

Is There a Chastity Belt on Perception?



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Abstract

Can one's ability to perform an action, such as hitting a softball, influence one's perception? According to the action-specific account, perception of spatial layout is influenced by the perceiver's abilities to perform an intended action. Alternative accounts posit that purported effects are instead due to nonperceptual processes, such as response bias. Despite much confirmatory research on both sides of the debate, researchers who promote a response-bias account have never used the Pong task, which has yielded one of the most robust action-specific effects. Conversely, researchers who promote a perceptual account have rarely used the opposition's preferred test for response bias, namely, the postexperiment survey. The current experiments rectified this. We found that even for people naive to the experiment's hypothesis, the ability to block a moving ball affected the ball's perceived speed. Moreover, when participants were explicitly told the hypothesis and instructed to resist the influence of their ability to block the ball, their ability still affected their perception of the ball's speed.

Keywords

spatial perception, response bias, perception and action, embodied perception, open data, open materials

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The perceptual experience of the environment gives the impression that the world exists as it is perceived. Yet vision scientists understand that there are many inaccuracies and biases within perceptual processes that taint the resulting experience. The scientist's task is to explore and understand these biases. In each case, the scientist must determine whether the bias genuinely influences perception. According to the action-specific account of perception, action is one of the biases that has a genuine influence (Proffitt, 2006; Proffitt & Linkenauger, 2013; Witt, 2011, 2017). For example, softball players who are hitting better than others see the ball as bigger (Gray, 2013; Witt & Proffitt, 2005). Hills look steeper and distances look farther to perceivers who would have to exert more effort to traverse the space (Bhalla & Proffitt, 1999; Sugovic, Turk, & Witt, 2016; Taylor-Covill & Eves, 2014, 2016). These results seem to indicate that perceivers' ability to act influences their spatial perception, but it is possible that such findings reflect an influence on judgments, rather than perception (Durgin et al., 2009; Firestone & Scholl, 2016a, 2016b; Loomis, 2016; Shaffer, McManama, Swank, & Durgin, 2013; Woods, Philbeck, & Danoff, 2009).

Manipulations of ability to act could alter participants' judgments as a result of response bias (e.g., donning a heavy backpack might make participants infer that they are supposed to report the hill as steeper than they might otherwise) or judgment-based processing (e.g., participants might report on felt steepness rather than perceived steepness of the hill). According to these explanations, the percept itself is the same regardless of action, but perceivers' judgments reflect their ability to act.

Among researchers who have challenged the action-specific account of perception, the most highly recommended strategy for differentiating effects on perception from effects of response bias involves using postexperiment surveys (Firestone & Scholl, 2016a, 2016b). The idea is to separate out participants who discerned the experiment's hypothesis from those who were naive (Durgin, Klein, Spiegel, Strawser, & Williams, 2012). If

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only the participants who correctly surmised the hypothesis showed the effect of action on perceptual judgments, this is strong evidence that the effect was driven by response bias. In contrast, if the influence of action on perceptual judgments was independent of whether or not participants accurately deduced the purpose of the experiment, this is strong evidence against a response-bias account.

Given that this strategy is so highly recommended by critics of the action-specific account, it is surprising that it has not been implemented within the Pong task, the task that has been the most thoroughly investigated in this line of research. The Pong task is a computerized game in which participants attempt to block moving balls with variously sized paddles. Participants estimate the ball as moving faster when they play with a smaller paddle, which makes it harder to block the ball, than when they play with a bigger paddle (Witt & Sugovic, 2010, 2012). Although experiments using the Pong task have provided substantial evidence that the effect is genuinely perceptual (King, Tenhundfeld, & Witt, 2017; Witt, 2017; Witt & Sugovic, 2012, 2013a, 2013b; Witt, Sugovic, & Dodd, 2016; Witt, Sugovic, Tenhundfeld, & King, 2016), participants have never been questioned afterward to determine if the effect of paddle size on estimated speed of the ball is found only for those participants who accurately surmised the study's hypothesis. This important gap was filled in the experiments reported here.

Experiment 1

Method

Participants. Sixteen participants were recruited via the psychology participant pool at Colorado State University and received course credit. Based on previously reported effect sizes (Witt & Sugovic, 2010, 2013b), a power analysis indicated that 9 participants were needed to achieve 80% power to detect an effect of paddle size on estimated speed of the ball.

Apparatus and stimuli. The experiment took place on a desktop computer with a 19-in. display. The background was either red or blue. The ball was a white circle that was 1 cm in diameter. The paddle was a white rectangle that was 0.86 cm wide and was either 1.86 cm or 9.28 cm tall. Participants used a joystick to control the movements of the paddle and to make their responses about the ball's speed.

Procedure. Participants completed two brief training phases followed by a test phase. During the first training

phase, they were exposed to the slow and fast anchor speeds. On each trial, text on the screen indicated if the ball would be slow or fast. The ball then traveled at the slow (18 cm/s) or fast (74 cm/s) speed horizontally, with no vertical displacement, from the left to the right of the screen. Each speed was shown three times, and order was randomized. During the second training phase, participants were tested on their ability to classify the anchor speeds. On each trial, the ball appeared on the left side of the screen. Participants then pressed the trigger on the joystick, and the ball traveled across the screen at either the slow or the fast speed. After the ball completed its movement, participants indicated whether it was slow or fast by pressing the left or right button on the joystick, respectively. They were given feedback after each response: "correct" in green or "incorrect" in red. Again, each speed was shown three times, and order was randomized.

After completion of both training phases, participants started the test phase. At the start of each trial, the ball appeared on the left side of the screen, and the paddle appeared on the right side of the screen. The paddle was set to one of the two sizes, and the ball was set to move at one of six speeds (26.2–67.5 cm/s). The background was set to either blue or red. The purpose of varying the background was to distract participants from the study's true purpose. Participants pressed the trigger on the joystick to begin each trial. The ball then traveled across the screen at the designated speed, moving along a diagonal; it reversed its vertical direction whenever it reached the top or bottom of the display and also at random throughout the trial. Participants could move the joystick to control the vertical location of the paddle. If the paddle was positioned to intersect with the ball, the ball stopped on the paddle. Otherwise, the ball continued past the paddle and past the right edge of the screen. After each attempt, regardless of whether the ball was successfully blocked or not, a prompt on the screen asked, "slow or fast?" This prompt remained on-screen until the participant responded. Participants indicated if the ball's speed had been more like the slow speed or more like the fast speed by pressing the corresponding button on the joystick. Each combination of the six test speeds, two paddle sizes, and two background colors appeared once in each block, for a total of, 24 trials per block. Order within block was randomized. Participants completed 12 blocks.

After completing the Pong task, participants were asked about the experiment and wrote their answers on a blank piece of paper. The eight questions are shown in Table 1, and participants' response sheets can be viewed in the Supplemental Material available online.

Table 1. Questions in the Survey Administered After the Pong Task in Experiment 1

Question
1. Did you spend any time trying to figure out the purpose of the experiment? If so, please indicate approximately how much time.
2. What do you think the purpose of this study was?
3. What aspects of the task seemed most important?
4. Did you use any particular strategies during the experiment?
5. The purpose of the study was to determine the factors that influence the perception of speed. What factor or factors do you think we were interested in? Do you think these factors should make the ball look faster or slower?
6. Do you think the size of the paddle changed how fast the ball looked? If so, how?
7. Do you think missing the ball changed how fast the ball looked? If so, did missing the ball make it appear faster or slower?
8. In this study, we wanted to know whether the size of the paddle would change the perceived speed of the ball. Did you ever suspect that this was the purpose of the study?

Results

As expected, paddle size significantly influenced participants' success in blocking the ball. For each participant, the mean proportion of balls successfully blocked with each paddle was calculated, and these values were submitted to a paired-samples *t* test. Paddle size significantly influenced the proportion of balls successfully blocked (small paddle: $M = .45$, $SD = .06$; big paddle: $M = .92$, $SD = .04$, $t(15) = 43.41$, $p < .001$, $d_{rm} = 4.00$, Bayes factor $> 1,000$. (All Bayes factors¹ were calculated using the BayesFactor package in R and a Cauchy prior; Morey, Rouder, & Jamil, 2014; R Core Team, 2017.)

Speed judgments were summarized by calculating the point of subjective equality (PSE) for each participant for each paddle size from the slopes and intercepts of binary logistic regressions (see Fig. 1 and Fig. S1 in the Supplemental Material). The PSEs for the small paddle ($M = 41.43$ cm/s, $SD = 3.06$) and the big paddle ($M = 45.07$ cm/s, $SD = 3.29$) were submitted to a paired-samples *t* test, which revealed that paddle size had a

significant influence on PSE (mean difference = 3.64 cm/s, $SD = 2.54$), $t(15) = 5.73$, $p < .001$, $d_{rm} = 0.50$, Bayes factor = 736. Thus, Experiment 1 replicated the typical effect found in the Pong task. We refer to the difference between the PSEs for the big and small paddles as the *Pong effect*.

Next, we analyzed the PSEs in conjunction with the survey data (Table S1 in the Supplemental Material shows which participants were included in each analysis). Of the 16 participants, 12 (75%) made no mention of the size of the paddle in response to Question 2 (see Table 1), an open-ended question about the purpose of the experiment. We analyzed the PSEs from just these 12 participants (small paddle: $M = 41.74$ cm/s, $SD = 3.16$; big paddle: $M = 45.47$ cm/s, $SD = 3.40$) and found a significant effect of paddle size (mean difference = 3.73 cm/s, $SD = 2.92$), $t(11) = 4.44$, $p = .001$, $d_{rm} = 0.56$, Bayes factor = 43. Even participants who did not surmise the purpose of the study when asked an open-ended question exhibited a strong Pong effect (Fig. 2 shows the Pong effect for all participants, categorized according to their responses to the survey questions).

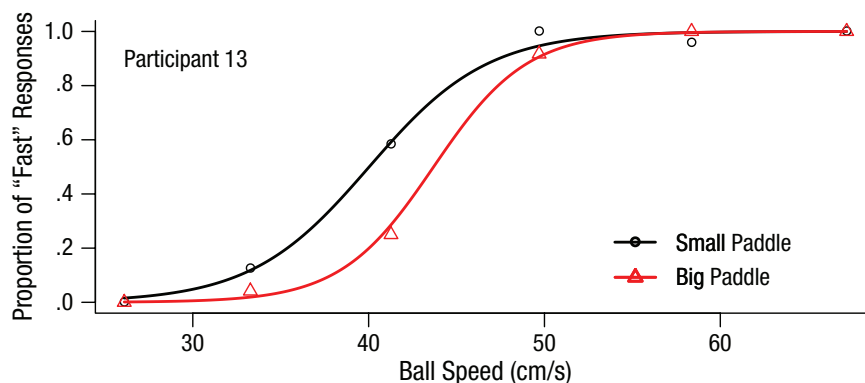


Fig. 1. Mean proportion of “fast” responses as a function of ball speed and paddle size for a representative participant in Experiment 1. The curves represent the binary logistic regressions for the two paddle sizes. See Figure S1 in the Supplemental Material for plots for each participant in this experiment.

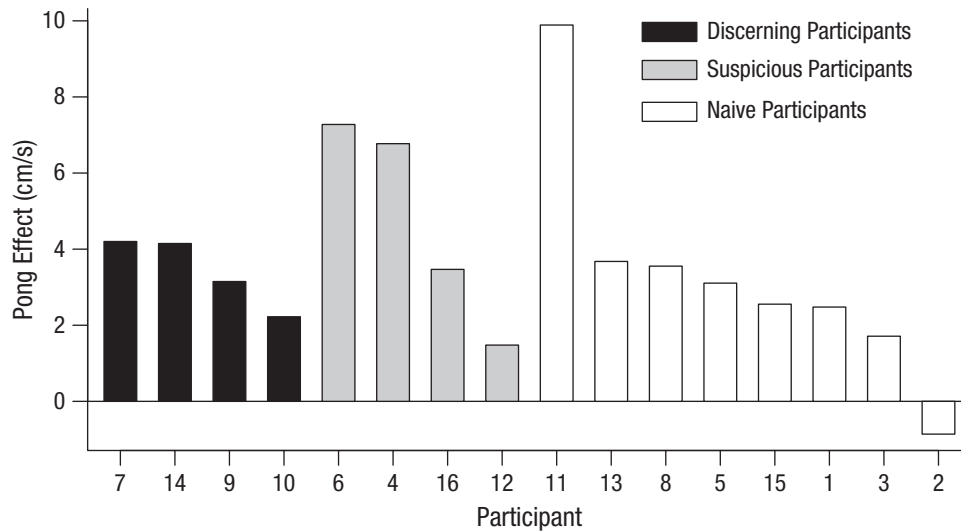


Fig. 2. Results from Experiment 1: the Pong effect for each participant. Participants are grouped according to whether they mentioned paddle size when asked an open-ended question about the purpose of the experiment (“discerning”), mentioned paddle size when asked what factors the researchers might think influence perceived ball speed (“suspicious”), or did not mention paddle size in response to either question (“naive”). Within each group, results are shown in rank order. The Pong effect was calculated as the point of subjective equality (PSE) for the big paddle minus the PSE for the small paddle. Thus, a Pong effect of 0 indicates no effect of paddle size, and a positive Pong effect indicates that the ball appeared to move faster when the paddle was small than when the paddle was big.

We next looked at these 12 participants’ answers to a more specific question. Question 5 explicitly told participants that the experiment was about factors that influence perceived speed and asked what factors they thought might be of interest to the researchers. Of these 12 participants, 8 did not mention paddle size as being a factor of interest to the researchers. Even among these 8 participants, paddle size still influenced PSE, (small paddle: $M = 41.72$ cm/s, $SD = 3.63$; big paddle: $M = 44.94$ cm/s, $SD = 3.73$; mean difference = 3.23 cm/s, $SD = 3.03$), $t(7) = 3.01$, $p = .02$, $d_{rm} = 0.40$, Bayes factor = 3.83 .

In response to Question 6, several participants indicated that the ball appeared to move faster when the paddle was small. It is unclear whether this response reflected an awareness of the study’s hypothesis or an awareness of the paddle’s effect on the ball’s perceived speed. We did not analyze the results for participants who mentioned this connection between perceived speed and paddle size because we could not differentiate between these two possibilities, and consequently the analysis would be uninformative regarding a potential effect of response bias.

The last question of the survey explicitly stated the hypothesis and asked participants if they had ever suspected the purpose of the experiment. Fewer than half of the participants ($n = 7$) said “yes.” Of the remaining 9 participants, 5 said “no,” and 4 were noncommittal

(e.g., “kind of,” “a little, but not too much”). One of these 4 reported “[trying] to not let paddle size affect what speed I thought it was.” Even among these 9 participants who did not explicitly report suspecting the purpose of the experiment, paddle size still influenced PSE, $t(8) = 3.65$, $p = .006$, $d_{rm} = 0.52$, Bayes factor = 9.35 .

The data showed that not many people inferred the purpose of the experiment. Only 25% even mentioned paddle size when asked an open-ended question about the purpose, and of the remaining 75%, only 33% mentioned paddle size when asked for specific factors that might be hypothesized to affect perceived speed. These data suggest that the purpose of the Pong task may not be as obvious to participants as it may seem to researchers well versed in the literature (see also Tenhundfeld & Witt, 2017, for evidence of similar naiveté with respect to perceived distances on hills). Moreover, the action-specific effect of paddle size on estimated speed was not driven by response bias based on inferring the study’s purpose. Even when we excluded participants who correctly inferred the purpose of the experiment, the Pong effect still emerged.

Experiment 2

Experiment 1 showed that there were no systematic differences between participants who were able to discern the purpose of the experiment and those who

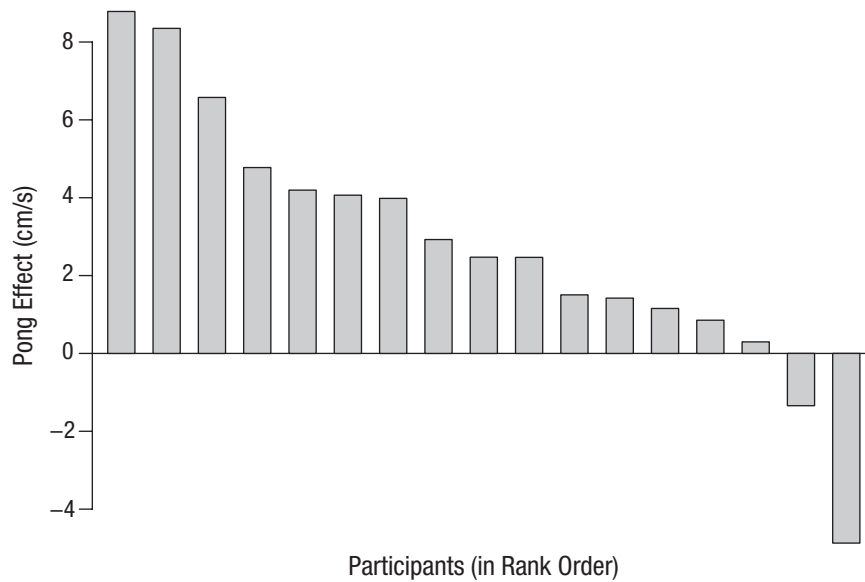


Fig. 3. Results from Experiment 2: the Pong effect for each participant in Experiment 2, in rank order. The Pong effect was calculated as the point of subjective equality (PSE) for the big paddle minus the PSE for the small paddle. Thus, a Pong effect of 0 indicates no effect of paddle size, and a positive Pong effect indicates that the ball appeared to move faster when the paddle was small than when the paddle was big.

were naive to the study's purpose. In Experiment 2, we examined whether participants could resist the Pong effect after being warned about it.

Method

Participants. Seventeen students volunteered to participate in exchange for course credit. We initially ran 16 participants, but 1 did not complete the survey at the end of the experiment, so we ran an additional participant. Given that all participants were informed of the study's purpose, all were included in the analysis.

Stimuli, apparatus, and procedure. Everything was the same as in Experiment 1 except that an additional instruction was presented on the screen at the beginning of the test phase:

Participants tend to report that the ball is faster when the paddle is small even though the balls move, on average, at the same speeds for both paddles. We want to know whether people can resist this tendency. Please report how the speed of the ball **APPEARS** without allowing your responses to be biased by extraneous factors like the size of the paddle.

Results

For each participant, the PSE for each paddle size was calculated from a binary logistic regression. These

values were submitted to a paired-samples *t* test. Paddle size significantly influenced PSEs (small paddle: $M = 46.12$ cm/s, $SD = 3.88$; big paddle: $M = 48.99$ cm/s, $SD = 4.67$; mean difference = 2.87 cm/s, $SD = 3.37$), $t(16) = 3.51$, $p = .003$, $d_{rm} = 0.66$, Bayes factor = 14. (As in Experiment 1, all Bayes factors were calculated using the BayesFactor R package and a Cauchy prior.) As shown in Figure 3, the Pong effect emerged even when participants were warned about this effect and explicitly instructed to resist it.

The instructions to resist the Pong effect not only were insufficient to eliminate the effect but also were insufficient even to lessen it. The Pong effect was not significantly reduced in Experiment 2 compared with Experiment 1, $t(31) = 0.84$, $p = .41$, $d = 0.31$, Bayes factor = 0.34. In contrast, the instruction to resist bias due to extraneous factors was effective at eliminating the effect of background color on estimated speed. Analyses of PSEs showed that in Experiment 1, participants reported the ball as moving faster when the background was red than when it was blue, $t(15) = 4.67$, $p < .001$, $d_{rm} = 0.64$, Bayes factor = 115, whereas in Experiment 2, background color did not influence estimated speed, $t(16) = -1.45$, $p = .166$, $d_{rm} = 0.19$, Bayes factor = 0.48. If anything, the pattern reversed itself, which suggests a possible overcorrection (see Fig. 4). Assuming that any effect of background color on estimated speed was due to response bias, the data show that the instruction was sufficient to eliminate response biases associated with background color. These results further highlight the robustness of the Pong effect even when participants

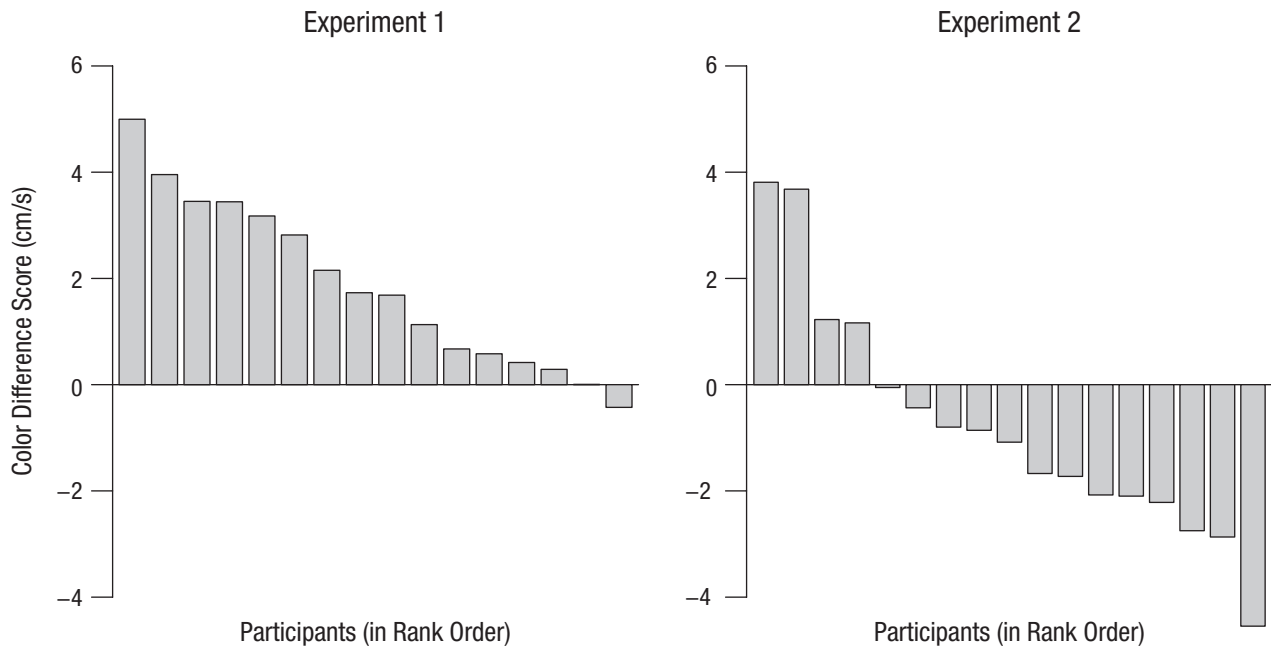


Fig. 4. Effect of background color on the point of subjective equality (PSE) in Experiment 1 (left) and Experiment 2 (right). The graphs show the color difference score (PSE when the background was blue minus PSE when the background was red) for each participant, in rank order from left to right. A color difference score of 0 indicates no effect of background color, and a positive color difference score indicates that the ball was estimated as moving faster when the background was red than when it was blue.

are given instructions that are effective at eliminating response bias.

General Discussion

By some accounts, perception is a modular system that involves encapsulated processes (Firestone & Scholl, 2016a, 2016b; Fodor, 1983; Pylyshyn, 1999, 2003). According to this view, external factors, such as cognition or action, cannot penetrate these processes, and thus, cannot influence what is seen. The action-specific account of perception challenges this view. Prior research has demonstrated that people's ability to block a moving ball influences their perceptual judgments of the ball's speed. Despite a plethora of studies that have ruled out alternative, nonperceptual explanations of this effect (Witt, 2017), this work has been criticized for not including postexperiment surveys (Firestone & Scholl, 2016b). Experiment 1 took this critical step, and its results support the claim that people's ability to act can exert a genuine influence on their perceptual experience. This claim was further supported by the results from Experiment 2, in which action's effect on perception persisted despite instructions for participants to resist any tendency to report that the ball was faster when the paddle was small than when the paddle was big. The results suggest that this action-specific effect is perceptual and is even immune to knowledge about

it. Just as knowledge about a visual illusion (e.g., knowing that the two tables are the same size in the case of Shepard's table illusion) does not lessen the magnitude of the illusion, knowledge about the effect of paddle size on estimated speed of the ball in the Pong task also does not lessen the effect of paddle size on perceived speed.

The data on the Pong effect suggest a role for top-down influences on perception. In the case of action's influence on spatial perception, the effects need not depend on explicit knowledge, however. Action's influence is likely rooted in unconscious motor processes, rather than thinking or reasoning about action. For example, a previous study demonstrated that golf performance, but not subjective ratings of golf performance, correlated with perceived size of the hole (Witt, Linkenauger, Bakdash, & Proffitt, 2008). In another study, physical body weight (but not subjective ratings of body size) related to perceived distance (Sugovic et al., 2016). Indeed, the results from Experiment 2 suggest that knowledge of the bias typically observed in the Pong task does not help to lessen the effect of paddle size on perceived speed of the ball. To understand the mechanism that drives action-specific effects, one must determine both the source of the information about action and how it exerts its influence. The source of information related to action may derive from sensors that detect physical states of the body, such as its size

and location (via proprioceptors) or hunger and fatigue levels (via interoceptors). If perception involves the integration of information extracted from body- or action-based sensory systems with information extracted from visual or auditory sensory systems, action-specific effects may be best considered as a new kind of multimodal effect (Witt & Riley, 2014). In other words, action-specific effects may result from the integration of information from sensors that detect the internal environment and sensors that detect the external environment. If so, action-specific effects on the perceptual experience of spatial layout would demonstrate that such experience is relative to the perceiver's own body and abilities.

Action Editor

Marc J. Buehner served as action editor for this article.

Author Contributions

All the authors designed and conducted the experiments. J. K. Witt performed the data analysis and drafted the manuscript. N. L. Tenhundfeld and M. J. Tymoski provided critical revisions. All the authors approved the final version of the manuscript for submission.

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Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

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Supplemental Material

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Open Practices



All data and materials have been made publicly available via the Open Science Framework and can be accessed at <https://osf.io/akp9n/>. The complete Open Practices Disclosure for this article can be found at <http://journals.sagepub.com/doi/suppl/10.1177/0956797617730892>. This article has received

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Note

1. Bayes factors were calculated as evidence for the alternative hypothesis. A Bayes factor of 3 or greater is considered substantial evidence for the alternative hypothesis (and a Bayes factor greater than 10 is considered strong evidence). A Bayes factor less than 0.33 is considered substantial evidence for the null hypothesis (and a Bayes factor less than 0.10 is considered strong evidence for the null hypothesis). A Bayes factor between 1 and 3 is considered anecdotal evidence for the alternative hypothesis, and a Bayes factor between 0.33 and 1 is considered anecdotal evidence for the null hypothesis.

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