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Spiders appear to move faster than non-threatening objects regardless of one's ability to block them☆

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ABSTRACT

We examined whether perception of a threatening object – a spider – was more accurate than of a non-threatening object. An accurate perception could promote better survival than a biased perception. However, if biases encourage faster responses and more appropriate behaviors, then under the right circumstances, perceptual biases could promote better survival. We found that spiders appeared to be moving faster than balls and ladybugs. Furthermore, the perceiver's ability to act on the object also influenced perceived speed: the object looked faster when it was more difficult to block. Both effects – the threat of the object and the perceiver's blocking abilities – acted independently from each other. The results suggest effects of multiple types of affordances on perception of speed.
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1. Introduction

An intuitively appealing idea is that perception should accurately represent the world as it is. Perception is the only source of information about the external world, and thus it stands to reason that a more accurate perception would be more adaptive. The system could handle some error due to noise and some systematic biases, yet one might expect (and hope) perception to be more resistant to these errors in critical situations. By critical situations, we mean situations that necessitate immediate, appropriate actions where behavioral errors could have important consequences. One example of a critical situation is the presence of a nearby threat. Thus, one hypothesis is that perception of a threatening object would be more accurate and resistant to perceptual biases.

Some existing research provides support for this hypothesis. Contrast sensitivity increases after viewing fearful faces (Phelps, Ling, & Carrasco, 2006). Although the fearful faces themselves are not threatening, they are indicative of threat nearby. After viewing a fearful face, participants were able to detect the orientation of sinusoidal gratings of lower contrasts than after viewing a neutral face. Thus, just as one might hope and expect, perception was more accurate in the presence of an indication of threat.

Another example of when perceptual sensitivity increases in the presence of a threat is derived from experiments with looming stimuli (Lin, Murray, & Boynton, 2009). Participants performed a challenging visual search task where they had to determine the orientation of an oval presented among circles. Prior to each search, a cue was presented. The cue was a circle that moved towards the observer and was either a looming target or a near miss. Had the circle continued on its trajectory, looming targets would have collided with the observer whereas near misses would pass by the observer without collision. The cue was either presented at the same location as the target or at the same location as a distractor. The target search was most efficient when the cue was a looming object and at the same location as the target. Looming objects pose a threat, and these results demonstrate that perception is more efficient to find target objects when they occur at the same location as the threat. In another experiment, visual search efficiency also increased after previously viewing a fearful face compared to a neutral or happy face (Becker, 2009).

A third example reveals a reduced bias in perceived size when the object contains an image with negative valence (van Ulzen, Semin, Oudejans, & Beek, 2008). Circles were presented with positive, neutral, or negative images superimposed on the circles. The perceived size of these circles was underestimated compared to a circle with no superimposed image. However, this bias to see the circles as smaller was reduced for circles with a negative image. These circles were still underestimated compared to blank circles but were not underestimated as much as circles with neutral or positive images.

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While these studies suggest increased perceptual sensitivity and accuracy in the presence of a threat or a negative stimulus, there is also evidence that perception in fearful situations is less accurate and more prone to biases. This evidence (reviewed below) is consistent with the New Look approach to perception. According to this approach, perceivers see objects in terms of their need and value (Bruner, 1992). For example, coins worth more look bigger than coins that are worth less, and poorer children see coins as bigger (Bruner & Goodman, 1947). The New Look approach was discounted largely based on methodological issues and the use of ambiguous terms (Carter & Schooler, 1949; Gordon, 2004), but the studies reviewed below are consistent with and provide new evidence for the New Look approach to perception.

One perceptual bias that is exaggerated in the presence of a threat is apparent in the perception of hill slant. In non-threatening situations, hill slant is grossly overestimated (Proffitt, Bhalla, Gossweiler, & Midgett, 1995). In a fearful situation, perception of hill slant is even more overestimated than in a non-fearful situation (Stefanucci, Proffitt, Clore, & Parekh, 2008). Participants viewed a hill from on top while standing on a skateboard or on a wooden platform. None of the participants had skateboarding experience, so standing on a skateboard created a fearful situation. In this case, the participants perceived the hill to be even steeper than did participants who stood on the wooden platform.

Another bias is also apparent in perception of heights, which also tends to be exaggerated (Stefanucci & Proffitt, 2009). Vertical extents look farther than their actual extent. Moreover, when the vertical extent is viewed from on top of a balcony, the perceptual exaggeration of the extent increases relative to when the extent is viewed from on the ground below. The balcony poses the threat of falling with severe consequences. Again, according to the original hypothesis proposed earlier, one might expect perception to be more accurate and less prone to bias in such a critical situation. Instead, these perceptual biases were further exaggerated.

More recently, research demonstrated that fearful objects look bigger and closer than neutral or disgusting objects. Perceived size of a live spider was correlated with spider phobia ratings (Vasey et al., 2012). In non-phobic participants, similar biases are also apparent. In one study, a live spider was placed on a toy train track, and participants had to pull the spider closer, then estimate the distance to the spider. Participants with depleted psychosocial resources, and thus with less capacity to cope with a threat, estimated the distance to the spider as closer than did participants who estimated the distance to a cat toy (Harber, Yeung, & Iacovelli, 2011). In another study, a live spider was placed on a tabletop, and participants rated their fear of the spider and their disgust of the spider (Cole, Balcetis, & Dunning, 2013). Fear ratings negatively correlated with perceived distance to the spider. Those who rated the spider as more fearful than did others perceived the spider to be closer. In a second study, participants met a confederate then watched a video in which he described himself performing threatening behaviors, disgusting behaviors, or neutral behaviors. Afterwards, the participant and confederate reconvened, and the participant judged the distance to the confederate. Participants who viewed the video describing threatening behaviors judged the confederate to be closer than did participants who viewed the video describing disgusting or neutral behaviors. In other words, the confederate looked closer when he was seen as a threat than when he was seen as disgusting or neutral.

In the last set of studies, the authors argued that threat, but not disgust, influences perceived distance because threat calls for immediate action (or at least immediate preparation for action) and that seeing the threatening object as closer could promote faster preparation time for action (Cole et al., 2013). In the current experiments, we extend on these findings to examine if threat also influences perception of speed. We tested whether a threatening object looks to be moving faster than a neutral object. Just as seeing a threatening object as closer could promote faster preparation for action, seeing a threatening object as moving faster could also be adaptive in promoting faster action preparation.

1.1. Does threat modulate action-specific effects?

The second aim of the current studies was to examine the relationship between two types of effects on perception: 1) the effects of threat on perception and 2) the effects of a person's ability to act on perception. The latter effects are known as action-specific effects on perception (Proffitt, 2006; Witt, 2011). For example, a softball player who is hitting better than others sees the ball as bigger (Gray, in press; Witt & Proffitt, 2005). Similarly, objects that are easier to block look to be moving slower (Witt & Sugovic, 2010, 2012). Dozens of studies have found effects of a variety of actions including walking, throwing, kicking, jumping, climbing, swimming, reaching, grasping, batting, hitting, putting, and shooting on perception[1]. Yet almost no research has examined the connection between ability-related effects and threat-related effects on perception.

These two types of effects could relate to each other in a number of ways. First, the two effects could operate independently from each other, and in an additive fashion. In this case, an object would look differently based on a person's ability to act on the object and also look differently based on the potential threat of the object. A result of separate, independent effects is predicted by claims that the two types of effects are driven by different anatomical mechanisms. Threat-based effects are thought to arise from processes in the amygdala (e.g. Phelps, 2006), whereas ability-based effects are thought to arise from premotor processes (Witt & Proffitt, 2008; Witt, Sugovic, & Taylor, 2012).

A second possibility is that threat could reduce or eliminate action-specific effects. In other words, a perceiver sees the world in terms of his or her ability to act but only in the absence of threat. In the presence of a threat, the world would be perceived in relation to the given threat and independently of the perceiver's ability to act. This idea has support from a previous experiment. Participants threw darts while standing on rock climbing footholds placed near the ground or several meters above ground. In the low height condition, dart throwing performance influenced perceived size of the target (Cañal-Bruland, Pijpers, & Oudejans, 2010), replicating previous work (Wesp, Cichello, Gracia, & Davis, 2004). Participants who hit the target more successfully than others perceived the target to be bigger. However, dart throwing performance did not influence perceived size in the high height condition. In the high height condition, the threat of falling was present and salient, and in this condition, perception was not influenced by the person's ability to successfully throw the darts. This study found that biases in perception based on a person's ability to act were eliminated in the presence of a threat.

A third possible outcome is that action-specific effects might modulate the effect of threat on perception. Under conditions for which there is a low likelihood of performing an action successfully (i.e. low ability to act), threat might have a large influence on perception. For example, a spider might appear much faster if a person is not capable of successfully blocking the spider. In contrast, under conditions for which there is a high likelihood of performing an action successfully (i.e. high ability to act), threat might have little-to-no influence on perception. For example, a spider might not appear any faster than a neutral object if both are easy to block.

[1] Bhalla & Proffitt, 1999; Bloesch et al., 2012; Cañal-Bruland & van der Kamp, 2009; Cañal-Bruland, Pijpers and Oudejans, 2010, 2012; Canal Bruland, Zhu, van der Kamp, & Masters, 2011; Davoli, Brockmole, & Witt, 2012; Doerrfeld, Sebanz, & Shiffrar, 2012; Geuss, Stefanucci, de Benedictis-Kessner, & Stevens, 2010; Kirsch & Kunde, 2012; Kirsch, Herbort, Butz, & Kunde, 2012; Kwon & Kim, 2012; Lee et al., 2012; Lessard, Linkenauger, & Proffitt, 2009; Linkenauger, Witt, Stefanucci, Bakdash, & Proffitt, 2009; Linkenauger, Mohler, & Proffitt, 2011; Linkenauger, Ramenzoni, & Proffitt, 2010; Linkenauger, Witt, & Proffitt, 2011; Moragado, Gentaz, Guinet, Osiurak, & Palluel-Germain, 2012; Osiurak, Morgado, & Palluel-Germain, 2012; Proffitt, Stefanucci, Banton, & Epstein, 2003; Schnall, Zadra, & Proffitt, 2010; Stefanucci & Geuss, 2009, 2010; Stefanucci, Proffitt, Banton, & Epstein, 2005; Taylor, Witt, & Sugovic, 2011; Van der Hoort, Guterstam, & Ehrsson, 2011; Wesp et al., 2004; Witt & Dorsch, 2009; Witt, Linkenauger, Bakdash, & Proffitt, 2008; Witt et al., 2004, 2005, 2010; Witt, Schuck, & Taylor, 2011; Witt, Sugovic, & Taylor, 2012

One previous study supports this possibility (Harber et al., 2011). Participants stood on a balcony and estimated the distance to the ground 5 stories beneath them. Critically, one group of participants was told to hold the handrail whereas another group had their hands tied behind their backs. As a result, the threat of falling was higher for the group with their hands tied than for the group holding the railing. In addition, participants' self-esteem was measured. Self-esteem is considered to be a psychosocial resource, and according to the authors' Resource and Perception Model, is interchangeable with physical support. Thus, one could argue that participants with high self-esteem therefore had higher ability to deal with the threat of falling, whereas participants with low self-esteem had lower ability to deal with the threat of falling. The results showed that self-esteem did not influence perception for participants in the hold-railing (less threat) condition, but self-esteem did influence perception for participants with their hands tied behind their back (more threat condition). In this condition, participants with lower self-esteem (i.e. less ability) perceived the height to be taller than did participants with higher self-esteem (i.e. higher ability) (Harber et al., 2011). The authors interpreted their results as showing that increased resources (in this case, psychosocial resources) modulate the effects of threat on perception. If we think of physical ability as a resource, then this would predict that the effects of ability on perception might be exaggerated in the presence of a threat.

In order to differentiate between these three possible outcomes, we examined the effect of a person's ability to block an object on perceived speed of the object (Witt & Sugovic, 2010, 2012) in the presence of a threat (a spider) or a neutral object (a ball). Participants attempted to block the object with various sized paddles, which made the blocking task easier or harder, and estimated the object's speed.

2. Experiment 1

2.1. Method

Sixteen students participated in exchange for course credit. Each was seated in a room at a uniformly white table (2.44 m by 1.22 m) onto which stimuli were displayed from a downward-facing projector (see Fig. 1). The projected area was 83 cm by 107 cm.

Participants first completed a training phase to familiarize them with the anchor speeds that they would later use to make speed judgments. During the first part of training, text indicated if the speed would be slow or fast. Then a white circle (4.7 cm in diameter) appeared at a distance 115 cm from the edge of the table closest to the participant and moved directly towards the participant with no horizontal displacement at the slow (.52 m/s) or fast (2.09 m/s) speed. Participants viewed 3 exposures to each speed and order was randomized. During the second part of training, participants viewed 3 additional exposures of each anchor speed. The speeds were not labeled, and participants had to indicate if the speed was slow or fast by pressing the left mouse button (labeled “slow”) or the right mouse button (labeled “fast”) on a wireless mouse. They received feedback on their responses. If participants made more than two incorrect assessments of circle speed, they repeated the training phase until they were able to accurately classify the two speeds.

Upon completing the training, lights were turned off and participants were then assigned to the ball or spider condition in alternating order. On each trial, an orange ball (4.7 cm in diameter) or an orange spider (4.5 cm^2) appeared 72 cm away. The paddle, a white rectangle 1.8 cm in depth and set to 1 of 3 widths (3.7, 11.5, or 23.5 cm), appeared 41.5 cm away. Participants clicked the mouse to initiate each trial, and then moved the mouse left and right to move the paddle left and right. The object-to-be-blocked zigzagged towards the participant at 1 of 6 speeds (.74–1.90 m/s). The object reversed the horizontal component of its direction at the display's edges and at random approximately 5% of the time. When participants successfully positioned the paddle to block the object, the object stopped on the paddle and they were awarded 5 points. When participants missed, the object continued 26.5 cm beyond the paddle and disappeared 15 cm before the edge of the table, and participants were penalized 5 points. This score was displayed on a monitor positioned to the right of the participant. After each blocking attempt, participants estimated the speed of the object by indicating if the object moved more like the slow anchor speed or more like the fast anchor speed by pressing the corresponding button on the mouse. This task was modeled after typical duration-bisection tasks (e.g. Penney, Gibbon, & Meck, 2008) and used in previous experiments (Witt & Sugovic, 2010, 2012). Each block contained 32 randomized trials (3 paddle sizes × 6 speeds × 2 repetitions), and participants completed 8 blocks.

2.2. Results and discussion

Data from one participant in each condition were removed because their responses were beyond 1.5 SD of the group interquartile range. Blocking performance (proportion of objects successfully blocked) was analyzed with a 2 (object-to-be-blocked) × 3 (paddle size) repeated-measures ANOVA. Paddle size significantly influenced

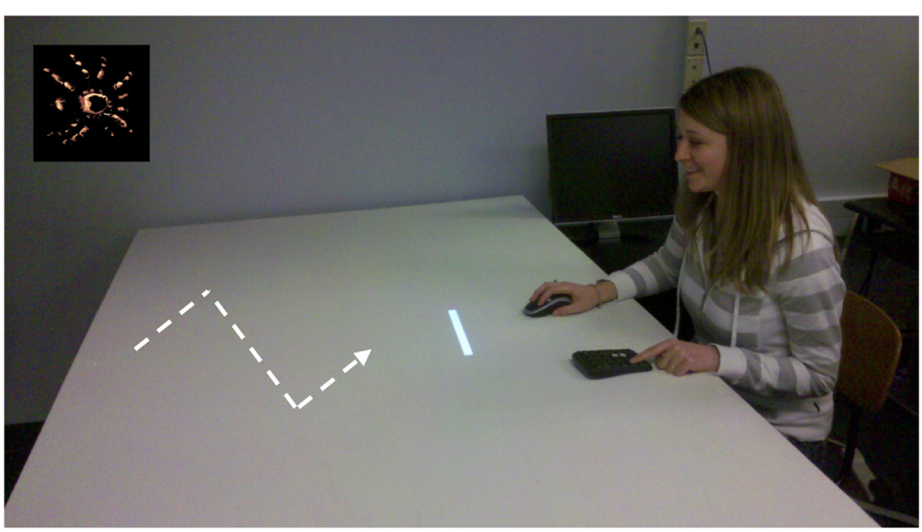

Fig. 1. Experimental set-up. A spider (image shown in top left corner) or a ball zigzagged towards the participant. A sample path is depicted by the dotted arrow. Participants attempted to block it with a paddle (the white bar) that they controlled with a wireless mouse. They estimated the object's speed on the wireless mouse (Experiment 1) or on the wireless keypad (shown; Experiment 2). During the experiments, the lights in the room were turned off.

blocking performance, $F(2, 24) = 282.97$, $p < .001$, $\eta_p^2 = .96$. Participants blocked the object more successfully as paddle size increased (see Fig. 2). The main effect of object-to-be-blocked and the interaction were not significant, $Fs < 1$.

With bisection tasks like the one used here, the raw data is used to compute the point of subjective equality (PSE). The PSE is the speed at which participants would classify the ball as fast 50% of the time. In other words, the PSE is the speed at which the object is seen as equally slow and fast. We calculated PSEs using the slopes and intercepts from binary logistic regressions with speed responses as the dependent factor and object speed as the independent factor. Separate regressions were run for each participant for each paddle size. The resulting PSEs were submitted to a repeated-measures ANOVA with object-to-be-blocked as a between-subjects factor and paddle size as a within-subjects factor.

Paddle size significantly influenced PSEs, $F(2, 24) = 11.94$, $p < .001$, $\eta_p^2 = .50$ (see Fig. 2). The PSEs were lower when participants played with the small paddle, suggesting that they perceived the object as moving faster when they played with the smaller, less effective paddle. This result replicates previous findings (Witt & Sugovic, 2010, 2012).

The interaction between paddle size and object-to-be-blocked was not significant, $F(2,24) = 1.18$, $p > .32$. This result suggests that the effect of paddle size on perceived speed is not modulated by the type of object being blocked. More broadly, the result suggests that action-specific effects are not modulated by threatening objects. Conversely, the results also suggest that the effect of a threatening object on perception is not modulated by one's ability to act on the object. This result supports the first possibility outlined in the Introduction.

The object-to-be-blocked significantly influenced the PSEs, $F(1,12) = 21.57$, $p = .001$, $\eta_p^2 = .64$. Spiders were perceived to be moving faster than the balls (see Fig. 2). Previous research demonstrates that spiders look closer and bigger (Cole et al., 2013; Harber et al., 2011; Vasey et al., 2012). This result shows that spiders also appear to be moving faster than a neutral, inanimate object.

3. Experiment 2

The purpose of this experiment was to replicate the findings from Experiment 1 using a different measure of speed perception. In this experiment, participants rated the speed of the object on a scale of 1 to 7. This measure has been used previously to demonstrate convergence across multiple types of speed judgments (Witt & Sugovic, 2012). Such convergence supports the idea that the effects occur in perception, rather than in the post-perceptual processes that generate a particular response (Witt, 2011).

3.1. Method

Forty-one students participated in exchange for course credit. Everything was the same as in Experiment 1 except that participants rated the speed of the object on a scale of 1 to 7. In order to input this range of responses, a wireless keypad was used to make the speed response (the mouse was still used to control the paddle). In addition, the initial training speeds were introduced as speed 1 and speed 7.

3.2. Results and discussion

Two participants in each group had multiple speed ratings that were at least 1.5 times beyond the group's interquartile range, and their data were removed prior to the analyses. Participants blocked the object more successfully as paddle size increased, $F(2, 70) = 617.25$, $p < .001$, $\eta_p^2 = .95$ (see Fig. 3). The main effect of object-to-be-blocked and the interaction were not significant, $Fs < 1$.

Mean speed ratings were calculated for each paddle size and entered into a repeated-measures ANOVA with object-to-be-blocked as a between-subjects factor. Paddle size significantly influenced speed ratings, $F(2, 70) = 13.73$, $p < .001$, $\eta_p^2 = .28$ (see Fig. 3). Participants estimated the object to move faster as paddle size decreased. Object-to-be-blocked significantly influenced speed ratings, $F(1, 35) = 15.15$, $p < .001$, $\eta_p^2 = .30$. Participants judged the spiders to be moving faster than the balls. The interaction between paddle size and object-to-be-blocked was not significant, $p > .89$.

These results replicate those found in Experiment 1. Objects that were easier to block looked to be moving slower than when the object was more difficult to block. As with prior research (Witt & Sugovic, 2010, 2012), this work demonstrates an effect of task ease on perceived speed. Also, spiders appeared to be moving faster than balls. The result

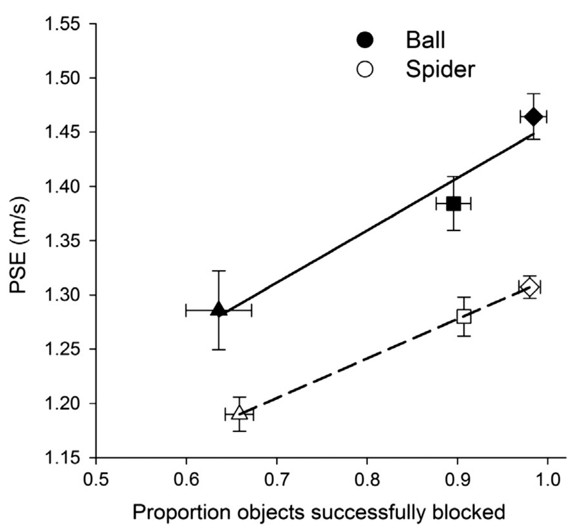

Fig. 2. Results from Experiment 1. PSE is plotted as a function of proportion of objects successfully blocked, paddle size (triangles: small paddle; squares: medium paddle; diamonds: big paddle) and object-to-be-blocked (filled symbols: ball; open symbols: spider). A lower PSE indicates the object was perceived as moving faster. Error bars are 1 SEM calculated within-subjects for each object condition. Lines represent linear regressions.

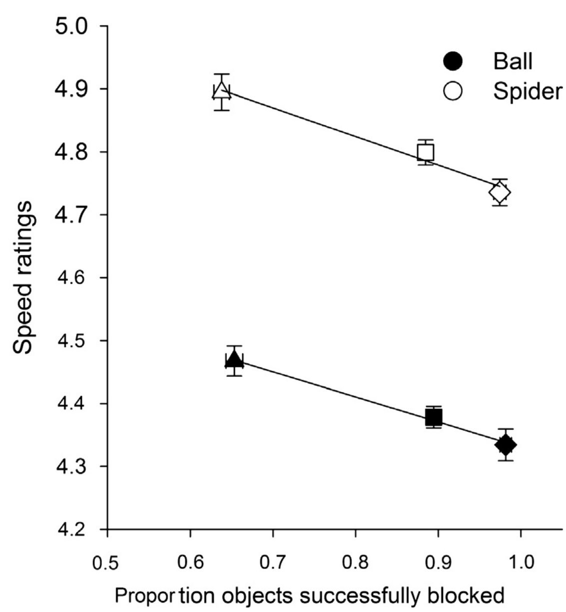

Fig. 3. Results from Experiment 2. Speed ratings are plotted as a function of proportion of objects successfully blocked, paddle size (triangles: small paddle; squares: medium paddle; diamonds: big paddle) and object-to-be-blocked (filled symbols: ball; open symbols: spider). A higher rating indicates the object was perceived as moving faster. Error bars are 1 SEM calculated within-subjects for each object condition. Lines represent linear regressions.

suggests that threatening objects appear faster than non-threatening objects. However, another difference between the two objects is that spiders are animate objects and balls are inanimate objects. Thus, animacy rather than threat could account for the difference in apparent speed across the two conditions. To examine this possibility, we examined the perceived speed of a non-threatening, animate object, namely ladybugs.

4. Experiment 3

4.1. Method

Fifty-four students participated in exchange for course credit. Everything was the same as in Experiment 1 except that participants judged the speed of a spider or of a ladybug. The ladybug was red with black spots and was the same size as the spider.

4.2. Results and discussion

Two participants in each condition had multiple mean speed ratings that were at least 1.5 times beyond the interquartile range, and were removed prior to the analyses. The remaining data were analyzed as before and are shown in Fig. 4. Paddle size significantly influenced blocking performance, $F(2, 96) > 1084$. Participants were more successful as paddle size increased (see Fig. 4). In this experiment, there was a significant effect of object-to-be-blocked, $F(1, 48) = 4.29$, $p < .05$, $\eta_p^2 = .08$, and a significant interaction between object and paddle size, $F(2, 96) = 6.76$, $p < .01$, $\eta_p^2 = .12$. As shown in Fig. 4, when playing with the small paddle, participants who attempted to block the ladybug had more success than did participants who attempted to block the spider.

PSEs were calculated as in Experiment 1 and entered into a repeated-measures ANOVA with paddle size as a within-subjects factor and object-to-be-blocked (spider versus ladybug) as a between-subjects factor. Paddle size significantly influenced the PSEs, $F(2, 96) = 8.93$, $p < .001$, $\eta_p^2 = .16$. As before, participants estimated the object to move faster as paddle size decreased.

Object-to-be-blocked significantly influenced PSEs, $F(1, 48) = 5.03$, $p < .05$, $\eta_p^2 = .10$. Participants judged the spiders to be moving faster than the ladybugs. This result is consistent with the idea that the difference observed before was due to the spider being a threat rather than an animate object. This result also suggests that the spiders did not look faster than the balls simply because the balls are naturally associated with the paddle whereas spiders are not because ladybugs are also not naturally associated with paddles. However, another possibility is that pre-existing knowledge about the maximum speed of movement of a spider and ladybug may be different, and this expectation may influence speed estimates rather than the effect being due to threat per se. While ladybugs can fly faster than spiders, spiders can walk faster than ladybugs. We did not have the participants assess anticipated maximum speed of each, so it is unknown if this is a driving factor in our results. More research will be needed to determine whether expectations of speed based on object knowledge influence perception.

The interaction between object-to-be-blocked and paddle size was not significant, $F(2, 96) = 0.10$, $p > .90$. As before, even though the spiders appeared to be moving faster, blocking a spider did not change the action-specific scaling of perceived ball speed. Thus, the action-specific effect of blocking ease on apparent speed and the threat-related effect on apparent speed do not modulate each other and instead are independent.

5. Experiment 4

Another difference between the spider and the ball or the ladybug is the shape of the object. While there is no previous literature to suggest that object shape could account for our effects on perceived speed, we decided to test this directly.

5.1. Method

Thirty-nine students participated in exchange for course credit. Everything was the same as in Experiment 1 except that participants judged the speed of an orange "X" or an orange circle. Both were 4.6 cm by 5 cm.

5.2. Results and Discussion

Data were analyzed as before and are shown in Fig. 5. Paddle size significantly influenced blocking performance, $F(2, 74) > 847$. The object-to-be-blocked did not significantly influence blocking performance, and the interaction was also not significant, $Fs < 1$. Paddle size also significantly influenced the PSEs, $F(2, 74) = 7.35$, $p = .001$, $\eta_p^2 = .17$. In this experiment, there was no significant difference in the PSEs when blocking an "X" than when blocking a

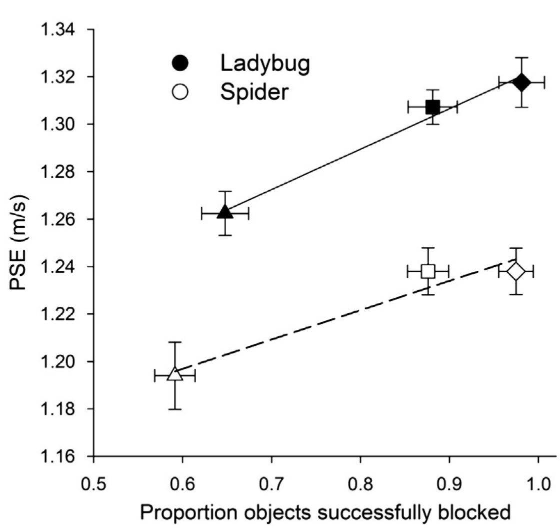

Fig. 4. Results from Experiment 3. PSE is plotted as a function of proportion of objects successfully blocked, paddle size (triangles: small paddle; squares: medium paddle; diamonds: big paddle) and object-to-be-blocked (filled symbols: ladybug; open symbols: spider). A lower PSE indicates the object was perceived as moving faster. Error bars are 1 SEM calculated within-subjects for each object condition. Lines represent linear regressions.

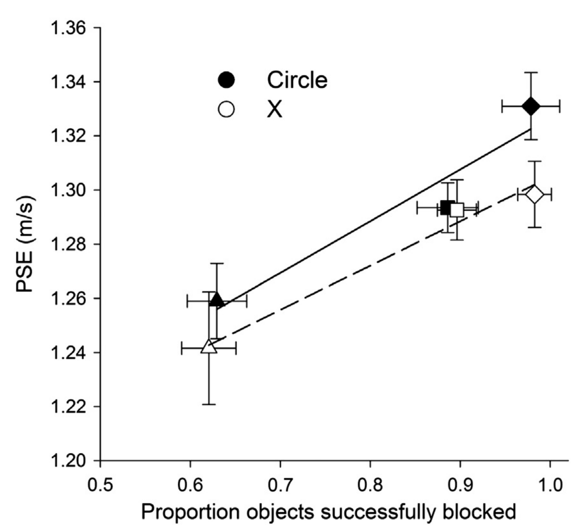

Fig. 5. Results from Experiment 4. PSE is plotted as a function of proportion of objects successfully blocked, paddle size (triangles: small paddle; squares: medium paddle; diamonds: big paddle) and object-to-be-blocked (filled symbols: circle; open symbols: "X"). A lower PSE indicates the object was perceived as moving faster. Error bars are 1 SEM calculated within-subjects for each object condition. Lines represent linear regressions.

circle, $F(1,37) = 0.22, p = .64$. This result shows that the previously observed differences when blocking a spider were not due to object shape. The interaction between object and paddle size was also not significant, $F < 1$.

6. General discussion

In the current experiments, participants blocked and estimated the speed of a spider (threatening, animate object), ball (neutral, inanimate object), or ladybug (non-threatening animate object). Several effects emerged. First, spiders looked to be moving faster than did non-threatening objects. Second, these studies replicate the effect of affordances on perception (e.g. Witt & Proffitt, 2005). In particular, objects that were easier to block appeared to be moving slower than objects that were more difficult to block (as in Witt & Sugovic, 2010, 2012, 2013). This replication provides further support for the idea that affordances are perceived even when judging aspects of the environment such as distance, size, and speed. Third, the effect of blocking ability on perceived speed was not modulated by the presence of a threatening object. We will address each of these findings in turn.

6.1. Spiders appear faster

Previous literature leads to mixed predictions regarding the perceived speed of a threatening object. On the one hand, many studies show increased perceptual performance in the presence of a threat (Lin et al., 2009; Phelps et al., 2006). On the other hand, other studies show increased perceptual biases in the presence of threat. For example, threatening objects look bigger, closer, steeper, or higher (Cole et al., 2013; Stefanucci & Proffitt, 2009; Stefanucci et al., 2008; Vasey et al., 2012). The present results are consistent with the latter literature. A threatening object, in this case, a spider, looked to be moving faster than a neutral inanimate object (a ball) and a neutral animate object (a ladybug).

The result from Experiment 3 suggests that it is the threatening aspect of the spider, and not just its animacy, that is responsible for this result. However, whereas ladybugs fly faster than spiders can move, they cannot walk as fast as most spiders. The results, therefore, could be due to a difference in expectation related to speed rather than to animacy per se. Prior results speak directly to this issue by showing that the distinctive feature of fear, not animacy, leads to perceptual biases. A person characterized as dangerous was perceived to be closer than when that same person was characterized as disgusting (Cole et al., 2013). Another issue with our current data is that we never measured participants' fear of the spiders. Prior work has shown that perceptual bias related to apparent size of spiders is correlated with fear of spiders (Vasey et al., 2012). Thus, even though we did not take these measurements, it is reasonable to think that the results with perceived size would generalize to our findings with perceived speed.

The finding that spiders appear to be moving faster than neutral objects could reflect a potentially adaptive perceptual process. As emphasized by Gibson (1979), perception expresses the relationship between the perceiver and the environment, and the expression of this relationship could help in selecting and planning future actions (Proffitt, 2006; Witt, 2011). For example, seeing hills as steeper when fatigued (Bhalla & Proffitt, 1999) could help the fatigued perceiver select a less energetically-demanding walking pace when ascending the hill or perhaps even find an alternative flat route (a preference shared by elephants, who rarely ascend steep hills to avoid expending the energy to do so, Wall, Douglas-Hamilton, & Vollrath, 2006). Similarly, seeing targets as bigger when shooting better (Lee, Lee, Carello, & Turvey, 2012; see also Witt & Dorsch, 2009; Witt & Proffitt, 2005) could help a hunter choose to shoot from his or her current location rather than to risk detection by moving closer (Witt, 2011).

However, there is not always much time to select and plan an action with nearby threats; consequently, more immediate, reactive actions are sometimes required. Seeing a threatening object as closer could initiate faster reactions and responses (Cole et al., 2013). By analogy, seeing a threatening object move at a faster rate could also help promote a faster reactive response. Thus, these perceptual effects could be useful for planning future actions as well as for initiating immediate reactions.

Returning to the predictions outlined in the Introduction, the current results add to the mixed literature demonstrating increased perceptual accuracy in the presence of a threat, on the one hand, and increased perceptual biases in the presence of a threat on the other hand. Currently, it is unknown when a threatening object will lead to greater perceptual accuracy and precision and when the threat will lead to increased perceptual bias. One proposal is that threat will lead to greater exaggerations when psychosocial resources are diminished, and threat will lead to greater accuracy when psychosocial resources are replenished (Harber et al., 2011; see also Schnall, Harber, Stefanucci, & Proffitt, 2008).

Another possibility is that the effect of a threatening object may depend on the type of response needed in a particular situation. For example, when a threat is implied but not yet seen (as when viewing fearful faces), the appropriate response is to seek out more information to detect the specific threat. In doing so, it may be useful to increase perceptual sensitivity. Consistent with this idea, the facial expression often made in a fearful situation is one that opens up the senses, thereby gathering more sensory information (Susskind et al., 2008). In contrast, when the threat requires the selection of a defensive fight-or-flight response, a perceptual bias that exaggerates perception of the threat could be useful for accelerating the response (Cole et al., 2013). Although this proposal is speculative, it can be used to generate novel predictions. In particular, we propose that when the proper response is further detection of information, perceptual sensitivity may be increased. When the proper response is an immediate flight-or-fight response, perceptual biases that exaggerate the threat will be apparent.

One thing to note is that threat did not impact the perceiver's ability to successfully act in these experiments. Even though the spiders appeared faster than the balls and the ladybugs, blocking performance was equal across all conditions. This raises the question as to why performance was unaffected. If the spiders appeared faster, that could have made them more difficult to block. One possibility is that different visual pathways are responsible for guiding the blocking action and for conscious perception of speed. This division of labor has already been proposed in the theory of two visual pathways (Milner & Goodale, 2006). According to this theory, the dorsal pathway provides visual information responsible for visually-guiding actions whereas the ventral pathway provides visual information for conscious perception.

The separation of duties into multiple pathways has been used to account for dissociations between conscious perception and visually-guided actions. In these studies, the same object looks different, but actions towards the object are the same regardless of how the object appears. For instance, visual illusions such as the Ebbinghaus illusion or the Ponzo illusion lead to misperceptions of objects' sizes but do not affect grasping movements (Aglioti, DeSouza, & Goodale, 1995; Ganel, Tanzer, & Goodale, 2008). Similarly, hills appear steeper to participants who are wearing a heavy backpack or are fatigued when assessed with conscious-based measures such as verbal reports and visual matching, but action-based measures of hill (such as the manual adjustment of a board) are accurate regardless of these physiological factors (Bhalla & Proffitt, 1999). In our blocking task, visual information is constantly available to guide the movements of the paddle, and so the blocking task may benefit from unbiased information processed in the dorsal pathway. It would be interesting to examine if actions that are not visually-guided (such as delayed actions or ballistic actions) would also be immune to action-specific effects or if these kinds of actions would reveal the same pattern of bias as the conscious reports of speed.

6.2. Objects that are more difficult to block appear faster

In addition to the finding that spiders appeared to be moving faster than neutral objects, we also found that both kinds of objects appeared to be moving faster when participants played with a smaller, less effective paddle. The finding that blocking ability – manipulated via paddle size – influenced perceived speed replicates our earlier work (Witt & Sugovic, 2010, 2012, 2013), and is consistent with a diverse range of effects of action on perception (see Proffitt, 2006, 2008; Witt, 2011, for reviews). These effects demonstrate that perception expresses the relationship between the perceiver and the environment. Consequently, the same object will look different depending on the perceiver's ability to act.

6.3. Action-specific effects are independent of threat

By examining the effect of paddle size in the context of a spider, we were able to assess whether this particular action-specific effect is modulated by threat. In the Introduction, we outlined three possible outcomes. Our results are consistent with the first possibility: we found that threat did not modulate the effect of blocking ability on perceived speed. Objects that were harder to block looked to be moving faster regardless of whether the object was a spider, a ball, or a ladybug.

While there is much research on action-related effects on perception (Proffitt, 2006; Witt, 2011) and affective-related effects on perception (Cole et al., 2013; Harber et al., 2011; Stefanucci & Proffitt, 2009), little research has examined the connection between them. The current data suggest two separate, independent, and complimentary effects on perception: threatening objects look faster than non-threatening objects, and harder-to-block objects look faster than easier-to-block objects. Both threat and ability can influence perception, and can exert their influence at the same time, but the two effects do not influence each other.

It is possible that a different pattern would result had we conducted the experiment in a different way. For example, we used the same image of a spider repeatedly, which could have led to habituation of the image. However, it is important to note that the single image of the spider did have an effect: the spider appeared to be moving faster than the ball. Similarly, it is possible that our image of the spider was not scary enough to be perceived as threatening, but again, the spider resulted in a main effect on speed. The image itself and its repeated use were both sufficient to result in a main effect. Therefore, the lack of interaction is not likely to be due to particulars in our design. In addition, participants acted on the object via a computer-based tool that was controlled by a mouse. Perhaps a more direct action on the object would lead to a different pattern of results. However, the indirect action on the objects still led to effects on perceived speed suggesting this manipulation of ability was sufficient. Nevertheless, converging evidence across a range of actions, including actions for which the body would have direct contact with the object, would be useful in order to fully understand these effects. Future research should also examine individual differences with respect to fear of spiders to examine whether interactions between ability and threat would emerge at certain levels of arachnophobia.

The finding of independent, additive effects is consistent with proposed anatomical mechanisms for the two types of effects. Premotor processes are argued to be involved in the effects of a person's ability to act on perception (Witt & Proffitt, 2008; Witt et al., 2012). Evidence for the involvement of these processes comes from a variety of experiments. First, when engaging in behaviors that activate premotor processes such as planning an action, imagining an action, or observing another person performing the action, the effects on perception are the same as when executing the action (Bloesch, Davoli, Roth, Brockmole, & Abrams, 2012; Witt & Proffitt, 2008; Witt et al., 2012). Second, when premotor processes are disrupted by means of a secondary task, action-specific effects on perception are eliminated (Witt & Proffitt, 2008). Both patterns of results suggest the involvement of premotor processes as an underlying mechanism for action-specific effects.

In contrast, threat-related effects on perception are thought to arise from processes in the amygdala. Evidence for this proposal comes from decreased effects of emotion on perception in patients with amygdala damage (e.g. Anderson & Phelps, 2001) and differential neural responses in the amygdala to threatening and neutral stimuli (e.g. Morris et al., 1996; for reviews, see Dolan, 2002; Phelps, 2006). The proposal that separate anatomical mechanisms underlie these two types of effects is consistent with the obtained pattern of independent, additive effects.

The finding of independent, additive effects is also consistent with Gibson's (1979) theory of affordances. Gibson argued that the main objects of perception are affordances. The action-specific account of perception has extended Gibson's theory by demonstrating that affordances are perceived even in basic features of the environment such as its spatial layout. Just as affordances include opportunities for action, many studies have shown that these opportunities influence aspects of perception such as distance, size, shape, weight, height, and speed. In addition, affordances also include events that would impact the perceiver. These types of affordances also influence perception of speed (present results), size (Vasey et al., 2012), and distance (Cole et al., 2013; Harber et al., 2011). Furthermore, the current results show that both types of affordances influence perception independently of each other. At any given time, there are multiple affordances presented to a perceiver. The current studies show that multiple relationships can be expressed in perception.

Based on these results, we propose that four action-related factors influence perception, and that each factor provides an independent contribution to perception. The first is the perceiver's likelihood of successfully completing the action. For example, the likelihood of success is higher when the paddle is bigger than when it is smaller. The second factor is the cost to perform the action. For example, ascending a hill while wearing a heavy backpack (c.f. Bhalla & Proffitt, 1999) is possible, but there are energetic costs associated with the action. These energetic costs also influence perception. Third, benefits that accompany successful performance will influence perception. For example, reachable objects that are more desirable look closer than less desirable objects (Balcetis & Dunning, 2010). Fourth, penalties associated with failure will influence perception. For example, the penalty associated with failure to block a spider or failure to maintain balance on a balcony will increase perceived speed or perceived height, respectively. We propose that only the aspect of these factors that are relevant to the intended action, and not to unintended actions, will influence perception (c.f. Witt, Proffitt, & Epstein, 2004, 2005, 2010), and we also propose that each of these factors can have independent effects on perception. The current results support this claim by demonstrating independent effects of likelihood to succeed and penalties associated with failure. Future research will be required to examine whether other combinations of these factors are also independent.

6.4. Conclusions

In summary, spiders appeared to move faster than balls and ladybugs. The implication is that threatening objects look faster than non-threatening objects. In addition, objects that were more difficult to block also looked to be moving faster than objects that were easier to block. Both factors – threat and ease to block – influenced perception, and did so independently of each other. The two effects may be driven by separate neural mechanisms.

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