Action-Specific Effects in a Social Context: Others’ Abilities Influence Perceived Speed

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According to the action-specific account of perception, perceivers see the environment relative to their ability to perform the intended action. For example, in a modified version of the computer game Pong, balls that were easier to block looked to be moving slower than balls that were more difficult to block (Witt & Sugovic, 2010). It is unknown, however, if perception can be influenced by another person’s abilities. In the current experiment, we examined whether another person’s ability to block a ball influenced the observer’s perception of ball speed. Participants played and observed others play the modified version of Pong where the task was to successfully block the ball with paddles that varied in size, and both the actor and observer estimated the speed of the ball. The results showed that both judged the ball to be moving faster when it was harder to block. However, the same effect of difficulty on speed estimates was not found when observers watched a computer play, suggesting the effect is specific to people and not to the task. These studies suggest that the environment can be perceived relative to another person’s abilities.

Keywords: speed perception, action-specific perception, affordances, social cognition

A recent and startling finding is that observing another person’s actions triggers an implicit imitation of the action in the observer’s own motor system. This implicit imitation, also known as a motor simulation, can interfere with the observer’s concurrent actions (e.g., Kilner, Paulignan, & Blakemore, 2003). It is as if one person can take over, or at least influence, the motor system of another. Moreover, these observed actions might penetrate mental processes beyond just the motor system. In the current experiments, we examined if perception of object properties such as speed would also be influenced by the observed actions and abilities of others. This prediction is inspired by the action-specific account of perception (Witt, 2011a), which claims that the perceived properties of the environment are influenced by the actor’s ability to perform the intended action. For instance, participants perceived the speed of a ball as a function of their ability to block it (Witt & Sugovic, 2010, in press). In the current studies, observers watched another person attempt to block a ball with various sized paddles and estimated the speed of the ball. We examined if the observers would also perceive the speed of the ball as a function of the actor’s ability to block it.

The action-specific perception account claims that perceivers see the world in terms of their ability to perform the intended action (Witt, 2011a). For example, softball players who are hitting better than others see the ball as bigger (Witt & Proffitt, 2005). This account is inspired by Gibson’s ecological approach to perception (Gibson, 1979). According to Gibson, the primary objects of perception are affordances, which include the possibilities for action in the environment. Affordances convey the mutual relationship between the perceiver and the environment, so by perceiving affordances, people perceive the environment in terms of this relationship. The action-specific perception account extends Gibson’s approach by demonstrating that affordances (and the mutual relationship between the perceiver and the environment) are perceived even in seemingly basic dimensions of the environment such as distance, slant, size, shape, and speed.

Action-specific effects have been demonstrated in a variety of contexts. For example, tennis players perceived the ball to be moving slower when they successfully returned the ball than when they missed the return (Witt & Sugovic, 2010). Children who successfully hit a target more than others did perceive the target as bigger (Cañal-Bruland & van der Kamp, 2009). Hills looked steeper and distances looked farther to perceivers who had to exert more effort to traverse them (Bhalla & Proffitt, 1999; Lessard, Linkenauger, & Proffitt, 2009; Proffitt, Stefanucci, Banton, & Epstein, 2003; Stefanucci, Proffitt, Banton, & Epstein, 2005; Witt, Proffitt, & Epstein, 2004, but see also Woods, Philbeck, & Danoff, 2009; Shaffer & Flint, 2010). Underwater distances looked closer to more skilled swimmers, especially if they wore swimming fins (Witt, Schuck, & Taylor, 2011), and walls appeared shorter to athletes skilled at parkour than to unskilled viewers (Taylor, Witt & Sugovic, 2011). Objects that were easier to reach and grasp looked closer and smaller than objects that were beyond reach or difficult to grasp (Linkenauger, Witt, Stefanucci, Bakdash, & Proffitt, 2009; Linkenauger, Witt, & Proffitt, 2011; Witt, Proffitt, & Epstein, 2005). When searching for a target of a specific orientation, fewer initial saccades were made to objects that were oriented in a different direction when planning to grasp an object.
compared to when planning to point to it (Bekkering & Neggers, 2002). Similarly, perceptual sensitivity to changes in orientation was enhanced when planning to grasp than when planning to point to the object (Gutteling, Kenemans, & Neggers, 2011). Planning or executing a rotational movement led to faster detection of an object rotating in the same direction (Lindemann & Bekkering, 2009), and planning or executing a lateral movement biased the perceived direction and orientation of a target object (Grosjean, Zwickel, & Prinz, 2009; Müßeler & Hommel, 1997a, 1997b; Zwickel, Grosjean, & Prinz, 2010). In summary, many aspects of the perceived environment are influenced by the perceiver’s action intentions and the ability to perform these actions.

Despite the wide range of experimental contexts, the effects always involved the perceiver’s ability to act. In the current studies, we manipulated another person’s ability to act. We examined if a perceiver would see the environment in terms of another person’s ability to act, or if these effects would be limited to the perceiver’s own abilities. One reason to anticipate a perceptual effect based on another’s ability is that the same motor process, namely motor simulation, may play an underlying role in both action-specific effects and observing others’ actions.

Motor simulation is a mechanism proposed to underlie action-specific effects (Witt & Proffitt, 2008). According to this proposal, perceivers simulate their intended action, and the outcome of the simulation influences perception. For example, if this outcome is that an object can be reached, the object looks closer than if the outcome is that the object is beyond reach. If this outcome is that throwing to a target requires more effort, the object looks farther away than if it requires less throwing effort. However, when there is no simulation, and thus no predicted outcome, perception is not influenced by the perceiver’s abilities. Previously, a behavioral interference paradigm was used to block the motor simulation. Participants squeezed a rubber ball while making distance judgments. In this case, the act of squeezing likely engaged the same processes that were necessary to simulate the intended action of reaching or throwing (e.g., Grèzes & Decety, 2001). As predicted, squeezing the ball disrupted the effect of ability on perceived distance (Witt & Proffitt, 2008). These findings suggest that motor simulation is involved in action-specific effects.

If motor simulation is an underlying mechanism for action-specific perception effects, then other factors that engage motor simulations may also influence perception. In particular, motor simulations are also involved in perceiving, understanding, and anticipating the actions of others. For example, motor areas in the brain traditionally associated with movement preparation and execution are also activated when observing another perform an action (Buccino et al., 2001; Grèzes & Decety, 2001), especially when the perceiver is an expert in those movements (Cross, Hamilton & Grafton, 2006; Calvo-Merino, Galar, Grèzes, Passingham & Haggard, 2004). Behavioral interference experiments also demonstrated involvement of the motor system when observing actions. For example, simultaneous observation of incompatible movements interfered with the perceiver’s own concurrent movements (Kilner et al., 2003). Similarly, watching another person play a modified virtual bowling game induced similar hand and head movements in the observer as in the player (De Maeght & Prinz, 2004).

Furthermore, involvement of the motor system when observing others’ actions influences perception of the observed actions. For example, observers who walked on a treadmill showed reduced accuracy in perceived walking speed of point-light walkers (Jacobs & Shiffrar, 2005). Perceivers who had reduced ability to jump due to wearing ankle weights gave decreased estimates of another person’s ability to jump (Ramenzoni, Riley, Shockley, & Davis, 2008). Conversely, observers who had been trained to perform an atypical walking movement displayed better perceptual sensitivity to this movement than did those who had not had the previous motor experience (Casile & Giese, 2006). Similarly, participants who had prior experience controlling a dot perceived greater forward displacement than did observers who did not have prior experience when the dot disappeared after being controlled by another person (Jordan & Hunsinger, 2008). These effects provide evidence for the idea that observing another person perform an action engages the observer’s motor system in a simulation of the action.

Further evidence that the perceiver’s own motor system is involved in the observation of actions comes from enhanced perceptual accuracy when watching one’s own movements. When observing oneself, the movements most closely match the simulated movements, so perceptual accuracy should increase. In accordance with this prediction, perceivers could more accurately distinguish actions depicted by point-light walkers when the videos were of the perceiver performing the action compared to when another person performed the same action (Loula, Prasad, Harber, & Shiffrar, 2005). Similarly, perceivers were better able to predict the outcome of their own actions, such as where a dart will land, than watching videos of themselves than when watching videos of others throwing darts (Knoblich & Flach, 2001). In summary, perception of other’s actions recruits processing from the perceiver’s own motor system.

The motor processes that are recruited when observing the actions of others may be the same processes that are involved in action-specific perception effects. This dual function of the motor system in perception inspired the following prediction: the perceived dimensions of the environment will be influenced by both one’s own and another person’s ability to act. Some evidence already suggests this may be the case. Perceivers rated a sack of potatoes as weighing less when they anticipated carrying the bag with another person who was fit and healthy than when they anticipated carrying the bag with a person who was on crutches (Doerrfeld, Sebänz, & Shiffrar, 2009). In this scenario, the other person’s ability influenced their own perception of weight in a joint-action task.

In the current experiments, we examined whether another person’s ability to act influences perception even when the observer simply watches and has no intention to interact with the other person. Observers watched another person play virtual tennis. A ball moved across the screen, and the actor had to block the ball with a racket, which varied in size from trial to trial. Then both the observer and the actor estimated the speed of the ball. When playing with a smaller racket, actors judge the ball to be moving faster than when playing with a bigger racket (Witt & Sugovic, 2010, in press). The question for the current experiments was whether ability—as a function of racket size—would also influence judgments of perceived ball speed for someone who was simply watching.
Experiment 1

Volunteers participated in pairs, and took turns being the Actor and the Observer. When assigned to be the Actor, participants played a modified version of the classic computer game Pong. They controlled a paddle presented on a screen with a joystick, and used the paddle to attempt to block a ball that moved across the screen. When assigned to be the Observer, participants watched the other person play the game. After each blocking attempt, both participants estimated the speed of the ball.

Method

Participants. Twenty students (6 females, 14 males) participated for course credit.

Stimuli and apparatus. Stimuli were presented on a projection screen. The projected area was 86.8 cm tall \(\times\) 115 cm wide, and the background was black. The participant playing the game (the Actor) sat approximately 180 cm from the projection screen. The participant watching the game being played (the Observer) sat approximately 259 cm from the screen and to the left of the Actor (see Figure 1). A joystick was placed on the table directly in front of the Actor. A white board (47 cm \(\times\) 47 cm) was placed on the table to the left of the joystick so that the Actor’s responses were not visible to the Observer (an initial pilot study without this board showed a similar pattern of results). This board also blocked the Observer’s view of the Actor’s movements of the joystick, although the movements could be detected from the movements of the paddle. A keyboard and a monitor were positioned on the table directly in front of the Observer. These were only used on training trials.

The ball was a white circle (5 cm in diameter) and started on the left side of the screen. The paddle was a white rectangle that was 2-cm wide and set to one of three heights (5.3, 16, 32 cm) and positioned on the right side of the screen. The paddle was placed on top of a white bar that was also 2-cm wide and 86.8 cm tall, covering the entire display height. As a result, the paddle was visually specified by two thin black horizontal lines that were the outline of the top and bottom of the paddle. This was done to help minimize the visual differences across the paddle sizes. The Actor’s ball-blocking performance score was displayed in the top left-hand corner of the projection area.

Procedure. Participants completed the experiment in pairs. One participant was assigned to start as the Actor and the other as the Observer, and they were seated accordingly. All stimuli appeared on the projection screen except during training when giving feedback. Participants were first exposed to the slow and fast speeds. Prior to each exposure, text on the screen said “This is the slow speed” or “This is the fast speed.” The ball then traveled from the left to the right side across the screen at 0.53 m/second (slow) or 2.13 m/s (fast). During training, the ball only moved horizontally and had no vertical displacement. Each speed was shown two times, and all trials were randomized.

Then both participants were tested on the training speeds to ensure that they could discriminate between them. Each speed was shown four times in a randomized order, and both participants made speed judgments. The Actor indicated the speed by pressing the left button labeled “slow” or the right button labeled “fast” on the joystick. The Observer indicated the speed by pressing either 1 (slow) or 2 (fast) on the keyboard. The Actor was provided feedback on their speed estimates on the projection screen while the Observer viewed their feedback on the monitor. If they correctly classified the speed of the ball, text on their designated screen said “Correct!” and if they incorrectly classified ball speed, text indicated that their response was “Incorrect”. Both participants were required to make a speed response before the next trial began, and both were required to accurately classify ball speed before continuing onto the test trials.

During the test trials, the ball appeared on the left side of the screen and the paddle appeared on the right side. To begin the trial, the Actor pressed the trigger button on the joystick, which initiated ball movement. The ball moved at a constant speed ranging from 0.75–1.94 m/s. The ball always moved along a diagonal (the ball moved 2–7 pixels horizontally and 2 pixels vertically at each displacement). The initial vertical direction (up or down) was randomized. The ball changed the vertical component of its direction whenever it reached the top or the bottom of the display. The ball also changed vertical direction at random, which made the task of blocking the ball more difficult. Every 4 ms, there was a 5% chance that the ball would change the vertical direction of its movement.

On each trial, Actors moved the joystick with their dominant hand to control vertical placement of the paddle with the goal of blocking the ball. They were given visual feedback on their performance after each trial. If they successfully positioned the paddle to stop the ball, the ball stopped on the paddle and they received five points. If they missed, the ball continued beyond the edge of the screen and they were deducted five points. A running total was displayed on the top left corner. The Observer watched the Actor attempt to block the ball. Then, both participants estimated the speed of the ball. They made their estimates by performing a speed bisection task. Participants indicated whether the ball moved more like the slow speed or more like the fast speed by pressing the corresponding button on the joystick or keyboard. This speed bisection task was used in previous experiments (Witt & Sugovic, 2017).
2010, in press) and is modeled after typical duration bisection tasks (e.g., Penney, Gibbon, & Meck, 2008). Both participants had to make a speed judgment before the next trial began, and they were not given feedback as to whether they were correct or how the other person had responded.

Participants completed four blocks of trials, then switched roles and completed another four blocks of trials. The Observer became the Actor and vice versa. The experimenter gave the new task responsibilities to each participant before continuing the experiment. The new Actor’s score started at zero. Each block contained two repetitions of the six speeds with each of the three paddle sizes for a total of 36 trials per block. Speed and paddle size were randomized within each block.

**Results and Discussion**

Paddle size significantly influenced participants’ success at blocking the ball. Propportion of successfully blocked balls was submitted to a repeated-measures ANOVA with paddle size as a within-subjects factor and role assignment order as a between-subjects factor. Paddle size significantly influenced blocking success, $F(2, 36) = 387.90, p < .001, \eta^2_p = .96$. Participants blocked more balls as paddle size increased (see Table 1). The data were best characterized by a linear contrast, $F(1, 18) = 670.24, p < .001, \eta^2_p = .97$, though the quadratic contrast was also significant, $F(1, 18) = 60.13, p < .001, \eta^2_p = .77$, and performance with each paddle was significantly different from each other, $p s < .001$. Role assignment order and the interaction between role assignment order and paddle size were not significant, $F s < 1$.

In order to assess apparent ball speed, we calculated the point of subjective equality (PSE) for each participant for each role (Actor and Observer) for each paddle size from binary logistic regressions. Lower PSEs correspond with estimating the ball as moving faster.

As is apparent in Figure 2, paddle size influenced the PSEs for both roles. This was confirmed with a 2 (role: Actor and Observer) $\times$ 3 (Paddle size: small, medium, and big) repeated-measures ANOVA with role assignment order as a between-subjects factor and PSEs as the dependent measure. Role significantly affected the PSEs, $F(1, 18) = 7.52, p < .05, \eta^2_p = .30$. Participants judged the ball to be moving faster when they were the Actor than when they were the Observer. The difficulty of having to position the paddle to block the ball may have increased perceived speed compared to when watching someone else position the paddle.

Paddle size affected the PSEs, $F(2, 36) = 32.49, p < .001, \eta^2_p = .64$. Participants judged the ball to be moving faster when the paddle was smaller and less effective for blocking the ball. The data were best characterized by a linear contrast, $F(1, 18) = 42.81, p < .001, \eta^2_p = .70$, though the quadratic contrast was also significant, $F(1, 18) = 8.50, p < .01, \eta^2_p = .32$. Simple contrasts revealed significant differences between each combination of paddles, $p s < .05$.

Critically, the interaction between paddle size and role was not significant, $F(2, 36) = .09, p > .91$. Participants’ estimates of speed were equally affected by paddle size when they observed as when they acted (see Figure 2).

The main effect of role assignment order was not significant, $F(1, 18) = .24, p > .63$. There was a significant interaction between role and role assignment order, $F(1, 18) = 6.37, p < .05, \eta^2_p = .26$. Participants in the act-then-observe group judged the ball to be moving faster when they acted ($M = 1.28 \text{ m/s, } SE = .05$) than when they observed ($M = 1.38 \text{ m/s, } SE = .05$), whereas participants in the observe-then-act group judged the ball to be moving at similar speeds when they acted ($M = 1.30 \text{ m/s, } SE = .05$) as when they observed ($M = 1.30 \text{ m/s, } SE = .05$). There were no other significant interactions with role assignment order, $p s > .34$.

The significant effect of paddle size on PSEs when observing someone else act suggests that another person’s ability to act can influence one’s own perception of speed. Specifically, the ease with which another person can block a ball, as determined by paddle size, may influence how fast the ball appears to move. One possibility is given that we simulate others’ actions (see introduction), the outcome of this simulation could influence perception in analogous ways to when the perceiver simulates his or her own actions (e.g., Witt & Proffitt, 2008). To test this possibility, we examined whether a similar effect would occur when observing an inanimate object play the game. When observing nonbiological agents, simulation is unlikely or less likely to occur (see General Discussion).

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**Table 1**

<table>
<thead>
<tr>
<th>Paddle size</th>
<th>All (and 1 SEM) Proportion of Balls Successfully Blocked as a Function of Paddle Size Across All Participants (All) and as a Function of Role Assignment Order for Experiment 1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All</td>
</tr>
<tr>
<td>Small</td>
<td>.53 (.02)</td>
</tr>
<tr>
<td>Medium</td>
<td>.85 (.01)</td>
</tr>
<tr>
<td>Big</td>
<td>.97 (.01)</td>
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</table>

*Note. A-O refers to participants in the act-then-observe group. O-A refers to participants in the observe-then-act group.*
Experiment 2

In this experiment, we examined whether the effect of paddle size on apparent speed in the Observer was due to watching another person play or if similar effects would be found when watching an inanimate object (i.e., a computer) play.

Method

Participants. Twelve students (2 females, 10 males) participated for course credit.

Stimuli, apparatus, and procedure. Everything was the same as in Experiment 1 except that only one person participated at a time. The participant completed half the experiment as the Actor and half the experiment as the Observer (order was counterbalanced across participants). As the Actor, they played the game as before, although no one else was observing them. As the Observer, they sat in the same seat as did Observers in the previous experiment, but rather than watching another person play, they watched the screen and observed the computer play. Participants were told that they would be watching a computer play the game. When the computer played, the paddle always moved in perfect synchrony with the vertical component of the ball’s location, which made it clear that a nonanimate object was playing the game.

Results and Discussion

Paddle size significantly influenced participants’ blocking performance, $F(2, 20) = 106.81, p < .001, \eta_p^2 = .91$. Participants blocked balls more successfully as paddle size increased (see Table 2). The data were best characterized by a linear contrast, $F(1, 10) = 330.72, p < .001, \eta_p^2 = .97$, though the quadratic contrast was also significant, $F(1, 10) = 5.99, p < .05, \eta_p^2 = .38$ and each paddle was significantly different from each other, $ps < .001$. The main effect of role assignment order and the interaction between role assignment order and paddle size were not significant, $Fs < 1$. The computer had perfect blocking performance for all three paddle sizes, so this data was not analyzed.

PSEs were calculated and analyzed as before and are presented in Figure 3. Role had a marginal effect on estimated speed, $F(1, 10) = 2.78, p < .12, \eta_p^2 = .22$. Participants tended to estimate the ball as moving faster when they played than when they watched. Role assignment order did not have a significant effect, $F(1, 10) = 0.10, p > .75$. Paddle size significantly affected estimated speed, $F(2, 20) = 15.91, p < .001, \eta_p^2 = .61$.

Table 2

<table>
<thead>
<tr>
<th>Paddle size</th>
<th>All</th>
<th>A-O</th>
<th>O-A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
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<td>.48 (.04)</td>
<td>.47 (.04)</td>
</tr>
<tr>
<td>Medium</td>
<td>.80 (.04)</td>
<td>.83 (.05)</td>
<td>.77 (.05)</td>
</tr>
<tr>
<td>Big</td>
<td>.95 (.01)</td>
<td>.95 (.02)</td>
<td>.96 (.02)</td>
</tr>
</tbody>
</table>

Note. A-O refers to participants who acted first then observed. O-A refers to participants who observed first then acted.

Critically, the interaction between role and paddle size was significant in this experiment, $F(2, 20) = 4.51, p < .05, \eta_p^2 = .31$. Participants’ estimates of speed were more affected by paddle size when they acted than when they observed the computer. We conducted separate repeated-measures ANOVAs for each role with paddle size as the repeated factor and PSEs as the dependent factor. When assigned to be the Actor, paddle size significantly affected estimated speed, $F(2, 22) = 20.08, p < .001, \eta_p^2 = .65$. However, when assigned to be the Observer and watch the computer play, paddle size only had a marginal effect on estimated speed, $F(2, 22) = 3.15, p = .063, \eta_p^2 = .22$.

We also conducted separate repeated-measures ANOVAs for each role (Actor or Observer) and role assignment order (act-then-observe or observe-then-act) with paddle size as the within-subjects factor and PSEs as the dependent factor. When assigned to be the Actor, paddle size influenced estimated speed for both groups, $Fs(2, 10) > 4.58, ps < .05, \eta_p^2 > .47$ (see Figure 4). However, a different pattern emerged for the analyses on PSEs as the Observer (see Figure 4). For participants who were assigned to the act-then-observe group, when they observed the computer play, paddle size influenced estimated speed, $F(2, 10) = 5.70, p = .022, \eta_p^2 = .53$. In contrast, for participants who were assigned to be in the observe-then-act group, when they observed the computer play, paddle size did not influence estimated speed, $F(2, 10) = 0.15, p = .87$.

This result suggests that the experience of playing the game is necessary for paddle size to influence speed judgments when watching an inanimate object play. When participants did not yet have experience with the effectiveness of each paddle, they did not rate the ball’s speed in terms of this effectiveness. However, for participants who did have experience as the Actor, when they observed the computer play, their ratings of ball speed were affected by paddle size. In the previous experiments, the effect of paddle size when observing another person play did not differ depending on order. Thus, the null-effect of paddle size for the observers-then-actors is not likely due to a reduced effect when observing first. Instead, perhaps participants who played first then...
watched the computer play anticipated their own abilities to block the ball even when watching the computer play. Given that the previous experiments revealed the same effects when playing as when watching another person play, the current pattern of results suggest that similar effects on perception are not apparent when watching an inanimate object perform the same task.

For participants in the observe-then-act group, there was no effect of paddle size on estimated speed when watching the computer play. This lack of effect could have occurred for several reasons. One possibility is that participants did not simulate the computer’s nonbiological movement. Another possibility is that because the computer did not make any errors, paddle size was irrelevant and therefore did not have an effect on estimated speed. To evaluate these possibilities, we conducted an experiment in which the computer made errors.

**Experiment 3**

In this experiment, participants observed an error-prone computer in which performance with each paddle was approximately matched to human performance.

**Method**

**Participants.** Nineteen students (5 female, 14 male) participated in exchange for course credit. One participant was excluded because he could not manage to sit up during the experiment and repeatedly fell out of his chair!

**Stimuli, apparatus, and procedure.** Everything was the same as in Experiment 2 except that the computer made mistakes and all participants observed first and acted second. We only used the observe-then-act order because we assumed that participants who acted first would perceive the speed of the ball similarly as in Experiment 2, and it was the observe-then-act condition that required better understanding.

In Experiment 2, when the computer played, the vertical position of the paddle was always set to the vertical position of the ball, so the computer never missed. In this experiment, the vertical position of the paddle was also set to the vertical position of the ball, but there was delay between each time the paddle was repositioned to match the ball. After each 288 ms delay, there was a 50% chance that the paddle would be repositioned or remain where it was currently located. Pilot studies determined that this set-up resulted in performance that most closely matched human performance. This delayed repositioning of the paddle resulted in movement that was clearly nonbiological but error-prone. In addition, participants were given instructions that they would be watching a computer play the game.

**Results and Discussion**

First we analyzed blocking success. A 2 (player: participant or computer) × 3 (paddle size) repeated-measures ANOVA with proportion of balls successfully blocked as the dependent measure revealed a significant interaction between player and paddle size, $F(2, 34) = 16.72, p < .001, \eta_p^2 = .50$. Although we equated for performance between the computer and human conditions as best we could, paddle size had a bigger effect on blocking success for the computer than for the participant (see Table 3). It is important to note that for both players, paddle size influenced blocking performance, $F(2, 34) > 193.18, ps < .001, \eta_p^2 > .91$, so unlike in the previous experiment, paddle size influenced the computer’s performance in this experiment.

The question of interest was whether participants would perceive the speed of the ball independently of paddle size (as in the observe-then-act condition in Experiment 2) or if they would perceive the speed of the ball as a function of the effectiveness of the paddle even when an inanimate object was playing. To preview our findings, the results seem to fall somewhere between these two possibilities.

As shown in Figure 5, paddle size appears to have a bigger effect when participants acted than when they observed the computer. PSEs were calculated as before and submitted to a 2 (role) × 3 (paddle size) repeated-measures ANOVA. Paddle size significantly influenced PSEs, $F(2, 34) = 14.14, p < .001, \eta_p^2 = .45$. Role did not significantly influence PSEs, $F(1, 17) = 1.15, p > .29, \eta_p^2 = .06$. While we had made no initial predictions with respect to the effect of role, it is interesting to note that when

**Table 3**

<table>
<thead>
<tr>
<th>Paddle size</th>
<th>Participants</th>
<th>Computer</th>
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<tbody>
<tr>
<td>Small</td>
<td>.52 (.02)</td>
<td>.43 (.02)</td>
</tr>
<tr>
<td>Medium</td>
<td>.83 (.02)</td>
<td>.78 (.01)</td>
</tr>
<tr>
<td>Big</td>
<td>.95 (.01)</td>
<td>1.00 (.00)</td>
</tr>
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</table>
observing another person play, the ball looked to be moving slower than when playing (Experiment 1) but that when observing an error-prone computer play, the ball did not look slower than when playing (Experiment 3). We can only speculate on the cause of this particular pattern of results. Our inclination is that the effects may have to do with the perceiver’s ability to anticipate the actions. The timing of the computer’s movements in Experiment 3 was fairly random, making it difficult to anticipate when the paddle would move and whether the ball would be successfully blocked. This lack of ability to anticipate the paddle’s movements may have contributed to the perception of the ball appearing to move faster than when observing another person play; however, more research will be necessary to understand the current pattern of results.

The interaction between role and paddle size was marginally significant, $F(2, 34) = 2.44, p = .10$, $\eta^2 _{p} = .13$, but the linear contrast of this interaction was significant, $F(1, 17) = 10.64, p < .01$, $\eta^2 _{p} = .39$. Because we expect an increase in PSE as paddle size increases, the linear contrast is the contrast of interest. This result suggests that paddle size had a bigger effect on perceived speed when playing than when observing an error-prone computer play.1

When participants played the game as Actors, paddle size influenced the PSEs, $F(2, 34) = 12.11, p < .001$, $\eta^2 _{p} = .42$. The linear contrast was significant, $F(1, 17) = 21.45, p < .001$, $\eta^2 _{p} = .56$. The quadratic contrast was not significant, $p > .95$. Paired-samples $t$ tests revealed significant differences between all of the paddles, $t(17) > 2.26$, $ps < .05$.

The next question of interest was whether paddle size influenced the PSEs when observing an error-prone computer. A repeated-measures ANOVA with paddle size as the within-subjects factor and PSEs when observing the computer play as the dependent factor did not reveal a significant effect of paddle size, $F(2, 34) = 1.67, p > .20$. However, the linear contrast was significant, $F(1, 17) = 7.79, p < .05$, $\eta^2 _{p} = .31$. Given that the linear contrast is the contrast of interest, this result implies that paddle size still influenced PSEs even when watching a computer play. Paired-samples $t$ tests revealed a significant difference between PSEs when the computer played with a small paddle versus a big paddle, $t(17) = 2.79, p < .05$, but not between the medium paddle and either of the other two paddles, $ps > .20$ (see Figure 5). Paddle size appears to have a small but significant effect on PSEs when observing an error-prone computer play.

To further analyze these results, we combined the data from Experiments 1 and 3 to determine if paddle size had a bigger effect on perceived speed when observing another person than when observing an error prone computer. Observer PSEs were entered into a repeated-measures ANOVA with paddle size as a within-subjects factor and experiment (1-human or 3-computer) as a between-subjects factor. Paddle size significantly influenced PSEs, $F(2, 72) = 15.56, p < .001$, $\eta^2 _{p} = .30$. There was a significant effect for experiment, $F(1, 36) = 3.95, p = .05, \eta^2 _{p} = .10$.

Participants who observed an error-prone computer judged the ball to be moving faster than did participants who observed another person.

Critically, there was a significant interaction between paddle size and experiment, $F(2, 72) = 6.86, p < .01$, $\eta^2 _{p} = .16$. Paddle size had a bigger effect on estimated speed when observing another person play than when observing an error-prone computer. To ensure that this significant difference was not due to population differences between experiments, we also compared PSEs when participants played as the Actor, and found no significant interaction between paddle size and experiment, $F(2, 72) = 1.39, p > .25$, $\eta^2 _{p} < .04$. The linear contrast for this interaction was also not significant, $F(1, 36) < 1$. We obtained the same pattern of results between the two experiments when we included only participants from Experiment 1 who, like those in Experiment 3, observed before playing. These results also suggest that the action-specific effect of paddle size on perceived speed is reduced when observing a computer play.

The goal of this experiment was to determine why paddle size did not affect PSEs when observing an error-free computer play in the observe-then-act condition in Experiment 2. More specifically, we aimed to determine if the lack of effect of paddle size was due to watching nonbiological movements or due to watching flawless performance. The answer appears to be that watching both nonbiological movements and flawless performance is necessary to eliminate the effect of paddle size on estimated speed. However, when watching error-prone performance by a nonbiological object, the computer’s ability to block the ball only had a limited effect on estimated speed.

One key factor for the effect of paddle size on estimated speed may be the extent to which participants can detect information related to the blocking ease of each paddle size. When participants observed nonbiological movements that made no errors, information about the ability of each paddle size was not as apparent, and

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1 We also computed difference scores between PSEs for the small and big paddles for when participants acted and when they observed. A larger score denotes a bigger effect of paddle size on PSEs. The difference scores for each role were submitted to a paired-samples $t$-test. Role had a significant effect on these difference scores, $t(17) = 2.68, p < .05$. The difference score was larger when participants acted ($M = 0.12 \text{ m/s, SD} = .11$) than when they observed the computer ($M = 0.05 \text{ m/s, SD} = .07$). This result also suggests that paddle size had a bigger effect when acting than when observing.
thus paddle size did not have an effect on estimated speed. When they observed nonbiological movements that did make errors, there was some information about the difficulty of blocking with each paddle size, so paddle size did have an effect on estimated speed. However, without being able to simulate the nonbiological movements of the computer, the effect of blocking ability on estimated speed was reduced.

General Discussion

The current studies suggest that we perceive the world in terms of our own abilities to act in it and in terms of other people’s abilities to act. Participants were tasked with blocking a ball and estimating its speed. They estimated the ball as moving faster when they had to block it with a smaller, less effective paddle, which replicates previous findings (Witt & Sugovic, 2010, in press). In addition, they also judged the ball to be moving faster when they observed someone else attempt to block the ball with the smaller, less effective paddle. In this case, the observer simply watched another person play, yet ratings of ball speed were influenced by how easy it was for the other person to block the ball. Anecdotal evidence from athletes suggests that when they are playing well, the game seems to move in slow motion. Our results suggest similar effects for the fans who are watching the game.

Traditional theories of perception consider the underlying processes to be behaviorally independent (e.g., Fodor, 1983; Loomis & Philbeck, 2008). According to this view, the ball should look like it is moving at the same speed regardless of the ease with which it could be blocked. Such a general-purpose percept could then be used by any number of postperceptual processes to comprehend the surrounding environment, make behavioral decisions, and execute actions. However, the current studies and previous research challenge this traditional account by proposing that perception is action-specific (Witt, 2011a). Instead of being behaviorally independent, perception may be informed by the motor system. Both anticipated action (as when playing the game) and observed action (as when watching someone else play) involve the motor system (see, e.g., Grèzes & Decety, 2001 for review). Here, we found that both anticipated and observed actions influenced estimates of ball speed.

There is currently debate about whether these effects of action on perceptual judgments stem from perceptual effects, judgment biases, or a combination of both (see, e.g., Loomis & Philbeck, 2008; Proffitt & Linkenauger, in press; Witt, 2011a, 2011b; Woods et al., 2009; see also Witt & Sugovic, in press, for discussion that directly relates to this empirical paradigm). The debate will only be acknowledged and not elaborated here (see above references for further discussion). Historical factors favor a nonperceptual account, but the current empirical evidence favors a perceptual account.

These results expand on the previous perception-action literatures in a number of ways. First, they demonstrate that action observation penetrates mental processes beyond just the motor system (see introduction). Not only do these observed actions play puppeteer with the observer’s motor homunculus (e.g., Calvo-Merino et al., 2005), but these actions may also provide a perceptual ruler that can be used to scale the environment. In other words, the observed actions of another person influence both motor processes and the perceived environment.

Second, the results expand on the action-specific perception account. This account proposes that perception expresses the relationship between the perceiver and the environment. The current results challenge this claim because even when the perceiver’s relationship to the ball was held constant (as when they observed another person play), the perceiver still saw the ball’s speed differently (as a function of the actor’s ability). We see two possible modifications to the original action-specific claim. One possible modification is that perception might express the relationship between the actor and the environment. The actor could be anyone interacting with the environment, not just the perceiver. When the perceiver is the actor, then the relationship is between the perceiver and the environment. When the perceiver is not the actor, then the relationship is between the other person and the environment.

This possibility is supported by research on the perception of affordances for others. The idea that perception expresses the relationship between the perceiver and the environment was originally proposed by Gibson (1979). In his theory of affordances, Gibson claimed that affordances were the main object of perception. These affordances specify the relationship between the perceiver and the environment, so according to Gibson, it is this relationship that is perceived. With respect to the affordances for others, if information to specify this relationship is available and if a perceiver is attuned to this information, then people should be able to detect affordances for others (Gibson, 1979, p. 141). In line with this claim, previous research suggests that people are able to do so even when the observed person’s abilities differed from the observer’s abilities (Rochat, 1995; Stoffregen, Gorday, Sheng, & Flynn, 1999). The current results might extend the action-specific account by demonstrating that these affordances for others are also detected when perceiving the speed of another person’s target.

A second possibility is that perception might express the relationship between the perceiver and the environment, and that each observer perceived the ball as if she or he was the one that had to block it. In other words, the observers may have perceived the ball as if they were in the Actor’s situation of having to block the ball. Previous research has demonstrated that imagining performing an action can influence perceived distance (Davoli, Brockmole, & Witt, in press; Witt & Proffitt, 2008). Perhaps observing another person led observers to imagine themselves blocking the ball, and perceived ball speed as a function of their own anticipated abilities.

Because participants in our experiments all had similar abilities, our current data do not allow us to differentiate between whether observers perceived ball speed in terms of the actor’s abilities or in terms of their own abilities as if they were in the actor’s situation of having to block the ball. In addition, the two possibilities are not mutually exclusive, and it is possible that both might occur. Indeed, neurological evidence suggests both of these types of processes exist and may be involved in simulating other people’s mental states (Waytz & Mitchell, 2011). One mechanism is for “mirroring”, in which the other person’s mental states are experienced vicariously. An example of this would be feeling pain when observing someone else who is experiencing pain. Another neurologically distinct mechanism is for “self-projection”, in which perceivers project or imagine themselves in another person’s situation and infer how they would feel in that situation. An example would be inferring that a particular situation, such as having a tooth removed, would be painful. With respect to the effect of
ability on perception, it is possible that both another person's abilities influence perception and that another person's abilities provide insight into one's own ability, which then influences perception. More research is necessary to determine if one or both of these types of processes occur and if so, the conditions under which each type of effect occurs.

The current results are consistent with the proposal that motor simulation is a mechanism underlying action-specific effects (Witt & Proffitt, 2008). According to this proposal, the intended action is simulated, and the outcome of this simulation informs perception about the perceiver's abilities. One prediction is that any situation that gives rise to simulation should also influence perception. For instance, as discussed above, observing another person perform an action engages motor processes involved in simulation (e.g., Grèzes & Decety, 2001). If motor simulation is involved in action-specific effects, then similar effects should also occur when watching another person attempt to block the ball. Our results matched this prediction: Observers saw the ball as moving faster when it was more difficult for the Actor to block it. According to a motor simulation account, when Observers watched the Actors play, they would have simulated the task. This simulation would allow the Observers to anticipate the difficulty with which the Actor would have in blocking the ball, and the outcome of this simulation would then influence perceived speed.

Another prediction of this motor simulation account is that situations in which a simulation does not occur should not lead to action-specific effects. Previous results showed that a dual-action task that was designed to interfere with the simulation eliminated action-specific effects with respect to reaching and throwing (Witt & Proffitt, 2008). Another situation in which motor simulations are not engaged occurs when observing nonbiological movements. For example, watching someone else perform incongruent arm movements interfered with one's own movements, but watching a robot perform incongruent movements did not interfere with performing the movements (Kilner et al., 2003). Similarly, watching a moving dot that is believed to be controlled by a human interfered with concurrent movements, but when observers believed the dot was controlled by a computer, similar interference did not occur (Stanley, Gowen, & Miall, 2007). Neuroimaging work reveals that observing human grasping movements elicits activity in the left premotor cortex. This same area was not activated when observing a facsimile robotic hand perform the same action (Tai, Scherfler, Brooks, Sawamoto & Castiello, 2004). There is some evidence that viewing robotic actions can prime compatible actions, but even then, the priming is demonstrably weaker than the same actions primed with human hands (Press, Bird, Flach & Heyes, 2005).

Consistent with the prediction that these effects are dependent on motor simulations, we found that action-specific effects disappeared or were reduced when observing a computer play. According to a motor simulation account, observers could not simulate the nonbiological movements of the computer, so the action-specific effects on perception were reduced.

While the current results are consistent with the idea of motor simulation as an underlying mechanism, other possible mechanisms may exist. One possible mechanism could involve differences in orienting attention. Although the role of attention in action-specific effects has not yet been examined, it is possible that attention contributes to or even is responsible for these effects. An attentional mechanism could also explain the reduced effect when observing a computer play. The presence of social cues, such as gaze or head direction, causes involuntary orienting of attention in the cued direction (Langton & Bruce, 1999; see Langton, Watt & Bruce, 2000 for a review). In the current experiments, social cues were present when participants observed humans play and absent when participants observed a computer play. Attention may have been directed differently when observing a person than when observing a computer, which could account for the reduced effect when watching the computer.

Another possible mechanism for the current results is that observers perceptually imagined the outcomes, and these outcomes influenced perceived speed. According to this account, motor processes are not involved in these effects. However, it is difficult to explain the results in Experiment 3 with an explanation that does not involve motor processes. In Experiment 3 where the computer made errors, there was perceptual information about the relationship between paddle size and blocking success. Therefore, the only difference between Experiments 1 and 3 was whether the motion perceived was biological or nonbiological. It is well known that the perception of biological motion is constrained by biological limitations. For instance, with apparent motion of the body, instead of seeing the shortest physical path, perceivers see the shortest biologically plausible path (Shiffrar & Freyd, 1990, see also Grosjean, Shiffrar, & Knoblich, 2007; Oh & Shiffrar, 2007). There is also evidence to suggest that perception of biological motion involves motor processes (e.g., Brass, Bekkering, & Prinz, 2001; Chartrand & Bargh, 1999; Knoblich & Flach, 2001; Loula et al., 2005; Serino et al., 2010; see also Wilson & Knoblich, 2005). For instance, perceived walking speed of point-light walkers is less accurate when the perceiver is also walking (Jacobs & Shiffrar, 2005). Given that motor processes are involved in perceiving biological motion, and given that ball speed is perceived differently when the paddle is controlled by a biological agent than a nonbiological object, the involvement of motor processes may be responsible for this difference in the action-specific effects when observing another person and observing a computer.

The reduced action-specific effect when observing the error-prone computer in Experiment 3 also speaks to the nature of action-specific effects in general. In particular, these results suggest that perceived speed, at least in this task, is not a function solely of feedback. When the computer played, feedback was given on trial success with each paddle size, yet this was not enough to induce a full action-specific effect. An experiment with false feedback would provide a more direct test of which aspects of the perceiver's ability influences perceived speed. With respect to the current task, it is unknown precisely which aspect of ability affects perception. Typically, we have found that overall blocking performance does not correlate with perceived speed (Witt & Sugovic, in press). However, overall performance has related to spatial perception as found in previous research (Canal-Bruland & van der Kamp, 2009; Witt & Dorsch, 2009; Witt & Proffitt, 2005; Witt & Sugovic, 2010). We have also found that trial-by-trial performance usually does not relate to perceived speed (Witt & Sugovic, 2010, in press). For the current task, we think that ability—as measured by average blocking success—with each paddle size is the relevant factor for perceived speed. Other candidate factors include perceived ability (which could be measured by how many balls participants think they blocked with each paddle), anticipated ability (which could be measured by how
many balls participants think they will block with each paddle), perceived effort (which could be measured with a perceived effort scale), and actual effort (which could be measured with a Newton meter attached to the joystick). Future studies will need to determine which of these factors can influence perceived speed.

One issue regarding the current findings is whether or not perceiving the environment in terms of another person’s ability to act is adaptive. For example, when watching a young child or an older adult, it might be useful to perceive objects in terms of that person’s ability to interact with them. Hills that would be too steep to climb for them could be avoided. Desirable objects that are too far for them to reach could be moved closer while dangerous objects could be moved farther away. As another example, consider being in competition with another person. A bias to perceive speeds, distances, and sizes in terms of the other person’s abilities would be useful for making quick decisions about what the other person could or could not do and use this information to make adjustments and decisions relevant to our own behavior. However, situations certainly exist in which perceiving in terms of another’s abilities would be maladaptive. Seeing a gap in terms of an Olympic jumper’s abilities might lead to a fatal misperception of the gap being small enough to jump over. More research is needed to understand the conditions under which another’s abilities are embodied and influence perception, and whether such effects are adaptive or maladaptive for subsequent behavior.

In summary, we propose that observation of another person’s goal-directed actions influences the way in which the observer perceives the target object. Balls that were easier to block were judged to be moving slower than balls that were more difficult to block. This effect was apparent both when people played the game themselves (which replicates previous research, Witt & Sugovic, 2010, in press) and when they watched someone else play the game. In fact, the effect was just as big when watching as when playing. However, the effect of ease to block the ball on speed judgments was reduced when watching a computer play. Thus, the movements of an inanimate object do not have the same effect on perceptual judgments as another person’s movements. However, when paired with another person, the world may be perceived in terms of that person’s abilities.

References


ACTION-SPECIFIC EFFECTS IN A SOCIAL CONTEXT


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