Mine in Motion: How Physical Actions Impact the Psychological Sense of Object Ownership

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Our attention and memory can be biased toward objects having high self-relevance, such as things we own. Yet in explaining such effects, theorizing has been limited to psychological determinants of self-relevance. Here we examined the contribution of physical actions to this ownership bias. In Experiment 1, participants moved object images on a touch interactive table that either arbitrarily belonged to “self” or “other,” and that were moved into locations closer or farther from their bodies. Subsequent recognition was highest for self-owned objects moved closer to the body, as measured via a subsequent memory recall test. In Experiment 2, when participants moved images via keyboard rather than overt action, the proximity effect of the body on attention was abolished. In Experiment 3, participants pulled or pushed self-owned or other-owned object images to side-by-side locations on a touch interactive table. Self-owned objects that were pulled were recognized the most. Our findings demonstrate that physical actions can have a direct impact on the psychological saliency of owned objects, with the act of bringing objects toward the self leading to greater recall.

Keywords: ownership, memory, peripersonal space, self, action

A sense of ownership over an object gives it a pervasive psychological advantage over other objects. When everyday objects are conceptualized as mine (vs. not mine), even when arbitrarily assigned, we pay more attention to them (Gray, Amバンド, Lowenthal, & Deldin, 2004; Turk et al., 2011), remember them better (Cunningham, Turk, Macdonald, & Neil Macrae, 2008; van den Bos, Cunningham, Conway, & Turk, 2010), implicitly prefer them (Huang, Wang, & Shi, 2009), and even assign them higher value (Morewedge, Shu, Gilbert, & Wilson, 2009) and favorability ratings (Beggan, 1992). Assumed to be at the heart of these owner-ship effects is the psychological construct of the self, and in particular, the cognitive relationship between the self and one’s possessions (e.g., Cunningham et al., 2008; van den Bos et al., 2010). For example, the “self” construct promotes deep elaborative and organizational processing (Klein, 2012), so much so that self-referential encoding of stimuli consistently surpasses semantic and other-referential encoding with respect to subsequent recall (Symons & Johnson, 1997). Yet the self is not just a psychological construct. It also has a physical counterpart—the body, which can exert a biasing influence on cognitive processes (e.g., Jostmann, Lakens, & Schubert, 2009; Niedenthal, 2007; Proffitt, 2006). Therefore, we sought to determine if and how the body contributes to the cognitive effects of object ownership.

The significance of the physical body for cognition arises from two of its main functions with respect to integrating afferent and efferent information (Tsakiris, Schütz-Bosbach, & Gallagher, 2007). First, the body registers external information. As a presence in the environment, the body acts as an anchor for orienting representation and integrating sensory inputs. Accordingly, the brain combines tactile, visual, and proprioceptive information through body-centric frames of reference (for reviews, see Maravita, Spence, & Driver, 2003; Lädavas, 2002). Likewise, spatial judgments are more accurate when encoded through an egocentric (vs. allocentric) perspective (Ruggiero, Ruotolo, & Iachini, 2009). Egocentric frames of reference also aid in remembering object locations (Coluccia, Mammarella, De Beni, Ittyerah, & Cornoldi, 2007).

Second, the body functions as an active agent, dynamically altering our cognitive perspective on the environment as we move. Underpinning this, there are multiple areas in the cortex devoted to movement-oriented representations of space (Kasai, 2008; Colby, 1998; Graziano & Gross, 1998), including the lateral intraparietal area, which has been shown to encode category-specific movement direction (Freedman & Assad, 2006). In situations with multiple potential targets, for example, where attention is not uniformly...
allocated, cognitive resources are selectively distributed, with more resources allocated toward objects that can be acted on. Most notably, there is preferential processing of objects near the hand (for review, see Brockmole, Davoli, Abrams, & Witt, 2013), such as improved visual detection and spatial discrimination (Dufour & Touzalin, 2008), greater stimulus-detail processing (Davoli, Brockmole, & Goujon, 2012), and even faster change detection (Tseng & Bridgeman, 2011). Similar effects have also been shown for near personal space in general, resulting in greater sensitivity to object orientation during a grasping task when objects were within but not beyond action range (Yang & Beilock, 2011).

Given these impacts of physical actions on numerous cognitive processes, we aimed to examine whether object-directed actions moderate or contribute to the cognitive effects of object ownership. Specifically, we investigated whether the location of, and actions we perform on, owned and other objects relative to the body would interact with recall performance for those objects. To incorporate the body into an object ownership context, we modified a paradigm used by Cunningham et al. (2008), who asked participants to sort images of objects based on an arbitrary assignment to an ownership category (“mine” or “other”) and found subsequent recognition was higher for self-owned objects. In our adaptation, sorting occurred on an interactive touch table. In Experiment 1, participants were required to move some objects from a start position to a location close to themselves, while other objects were moved to a location far from themselves. This novel use of the physical movement of stimuli emphasized the dynamic spatial relationship between the participant’s body and the objects. To assess object processing, after the sorting task we examined participants’ recognition of the objects via a surprise memory test. We predicted that the manipulation of object location would differentially affect encoding and subsequent recall of the objects, such that the previously reported memory advantage for owned objects would be stronger for objects that were moved toward versus away from the physical body.

**Experiment 1**

**Method**

Participants. Final sample size was based on sample sizes from other studies involving reaching behavior (e.g., Chapman et al., 2014; Milne et al., 2013) and adjusted upward to equalize the number of participants in each configuration order (e.g., self-close/other-far, then other-close/self-far). Additional support for this decision came from a recent review by Gallivan and Chapman (2014), which stated that researchers should aim for approximately 30 participants in order to achieve sufficient power in reaching tasks. Fifty participants were recruited to do the experiment. Exclusions were as follows: One participant was left-handed, seven participants misunderstood or ignored experiment instructions (e.g., mixed up the color-ownership associations, or did not look at the objects), seven failed our manipulation check (i.e., when verbally quizzed, these participants reported that they did not feel like they “owned” the self-owned objects more than the other-owned objects), and three demonstrated extreme variability in their reaching movements (i.e., subject-level standard deviations for movement times were more than two group-level standard deviations beyond the grand-averaged standard deviations). In the end, 32 right-handed participants (29 women, age: $M = 20.38$ years, $SD = 2.96$) completed the experiment in exchange for course credit. Participants had normal or corrected-to-normal vision, and provided written informed consent.

**Set-up.** Participants sat at a table covered with white poster board onto which experimental stimuli were projected. The projector (Dell M410HD) was mounted ~2 m above the table and produced a projected image of ~90 cm × ~70 cm. A passive reflective marker was attached to the right index finger of each participant and was tracked using six Optitrak V100:R2 cameras (NaturalPoint, Inc., Corvallis, Oregon) mounted on three tripods around the table (see Figure 1a). The position of the finger marker was sampled at 60 Hz (synchronized with the projector refresh rate) and was coregistered in space with the projected image to allow for the table top to be used as a touch interactive surface. All stimuli presentation and data collection were controlled with Matlab (Version 2010a) using Psychtoolbox (Version 3, Brainard, 1997; Pelli, 1997; Kleiner et al., 2007).

Participants viewed and sorted images of everyday objects (e.g., baseball, mango, clothespin, randomly selected from a 315-image stimulus set) in two different tasks, a sorting task followed by a surprise memory task. Projected object images were ~9 cm × ~9 cm and set against a white background. In the sorting task, participants dragged objects into one of two square (18 cm × 18 cm) target regions projected on the table, one labeled “mine” and the other labeled “other person’s” (see Figure 1b). These two regions were aligned horizontally on the lateral midline (participants sat centered on this point), with one closer to (center 12 cm away) and one farther from (48 cm away) the front edge of the projected image. The “far” distance was pilot-tested to ensure that participants would need to fully extend their arm to touch the box but not need to also shift their torso forward. To minimize variability in movement trajectories, starting positions were designated for each task and projected onto the table. In the sorting task, the start position (~2 cm black ring) was located ~22.5 cm to the right of the lateral midline and 30 cm from the front edge of the projected image.

In the memory task, the entire display was rotated 90° clockwise around the display center and the target region labels were changed to “old” and “new.” This resulted in a start position placed at lateral midline 7.5 cm from the front edge of the display and target regions aligned in depth (in the plane of the table) 30 cm from the front edge of the display, one 18 cm to the left of midline and one 18 cm to the right of midline (see Figure 1c).

**Procedure.**

**Sorting task.** Participants were told they had just returned home from a shopping trip with the research assistant and that it was time to sort out which items belonged to the participant (“mine”) and which items belonged to the research assistant (“other person’s”). For each trial, participants began by placing their right index finger on the start position. After a variable interval of 500–1,000 ms the object image was presented. It appeared between the two sort boxes with its center on lateral midline, 30 cm from the front edge of the projected image. Following another variable interval of 400–800 ms, a colored border (either blue or green) appeared around the image, denoting ownership category (e.g., blue = mine and green = other person’s, counterbalanced across participants). At the same time, a beep signaled participants to initiate their sort movement, requiring
them to quickly and accurately touch the object image and drag it into the appropriate target region. Participants were given error feedback projected on the table regarding the reaching movement if the movement was “too early” (initiated <100 ms postbeep), “time out” (initiated >2 s postbeep), or “too slow” (movement completion was >3 s following initiation). Feedback regarding sorting accuracy (i.e., whether the participant correctly put an object in the right box) was verbally given during practice trials but withheld during regular trials. Participants completed 10 practice trials followed by 52 regular trials with one configuration of target regions (e.g., Block 1: mine-close/other-far) followed by another 10 practice trials and 52 regular trials in the other configuration of target regions (e.g., Block 2: other-close/mine-far). The starting configuration of target regions was counterbalanced across participants.

**Memory task.** Upon completion of the sorting task, participants were given a surprise object recognition test. Participants were presented with individual images that were seen during the sorting task (“old”) and an equal number of not previously seen images (“new,” but from the same 315-item stimulus set) and were required to move the images into the appropriate target regions. Trials for the memory test followed the same timing as the sort task, but differed in that the object image borders were always black. Participants completed 20 practice trials and 104 regular trials for each target region configuration (e.g., Block 1: old-left/new-right, Block 2: old-right/new-left) with the first target region configuration counterbalanced across participants. “Old” objects from the first block of trials in the sorting task appeared in the first memory task block, and old objects from the second sorting block appeared in the second memory task block. For the following analyses (Experiments 1, 2, and 3), all of the manipulations and dependent measures, whether statistically significant or otherwise, have been reported.

**Results**

**Sorting task.**

**Reaction time.** For descriptive statistics of Experiment 1, please refer to Tables 1 and 2. Reaction time was defined as the time elapsed between the beep and the initiation of a movement. A 2 (Ownership) × 2 (Location) repeated-measures (RM) analysis of variance (ANOVA) revealed a marginal effect of ownership, $F(1,$
Table 1
Mean Reaction and Reach Times for the Sorting Task in Experiment 1

<table>
<thead>
<tr>
<th>Condition</th>
<th>Reaction time (s)</th>
<th>Reach time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-owned</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Close</td>
<td>.25 (.05)</td>
<td>.59 (.09)</td>
</tr>
<tr>
<td>Far</td>
<td>.25 (.05)</td>
<td>.55 (.09)</td>
</tr>
<tr>
<td>Other-owned</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Close</td>
<td>.26 (.05)</td>
<td>.60 (.09)</td>
</tr>
<tr>
<td>Far</td>
<td>.26 (.06)</td>
<td>.56 (.10)</td>
</tr>
</tbody>
</table>

Note. Standard deviations are in parentheses. Reaction and reach times reflect all trials as accuracy was at ceiling.

Table 2
Mean Percentage of “Old” Objects Correctly Recognized, Mean Reaction Times, and Mean Reach Times for the Memory Task in Experiment 1

<table>
<thead>
<tr>
<th>Condition</th>
<th>Objects recognized (%)</th>
<th>Reaction time (s)</th>
<th>Reach time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-owned</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Close</td>
<td>68.50 (18.61)</td>
<td>.23 (.06)</td>
<td>.63 (.10)</td>
</tr>
<tr>
<td>Far</td>
<td>61.18 (19.74)</td>
<td>.25 (.07)</td>
<td>.64 (.10)</td>
</tr>
<tr>
<td>Other-owned</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Close</td>
<td>58.12 (19.83)</td>
<td>.25 (.08)</td>
<td>.63 (.11)</td>
</tr>
<tr>
<td>Far</td>
<td>60.43 (18.69)</td>
<td>.24 (.07)</td>
<td>.63 (.11)</td>
</tr>
</tbody>
</table>

Note. Reaction and reach time values are for correct trials only. Standard deviations are in parentheses.
ship effect, we ran a second experiment, one designed to isolate the influence of peripersonal space from the influence of action.

Specifically, participants completed an experiment that mirrored Experiment 1 but rather than directly manipulating object location via reaching movements, participants pressed keyboard keys to “sort” self-owned or other-owned objects into locations close to or relatively further away from the body. By presenting stimuli at different distances from the body but not allowing participants to touch or physically move them, we manipulated the effect of location in the absence of movement action. If proximity to the body were sufficient to generate encoding differences, we would anticipate some effect of location. On the other hand, if space were only meaningful if you acted in it, then we would anticipate only the typical ownership effect and no location effect.

Experiment 2

Method

Participants. Sample size was chosen to match Experiment 1 and we applied the same exclusion criteria, including a verbal manipulation check. No observations were excluded, likely a function of the less-demanding nature of the task (i.e., button-pressing is less demanding than time-sensitive reaching movements), as well as improved/clarified instructions at the outset of the experiment. Thirty-two right-handed participants (22 women, age: \( M = 20.31 \) years, \( SD = 2.33 \)) completed the experiment in exchange for course credit. Participants had normal or corrected-to-normal vision, and provided written informed consent.

Set-up. Participants completed a sorting task and a memory task using the same stimulus presentation set-up and same pool of stimulus images as Experiment 1. The box locations, the colored borders, and their respective counterbalances also remained unchanged. Because the participants no longer needed to move object images across the table surface, the start position landmarks were removed from the projected display and the participants did not wear motion-tracking markers. Instead, a keyboard was set up at the front edge of the table.

Procedure. Sorting task. Like in Experiment 1, participants were given a shopping scenario and were told they needed to sort the items by owner into “boxes” at different locations on the table. Again, each trial featured an object image appearing between the two boxes, followed by the appearance of a colored border (denoting ownership category) around the image. A beep, time-locked to the border, signaled participants to respond via keyboard press (e.g., “D” for mine box or “K” or other person’s box, counterbalanced across participants). Pressing one of the two assigned keys would lead to the image disappearing from the center of the screen and reappearing in the corresponding box selected by the participant. Trials were rejected and participants were given error feedback projected on the table if the keyboard response was “too early” (initiated \( \geq 100 \) ms post-beep), or given later than 2 seconds post-beep (“time out”). Feedback regarding sorting accuracy was verbally given during practice trials but withheld during regular trials. The remaining procedure (practice vs. experimental trials, configuration block ordering etc.) was identical to Experiment 1.

Memory task. The memory task for this experiment mimicked that of Experiment 1 with respect to the ratio of “old” to “new” objects, as well as the temporal order of stimulus presentation. For each trial, participants again responded via keyboard press. Key presses would lead to the displayed image disappearing from the central location and reappearing in the box selected by the participant. The remaining procedure (practice vs. experimental trials, configuration block ordering etc.) was identical to Experiment 1.

Results

Sorting task. For descriptive statistics of Experiment 2, please refer to Table 3. A 2 (Ownership) \( \times \) 2 (Location) RM-
Table 3
Mean Percentage of “Old” Objects Correctly Recognized in the Memory Task, and Mean Response Times for the Sorting Task and Memory Task in Experiment 2

<table>
<thead>
<tr>
<th>Condition</th>
<th>Objects recognized (%)</th>
<th>Response time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Sorting task</td>
</tr>
<tr>
<td>Self-owned</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Close</td>
<td>62.79 (19.13)</td>
<td>.53 (.14)</td>
</tr>
<tr>
<td>Far</td>
<td>64.05 (17.57)</td>
<td>.52 (.15)</td>
</tr>
<tr>
<td>Other-owned</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Close</td>
<td>60.20 (19.50)</td>
<td>.52 (.15)</td>
</tr>
<tr>
<td>Far</td>
<td>55.27 (17.42)</td>
<td>.52 (.15)</td>
</tr>
</tbody>
</table>

Note. Response times for the sorting task reflect all trials as accuracy was at ceiling. Response times for the memory task are for correct trials only. Standard deviations are in parentheses.

ANOVA revealed no main effect of ownership, $F(1, 31) = 0.15, p = .71$, partial $\eta^2 = 0.005$. The main effect of location was not significant, $F(1, 31) = 0.86, p = .36$, partial $\eta^2 = 0.027$, nor was the ownership by location interaction, $F(1, 31) = 0.21, p = .65$, partial $\eta^2 = 0.007$.

**Memory task.**

**Object recognition.** A 2 (Ownership) × 2 (Location) RM-ANOVA revealed a significant main effect of ownership, $F(1, 31) = 10.33, p = .003$, partial $\eta^2 = 0.25$, 95% CI [2.08, 9.29], such that recognition for self-owned objects was significantly higher than recognition for other-owned objects (see Figure 3). The main effect of location was not significant, $F(1, 31) = 2.16, p = .15$, partial $\eta^2 = 0.065$, nor was the ownership by location interaction, $F(1, 31) = 1.62, p = .21$, partial $\eta^2 = 0.05$.

**Response time.** Only trials where old objects were correctly identified as being old were analyzed. A 2 (Ownership) × 2 (Location) RM-ANOVA revealed no main effect of ownership, $F(1, 31) = 0.60, p = .44$, partial $\eta^2 = 0.019$, as well as no main effect of location, $F(1, 31) = 0.10, p = .92$, partial $\eta^2 < .001$, and no ownership by location interaction, $F(1, 31) = 0.05, p = .83$, partial $\eta^2 = 0.001$.

**Discussion**

In Experiment 2, we disentangled the dual influences of the physical body on the ownership effect by limiting its role to only a passive viewer of relative spatial proximity. We found that when participants experienced this “proximity without action” version of the experiment, there was still a significant effect of ownership in which self-owned objects were recognized more often than other-owned objects. However, the removal of action from the paradigm abolished the body’s moderating effect on the ownership bias. This suggests that the widespread evidence that spatial proximity can lead to enhanced neurocognitive processing of an object (e.g., Brockmole et al., 2013; Gallivan et al., 2009; Graziano & Cooke, 2006) necessarily depends on motor-related engagement with those objects.

Although the necessity of motor action is clear, the nature of the actions is as yet unresolved. Previous findings by Cunningham and colleagues (2008), whose paradigm we adapted for the current work, partially complement our Experiment 2’s “space only” design by employing an “action only” design. In their study, the authors implemented an ownership by action factorial design: Participant-confederate dyads took turns placing object image cards into one of two side-by-side baskets based on who (the participant or the confederate) “owned” each item. Subsequent recognition memory tests showed the typical ownership effect, but neither an effect of action nor an action by owner interaction. While this result suggests that actor may not make a discernible difference, the type of action still might.

During Experiment 1, participants made movements toward and away from themselves. By moving an object to the close location, participants were also making a “pulling” motion, whereas moving an object to the far location could be seen as a “pushing” motion.

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**Figure 3.** (a) Mean percent recognition scores as a function of ownership and target location for Experiment 2. (b) Mean response times for correct trials in the memory task as a function of ownership and target location for Experiment 2. Error bars represent 95% confidence intervals calculated for within-subject designs (Loftus & Masson, 1994).
While the pushing motion was used to push an object into a “mine” box location (for instance), such a movement could be denoted with some sense of “rejecting” the object. To this point, several studies have investigated pulling and pushing movements in approach/avoid contexts and have found pulling movements are more easily associated with positively valenced/approach-oriented stimuli (e.g., Markman & Brendl, 2005; Cacioppo, Priester, & Bernstein, 1993). Because movement toward the body could not be distinguished from movement close to the body, the question of what underlies the original ownership by location interaction remains. To address this question, we returned to the touch interactive table for a third and final experiment. In Experiment 3, participants reached for self-owned and other-owned objects and pushed or pulled them to adjacent target boxes. An action-type-based explanation would predict another two-way interaction with pulled self-owned attaining the highest levels of recognition and, given the equal distance of the target boxes away from the body, an action-destination-based explanation would predict only a main effect of ownership.

**Experiment 3**

**Method**

**Participants.** Forty-six participants were recruited to do the experiment. Exclusions were as follows: Due to experimenter error six participants were given the wrong number of trials, three participants misunderstood or ignored experiment instructions (e.g., mixed up the color-ownership associations, or did not look at the objects), and two demonstrated extremely poor performance in the translation check. In the end, 35 right-handed participants (23 women, age: $M = 20.06$ years, $SD = 2.70$) completed the experiment in exchange for course credit. Participants had normal or corrected-to-normal vision, and provided written informed consent.

**Set-up.** The projection of the experiment onto a tabletop, motion-tracking via Optitrak, and use of the pool of stimulus images was identical to Experiment 1.

In order to manipulate the type of action required to move the images, the target regions and start position were altered. In the sorting task, the target region boxes for “mine” and “other person’s” were located side by side and centered 29 cm from the front edge of the projected image, one centered 11 cm to the left of midline and one centered 11 cm to the right of midline. The start position was centered 29 cm from the front edge of the projected image, and 22 cm to the right of midline. In the memory task, the display was again rotated 90° with target region boxes for “old” and “new” aligned horizontally on the lateral midline, with one closer to (center 18 cm away) and another farther from (center 41 cm away) the front edge of the projected image. The start position for the memory task was 8 cm the front edge of the projected image, centered along the midline (see Figure 4).

**Procedure.**

**Sorting task.** All details were identical to Experiment 1 except for the configuration changes outlined above and the location that the object image was initially presented. It appeared 29 cm from the front edge of the display and was centered 20 cm to the left or right of the midline during “right” or “left” trials, respectively (see Figure 4). The order of push versus pull trials was randomized.

**Memory task.** All details were identical to Experiment 1 except for the configuration changes outlined above and the location that the object image was initially presented. It appeared 29 cm from the front edge of the display and was centered 20 cm to the left or right of the midline during “right” or “left” trials, respectively (see Figure 4).

**Results**

Note that for all analysis conducted in Experiment 3 we collapsed across the irrelevant factor of configuration (e.g., across blocks) such that pull (and push) actions to left and right locations in the sort task were grouped together. Similarly left (and right) actions to close and far locations in the memory task were also grouped together.

**Sorting task.**

**Reaction time.** For descriptive statistics of Experiment 3, please refer to Tables 4 and 5. A 2 (Ownership) × 2 (Action) RM-ANOVA revealed no main effect of ownership, $F(1, 34) = 1.82, p = .19$, marginal $\eta^2 = 0.058$, no main effect of action, $F(1, 34) = 0.003, p = .96$, and no ownership by action interaction, $F(1, 34) = 0.32, p = .86$, partial $\eta^2 = 0.001$.

**Reach time.** A 2 (Ownership) × 2 (Action) RM-ANOVA revealed no main effect of ownership, $F(1, 34) = 0.001, p = .98$, partial $\eta^2 < .001$. There was a significant main effect of location, $F(1, 34) = 115.37, p < .001$, partial $\eta^2 = 0.77$, such that pushing movements were faster than pulling movements (consistent with Experiment 1). There was no ownership by action interaction, $F(1, 34) = 0.15, p = .70$, partial $\eta^2 = 0.004$.

**Memory task.**

**Object recognition.** A 2 (Ownership) × 2 (Action) RM-ANOVA revealed a main effect of ownership, $F(1, 34) = 4.89, p = .034$, partial $\eta^2 = .13$, 95% CI [0.35, 8.21], such that recognition for self-owned objects was significantly higher than that of other-owned objects. There was a marginal main effect of action, $F(1, 34) = 3.58, p = .067$, partial $\eta^2 = .10$, 95% CI [−.02, 6.43], such that recognition for pulled objects was marginally higher than that for pushed objects. There was a significant ownership by action interaction, $F(1, 34) = 4.64, p = .038$, partial $\eta^2 = .12$. Simple main effects analysis for this interaction revealed that when objects were pulled, self-owned objects were recognized significantly more than other-owned objects ($p = .005, 95\% \text{ CI} [2.23, 11.87]$), and when objects were pushed, recognition for self-owned versus other-owned objects did not differ ($p = .51$, 95% CI [−3.10, 6.13], see Figure 5). Pairwise contrasts between pulled self-owned objects and the other conditions confirmed that pulled self-owned objects were the most recognized (all $p$s < .01).

For the following reaction time and reach time analyses, only trials where old objects were correctly identified as being old were analyzed.

**Reaction time.** A 2 (Ownership) × 2 (Action) RM-ANOVA revealed a marginal main effect of ownership, $F(1, 34) = 2.30, p = .14$, partial $\eta^2 = 0.063$ such that self-owned items were marginally reacted to faster than other-owned objects. There was a marginal effect of action, $F(1, 34) = 3.13, p = .086$, partial $\eta^2 = .084$, such that initially pulled objects were marginally reacted to faster than initially pushed objects. Lastly, there was no ownership by action interaction, $F(1, 34) = 0.22, p = .64$, partial $\eta^2 = .006$.

**Reach time.** A 2 (Ownership) × 2 (Action) RM-ANOVA revealed no main effect of ownership, $F(1, 34) = 1.38, p = .25,$
partial $\eta^2 = .039$, and a marginal effect of action, $F(1, 34) = 2.32, p = .14$, partial $\eta^2 = .064$, such that initially pulled objects were moved marginally faster than initially pushed objects. There was no ownership by action interaction, $F(1, 34) = 0.22, p = .64$, partial $\eta^2 = .006$.

**Discussion**

In Experiment 3, we manipulated the type of action required to sort self-owned and other-owned objects by having participants either pull or push the objects into adjacent target regions. This allowed a disentangling of the effect of motion-direction from motion-destination. Consequently, we found an action by ownership interaction that very closely mirrored the initial ownership by location interaction in Experiment 1: In addition to a significant and expected main effect of ownership, self-owned objects that were pulled (that is, moved toward the self) were subsequently recognized the most often relative to all other objects.

**General Discussion**

The self is a complex, multidimensional construct that wields influence on the processing of stimuli in the environment through a number of mechanisms. In the present study, we investigated two
aspects of the self—physical and psychological—and examined their independent and interactive effects on cognitive processing. Experiment 1 showed that self-owned objects moved to a location close to the body are subsequently remembered significantly better than self-owned objects moved to a far location as well as other-owned objects moved to either location. Experiment 2 showed that the modulatory effect of relative body proximity is absent when participants only experienced the location manipulation passively. Lastly, Experiment 3 showed that pulling self-owned objects toward the self and not necessarily moving objects near the self leads to greater recognition. Taking these findings together, our data suggest that the physical, active self plays a vital role in moderating the cognitive enhancements afforded to self-owned objects.

What do our results regarding ownership, proximity, and action tell us about the body’s role in object ownership effects? The evidence is that enhanced object processing is seen only when the object is both self-related and self-moved toward the self. We believe the resultant self-relevance allows for a convergence between the ability to act on an object and the desire or appropriateness to act on objects that you own. Acting on an object through bringing it toward the body may enable the body to incorporate the object into an egocentric frame of reference in a way that is different than static objects already existing in peripersonal space. We argue that this represents a conjunction of two aspects of the self: as an actor and as a receiver. Here these aspects work together to prioritize certain objects—an effect that mirrors recent work with feeding behaviors showing that bringing food items toward the self specifically for the purposes of being a receiver (eating) results in different kinds of movements than those produced when the self is not the target of the action (Flindall & Gonzalez, 2014). In other words, when you are the actor moving objects toward your own body as a receiver, self-relevance can literally be brought to attention.

From a theoretical perspective, the current data lend support to embodied theories of cognition which are centered on the physical self rather than abstract representations of self. For example, Markman and Brendl (2005) conducted a study in which participants pulled and pushed a lever to move positive and negative words on a computer screen toward or away from their name (an abstract representation of self). The authors found movements were faster for positive-toward/negative-away trials than negative-toward/positive-away trials regardless of movement direction. They argued that the representation of self (i.e., one’s name) superseded the physical location of self. In contrast, the current work showing no memory enhancement for pushed self-owned objects suggests a disembodied view of cognition is not viable, a conclusion also reached by Van Dantzig, Zeelenberg, and Pecher (2009), who found approach/avoidance movements do rely on relative distance between the physical self and a stimulus. Importantly, our use of real reaching/sorting movements on an immersive touch table serves as a more direct test of the influence of physical self than the lever actions in Markman and Brendl (2005).

Importantly, the presence of an ownership by action interaction in Experiment 3, and the functionally equivalent ownership by location interaction in Experiment 1, aligns with other recent studies examining the relationship between action, space, and self. For example, Constable, Kritikos, and Bayliss (2011) found a stimulus-response compatibility effect, demonstrating faster right responses for right facing mug-handles, but only for participants moving their own mugs and not the experimenter’s mugs. Similarly, Lugli, Baroni, Gianelli, Borghi, and Nicoletti (2012) observed faster saliency discriminations during a sentence-judgment task, but only for positively valenced words that moved toward the body. Collectively, these studies reveal an attentional asymmetry in which the influence of action works to stratify the saliences of stimuli associated with the self without impacting the relative salience of stimuli associated with another.

Across all three experiments, the “other” contrasting the self was the experiment’s research assistant, a choice that has been used previously (e.g., Constable et al., 2011) but not exclusively (e.g., Turk et al., 2011). In these experiments, the research assistant remained in the room but did not actively participate in the moving of objects or sit close enough to the participant to reach into his or her peripersonal space. Despite the relative detachment of the “other” from the experimental proceedings, our main effects of ownership appear to be similar in effect size to that of Cunningham et al. (2008), who did use an active but nonoverlapping other. Had the research assistant partaken in the sorting task, there is evidence that suggests different results could emerge. Griffiths and Tipper (2012) found that when action environments are shared, one person’s movements affect the other person’s subsequent movements toward the same objects. Furthermore, participants’ perception of space can be altered as a function of observing another person moving in said space (Bloesch, Davoli, Roth, Brockmole, & Abrams, 2012). These behavioral and perceptual changes could

### Table 4

<table>
<thead>
<tr>
<th>Condition</th>
<th>Reaction time (s)</th>
<th>Reach time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-owned</td>
<td>.32 (.06)</td>
<td>.85 (.21)</td>
</tr>
<tr>
<td>Pulled</td>
<td>.32 (.07)</td>
<td>.74 (.21)</td>
</tr>
<tr>
<td>Pushed</td>
<td>.32 (.07)</td>
<td>.84 (.18)</td>
</tr>
</tbody>
</table>

Note. Standard deviations are in parentheses. Reaction and reach times reflect all trials as accuracy was at ceiling.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Objects recognized (%)</th>
<th>Reaction time (s)</th>
<th>Reach time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-owned</td>
<td>59.66 (15.30)</td>
<td>.30 (.10)</td>
<td>.85 (.22)</td>
</tr>
<tr>
<td>Pulled</td>
<td>53.80 (15.73)</td>
<td>.31 (.09)</td>
<td>.88 (.23)</td>
</tr>
<tr>
<td>Pushed</td>
<td>52.62 (14.96)</td>
<td>.30 (.11)</td>
<td>.88 (.27)</td>
</tr>
<tr>
<td>Other-owned</td>
<td>52.28 (15.08)</td>
<td>.32 (.11)</td>
<td>.89 (.23)</td>
</tr>
</tbody>
</table>

Note. Reaction and reach time values are for correct trials only. Standard deviations are in parentheses.
affect object encoding; future research is needed to address these factors.

One plausible alternative explanation for the data emerges from previous research by Chen and Bargh (1999), who found that people are faster to push negative items away and pull positive items toward themselves. Combined with Beggan’s (1992) finding that self-owned objects are viewed more favorably than non-self-owned objects, one might expect an ownership by action interaction on the various movement related measures and perhaps in turn, some downstream effects on object recognition. This was not the case in the current work for a couple of possible reasons. First, Seibt, Neumann, Nussinson, and Strack (2008) found that push (and pull) movements can represent both approach and avoidance actions and are based on and sensitive to experimental context. Our task instructions framed the encoding phase as a “sorting task” and likely did not strongly signal either approach or avoidance motivations. Second, each trial required a movement toward the object followed by a movement to drag the object to a box. This complex two-part action may have diminished prospective latency-related effects.

More broadly, McClelland (1951) argued over half a century ago that ownership creates a strong connection between external objects and the people who possess them, and that such objects become part of the psychological self when they can be controlled in the same way as one’s limbs. In the decades since then, other researchers have discovered psychological processes are often embodied (e.g., Glenberg, 2010; Wilson, 2002), leading to greater recognition of the physical self as a key component to cognition. In the present work, we investigated the unique contributions of the psychological and physical self to the differential encoding of everyday objects. Crucially, we considered both the presence/absence of action and the type of action made during exposure to objects. Our results suggest that the act of bringing an already self-relevant object toward the self leads to greater cognitive processing for the object than merely having the object nearby. These findings reveal the distinctive way in which ownership, body, and action interact, and reinforce the importance of seeing cognition as something that extends well beyond mere processes in the brain.

References


Figure 5. (a) Mean percent recognition scores as a function of ownership and action type for Experiment 3. (b) Mean reaction times for correct trials in the memory task as a function of ownership and target location for Experiment 3. Error bars represent 95% confidence intervals calculated for within-subject designs (Loftus & Masson, 1994).

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