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ORIGINAL ARTICLE

Perceptually walking in another's shoes: goals and memories constrain spatial perception

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Abstract Perceptual variables such as perceived distance contain information about future actions. Often our goals involve the integration of another's goals, such as lifting heavy objects together. The purpose of this study was to investigate how another's actions might influence one's own goal-oriented perceptions (i.e., verbal distance estimates). Using a within-subject paradigm, we replicated a well-known finding that carrying a weighted backpack results in larger distance estimates relative to not carrying a backpack. In a crucial second condition, this effect was reversed: distance estimates were significantly greater when not carrying a weighted backpack than when carrying a backpack. In this condition, participants provided distance estimates while wearing a weighted backpack during the first phase and then gave estimates while not wearing a backpack, but following an experimenter wearing a weighted backpack in the second phase. Three additional conditions systematically documented how the observation of another's actions influenced distance estimates.

Introduction

Perceived distances are greater if one wears a weighted backpack while estimating distance relative to not wearing a weighted backpack (Proffitt, Stefanucci, Banton, & Epstein, 2003). In their now classic work, Proffitt and colleagues found that while standing, participants' estimates to targets at a variety of distances are systematically greater when wearing a weighted backpack (see also Bhalla & Proffitt, 1999). This difference increases as actual distance increases. This effect also varies with a host of factors such as knowledge about the contents of one's backpack (Durgin, Baird, Greenburg, Russell, Shaughnessy, & Waymouth, 2009), blood glucose levels (Schnall, Zedra, & Proffitt, 2010), and current action capabilities (see Witt, 2011 for review). Often, findings such as these are accounted for via appeals to factors such as implied effort (Proffitt, 2006), action capabilities (Witt, 2011) and affordances (Gibson, 1979).

Common to each of the above-listed frameworks is the notion that perception contains information about future action: how much energy one will have to expend to complete a future action (Proffitt, 2006), what types of actions one's current skill set will allow (Witt, 2011), and what action options the current optic array affords (Gibson, 1979). In each case, perceptions are contextualized by future actions that are possible within one's current environment (e.g., a steep hill or a heavy backpack).

One explanation of how it is that possible future actions influence perception is the theory of event coding (TEC) (Hommel, Müsseler, Aschersleben, & Prinz, 2001), which posits the following: (1) actions are planned in terms of the distal effects they are to produce and (2) perception and action-planning utilize overlapping neural resources. In addition, TEC asserts that action planning develops an influence on perception because any sensory effect, intended or unintended, that repeatedly accompanies a given motor movement will form associations with the neural dynamics underlying the generation of that movement. As these associations between movements and sensory effects

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develop, later presentations of these effects will prime the movements necessary to produce them. As an empirical example, Hommel (1996) trained participants on a stimulus–response mapping (e.g., press the right button in response to a green stimulus and the left button in response to the red stimulus) and then paired an irrelevant response tone (i.e., an unintended action–effect that occurred when the button was pressed) with the button press (e.g., a high tone with the right button press and a low tone with the left button press). In later testing, participants completed the same stimulus–response task, but one of the two effect tones (i.e., high or low) was simultaneously presented with the stimulus. The tone was either the tone originally presented with the button press (i.e., the compatible condition) or the tone originally presented with the opposite button press (i.e., the incompatible condition). Reaction times were significantly longer in the incompatible condition. Hommel argued that because the irrelevant response tones become paired with the button presses, later presentation of the tones primed the associated response. Thus, when the stimulus and the effect tone primed different responses (i.e., the incompatible condition), participants had to inhibit the incorrect response, which, in turn, resulted in longer reaction times.

The reason for reviewing Hommel's (1996) experiment in such detail was to clarify just how easily movement effects become associated with planning dynamics. Even unintended effects of actions become paired with movement generation, such that later presentation of the effect primes the associated neurodynamics necessary to generate the movement. This, of course, explains why perception is influenced by future behavioral possibilities. The perception of previously generated action–effects (e.g., perceiving a hill to climb, a distance to traverse, or a target to walk toward) activates the plans to produce those effects (e.g., climbing the hill, traversing the distance, or walking toward the target). In other words, one perceives the event in terms of one's past movement-effect (i.e., planning) experiences in relation to that event. Thus, when perceiving the distance to a target, for example, distance will be perceived in terms of the numerous 'walking-to-target' experiences one has accumulated over their life-course up to that point. Included in the numerous 'walking-to-target' experiences are movement–effect associations such as walking at different levels of fatigue, different levels of burden (e.g., carrying a backpack or not), and different levels of resistance (e.g., walking on a smooth surface vs. through sand). The future aspect of perception referred to in Proffitt's (2006) Economy of Action approach, Witt's (2011) Action-specific hypothesis, and Gibson's (1979) notion of affordances can be accounted for in terms of the complex, multi-modal patterns of movement–effect associations one develops over the life-course.

Neural support for TEC derives from data revealing that pre-motor centers involved in motor planning are also involved in perceiving objects that afford motor activity (Rizzolatti, Fogassi, & Gallese, 2001). This overlap between planning and perception also extends to perceiving others, in that the observation of another's actions involves motor-cortical activation similar to that of acting oneself. For example, expert dancers who observe the dancing of other experts exhibit greater activation in premotor areas involved in action planning than do novice dancers. Importantly, less motor-cortical activation occurs when expert dancers observe dances that are not within their own expertise (e.g., when an expert Capoeira dancer observes a Ballet dancer; Calvo-Merino, Glaser, Grézes, Passingham, & Haggard, 2005).

Given TEC's assertion that (1) actions are planned in terms of distal effects and (2) perception of such effects primes motor planning associated with those effects, it should be the case that perceptions of distal effects produced by another person (e.g., watching another climb a hill or walk toward a target) will be perceived in terms of the motor planning one would have to generate to produce the distal effect oneself. Empirical support for this assertion derives from experiments in which participants make perceptual judgments after watching someone else produce an action–effect themselves. For example, when participants observe a computer stimulus whose movements are controlled by another person, and the stimulus unexpectedly vanishes, the perceived vanishing point is typically displaced beyond the actual vanishing point, in the direction of motion (Jordan & Hunsinger, 2008). Crucially, this displacement is larger if the observer previously experienced controlling the stimulus. As another example, novice and expert pianists who press two buttons, one after the other, on either a piano or computer keyboard, perceive significantly more of the press pairs as causing an increase in pitch when the second key press is to the right of the first key press (i.e., the relative key-pitch layout is consistent with that of a piano) than when the second press is to the left of the first (Repp & Knoblich, 2009). This effect is significantly larger for expert pianists, and it also occurs if experts passively observe another person press the tone-generating keys. Clearly, observing another control an event that one has previous experience controlling leads to activations of action-planning memories that influence perception.

From the perspective of TEC (Hommel et al., 2001), observing stimulus movements controlled by another activates remembered movement–effect dynamics similar to those generated while controlling the stimulus oneself. As another empirical example, when playing a classic Pong game on a computer, participants perceive the speed of the virtual ball to be faster when using a smaller (vs. bigger) paddle and when they observe another use a smaller paddle, but not when observing a computer use a smaller paddle, even when the computer was error prone simulating human movement (Witt, Sugovic, & Taylor, 2012). Moreover, participants who first play the Pong game and then observe another play the game experience the speed of the virtual ball in terms of their own action capabilities (i.e., movement–effect memories). Specifically, participants who were better Pong players than the person they observed perceived the ball to be slower than participants who were worse Pong players than the player they observed (Witt, South, & Sugovic, 2014). Collectively, these findings are consistent with TEC and the idea that observing the goals and actions of another (i.e., effects and movements, respectively) puts one in a state of planning for the very same goals and actions, depending, of course, on one's abilities (as action planning and perception share neural overlap). In short, we perceive the goals and actions of others in terms of our own abilities (i.e., in terms of our movement–effect memories) in relation to those of the person we are observing.

Given TEC's ability to clearly explain how both social (Witt et al., 2014) and memory (Jordan & Hunsinger, 2008) factors give rise to information regarding possible future actions within perception, the purpose of the present experiment was to test whether we could use TEC to combine memory and social factors in a way that would significantly influence the effect that originally inspired so much research in this area; namely, the traditional backpack effect (Proffitt et al., 2003). To do so, we utilized a distance estimation paradigm in which participants completed two phases of distance estimations, while either carrying or not carrying a weighted backpack. This two-phase method was included in five different conditions (see Fig. 1). The first condition—the Replication condition—was designed to replicate the results of Proffitt et al.'s (2003) between-subjects experiment, using a within-subjects design. Thus, participants made distance estimates in both phases, but wore a backpack in Phase One, and did not wear one in Phase Two. We predicted that distance estimates in Phase One would be greater than distance estimates in Phase Two.

The second condition—the Reversal condition—was exactly the same as the Replication condition, save for one crucial difference. Specifically, in Phase Two, when participants made distance estimates while not wearing a backpack, they followed an experimenter who was, in fact, wearing a weighted backpack. The Reversal condition tested what would happen to the participants' distance estimates in Phase Two when (1) their action memories of having carried a backpack in Phase One were activated by someone else carrying a weighted backpack and (2) the participants' current action capabilities in Phase Two were

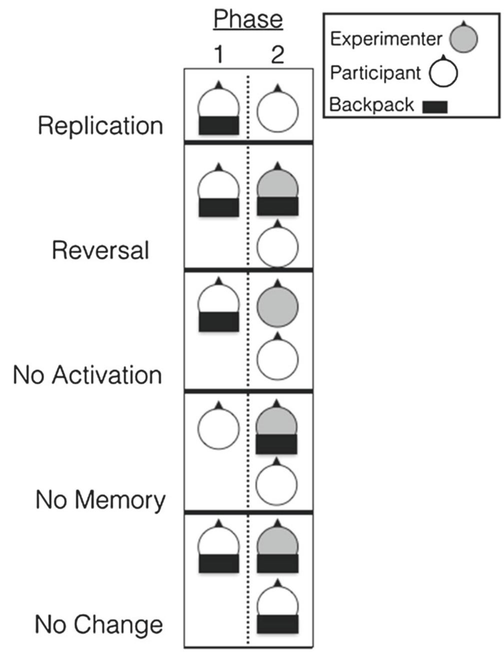

Fig. 1 Experiment design. Each condition (*left*) contained two phases (*top*), in which participants (*white circles*) either carried a backpack (*black rectangle*) or not. In some conditions participants followed an experimenter (*gray circles*) in Phase Two who carried a backpack or not

different from those of the actor (i.e., the participant did not wear a weighted backpack in Phase Two, while the experimenter did). We liken our Phase Two participants in the Reversal condition to the Phase Two participants in Witt et al. (2014), who watched another play Pong (during Phase Two) after having done so themselves (during Phase One). As was stated above, Witt et al. (2014) discovered that participants who were better at Pong than the person they observed perceived the ball to move more slowly than participants who were worse than the person they observed. If one assumes better participants experienced the Pong game as being "easier" than worse participants experienced it to be, it might be the case that our Phase Two participants will experience the trek from target to target as being more difficult for the experimenter, particularly in relation to (1) the participant's own experiences carrying the backpack (i.e., backpack-carrying memories) and (2) the participant's current action abilities (i.e., not wearing a weighted backpack) in relation to those of the experimenter (i.e., wearing a backpack). As a result, experiencing the experimenter's trek as being more difficult than their own should lead their own distance estimates to be larger in Phase Two than in Phase One. In short, we predicted a reversal of the traditional backpack effect.

The remaining three conditions were designed to test whether the predicted results of the Replication and Reversal conditions were due to (1) the activation of action memories and (2) the discrepancy in action capabilities between the participant and the experimenter in Phase Two. Thus, we included a No Activation condition in which we replicated the Reversal condition, but did not allow the experimenter to wear a backpack in Phase Two. We assumed this would prevent the experimenter from activating (i.e., no activation) "backpack-carrying" memories in the participant during Phase Two. If the reversal requires the activation of such memories, the reversal should not replicate in this condition. Since the participant is wearing a backpack in Phase One, but not in Phase Two, we expected a replication of the traditional backpack effect (i.e., larger estimates while wearing a backpack).

To test whether Phase One generation of backpack-carrying memories is necessary to produce a reversal, we ran a No Memory condition in which we replicated the Reversal condition but did not allow the participant to wear a weighted backpack during Phase One. If the reversal requires the activation of backpack-carrying memories from Phase One, we should not replicate the reversal in this condition. Rather, since there is no change in the participant's action capabilities between phases (i.e., the participant does not wear a backpack in either phase) and there is no action capability difference between the experimenter and the participant in Phase Two, there should be no difference in the distance estimates obtained in both phases.

Finally, to test whether the reversal requires an action capability discrepancy between the participant and experimenter in Phase Two, we replicated the Reversal condition, but negated the action capability discrepancy in Phase Two by having the participant wear a weighted backpack in Phase Two, as well as Phase One. We call this the No Change condition. If the reversal requires an action capability difference in Phase Two, we should not replicate the reversal in this condition because both the participant and the experimenter wore a weighted backpack during Phase Two. In addition, because participants wore a backpack in Phases One and Two, there should be no difference in distance estimates between phases. However, since participants carried the weighted backpack during both phases, potential fatigue might result in larger distance estimates in Phase Two.

Method

Sixty undergraduate students were recruited from Illinois State University's Department of Psychology participant sign-up system. All participants were at least 18 years of age with normal or corrected to normal vision. Participants weighed between 100 and 200 pounds and did not have current or chronic back problems. Participants received credit for psychology courses for their participation in this study.

Each session lasted approximately one half hour. After providing informed consent, participants were asked to give their weight by standing on a scale. Then, weights equal to 20 % of the participant's body weight but no more than the maximum weight limit of 30 pounds were placed inside a backpack to be carried by the participant, replicating the experimental design from previous studies (Proffitt et al., 2003). Crucially, participants did not know how much weight the backpack contained. The participant then put on the weighted backpack. If participants were not in a condition in which carrying a weighted backpack was necessary, this step was omitted. They were then given a ruler (0.3 m) as a guide to making estimates of distance. Both the experimenter and participant exited the lab and walked side by side through the basement hallways of the psychology building along a predetermined route, stopping at specific locations for the participant to estimate verbally the distance to a target sign in feet (converted to meters for analysis).

We utilized a 5 (condition) × 4 (distance) × 2 (phase) mixed design with distance and phase as within-subject variables, and condition as a between-subjects variable. Twelve participants were assigned to each condition. Sample size was determined a priori based on the sample size used in the between-subjects design from Proffitt et al. (2003) that we sought to replicate. In the Proffitt et al. study, significant results were obtained with 12 participants in each condition. In our study, all participants completed two phases. During each phase, participants stopped and made distance estimates eight times. There were four unique target locations (i.e., signs on the wall with the word "target" printed in large, bold letters). Participants made two distance estimates to each target during each phase, but from a different distance each time. Target distances were 8, 10, 12 and 14 m, replicating Proffitt et al. (2003). Thus, across both phases, participants made four distance estimates for each unique target location, with one of the four being made from each of the four distances for a total of 16 estimates. Target locations were completely crossed with target distances within and across phases. When the experiment was finished, participants were asked the following: (1) did they have any idea when the experimenter was going to ask them to stop and make their next distance estimate, (2) did they think target distances were repeated or simply felt similar, (3) did they know why the experimenter conducted the experiment, and (4) did they have an idea of what they thought the experiment was about. These questions allowed us to assess the extent to which our use of a within-subjects design to examine the backpack/no-backpack difference influenced our results. This is important because many previous experiments utilized between-subjects designs (Bhalla & Proffitt, 1999; Proffitt et al., 2003).

As was stated previously, the first two conditions (i.e., the Replication and Reversal conditions) were designed to replicate and reverse the Proffitt et al. (2003) finding that distance estimates are larger when one wears a weighted backpack. The remaining three conditions (the No Activation, No Memory and No Change conditions) were designed to ensure that the predicted results of the Replication and Reversal conditions were due to (1) the activation of action memories and (2) the discrepancy in action capabilities between the participant and the experimenter in Phase Two. Our design did not test all possible combinations of participant backpack/no backpack, 'other' backpack/no backpack, and phase. Instead, we only tested those conditions that were essential to determine the necessary and sufficient conditions for producing a difference between the Replication and Reversal conditions.

Results and Discussion

Our post-experimental questions revealed that not one of our participants (1) knew when the experimenter was going to stop and ask them to make their next judgment, (2) thought the target distances were repeated or felt similar, (3) knew why the experimenter was running the experiment, nor (4) knew what the experiment was about. We then averaged distance estimates for each participant at each distance in each phase. We subtracted estimates in Phase One from estimates in Phase Two (Phase Two − Phase One) for each distance. A negative difference score reveals distance estimates were larger in Phase One than in Phase Two, as in the classic backpack effect. In contrast, a positive difference score indicates that distance estimates were larger in Phase Two than in Phase One, reversing the classic pattern.

Average difference scores were analyzed using a 4 (distance) × 5 (condition) mixed ANOVA including a within-subjects by distance error term: error (subject/distance). We report p values along with estimates of effect sizes—partial eta squared (η_p^2) and Cohen's d.[1] As predicted, there was a main effect of condition, $F(4,216) = 4.56$, $p = .001$, $\eta_p^2 = .077$, and no main effect of distance or interaction between distance and condition (all Fs < 1). Follow-up tests with Bonferroni correction revealed that the main effect was driven by multiple significant differences between conditions.

First, there was a significant difference between the Replication and Reversal conditions ($p < .001$, $d = 1.38$). As can be seen in Fig. 2, the traditional backpack effect was replicated in the Replication condition and reversed in the Reversal condition. That is, difference scores were negative in the Replication condition (M −2.97, SD 4.42) and positive in the Reversal condition (M 2.59, SD 3.57). In addition, one sample t tests revealed that the difference scores were significantly different from zero in both the Replication [$t(11) = -2.33$, $p = .04$, $d = .67$] and the Reversal [$t(11) = 2.51$, $p = .03$, $d = .72$] conditions albeit in opposite directions.

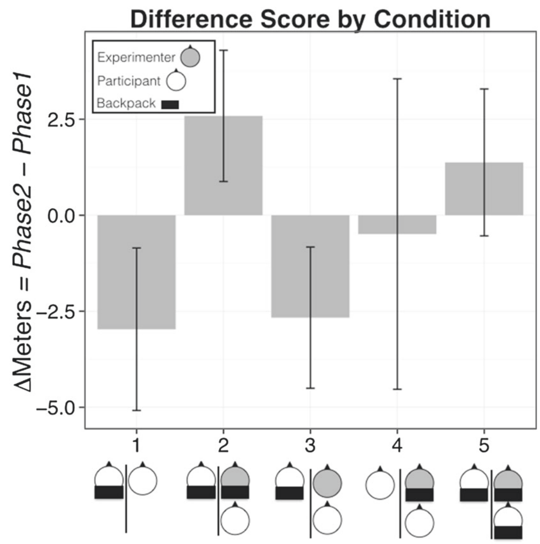

Fig. 2 Mean difference scores (Phase 2–Phase 1) with standard error bars for distance estimates (in meters) are shown for each condition. Design features for Phase One (*left*) and Two (*right*) are represented by the experimenter, participant and backpack markings below each condition, as described in Fig. 1

The results of the remaining three experimental conditions collectively indicate that the reversal observed in the Reversal condition was, in fact, due to memory activation and the presence of action capability discrepancies. Specifically, by preventing the experimenter from wearing a weighted backpack during Phase Two (i.e., the No Activation condition), we eliminated the reversal, in that difference scores in this condition were negative (i.e., visual estimates were larger in Phase One when the participant wore a backpack; M −2.67, SD 3.84). Furthermore, difference scores in the No Activation condition were significantly different from those in the Reversal condition ($p < .004$, $d = 1.42$), and were significantly different from zero, $t(11) = -2.41$, $p = .03$, $d = .70$. These results indicate that because the experimenter did not activate backpack-carrying memories in the participant during Phase Two, what we actually did in this condition was replicate the traditional backpack effect. In short, the results of this condition clearly indicate that the reversal observed in the Reversal condition required that the experimenter activate backpack-carrying memories in the participant during Phase Two.

[1] Cohen's d for follow up tests was determined by using the mean difference score for each participant, collapsed across distances.

Regarding the No Memory condition, in which we prevented the participant from generating backpack-carrying memories during Phase One, we once again eliminated the reversal. In fact, the difference scores in this condition (M −.49, SD 8.4) were not significantly different from zero, $t(11) = -0.20$, $p = .84$, $d = .06$, nor were they significantly different from the difference scores from any other condition. In short, the magnitude of the participants' visual distance judgments did not change across phases because (1) they did not generate backpack-carrying memories in Phase One that could be activated by the experimenter in Phase Two and (2) there was no change in their action capabilities across phases (i.e., they did not wear a backpack in either phase).

Finally, in the No Change condition, in which we eliminated the action capability discrepancy between the experimenter and the participant in Phase Two—by having both wear a weighted backpack, we once again eliminated the reversal. To be sure, difference scores in the No Change condition (M 1.38, SD 4.0) were significantly different from those in the Replication condition ($p = .006$, $d = 1.03$) and marginally significantly different from those in the No Activation condition ($p = .063$, $d = 1.03$), which seems to imply we replicated the reversal found in the Reversal condition. However, the No Change condition difference scores were not significantly different from zero [$t(11) = 1.19$, $p = .26$, $d = .34$]. These results indicate that, while the similarities between the Replication and No Change conditions might imply that the No Change condition also constitutes a reversal of the backpack effect, this condition is not significantly different from zero and, therefore, does not reflect a significantly positive difference score.

The present data support our predictions derived from a TEC-based account of the traditional backpack effect. The Replication condition replicated the well-known finding that distance estimates are larger when one wears a weighted backpack (Proffitt et al., 2003). Importantly, the Reversal condition reversed this traditional pattern such that distance estimates were larger in Phase Two, while participants were not wearing a weighted backpack. Again, according to the TEC-based account we use here, the reversal occurred because (1) participants generated and formed backpack-carrying memories (i.e., movement–effect associations) in Phase One, (2) these action memories were activated by observing the experimenter carrying a weighted backpack in Phase Two, and (3) the discrepancy between the participant's and the experimenter's action capabilities in Phase Two led the participant to experience the experimenter as having a more difficult task, thus leading the participant to generate larger distance estimates than when carrying a weighted backpack oneself.

The No Activation condition lends support to TEC by showing that the reversal does not occur if the experimenter does not wear a weighted backpack during Phase Two. This reveals that simply observing another during Phase Two is not sufficient to generate the reversal. Rather, for the reversal to occur, there must be a discrepancy in the action capabilities of the participant and the observed other. It is as if, in Witt et al.'s (2014) study, a participant observed another play Pong whose skill level was equal to his or her own. The lack of discrepancy in action capabilities between the participant and the other player, or the participant and the experimenter in the present experiment, led the participant to experience the events produced by the other (i.e., paddle movements toward the moving stimulus in Witt et al., 2014, or movements made through the hallways in the present study) in terms of their own action capabilities. Given participants in the present study wore a backpack in Phase One, and did not wear one in Phase Two, their data simply replicated the traditional backpack/no backpack effect.

The No Memory condition also lends support to TEC because it reveals that the reversal requires the creation of backpack-carrying memories in Phase One, even if there is an action capability discrepancy in Phase Two. This indicates that the Phase Two action capability discrepancy in the Reversal condition produced the reversal because the backpack-carrying dynamics (i.e., movement–effect patterns) of the experimenter activated the backpack-carrying memories (i.e., movement–effect memories) the participant had created during Phase One. This finding is akin to the Calvo-Merino et al. (2005) finding that the amount of premotor activation generated while one observes another dancing is contingent upon the observer's amount and type of dance experience. Given participants in this condition did not wear a backpack in either Phase One or Phase Two, they were unable to experience the experimenter's burden as if they were carrying the backpack themselves, so there was no difference in distance estimates between phases. In addition, the No Memory condition demonstrates that phase differences in other conditions were not due to simple repetition effects.

Finally, at first glance, the No Change condition seems to provide equivocal support for TEC. Specifically, the differences between the No Change and Replication conditions (significant), and No Change and No Activation conditions (marginally significant) make the No Change condition look as though we have replicated the Reversal condition even though there was no action capability discrepancy between the participant and the experimenter in Phase Two (i.e., both were wearing backpacks). In other words, the No Change condition might be taken to imply one can reverse the traditional backpack effect without a Phase Two action capability discrepancy. However, the finding that the positive difference scores in the No Change condition are not significantly different from zero challenges the notion that they reflect the same processes that occurred in the Reversal condition. Alternatively, it may be the case that, since participants developed backpack-carrying memories during Phase One and there was no action capability discrepancy between the participant and the experimenter during Phase Two, participants perceived distances in terms of their own current action capabilities during Phase Two. However, given Phase Two constituted a second time during which participants were asked to carry the backpack, participants may have been somewhat fatigued and, thus, perceived distances in Phase Two in terms of the extra effort required to carry the backpack. In short, they perceived distances during Phase Two in terms of their own, current action capabilities (i.e., more effort required during Phase Two than Phase One). In light of this interpretation, it seems the positive difference scores in the Reversal condition actually constitute a reversal of the traditional backpack effect, while positive difference scores in the No Change condition occurred due to fatigue (brought on by carrying the backpack in two consecutive phases).

Collectively, the results of the present experiment are consistent with the findings of Calvo-Merino et al. (2005), Jordan and Hunsinger (2008), Repp and Knoblich (2009) and Witt et al. (2014). In addition, our findings as a whole are most consistent with TEC (Hommel et al., 2001), lending further support to the notion that (1) actions are planned in terms of their intended distal effects and (2) action planning and perception share overlapping neural resources. To be sure, one could claim that our findings are also consistent with Proffitt's Economy of Action account (2006), Witt's Action-Specific hypothesis (2012), and Gibson's theory of affordance detection (1979) because all these theories assert that perception is influenced by future action possibilities. A major difference between these theories and TEC, however, is the manner in which they explain why perception is influenced by future action possibilities. Specifically, the explanations generated by these theories tend to resort to appeals regarding evolutionary necessity. That is, they assert that perception is influenced by future behavioral possibilities because, from an evolutionary perspective, it is important that the organism's behaviors be guided by perceptions that are informed about both the external environment and the organism's internal states (e.g., fatigue, dehydration, or arousal).

TEC's explanation of why perception is influenced by future action possibilities is stated in terms of clearly specified mechanisms, not assumptions regarding evolutionary necessity. Specifically, TEC clearly describes both (1) the mechanisms by which "future action possibilities" come to be and (2) the mechanisms by which they influence present perceptions. TEC asserts that any sensory effect that is reliably paired with movement, be it an intentional or unintentional effect, becomes associated with the movement that produced the effect. Thus, "perception" of a previously experienced effect (e.g., seeing a hill to climb, a distance to traverse, or a target to walk toward) takes place in terms of the motor planning it would take to produce that effect. In short, perceived "future action possibilities" (i.e., affordances) are actually stimuli that activate movement–effect memories that garner their ability to do so as one repeatedly moves one's body through the world, generating a host of continuous movement effects (e.g., the sounds of shoes scuffling the sidewalk, the sight of a target looming closer as one walks toward it, or the feel of water as one wades through it), all of which are capable of being paired with movement. We argue that future action possibilities do not influence perception because they "have to" from an evolutionary—survival-based—perspective. Rather, future action possibilities influence perception because of our ability to associate movements with their effects. The evolutionary, selective advantage of these mechanisms is that they allow us to automatically (i.e., without conscious awareness) organize and control our behavior in ways that are appropriate for the current context.

There are those who argue that the presence of future behavioral possibilities within perception is actually just an experimental artifact due to demand characteristics (Firestone, 2013; see Proffitt, 2013, for a response). Three issues discount this position. First, our post-experimental questions revealed that not one of our participants (1) knew when the experimenter was going to stop and ask them to make their next judgment, (2) thought the target distances were repeated or felt similar, (3) knew why the experimenter was running the experiment, nor (4) knew what the experiment was about. Second, there were different groups of participants in each of the five conditions. It seems highly unlikely that the systematic changes in the visual distance judgments we discovered across these conditions could have emerged solely due to demand characteristics hinging on the manipulation of condition. The only difference between the replication condition and the reversal condition was the fact that the experimenter wore a backpack in Phase Two of the reversal condition. It seems quite a stretch to assert participants saw the experimenter wearing a backpack in Phase Two and assumed this somehow meant they were supposed to give larger distance estimates than when wearing a backpack oneself in Phase One. Given we were able to replicate the traditional backpack effect twice, reverse it once, and negate it twice, all in ways that are predicted by TEC, it seems more reasonable to assume that future action possibilities are present in how we perceive the world. Finally, the results of our study cohere with those from neuroscience that show perception and action-planning share overlapping neural content (Rizzolatti et al., 2001). Thus, instead of treating changes in perception due to action planning as distortions, bias, or errors, it may be more appropriate to see them as evolutionarily emergent, functional achievements (Clark, 2013; Jordan, 1998, 2009, 2013).

Another argument against the idea that perception entails information regarding future behavioral possibilities is the assertion that variables such as visual distance judgments actually measure cognition (i.e., remembered distances), not perception (Cooper, Sterling, & Bridgeman, 2012), particularly in cases in which the participant is unable to see the target at the moment they indicate their judgment. The assumption is that by the time the participants indicate their perceived distance, the information they actually use when making the judgment is the remembered (i.e., cognitive) distance, not the perceived distance. The "perception or cognition" concern does not apply to the results of the present study because participants had continuous visual access to the targets while making their judgments. In addition, while we appreciate the spirit of this debate, the existence of neural overlap between action planning and perception, in and of itself, logically negates any clear attempt to distinguish perception from cognition. That is, if perception and action-planning share overlapping neural resources, and action-plans are actually movement–effect memories, then every moment of perception entails movement–effect memories. That is, every moment of perception is simultaneously cognitive. More importantly, in this study, we replicated a well-known finding, interpreted it in terms of a different theoretical framework (i.e., TEC), and controlled changes in the finding via theoretically generated predictions. Whether or not we end up referring to the phenomenon as perception or cognition will not change the fact that our findings, in conjunction with others, strongly support TEC and its assertions that (1) actions are planned in terms of distal effects and (2) perception and action-planning share overlapping neural resources.

Finally, in addition to accounting for why perception is influenced by future action possibilities, TEC provides an elegant account of why it is people can so easily coordinate actions with each other. Specifically, since the associations we learn are between movements and their effects, observing another produce an effect primes us to produce that very same effect. When we perceive another control an event that we have previously controlled (e.g., complete a specific dance, control a stimulus on a computer screen, play notes on a piano, or walk to a location and estimate the distance to a target) our perceptions of the event are influenced by (1) our own, remembered, action capabilities (i.e., movement–effect memories) and (2) our current action capabilities in relation to those of the person we are observing. In short, perception is continually modulated by our movement–effect memories, and these memories can be activated by the observation of others. Said another way, we are capable of perceptually walking in another's shoes to the extent we have actually walked in them ourselves.

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