16$ ), with high fear individuals overestimating the vertical extent more when they imagined themselves falling off the balcony (Balcony: Imagery) versus when they did not (Balcony: No Imagery). There was no significant effect for Balcony within the low fear group ( $F_{(1,61)} = .48$ ,  $p > .10$ ,  $\eta_p^2 = .008$ ), nor was there a significant between-group fear difference in height estimation on either balcony (both  $p > .10$ ). See Fig. 2. These results suggest that enhancing images of falling led to greater height overestimation, particularly for those individuals who were predisposed to be afraid of heights.

#### 2.3.2. Follow-up analyses

While the overall pattern of results was clear, we should note two surprising findings that emerged when conducting exploratory follow-up tests, looking at results for the 26- and 33-ft balconies separately. First, individuals low in height fear overestimated the balcony height more than individuals high in height fear on the No Imagery 26-ft balcony ( $F_{(1,61)} = 5.21$ ,  $p = .03$ ,  $\eta_p^2 = .08$ ). This finding contradicts an earlier finding from our lab (Teachman et al., 2008), where individuals high (versus low) in height fear *overestimated* the vertical extent of the same balcony. However, this surprising result in the current study should be

<sup>3</sup> One individual within the high fear group exhibited an extremely large height overestimation on the first balcony (three times the interquartile range for the rest of the scores within the high fear group, and within the rest of the scores across the entire sample); thus, this outlier data point was removed from all analyses.

interpreted cautiously given that there was no difference in height overestimation as a function of fear status for any of the other balcony comparisons (26-ft Imagery, 33-ft Imagery, 33-ft No Imagery; all  $p > .10$ ). Second, the height estimation results appear to be driven primarily by the 26-ft balcony (i.e., the main effect for Height Status and the Height Status by Imagery interaction were not significant when looking at the 33-ft balcony alone, but were both significant for the 26-ft balcony). One explanation for this discrepancy across balconies is that due to the shape of the 33-ft balcony, it was somewhat more difficult for participants to look over the balcony's ledge and back to the experimenter on the 33-ft (versus 26-ft) balcony, resulting in more measurement error and reduced opportunity for the imagery manipulation to impact height estimates.

### 2.3.3. Size overestimation

To provide a relatively less direct measure of visual perception, we also assessed the extent that participants overestimated the size of a disk. As expected, the visual matching tasks on both balconies were positively correlated with the size estimation tasks on both balconies (Balcony: Imagery size and height:  $r = .46$ ,  $p < .001$ ; Balcony: No Imagery size and height:  $r = .56$ ,  $p < .001$ ), suggesting that visual matching and size estimation both tapped into visual perception. In addition, to examine whether size estimation differed as a function of the imagery manipulation and/or fear status, we calculated a repeated-measures ANCOVA with one between-subjects factor (Height Status) and one within-subjects factor (Balcony: Imagery versus No Imagery). Contrary to expectations, there was not a significant effect for Height Status ( $F_{(1,49)} = .003$ ,  $p > .10$ ,  $\eta_p^2 < .0001$ ), Balcony ( $F_{(1,49)} = .0001$ ,  $p > .10$ ,  $\eta_p^2 < .0001$ ), or the Height Status by Imagery Status interaction ( $F_{(1,49)} = .10$ ,  $p > .10$ ,  $\eta_p^2 = .002$ ). Note, however, that these findings should be interpreted with caution given the limited sample size and power for this test (i.e., size data were not available for the full sample).

### 2.4. Relationships among perceptual and traditional height fear measures

We hypothesized that measures of perceptual biases and height fear would show the strongest relationships to one another when concerns about acting in the height environment were activated. Thus, we expected that height overestimation would be associated more strongly with state (than trait) measures of height fear, particularly on the Imagery balcony.

To examine relationships among variables, we first computed an average score across the state fear measures for both balconies: peak anxiety (referred to as SUDS-average), anxious cognitions (referred to as ACQ-average), and anxiety-related bodily sensations (referred to as BSQ-average). Additionally, we computed a total score for the AQ—Anxiety and AQ—Avoidance trait measure. Partially in line with predictions, the height estimates (using visual matching) were more strongly related to the measures reflecting state height fear on the Imagery (relative to No Imagery) balcony. Specifically, fear of bodily sensations (BSQ-average) and anxious cognitions (ACQ-average) were significantly related to height overestimation only in the Balcony: Imagery condition. Surprisingly, there was also a significant relationship in the *opposite* direction to hypotheses between trait height fear (AQ—Anxiety and Avoidance) and height overestimation in the Balcony: No Imagery condition. Finally, there was no significant relationship between AQ—Anxiety and Avoidance and height overestimation on the Imagery balcony, nor was there a significant relationship between height overestimation and SUDS-average. See Table 2.

Note, the pattern of correlations was fairly similar when examined solely within the high fear group, but the results more

**Table 2**

Pearson correlation coefficients among perceptual and 'traditional' height fear measures.

	Visual Matching: No Imagery Balcony	Visual Matching: Imagery Balcony
Anxious cognitions (ACQ-average)	.16 <sup>†</sup> [.35 <sup>**</sup> ]	.22 <sup>†</sup> [.29 <sup>*</sup> ]
Anxiety-related bodily sensations (BSQ-average)	.13 [.27 <sup>*</sup> ]	.23 <sup>*</sup> [.28 <sup>*</sup> ]
Peak state anxiety (SUDS-average)	.01 [.20]	.11 [.15]
Trait anxiety and avoidance (AQ—Anxiety and Avoidance)	-.19 <sup>†</sup> [-.19]	-.01 [-.16]

Note: The state fear measures reported in this table refer to the average score for both balconies, including: anxious cognitions (referred to as ACQ-average), anxiety-related bodily sensations (referred to as BSQ-average), and peak anxiety (referred to as SUDS-average). Additionally, AQ—Anxiety and Avoidance refers to the total score for the AQ—Anxiety and AQ—Avoidance trait fear measure. The numbers in brackets refer to correlation coefficients in the high fear group alone.

<sup>†</sup>  $p < .10$  level.

<sup>\*</sup>  $p < .05$  level.

<sup>\*\*</sup>  $p < .01$  level.

consistently followed hypotheses. Specifically, among individuals high in height fear, there was the expected significant positive relationship between height overestimation on the No Imagery balcony and ACQ-average ( $r = .35$ ,  $p = .005$ ) and BSQ-average ( $r = .27$ ,  $p = .03$ ). Furthermore, the surprising relationship between height overestimation on the No Imagery balcony and AQ—Anxiety and Avoidance did not reach significance ( $r = -.19$ ,  $p = .13$ ), though the magnitude of the effect was comparable. Despite some inconsistencies, overall these results suggest that, particularly among individuals high in height fear, the height estimates were more consistently related to the measures reflecting state (rather than trait) height fear, especially when costs of interacting in the environment were activated (i.e., on the Imagery balcony).

### 3. Discussion

The current study provides initial evidence that imagery designed to enhance the perceived costs of interacting in a high place may influence what people see at a perceptual level. As expected, we found that individuals overestimated the vertical extent of a balcony to a greater degree after they imagined themselves falling over the balcony's ledge, particularly if they were already afraid of heights. Notably, because we used a visual matching task that did not rely on verbal or retrospective report, it is unlikely that height overestimation was simply a function of distortions in judgment or other cognitive biases (as opposed to biased visual perception). This view is strengthened by the finding that the height estimates were positively related to estimates of disk size, an indirect measure of the vertical extent.

These findings raise a number of intriguing possibilities with respect to the relationship between perceptual biases and height fear. First, the effect of imagery on visual perception suggests that when participants enhanced the images of falling over the ledge, thereby presumably increasing the subjective costs of being on the balcony, this led to greater overestimations of the vertical extent. This fits with Proffitt's (2006) notion that visual perception is not only related to sensory input, but also to the subjective costs of acting in a given environment. If one fears that he or she will fall from a high place, it is adaptive to overestimate the height given that this presumably will serve as a deterrent from getting too close to the ledge. In other words, these findings suggest that fearful individuals are not only *thinking* about the world in a more threatening manner, they may be *seeing* it differently as well.

Nevertheless, we failed to find fear group differences in height overestimation. The primary exception to this pattern is our surprising finding that individuals low (versus high) in height fear actually overestimated the balcony height more on the No Imagery

26-ft balcony. These findings are contrary to previous research from our lab where we found that individuals high (versus low) in height fear were more likely to overestimate the vertical extent of a balcony (Teachman et al., 2008). Instead, in the current study we did find a significant interaction between height fear and the imagery condition. Individuals high in height fear overestimated the vertical extent of the balcony significantly more following the imagery induction (versus without imagery), but this did not occur for those low in height fear.

This finding is consistent with classic diathesis-stress models of psychopathology (Abela, Brozina, & Seligman, 2004) and implies these models might also apply to biased visual perception in fears and phobias. Specifically, these findings suggest that preexisting height fear may serve as a vulnerability (or diathesis) that leads to greater perceptual biases when triggered by a stressor (in this case, imagery designed to enhance perceived threat). One reason why we found fear group differences in height estimates in our previous work (Teachman et al., 2008), even without the explicit imagery stressor, may be that there was a lot of spontaneous imagery of falling occurring for the high fear group. This idea is supported by the finding in the current study of elevated rates of mental imagery of falling for the high fear group on the first balcony (before the imagery induction; see Fig. 1). It will be important in future work to determine when fear alone will be sufficient to amplify the perceived costs of acting in a high place and influence perception, or when a stressor will also be necessary (as in the current study). It is also possible that the relationship between perceptual and cognitive biases is bidirectional, and it will be critical to manipulate each bias independently in the future in order to evaluate their causal links more clearly.

Finally, we hypothesized that the relationships between measures of perception and height fear would be stronger when concerns about interacting in the environment were triggered. Partially in line with this idea, we found that estimates of height overestimation were more strongly related to the measures reflecting state height fear on the Imagery (versus No Imagery) balcony. Furthermore, when examining correlations solely within the high fear group, we found a significant positive relationship between height overestimation and anxious cognitions (ACQ-average) and fear of bodily sensations (BSQ-average) across both balconies. Note that in the current study, each of these measures was administered while participants were standing on the balcony, so the costs of being on the balcony (e.g., physical injury, psychological distress) were likely salient. Surprisingly, there was not a significant relationship between height overestimation and peak anxiety (measured with SUDS), another measure of state height fear. This null finding may have been due to measurement error, given that SUDS ratings (a single-item measure) have been shown to lack sensitivity to differences in highly anxiety-provoking situations (Tryon, 1977).

### 3.1. Limitations and conclusions

These findings must be interpreted in light of several limitations. First, it is difficult to draw firm conclusions about the disk size estimation task, given that only a subsample had available data. Additionally, while planned analyses were largely in line with hypotheses, exploratory follow-up tests revealed some inconsistencies. For instance, individuals low (versus high) in height fear actually overestimated the height more on one of the four balcony comparisons (26-ft Balcony: No Imagery). This finding directly contradicted earlier evidence from our lab (Teachman et al., 2008), and points to the possibility that individuals high in height fear may not experience greater perceptual distortions than those low in height fear, particularly when the costs of interacting in the environment have not been primed (e.g., through imagery).

Furthermore, our height estimation results seemed largely driven by the 26-ft (versus 33-ft) balcony. We recognize the limitations of interpreting exploratory follow-up analyses; thus, we believe it is important for future research to replicate our primary results using a variety of different balconies and converging measures of height estimation. Another potential limitation of the current study is that our balconies had differing heights. While we minimized this issue by using a ratio of height overestimation and by counterbalancing balcony order, it does make direct comparison across the balconies more difficult. Finally, it will also be valuable to replicate these findings in a diagnosed phobic, rather than high fearful sample.

In spite of these limitations, this study provides intriguing clues regarding the relationship between visual perception, imagery, and height fear. In particular, it appears that using imagery to enhance fears of interacting in a dangerous environment can alter the perception of that environment. Results also suggest that height fear may serve as a vulnerability factor that leads to perceptual biases when triggered by a stressor (in this case, images of falling). It will be critical to determine which stressors interact with height fear to enhance the costs of acting in a high place, because we expect that perceptual biases will be most apparent when these costs are heightened. Finally, exploring the parameters under which perceptual biases will be related to other markers of fear, as well as determining the extent to which these biases predict onset and maintenance of fears and phobias, will be important next steps.

### Acknowledgements

The authors would like to thank the Program for Anxiety Cognition & Treatment (PACT) Lab for their helpful feedback. For research assistance, thanks to: Christopher Chen, Timothy Aikens, and Christina Appleman. Finally, this research was supported by an NIH RO1MH075781-01A2 grant to Dennis Proffitt and Bethany Teachman.

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