Original Article

Fear influences perceived reaching to targets in audition, but not vision

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A B S T R A C T

The superordinate mechanism view of emotions predicts that fear should influence perception to carry out the evolved function of overcoming immediate threats. Previous work demonstrates that fear does adaptively influence visual perception. However, there are recurring situations in which auditory perception is used for overcoming immediate threats (e.g., avoiding predators after dark). Some research suggests that the auditory system, independent of fear, is adaptively biased to hear approaching sounds as closer than equidistant receding sounds (a.k.a. the looming bias). The present study investigated whether fear, as a superordinate mechanism, influences auditory perception such that sounds are perceived to be closer, ultimately providing an advantage when avoiding immediate threats. Participants judged whether or not they could reach to an aurally or visually perceived target while either in a fearful or neutral state. The results demonstrated that while in a fearful state, participants judged targets to be closer to them, but only when the target was perceived aurally. This finding extends previous work on adaptive biases in auditory perception to include the influence of fear.

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1. Introduction

Fear evolved to solve the recurring adaptive problem of quickly avoiding or overcoming an immediate threat (e.g., avoiding cliffs, hiding from a predator; Marks & Nesse, 1994; Nesse, 1990; Ohman, 2009). The superordinate view of emotions, proposed by Tooby & Cosmides (2008), suggests that emotions operate to coordinate the activity of many other processes in order to carry out an evolved function. Therefore, fear should impact many other processes as a means to overcoming immediate threats. For example, if you are hungry and searching for food when a predator appears in the distance, the emergence of fear could suddenly override your foraging behavior to prepare you for running, fighting, or hiding. This example highlights the particular influence fear may have on hunger and foraging processes, but the superordinate view of emotions predicts that fear can coordinate the activity of many other processes, including perception.

Stefanucci and Proffitt (2009) provided initial correlational evidence suggesting that fear is capable of influencing visual perception. In their work, higher fear of heights was correlated with greater estimates of the extent of the height. Similarly, fear has been shown to increase the reported steepness of hills when viewed from the top of the hill (Stefanucci, Proffitt, Clore, & Parekh, 2008). Further research demonstrates that participants overestimate short heights (e.g., less than 3 meters) when there are negative consequences for jumping off of that height (i.e., nail- and glass-filled pool below; Stefanucci, Gagnon, Tompkins, & Bullock, 2012). These findings are in line with the superordinate view of emotions, demonstrating that fear carries out its evolved function to avoid threats, in part, by influencing visual perception.

Although humans rely heavily on visual information to understand the location or size of objects in the environment, there are crucial and recurring situations in which visual information alone is not sufficient to overcome a threat. For example, humans may have to detect predators at night with very little, if any, light source available. Similarly, when hiding, auditory information can be used to determine the proximity of a predator without the risk of revealing oneself to visually perceive it. Finally, in environments in which distant visual information is obscured (e.g., thick woods, inside buildings), auditory information can be used to detect the presence and location of a threat. Importantly, these recurring scenarios would allow evolution to shape a specific relationship between fear and auditory perception, but the lack of visual information about the threat would not necessarily be required for a fear and auditory perception relationship to emerge via natural selection. That is, humans often had to avoid threats when both visual and auditory information was present, in which case, we suggest that fear could adaptively bias both perceptual modalities.

Independent of emotion, research has shown that people can use audition to determine multiple properties about an inhabited space. For example, participants are able to judge whether an object is within reach from hearing the object (Rosenblum, Wuestefeld, & Anderson, 1996), judge whether an aperture affords passage from hearing sounds played through the aperture (Russell & Turvey, 1999), and determine the general size of a space from transient sounds (Robart &
Rosenblum, 2005). In addition, Neuhoff (2001) suggests that the auditory system is adaptively biased to allow one to perceive an approaching sound to be closer than an equidistant receding sound. This bias to hear approaching sounds as closer is greater for those who are physically less able to escape that potential threat (Neuhoff, Long, & Worthington, 2012). In addition, recent work that examined the influence of fear on auditory perception found that neutral tones are perceived to be louder when in a state of fear relative to a neutral state (Siegel & Stefanucci, 2011). This tendency to perceive sounds as louder when frightened could indicate that the sound was perceived as closer, in line with Neuhoff’s (2001) explanation. However, since the amplitude of a sound does not always correlate with the distance to the sound source, a more direct test of the perceived distance to a sound is needed to understand the potential adaptive relationship between audition and fear. The current study investigated whether participants in a fearful state estimated the distance to an object in the environment, presented either visually or aurally, to be closer than those in a neutral state.

Although fear may change perceptual processes, if it does not ultimately change action, it does little to help the organism overcome an immediate threat. Theoretical (Gibson, 1979, Proffitt, 2006) and empirical (Warren, 1984; Warren & Whang, 1987; Witt, Proffitt, & Epstein, 2005) work suggests that the function of perception is to regulate action. Thus, if fear alters perception (as has been shown in previous work), then it may also regulate actions through perception. Specifically, fear might change which actions the organism decides to initiate (e.g., continue to eat or run), how they perform these actions (e.g., walk or run), and when they perform them (e.g., hide now and run later). Although the current investigation does not measure a behavioral response to a potential threat, it does measure a perception that should be important for regulating this behavioral response.

To measure distance perception in this study, we asked participants about their ability to reach to a target. Specifically, participants estimated whether or not they could reach an object that was only seen (and not heard) or only heard and not seen. This measure is known as an affordance judgment because it requires participants to relate their body’s capability for action to the perceived stimulus in the environment (Gibson, 1979). For example, a chair affords sitting if a participant is tall enough to effectively sit on it and the object is strong enough to hold the participant’s weight (Mark, 1987). A distance affords reaching if an observer is able to stretch her arm to cover that distance without being impeded. The current study used reaching judgments as a measure of perceived distance to a visual or auditory object. The same affordance measure (i.e., “reachability”) was used in previous work and showed that participants are accurate in judging whether a sound is within reach or not (Rosenblum, Wuestefeld, & Anderson, 1996). We used affordance judgments for three reasons. First, they are one of the few perceptual measures that allow us to make comparisons across modalities, such as vision and audition. Second, affordance judgments are sensitive to the animal–environment relationship, while verbal reports of absolute spatial dimensions (e.g., it is 2 m away) are not (Rosenblum et al., 1996). As such, it has been demonstrated that people are more accurate in making judgments related to their own action capabilities in comparison to judgments made about absolute spatial dimensions (Rosenblum et al., 1996; Bingham, Schmidt, & Rosenblum, 1989). Third, one of the seminal articles (Rosenblum et al., 1996) examining auditory distance perception used affordance judgments (i.e., reachability). It is important to remain methodologically consistent with previous work so that meaningful comparisons can be made across studies.

We asked participants to make a judgment about whether or not they could reach to a target. Their judgment would necessarily relate to their perception of the distance to the target in order to make a response. It is important to distinguish this judgment from behaviors that are more typically related to avoiding a potential threat (e.g., running or hiding). Although we think behaviors related to avoiding a potential threat should be influenced by one’s perception of the distance to the threat (e.g., when to run or hide), judgments of reach allow us to systematically and precisely test the influence of fear on distance perception.

Given prior research, we hypothesized that participants in a state of fear would perceive sounds to be closer than participants in a neutral state. Such a finding would suggest that fear and auditory processes coordinate to provide the organism with a functional bias, consistent with the error management theory (Haselton & Buss, 2000) and Neuhoff (2001) account of the looming bias. Perceiving a sound to be closer when in a state of fear might encourage one to run from a predator before it is too late, or remain hidden from a nearby predator for a longer period of time.

We also included visual estimates to test the boundary conditions for the influence of fear on perceptual processes. Previous work found that fear influenced judgments of dangerous extents, but had no influence on safe heights and distances (Stefanucci & Torbeck, 2009; Stefanucci, Gagnon, Tompkins, & Bullock, 2012). These findings suggest that fear may only influence the perception of spatial dimensions that are indicative of an immediate threat (e.g., high heights), demonstrating there are conditions under which the influence of fear on perception does not hold (i.e., a boundary condition). In the current study, we are primarily interested in the influence of fear on auditory perception. It is unknown whether fear will influence visual perception as well. Though our stimuli are visually and aurally neutral, identifying the level of threat associated with the object may be more difficult with only auditory information. Thus, we might expect fear to only influence audition as participants in the vision condition could be more certain that the stimulus is not a threat.

2. Method

2.1. Participants

Sixty-Seven (40 female, 27 male) University of Utah students participated in the experiment for course credit. All participants had normal or corrected to normal vision and reported no known hearing problems. In addition, all participants were naïve to the purpose of the experiment and gave written informed consent.

2.2. Apparatus

Participants either viewed or heard a commercial dog training clicker (3 cm diameter; www.aboutdogtraining.com) in a 2.39 m tall by 3.85 m long by 2.65 m wide uncluttered (nearly empty) room. The participant sat in front of a table (91.5 cm × 91.5 cm × 75 cm) so that their chest was located 35 cm from the edge of the table. The table was located in the center of the room. Participants wore a blindfold in between trials in the vision condition and for the duration of the experiment in the audition condition.

2.3. Design

Condition (fear, neutral) and modality (vision, auditory) were fully crossed as between-participant factors resulting in four conditions. Participants were randomly assigned to one of the conditions. Each participant estimated whether they could reach out and touch the clicker 3 times at 16 different distances (35 cm to 110 cm at 5 cm intervals). The average arm length in our sample was 69.2 cm (SD = 5.55). Mean and standard deviations of arm lengths for each condition were: Auditory Neutral (M = 69.0, SD = 3.80), Auditory Fear (M = 68.3, SD = 7.20), Vision Neutral (M = 69.8, SD = 5.79), Vision Fear (M = 69.0, SD = 5.40). The mean arm length and variability in arm length did not differ across conditions (ps > .05). Therefore for each
condition half of the target distances were within reach and half were out of reach. For each judgment of reach, participants also rated how confident they were in their answer. The presentation order of distances was randomized.

In this design the vision condition contains much more information that can be used to specify the distance to the target than the auditory condition. For example, the vision condition contains distance cues from lighting and shading, familiar size, texture gradient, and accommodation information. However, outside of experimentally controlled labs, visual information nearly always contains more information that can be used to determine distance than auditory information (Loomis et al., 1998). The current study was primarily concerned with whether fear can influence auditory distance perception under the most ecological valid conditions possible. Furthermore, if these results are to generalize to real world scenarios in which humans have evolved, then maintaining ecological validity is important.

2.4. Procedure

After participants signed the informed consent, they completed a modified version of the Positive and Negative Affective Schedule (PANAS: Watson, Clark, & Tellegen, 1988) for which they rated on a scale of 1 to 5 how much they were currently feeling six emotions (calm, nervous, anxious, afraid, at ease, and scared). The experimenter told participants they would be writing about events that had occurred in their lives. They would start writing and then would be asked to take a break before finishing their writing. The participants were told that the purpose of the experiment was to determine whether taking a break affects writing about past personal events. The experimenter asked the participants if they would be willing to “help another lab” by participating in another experiment during the break from writing. All participants agreed to participate. They were then told about the procedure for the reaching task (based on the condition to which they were randomly assigned). They performed two practice trials for the reaching judgments. For these practice trials, participants either saw or heard the clicker and judged whether they could reach the clicker. In both conditions participants were free to move their head during the entire experiment, allowing them to obtain more information about the location of the auditory stimuli through auditory parallax. A ‘yes’ response indicated that participants believed they could stretch out their arm and touch the clicker without leaning forward at the waist. A ‘no’ response meant that they did not believe they could reach the clicker. After each ‘yes’ or ‘no’ response, participants rated on a scale of 0–7 how confident they were that their response was correct, with 7 being they were absolutely sure that their ‘yes’ or ‘no’ response was correct and 0 being they had no idea whether their judgment was correct.

After completing all 39 trials, participants’ arm lengths were measured from the intersection of their arm and chest out to their finger tip. They also completed the same survey of currently felt emotions as they did at the beginning of the experiment, but were asked to rate how they felt during the writing task. These second ratings of emotion were given after the affordance judgments so that they did not 1) dissipate participants’ level of fear by associating their fear with the writing task or, 2) help participants intuit the hypothesis and alter their judgments. Finally, participants were told that they would not have to continue writing.

3. Results

3.1. Manipulation check

Difference scores were calculated from the pre-manipulation and post-manipulation scores for each item on the modified version of the PANAS. For positive items, like ‘calm,’ the post-manipulation scores were subtracted from the pre-manipulation scores. For negative items, like ‘afraid,’ the pre-manipulation scores were subtracted from the post-manipulation scores. Therefore, positive difference scores on all items indicated that the participant became more afraid due to the manipulation. Negative difference scores indicated that they became less afraid.

A 2 Condition (fear, neutral) × 6 Item (calm, at ease, nervous, anxious, afraid, scared) repeated measures ANOVA was run on the difference scores with condition as a between-participants factor and item as a within-participants factor. There was no significant effect of item, ANOVA: F1, 65 = 0.56, P = 0.46. There was a significant main effect of condition, ANOVA: F1, 65 = 7.63, MSE = 2.7, P = 0.007, ηp2 = 0.11. In the fear condition, participants ratings of emotions exhibited a greater positive change (Mean ± SE = 0.40 ± 0.12) than participants in the neutral condition (Mean ± SE = −0.05 ± 0.12; see Fig. 1). These

![Fig. 1. The average change in self-reported emotions from pre-manipulation to post-manipulation for both neutral and fear conditions. Positive scores indicate an increase in the emotion labelled on the x-axis. Error bars represent ± 1 S.E.M.](image-url)
results demonstrated that writing about a fearful experience raised participants’ level of fear in this study.

3.2. Affordance judgments

For each participant, we determined the cross-over point to be the furthest distance that each participant indicated they could reach on 2/3 of the trials (Burton, 1992; Carello, Grossofsky, Reichel, Solomon, & Turvey, 1989; Gordon & Rosenblum, 2004; Heft, 1993; Wagman & Taylor, 2005). In addition, participants must have indicated that they could reach the target on 2/3 of the trials for each distance shorter than this furthest ‘yes’ distance. Analyses were run on the ratio created by dividing the judged reachable distance by the participant’s arm length (i.e., their actual reaching ability). This calculation captured the average perceived “reachability” scaled to each participant. Therefore, a ratio of 1.0 is interpreted as the participants judging that their average reach is the same as their arm length. A ratio larger than 1.0 suggests that participants perceived a target to be within reach, when it was outside of their actual reach, and a ratio less than 1.0 suggests that participants perceived a target to be out of reach when it was in fact within their reach. A 2 Condition (fear, neutral) × 2 Modality (vision, audition) univariate ANOVA was conducted on the ratio of judged distance over actual distance with both condition and modality as between-participants factors. There was a significant main effect of condition such that participants in the fear condition indicated that they could reach to farther distances (Mean±SE=1.14±0.04) than participants in the neutral condition (Mean±SE=0.97±0.04), ANOVA: F 1, 63 = 7.99, MSE = 0.06, P = 0.006, η² = 0.11. There was no main effect of modality, ANOVA: F 1, 63 = 1.3, P = 0.26. However, there was a significant interaction between condition and modality, ANOVA: F 1, 63 = 4.44, MSE = 0.06, P = 0.039, η² = 0.066 (see Fig. 2).

Planned comparisons were run to test the influence of the fear manipulation within each modality. In the auditory modality, participants in the fear condition (Mean±SE=1.17±0.08) indicated that they could reach to significantly farther distances than participants in the neutral condition (Mean±SE=0.88±0.08), ANOVA: F 1, 30 = 6.61, MSE = 0.1, P = 0.015, η² = 0.18. In the visual modality, there was no difference between participants in the fear (Mean±SE=1.11±0.03) and neutral conditions (Mean±SE=1.07±0.03), ANOVA: F 1, 33 = 0.89, P = 0.35. There was a significant difference between affordance judgments for participants in the auditory neutral condition (Mean±SE=0.88±0.05) and the visual neutral condition (Mean±SE=1.07±0.05), ANOVA: F 1, 31 = 6.54, MSE = 0.05, P = 0.016, η² = 0.18. The average ratio in the auditory neutral condition of 0.88 (underestimation of reach) is similar to that found by Rosenblum, Wuestefeld, & Anderson (1996) of .94 for long armed participants and .91 for short armed participants when participants are asked to reach without leaning forward. The average ratio in the vision neutral condition of 1.07 (overestimation of reach) is also what is commonly found when participants are asked to judge their reach without feedback of their arm length and at midline positions of the body (Bootsma et al., 1992; Carello et al., 1989).

3.3. Confidence ratings

For each participant, we analyzed the confidence ratings for the farthest distance the participant indicated that they could reach and the shortest distance the participant indicated they could not reach. We analyzed only the confidence ratings around participants’ cross-over points (i.e., when they switched from ‘yes’ to ‘no’ responses) because confidence in a decision is more behaviorally relevant when a decision needs to be made than when the correct decision is obvious (i.e., at extremely close or far distances). This approach for analyzing confidence ratings in affordance judgments has been used in prior studies (Wagman & Taylor, 2005). A 2 Condition (fear, neutral) × 2 Modality (vision, audition) × 2 Distance (closer or farther distance) × 3 trial repeated measures ANOVA was run with confidence ratings as the outcome and condition and modality as between-participants factors. There was no significant main effect of condition, ANOVA: F 1, 63 = 0.81, P = 0.37. However, there was a significant main effect of modality such that participants in the auditory conditions were, on average, less confident in their decisions (Mean±SE=4.55±0.18) than participants in the visual conditions (Mean±SE=5.17±0.18), ANOVA: F 1, 63 = 6.11, MSE = 6.41, P = 0.016, η² = 0.088.

Interestingly, there was a trend toward a significant interaction between modality and condition, ANOVA: F 1, 63 = 3.57, MSE = 6.41, P = 0.063, η² = 0.054 (see Fig. 3). The influence of the fear manipulation on confidence in judgments was different across the two modalities. Specifically, participants in the auditory condition were more confident in their judgments than participants in the auditory neutral condition. However, participants in the visual fear condition were less confident than participants in the visual neutral condition.

4. Discussion

The results show that under the current experimental conditions, writing about a fearful event influenced auditory distance perception but not visual distance perception. Specifically, afraid participants
judged aurally presented targets to be reachable at distances that were 33% further than participants who were not afraid.

The effect of fear on reachability judgments made from auditory information can be interpreted in one of two ways. First, participants could have perceived their arm length to be longer when experiencing more fear, suggesting that targets out of reach were actually within reach. Second, participants could have heard the sound to be closer when experiencing more fear, suggesting that the targets were closer, and more likely to be within reach. We believe the second option to be more likely given that previous work has shown that sounds are rated as louder when afraid than when not (Siegel & Stefanucci, 2011) and that there was no effect of fear in the vision condition. If sounds are perceived to be closer when afraid than when not afraid, then this would encourage one to run or hide from a threat sooner.

In our study, there was not a significant difference in reachability judgments between the fearful and non-fearful groups in the vision condition. The null effect of fear on cross-over points for vision is consistent with previous work that found that anxiety did not influence cross-over points for judgments of reach (Bootsm et al., 1992). There are several reasons why this may have occurred. First, there were differences in the quantity and quality of information about the stimulus available in the auditory and visual conditions. In particular, the visual condition contained lighting, shading, familiar size, texture gradient, and accommodative information that the auditory condition did not contain, all of which are known to be useful cues to distance. As such, the target percept was likely better specified in the vision condition compared to the auditory condition allowing fear to have a greater (and experimentally detectable) influence on audition, but not vision. We have made a similar argument for why fear seems to influence height perception, but not distance perception on the horizontal ground plane (Stefanucci & Storbeck, 2009). That is, cues specifying the extent of a height are reduced in comparison to those present when judging extents on the ground. Second, participants wrote about a fearful event and then judged whether they could reach to various distances. However, the stimuli were not inherently threatening. In the vision condition, it is possible that after seeing the benign target, participants did not use fear as information for estimating reach because it was somewhat irrelevant in a clearly non-threatening environment. Indeed, prior work showed that one's level of arousal influences visual perception when the stimulus is dangerous but not when it is benign (Stefanucci & Storbeck, 2009).

In the auditory condition, participants' level of fear may have influenced perceived reachability because the nature of the stimulus was more ambiguous and less benign than in the visual condition. Furthermore, participants in the auditory condition were unaware of the size of the room, so they may have been surprised if the distances seemed close on some trials. Also, the sounds from the target were fairly loud and their onsets were not as predictable as in the vision condition. These elements of surprise and unpredictability may have made the auditory condition more threatening in the context of our study, thereby keeping levels of fear higher throughout the study as compared to the vision condition. Although participants gave self-reports of fear after the experimental trials, they were asked to rate their emotions during the writing task, and not necessarily how they felt during the reaching task. Future work might consider including continuous measures of fear to address the possibility that levels of fear differed across conditions during the reaching task. Given this, our current study was not able to detect an influence of fear on visual distance perception, but there is no reason to believe that this relationship could not be demonstrated using a different methodology.

The recurring contexts in which a fear and auditory perception relationship likely evolved imply that visual information was either degraded (e.g., thick woods), or altogether absent (e.g., night time). Under these circumstances how does one know if a sound is good or evil if the source of the sound is not visible? Although there are cases in which a sound overwhelmingly indicates danger (e.g., sound of a rattlesnake, or snarling growls), more often than not predators make threat-neutral sounds (e.g., footsteps snapping twigs on the ground). In this situation, it is less costly to assume a neutral sound to be a threat, than to assume it to be a friend (Neuhoff's (2001) finding that participants hear approaching sounds to be closer than equidistant receding sounds supports this possibility. In addition, neutral tones were used suggesting that we err on the side of caution and hear the sound as approaching faster, even if there is a good chance that what is approaching is not harmful. If auditory stimuli are more ambiguous in terms of threat evaluation, it is possible that one merely needs to feel afraid (and not necessarily be afraid of a particular target) in order for fear to influence audition. However, just feeling afraid or aroused does not influence the perception of non-threatening visual targets (Stefanucci & Storbeck, 2009; Stefanucci, Gagnon, Tompkins, & Bullock, 2012). Future research should manipulate the perceived threat of the target both with vision and audition.

It is important to note that the current study does not truly address whether hearing the sound as closer adjusts the selection of an action, how the action is performed, or when the action is performed. We measured judgments about a potential action that would indicate how far away participants perceived the target. We never measured the actions themselves, nor did we measure actions that a human would likely take when faced with a threat (e.g., running or hiding). Therefore, we must acknowledge that the subsequent discussion of how the influence of fear on auditory perception might change action is purely speculative. First, we asked participants to make judgments about whether or not they could reach the target. Reaching is not usually a threat avoidance behavior, but reaching gave us an indication of the participants' perceived distance to the targets, which was our main question of interest. If fear is adaptively biasing auditory perception such that potential threats sound closer, then we might expect other threat avoidance behaviors, like running, to be initiated earlier. Theoretically, if fear does not have an impact on action, then it does little to help the organism overcome a threat, making any change to perception a moot point. However, one must decide which action to perform and when to perform it, meaning that fear can encourage adaptive behaviors through changes in perception. Further, if one is not confident in their judgments about potential actions, they are less likely to perform that action. For example, if you are unsure whether you can climb a rather tall step, you are less likely to attempt it. Similarly, if sounds are heard to be closer while in a state of fear in order to encourage one to run, hide sooner or remain in hiding longer, then one would also have to be fairly confident about the distance to the sound so as not to debate too long about which action is best. Within the auditory condition, there was a trend towards those in the fear condition being more confident in their judged reachability as compared to those in the neutral condition.

Finally, it is not clear from this experiment whether fear influences auditory perception directly, which in turn influences judgments of action, or if fear influences decisions about actions while bypassing an influence on perception. Both interpretations of the effect of fear on affordance judgments are supported by our results. However, two pieces of evidence lead us to believe that fear may influence judgments through a change in auditory perception. First, previous work has shown that sounds are rated as louder when one is more afraid (Siegel & Stefanucci, 2011). Second, if fear influenced only decisions about actions, then an influence of fear on vision would have appeared in addition to that observed in the auditory condition, given the decision process was likely similar across modalities. This was not the case, which suggests that fear does not generally bias judgments of action capability across modality. There is a third possibility that cannot be ruled out with the current investigation. That is, fear could influence perception without influencing action. Work on the two visual streams hypothesis (Goodale & Milner, 1992) has
demonstrated instances when perception and action appear independent of one another. Therefore, it is possible that fear may only influence perception without influencing action. Future work might consider measuring threat avoidance behaviors to examine this possibility. However, as stated in the introduction as well as in Neuhoff et al. (2012), we believe this possibility is unlikely. If fear influences perception to provide the organism with an adaptive bias that allows it to more successfully avoid immediate threats, then this should be reflected in the organism's behavior. A fear and perception relationship would not evolve through natural selection without having an impact on behavior that ultimately provided a more successful strategy in overcoming immediate threats. If indeed the influence of fear on perception does not ultimately change behavior in at least some circumstances then it is possible that our observed effect is not an adaptive bias.

Our results support the hypothesis that while in a state of fear people hear the source of sounds to be closer to them. Specifically, our results are consistent with Siegel & Stefanucci's (2011) finding that in a state of fear, sounds are perceived to be louder. Perhaps sounds are perceived to be louder as a result of actually hearing them to be closer, thereby creating an adaptive bias in preparing to take action during predator avoidance. However, our results cannot confirm this to be the case. In addition, this finding augments Neuhoff et al.'s (2012) work on the adaptive looming bias. Human evolutionary history has certainly shaped how we interact in our ecology using visual information, but the problem of avoiding immediate threats was certainly shaped how we interact in our ecology using visual information present to guide actions. This is the first study to our knowledge, that demonstrates the possibility that fear can adaptively bias auditory perception as well.

References


