Object ownership and action:

The influence of social context and choice on the physical manipulation of personal property

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Abstract

Understanding who owns what is important for guiding appropriate action in a social context. Previously, we demonstrated that ownership influences our kinematic patterns associated with hand-object interactions (Constable et al. 2011). Here, we present a series of experiments aimed at determining the underlying mechanisms associated with this effect. We asked participants to lift mugs that differed in terms of ownership status (Experiments 1 & 2) and personal preference while recording spatial and acceleration measures. In Experiment 1 participants lifted their own mug with greater acceleration and drew it closer to themselves than they did the experimenter's mug. They also lifted the experimenter's mug further to the right compared with other mugs. In Experiment 2, spatial trajectory effects were preserved, but the acceleration effect abolished, when the owner of the 'Other-Owned' mug was a known – but absent – confederate. Experiment 3 demonstrated that merely choosing to use a mug was not sufficient to elicit rightward drift or acceleration effects. We suggest that these findings reflect separate and distinct mechanisms associated with socially related visuomotor processing.

Keywords: ownership, possessions, kinematics, embodied cognition, preference, social cognition

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Ownership is fundamental in conceptual, practical, and legal terms to human society. The purpose of the present research is to examine how the attribution of social meaning manifests in human kinematic patterns. The following experiments are specifically designed to be sensitive to differences in the kinematics associated with differing ownership status. Crucially, we manipulate the social context the participant experiences to reveal the cognitive mechanisms that underpin social cognitive processes associated with personal property.

What's mine is mine and what's yours is yours: Cognitive processing of self- and other-owned objects

Generally speaking, we like what we own more than that which we do not (e.g. mere-ownership effect, Beggan 1992). Humans also show an enhanced awareness and more robust processing of what is theirs, as evidenced by research into memory for owned and non-owned objects (Cunningham et al. 2008; Cunningham et al. 2011; Kim and Johnson 2012; Turk et al. 2013;Turk et al. 2011a; van den Bos et al. 2010) and attention biases towards self-related stimuli(Alexopoulos et al. 2012; Turk et al. 2011b). For example, Cunningham et al. (2008) show that temporary ownership elicits a memory advantage. They gave participants a set of cards to separate into two baskets. One basket was designated their own, and one was designated as another participant's. The cards placed in the participant's 'own' basket were recognised more frequently than those placed in the other participant's basket. Using a similar task, Turk and colleagues (2011b) also demonstrated a narrowing of attention towards self-owned items. Overall, these processing and attentional biases suggest that the cognitive system prioritises the representation of self-owned items.

There is a wealth of research focusing on 'what I own' but is still relatively little investigating the cognitive basis of how adults identify, process, reason about, or interact with *other people's* property. We do know, however, that other-owned objects are not represented the same way as self-owned objects in terms of motor affordances (Constable et al. 2011; Turk et al. 2011a) is a first step towards answering these questions. The concept of ownership is a fundamentally social one (Merrill 1998) so it is not surprising that preparatory motor responses are different towards other- versus self- owned objects. After all, violating social rules regarding the *use* of another person's property could be considerably detrimental to our standing within a community.

An embodied social cognitive approach to studying object ownership

According to theories of embodied cognition cognitive processes such as thought cannot be clearly separated from perception and action (Anderson et al. 2012; Borghi 2005; Foglia and Wilson 2013; Gibbs 2006; Niedenthal et al. 2005; Smith 2005; Willems and Franken 2012). For example, if participants are required to say the word ‘climbing’ as compared to ‘sinking’ while performing a reach greater perturbation along the vertical plane is observed (Kritikos et al. 2011). We propose that the principles of embodied cognition can also apply to less tangible and predictable concepts such as ownership. Indeed, according to Borghi and Cimatti (2010) representing objects in terms of their contextual properties when dealing with complex action situations may be useful rather than simply attending to their lower level perceptual qualities, such as shape and weight.

Kinematic research reveals the automaticity with which we incorporate concepts associated with social context into our own action planning and representations. For example, cooperative and competitive intentions are reflected in different motor patterns (Georgiou et al. 2007) and a participant’s kinematics are sensitive to another person’s attitude within these contexts (Becchio et al. 2008). A request for an object can alter kinematic patterns: when participants are in the process of transferring an object to a container and a confederate holds out their hand, the movement tends to deviate towards the hand. In some cases, participants ignore their goal altogether and place the object in the confederate’s hand (Sartori et al. 2009).

The attribution of meaning can change the way we respond and interact with stimuli. The intrinsic affective valence associated with an object alters our perception of reachable space (Valdés-Conroy et al. 2012) and valenced stimuli such as ‘kiss’ or ‘funeral’ elicit an approach or avoidance effects in reaction time (Chen and Bargh 1999; Markman and Bendl 2005; van Dantzig et al. 2008). For example, participants would be faster to initiate an ‘approach’ action in response to ‘kiss’. This notion has been extended recently using positively or negatively construed inanimate objects and socially relevant contextual indicators (Lugli et al. 2012). Similarly, individual spontaneous interactions with stimuli influence our subsequent evaluation of it (Constable et al. 2013).

We have previously shown that the attribution of ownership status to an object influences adult’s hand-objects interactions (Constable et al. 2011). We asked participants to lift mugs that differed on the basis of ownership: a mug they owned, a mug owned by the experimenter, or a mug without a designated owner. Participants kinematic patterns were consistent with an inhibition of action towards other-owned objects: participants bring their own objects closer to the body, push objects owned by a known, present other away from the body while treating them more carefully (less acceleration).

Broadly, we propose that participants' attribution of socially relevant semantic information to each mug directly influences visuomotor processing. In fact, the effects on different kinematic measures may be associated with specific aspects of the social cognitive construct of ownership and reflect separate and distinct processes. Further investigation is needed, however, to determine the distinct social cognitive mechanisms underlying these kinematic differences. Further, it is important to confirm that they are indeed a result of the ownership manipulation, rather than reflecting a more parsimonious explanation. For example, it is possible that the differences could be attributed to preference, familiarity or the particular spatial layout of the experimental set-up.

The present study

We aimed to replicate the kinematic results obtained by Constable and colleagues (2011) in order to confirm that the influence of ownership status on action execution is indeed robust as well as establish the boundary conditions of these effects. Experiment 1 was a direct replication of our previous study, with one additional manipulation. In Constable et al. (2011), we found that people drew their own mug closer to their own body, and with greater acceleration, while lifting it from the table. We also found – in accordance with our proposition that the ownership status of *other people's property* is coded in our motoric interactions – that the Experimenter's mug drifted further to the right, than the participant's mug. In our present Experiment 1, we aim to arbitrate between two possible explanations of this effect. One explanation is that the ownership status of the object ('Owned by someone else') led the participants to exaggerate the natural trajectory of a right-handed lifting action which moves away from one's own body. The second explanation relates to the fact that the Experimenter was seated to the right of the workspace. Combined with the observation that participants drew their mugs towards themselves, and the Experimenter's mug drifted towards the Experimenter, we might conclude that the kinematics of the lifting action are biased spatially *toward the mug's owner*. Therefore, we manipulated between-subjects where the experimenter stood ('Experimenter Location': to the left or the right). If the participant acts so as to take the Experimenter's mug away from the self, the Experimenter's mug will drift further to the right irrespective of Experimenter location. The alternative explanation would be supported if Experimenter location influences deviation as a function of ownership status.

After broadly replicating the findings of Constable et al. (2011) in Experiment 1, we explored the influence of Owner presence in Experiment 2 by removing the owner from the environment entirely. There are a wide variety of effects demonstrating that the mere presence of another person can alter behavior (e.g. the bystander effect, Fischer et al. 2011; social facilitation, Snyder et al. 2012; social inhibition, Bell and Yee 1989). In the present research, is the presence of the owner critical for the emergence of the differential motor effects on our critical spatial and acceleration measures found in Experiment 1? Perhaps the standard motor codes associated with other people's property are not triggered when the social context of ownership is no longer salient or important. If this is the case, the differences in the dynamic manipulation between the mugs will not be as robust.

Finally, Experiment 3 was conducted to determine if the ownership effects obtained in Experiments 1 and 2 could be explained simply in terms of mere preference and choice, which are frequently confounded with ownership (see the mere ownership effect, Beggan 1992). Rather than inducing ownership over mugs, participants were asked to choose a mug to use during the experiment. The experimenter also chose a mug. Importantly, neither the participant nor the experimenter owned the mugs used in this experiment. As such, we predicted that the participant's and experimenter's chosen mugs would be manipulated in the same way as each other. If, however, the effects reported in Experiments 1 and 2 can be elicited even in this minimal personally-relevant experimental context, then it would be difficult to credit them as ownership effects. To pre-empt the findings, aside from drawing one's chosen mug towards oneself, Experiment 3 did not reveal any influence of mug choice on kinematics.

Across the three experiments we show that (a) the pattern of lift trajectories is stable when comparing mugs with differing ownership status, regardless of the location of the owner, (b) the acceleration effects associated with ownership seem to rely on the presence of the owner, and (c) the drift towards the participant's body may be associated with preference rather than ownership directly. Broadly speaking, these three experiments provide further evidence that ownership influences visuomotor processing and performance. Only two of the previously found ownership effects obtained (rightward drift and acceleration), however, are dissociable effects specifically associated with ownership. The results are largely consistent with the notion that the link between perception and action is socially mediated: socially related variables can be embodied within the motor system and influence object-oriented actions as a function of the social information regarding that object.

Experiment 1

Experiment 1 was a replication of Constable et al. (2011, Experiment 1), except that the Experimenter's location relative to the workspace was manipulated between-subjects in order to explore the influence of spatial-social context in this paradigm. We used motion capture to record participants' natural lifts with three different mugs (their own, the experimenter's, and one without a designated owner). We predicted that the pattern of data shown by Constable et al. (2011) would be reproduced. Specifically, that the Experimenter's mug would drift to the right further than the other two mugs; the Participant's mug would deviate further towards the participant's body and achieve greater acceleration and greater deceleration the interaction than the other two mugs.

Method

Participants.

Forty-nine right-handed individuals took part in the experiment (mean age = 20.67 years, *SD* = 4.29 years; 10 were male) in exchange for partial course credit or AU$30. All participants gave informed consent and were unaware of the purpose of the experiment.

Materials and Apparatus.

Fifty-one white ceramic mugs (height =10cm, diameter of base = 6 cm) were used in the experiment. Each participant was given a mug and instructed to paint a design of their choosing with any of eighteen colours provided. During the experiment, two other mugs were used; the experimenter's, which was also painted, and a blank mug without an explicitly defined owner (see Fig 1a for examples). Lifts were recorded in Cartesian coordinate space (x = left-right; y = forward- back; z = up-down) using three spherical reflective markers (12mm diameter) attached to each mug and a three camera infrared motion capture system (ProReflex, Qualisys; 100-Hz sample rate, measurement error < 0.3mm). Four markers were also attached to the participant's hand (index finger and thumb) and wrist (styloid process of both the radius and ulna).

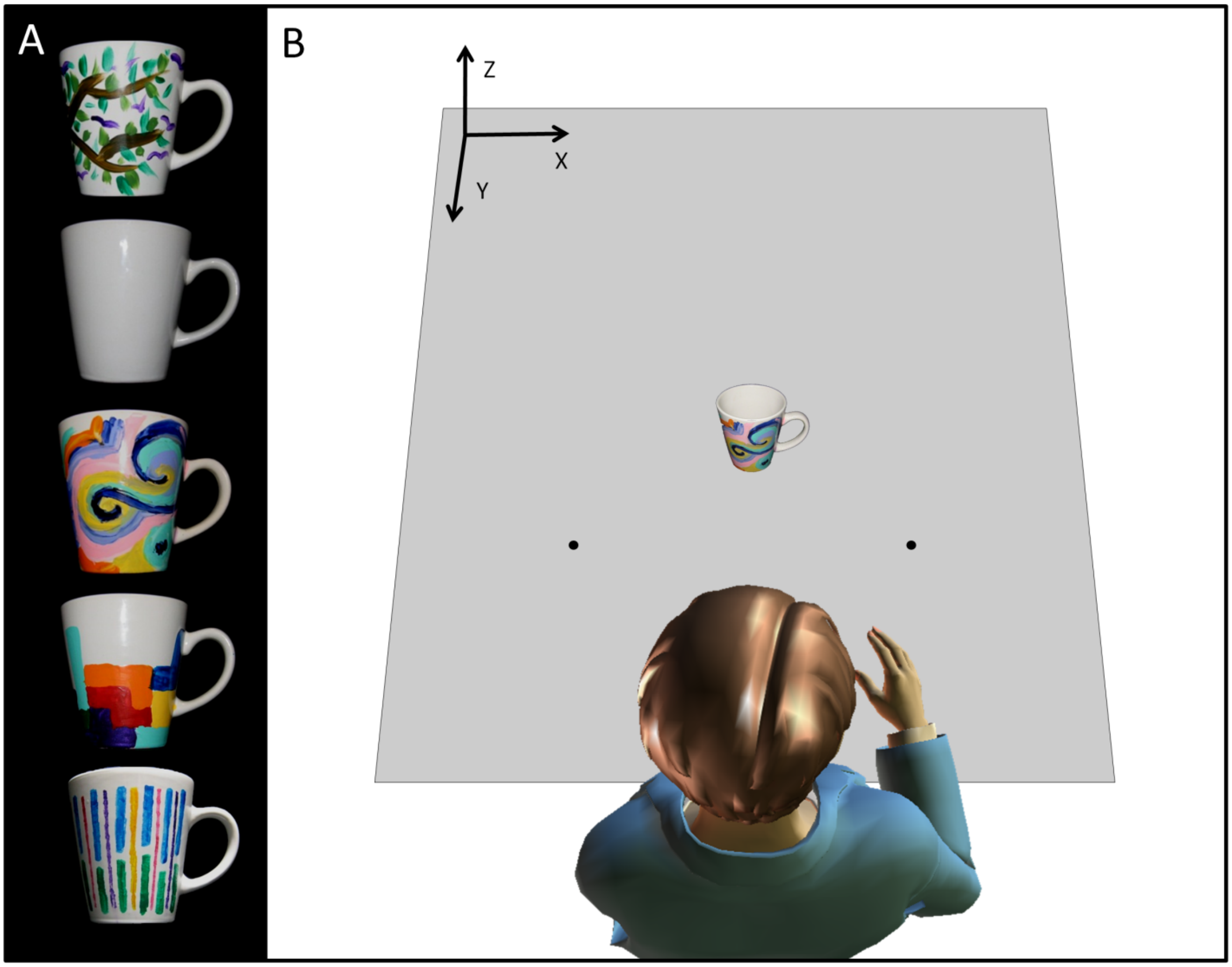

Fig 1 Panel a: Examples of the mugs used in Experiments 1 & 2. From top, Experimenter's/Confederate's mug, Unowned mug, three Participants' mugs. Panel b: Illustration of the experimental set-up (not to scale) for Experiments 1, 2 & 3

Design & Procedure.

After the participant's painted mug dried they were asked to take it away with them to use before returning to complete the experiment. Participants used the mug for an average of 12.83 days (*SD*= 3.77) prior to the experimental session. Self reported usage rates averaged 1.57 times per day (*SD* = 1.18, min = 0.36, max = 6.11). The participant was seated in front of a table and told that their movements (reach, grasp, lift, replace with each of the three mugs) would be recorded. The experimenter introduced the three mugs by explicitly stating that the participant should make the action towards whichever mug was on the table at the time and that this might be their own mug, 'my mug' (the experimenter's), or 'this unpainted mug'. It should be noted that the 'unowned' mug was not given an explicitly defined owner and it was never referred to as the 'unowned' mug in the presence of the participant. Participants were then asked to make a practice reach, grasp, lift, and replace action using only the handle to ensure they understood their task and were doing it in a natural manner. Each trial began with the participant closing their eyes, and their hand resting comfortably in front of them at a marked location with their thumb and index finger gently opposing. The experimenter would then place a mug in front of the participant at one of three marked locations 30cm away from the starting position (directly in front, or 40° to the right or left, see Fig 1b). A tone would sound to indicate that the participant should open their eyes and initiate their movement. There were a total of 108 trials, 36 per mug (Participant's, Experimenter's, Unowned) divided equally between the three marked locations, presented randomly. For half of the participants (n = 24) the experimenter stood to the right of the table, for the other half (n = 25) the experimenter stood to the left of the table.

Data Analysis.

Two participants' data from the 'experimenter on the left' condition were discarded prior to analysis as their means lay 3*SD*s above/below the group mean on multiple critical measures. Individual trials with recording errors (0.47%) were also removed before analysis. Four measures, as previously examined by Constable and colleagues (2011), were calculated using the coordinate and timing data recorded. At the maximum height reached by the mug we took both the *x*- and *y*- coordinates to look at the displacement along these axes from the mugs' starting position (resulting in the measures '*x* at *z*-max' and '*y* at *z*-max'). We also examined 'Peak acceleration during lift' and 'Peak deceleration during placement' which refer to the maximum acceleration a participant reached from the beginning of lift until the maximum height was reached and the maximum deceleration the participant achieved from the time at which maximum height was reached until the mug was rested on the table once more. A 3 X 2 mixed-factors measures ANOVA, with 'Mug Type' (participant's, experimenter's or unowned) as the within-subjects factor and 'Experimenter Position' (right or left) as the between-subjects factor, was conducted on all four measures.

Results

As directed, participants interacted with the mugs in a natural manner. On average participants took 707ms (*SD* = 195ms) to initiate movement towards the mug after hearing the tone. The entire action took 2054ms (*SD*= 508), with the mug in flight for 1046ms (*SD* = 297ms). These measures are consistent with previously observed data (Constable et al., 2011). Where appropriate we used a Huynh-Feldt correction.

Spatial Manipulation.

During the lift phase of the movement, 'x at z-max' indicated that the mugs tended to drift to the right (6.8 mm; see Fig 2a). This rightward drift varied as a function of 'Mug Type', $F(1.86, 83.56) = 6.04$, $MSE = 7.25$, $p = .004$, $\eta_p^2 = .118$. The experimenter's mug drifted significantly further to the right (7.9 mm) compared with the participant's mug (6.4 mm, $t(46) = 2.45$, $p = .018$, $d_z = .36$) and the unowned mug (6.2 mm, $t(46) = 3.46$, $p = .001$, $d_z = .50$). The participant's mug and the unowned mug did not differ, $t(46) = .36$, $p = .72$, $d_z = .05$. Interestingly, there was a trend for smaller rightward drift when the experimenter stood on the left (4.1 mm) than the right (9.5 mm), $F(1, 45) = 3.61$, $MSE = 285$, $p = .064$, $\eta_p^2 = .074$. However, the critical 'Experimenter Position' by 'Mug Type' interaction did not approach significance, $F(1.86, 83.56) = .009$, $MSE = 7.25$, $p = .99$, $\eta_p^2 < .001$. The mugs also tended to drift towards the participant's body during lift (17.5 mm; see Fig 2a). Again, this varied as a function of 'Mug Type', $F(1.60, 72.12) = 13.67$, $MSE = 10.22$, $p < .001$, $\eta_p^2 = .233$. The participant's mug drifted significantly further towards the participant (19.2 mm) compared with the experimenter's mug (16.1 mm, $t(46) = 4.38$, $p < .001$, $d_z = .64$) and the unowned mug (17.3 mm, $t(46) = 2.99$, $p = .004$, $d_z = .44$). The unowned mug also drifted further towards the participant's body compared to the other owned mug, $t(46) = 2.91$, $p = .006$, $d_z = .42$. A main effect of experimenter position was also observed, $F(1, 45) = 12.38$, $MSE = 614$, $p = .001$, $\eta_p^2 = .216$. When the experimenter stood to the left all mugs drifted further towards the participant (25.0 mm) compared with when the experimenter stood to the right (10.3 mm). Again, critically, the interaction between 'Mug Type' and 'Experimenter Position' was non-significant, $F(1.60, 72.12) = 1.81$, $MSE = 10.22$, $p = .18$, $\eta_p^2 = .039$.

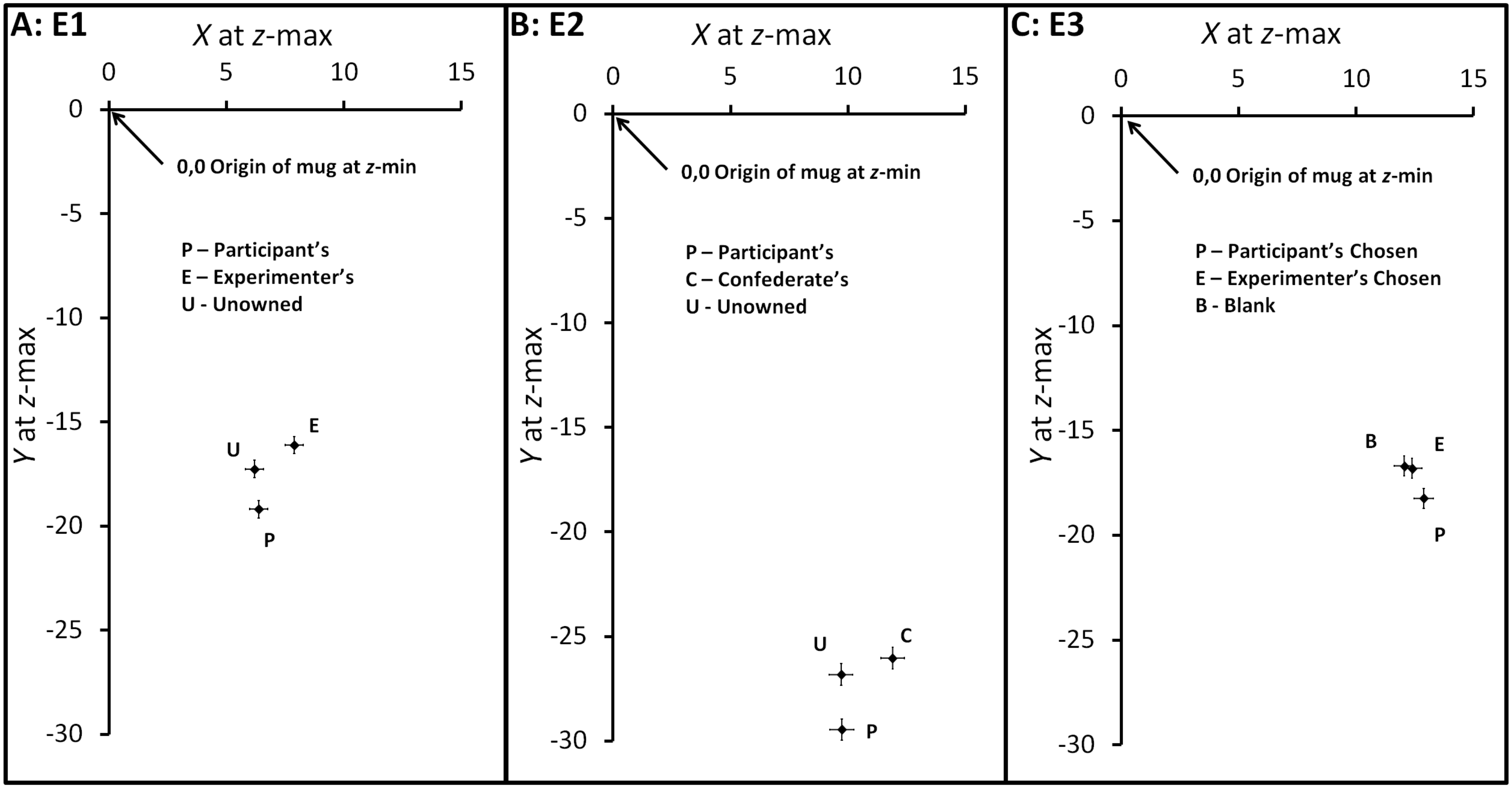

Fig 2 Graph illustrating the *x* (left–right) and *y* (toward-away) positions of the mug at the maximum mug height for each of the mugs used in Experiments 1, 2, & 3 attained during lift phase of the action relative to the starting position on the table (i.e. x = 0, y = 0, z = 0). Panel a: Experiment 1. Panel b: Experiment 2. Panel c: Experiment 3. Error bars represent standard error of the mean for within-subjects effects (Loftus and Masson 1994)

Dynamic Manipulation.

This measure varied as a function of 'Mug Type', $F(1.56, 70.25) = 4.54$, $MSE = 1531496$, $p = .02$, $\eta_p^2 = .092$. Participants reached a higher acceleration with their own mug (8477mm/s^2) compared with the experimenter's mug, (7825mm/s^2, $t(46) = 2.65$, $p =.01$, $d_z =.39$) and a trend for a difference with the unowned mug was observed (7954mm/s^2, $t(46) = 1.84$, $p =.07$, $d_z =.27$), see Fig 3a. The difference between the experimenter's and unowned mugs was not significant, $t(46) = .84$, $p =.41$, $d_z =.12$. Again, there was no main effect of 'Experimenter Position', F(2, 90) = 1.42, $MSE = 4.67 \times 10^7$, $p = .24$, $\eta_p^2 = .03$. Therefore, the pattern of data is consistent with Constable et al.'s (2011) data, with greatest acceleration applied to the participants' own mug, and least acceleration applied to the Experimenter's mug.

This pattern was, however, qualified by a significant interaction between 'Mug Type' and 'Experimenter Position', F(1.56, 70.25) = 4.71, $MSE = 1531496$, $p = .01$, $\eta_p^2 = .095$. When the experimenter stood to the right, participants reached a higher acceleration with their own mug (9494mm/s^2) compared to the experimenter's, (8481mm/s^2, $t(23) = 2.64$, $p =.02$, $d_z =.54$) and the unowned mug (8294mm/s^2, $t(23) = 3.11$, $p =.005$, $d_z =.64$). There was no difference between the other owned and unowned mugs, $t(23) = 1.18$, $p =.25$, $d_z =.24$. When the Experimenter was situated to the left, greater acceleration was again applied to the participant's mug (7417mm/s^2) than the Experimenter's mug (7140mm/s^2), a difference that approached significance, t(22), $p = .08$, $d_z = .20$. Curiously, in this particular condition, of the 3 mugs the Unowned mug had the greatest acceleration applied to it (7600mm/s^2) . So, although when the experimenter stood to the right of the participant, greater acceleration was applied to the Participant's mug than to the Experimenter's mug, this pattern was disrupted in the 'Experimenter-on-left' condition.

The only effect of mug ownership that failed to replicate Constable et al. (2011) was the effect of 'Mug Type' on 'Peak deceleration during placement', $F(2, 90) < 1$, $MSE = 4975866$. Moreover, experimenter position did not significantly interact with ownership, $F(2, 45) = 1.53$, $MSE = 5.3 \times 10^7$, $p = .22$, $\eta_p^2=.03$.

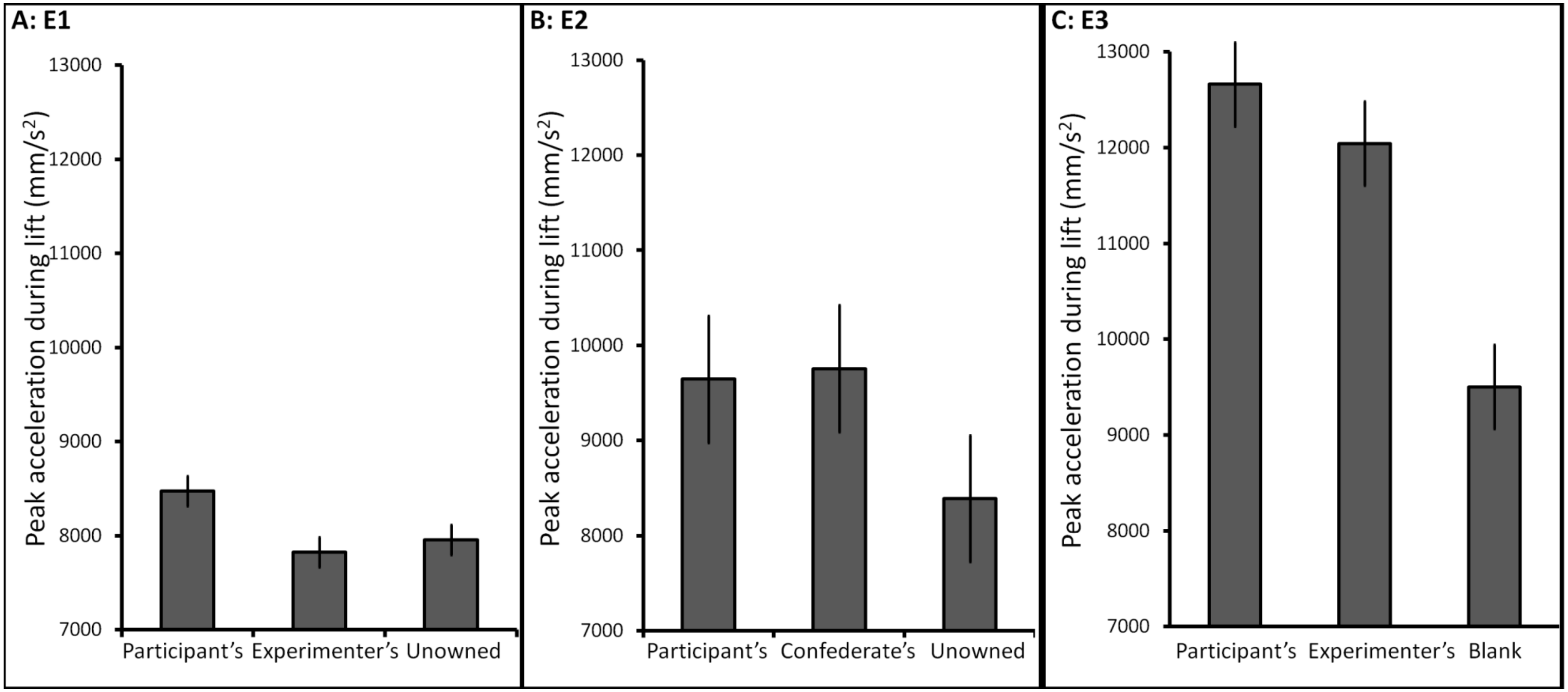

Fig 3 Graph illustrating the mean peak acceleration reached during the lift phase of the action for each mug in Experiments 1, 2, & 3. Panel a: Experiment 1. Panel b: Experiment 2. Panel C: Experiment 3. Error bars represent standard error of the mean for within-subjects effects (Loftus and Masson 1994)

Discussion

Participants drew their own mug closer towards themselves and displayed greater acceleration during lift compared to the experimenter's mug and the unowned mug. Moreover, when participants lifted the experimenter's mug it drifted further to the right than when they lifted their own mug or the unowned mug. We also varied 'Experimenter Position' in this experiment, but this factor did not interact with 'Mug Type' on either spatial measure. Hence, it is unlikely that these effects are due to the location of the experimenter or in some way idiosyncratic to our design and experimental set-up. More likely, we are observing an exaggerated rightward drift due to biomechanical factors involved in a right-handed abductive movement. When interacting with the Experimenter's mug, this exaggerated repulsion from the body may be due to a reticence to interact with the experimenter's mug.

However, there were some main effects of experimenter location on the spatial measures of lift trajectory. Overall, it seemed that participants in the 'Experimenter on the left' condition showed less deviated lifts in general than the participants who completed the experiment when the experimenter stood to the right. This is an unexpected finding that is orthogonal to the ownership effect, but may be consistent with literature involving a bias towards one side of space that contains a distractor stimulus, such as in a cued line bisection task (e.g. Milner et al. 1992; Riddoch and Humphreys 1983). In the present study, the 'distractor' may be the experimenter. Indeed, experimenter location has previously been shown to bias line bisection (Garza et al. 2008).

With the acceleration data, the replication of our previous work was only partial. Although deceleration was significantly affected by ownership in our previous report (Constable et al. 2011) it was non-significant in the present study. Acceleration during lift, however, mirrored our previous data well. We consistently observed greater acceleration being applied to the participant's own mug compared with the experimenter's or the unowned mug.

In sum, we have demonstrated the reliability of Constable et al's (2011, Experiment 1) methodological approach, replicated the findings and demonstrated that although the location of the experimenter may have some influence on how people lift objects, this does not have a great influence on the effects associated with the main manipulation of interest: the ownership status of the target interaction object. In the next experiment, we further investigate these phenomena by modulating the social context in which the objects are presented.

Experiment 2

Experiment 1 suggests that knowledge of ownership status alters visuomotor processing during hand-object interactions. Further, it seems that interactions with other people's property are somewhat restrained. Therefore, reducing the salience of a socially relevant relationship between objects and their owner may moderate the need to treat other's property any differently to one's own. Consequently, Experiment 2, was designed to assess if the presence of an owner is necessary for ownership status to produce kinematic effects. As such, a confederate brought the 'other owned' mug to the room, then left before the experiment began. If the effects rely entirely on the fact that the experimenter is the owner of the 'Other-owned mug' and is present at the time, then the effects of ownership should be abolished. However, the effects will remain if they are based solely on knowledge about ownership status.

Method

Participants.

Twenty-seven naive right handed individuals took part in the experiment (mean age = 21.63 years, SD = 4.50 years; 6 were male) in exchange for either course credit or AU$30. Three participants' data were removed from the analysis because they indicated they were aware of the staged nature of the confederate scenario. One participant mug's design degraded due to aggressive washing, but we retained their data because they were able to identify the mug as their own.

Materials, Apparatus, Design & Procedure.

These were identical to Experiment 1 except for the introduction of a confederate scenario at the beginning of the experimental session. Participants used their mug for an average of 13.63 days (*SD* = 3.43 days), and self-reported usage rates from 0.57 to 6.5 times per day (*M* = 1.56, *SD* = 1.30).

Each participant was seated in front a table while the experimenter began to attach markers to the mugs. She then pretended to look for her own mug and indicated to the participant that she could not find it but would call another lab member and ask to borrow theirs in order to complete the experiment. The confederate then came and gave the experimenter the same mug that was used as the 'Experimenter's mug' in Experiment 1 and left. The experimenter finished attaching markers to the mugs and commenced the experiment. Although each participant was exposed to only one confederate, two were used during the study. A confederate was assigned on the basis of convenience. Both confederates were, like the experimenter, young female graduate researchers with dark hair, blue/green eyes, of average height and similar names (Hayley and Harriet). The experiment then proceeded as usual with the experimenter positioned to the right of the participant.

Results

Trials with recording errors (1.23%) were removed before analysis. We looked at the same measures reported in Experiment 1. On average participants took 679ms (*SD* = 136ms) to initiate movement towards the mug after hearing the tone. The entire action took 2085ms (*SD* = 337ms), with the mug in flight for 1035ms (*SD* = 221ms). A Huynh-Feldt correction was applied to degrees of freedom where appropriate.

Spatial Manipulation.

As before, 'Mug Type' had a significant effect on '*x* at *z*-max', $F(2,46) = 6.22$, $MSE = 6.09$, $p = .004$, $\eta_p^2 = .213$. The other owned mug drifted significantly further to the right (11.9 mm) during lift compared to the participant's mug (9.7 mm, $t(23) = 2.69$, $p = .01$, $d_z = .55$) and the unowned mug (9.7 mm, $t(23) = 3.17$, $p = .004$, $d_z = .65$, see Fig 2b). The participant's mug and the unowned mug did not differ significantly, $t(23) = .039$, $p = .97$, $d_z = .01$. 'Mug Type' had a significant effect on '*y* at *z*-max', $F(2,46) = 12.00$, $MSE = 6.40$, $p < .001$, $\eta_p^2 = .343$. As Fig 2b indicates, the participant's mug drifted significantly further toward the participant during lift (29.5 mm) than the other owned mug (26.0 mm, $t(23) = 3.17$, $p < .001$, $d_z = .89$) and the unowned mug (26.8 mm, $t(23) = 3.37$, $p = .003$, $d_z = .67$). The unowned mug and other owned mug did not differ significantly, $t(23) = 1.28$, $p = .21$, $d_z = .26$.

Dynamic Manipulation.

There was no effect of 'Mug Type' on 'Peak acceleration during lift', $F(1.61, 36.91) = 1.3$, $MSE = 13275297$, $p = .28$, $\eta_p^2 = .053$ (see Fig 3b). The main effect of 'Mug Type' on deceleration was also not significant, $F(1.51,34.68) = 1.05$, $MSE = 10379363$, $p = .34$, $\eta_p^2 = .043$.

Discussion

When we removed the owner of the 'other' object from the room during testing the trajectory effects remained. We observed a greater rightward drift with the confederate's mug compared to the other mugs and participants drew their own mug closer towards themselves compared with the confederate's and the unowned mug. Consistent with Experiment 1, no effect of deceleration during placement was obtained. Contrary to Experiment 1, however, mug type did not have an effect on acceleration during lift. Given that an *a priori* power analysis on the basis of the effect size obtained by Constable et al. (2011), $d_z = .86$, revealed that a sample of 10 participants would be required to reach sufficient power at the recommended .80 level (Cohen 1988), failure to obtain an acceleration effect here is unlikely to be the result of a small sample size. This suggests that the ownership effects previously associated with acceleration during lift are context dependent and may be dissociable from the trajectory measures being investigated.

As we still obtain a trajectory effects, it is not likely that a reduction in salience of the owner-object relationship is responsible for the lack of an effect on our acceleration measure. Perhaps, as previously suggested (Constable et al. 2011) differences in acceleration reflect different degrees of care taken. Therefore, this established boundary condition is more consistent with the idea that the observed differences are associated with a conflict prevention strategy aimed at developing, smoothing, and maintaining interpersonal relationships. A desire to take care of other people's property leads to less acceleration when interacting with the mug. If the owner is not present, however, this socially related goal is no longer salient and we observe no difference between the confederate's and the participant's mug in terms of acceleration. In the final experiment we investigate if the effects obtained in Experiment 1 are truly representative of ownership by focusing on the commonly confounded variable of preference.

Experiment 3

One fundamental difficulty for the study of ownership is that ownership is often confounded with preference and choice. When we own an object we also tend to evaluate it more favorably compared to other objects (Beggan 1992). In order to determine if a participant's knowledge of ownership status is actually associated with the embodiment of *ownership* rather than *preference differences*, we repeated the experiment but without an ownership component. Instead, participants chose a mug to use during the experiment and were not permitted to keep it. No mention of ownership was made to participants nor did they use the mug outside of the experimental task. Hence, preference and choice are still imbued in the mug, but ownership is absent. Upon completing the lifting task, participants indicated their degree of liking for the three mugs used during testing.

Method

Participants.

Thirty-seven new right handed individuals took part in the experiment (mean age = 19.46 years, SD = 2.04 years; 11 were male) in exchange for course credit.

Materials & Apparatus.

White ceramic mugs that were physically identical to those used in Experiments 1 and 2 were used. Eleven mugs painted by laboratory assistants were rated by 22 independent raters who were given a 7-point Likert scale, and asked to rate how much they liked the mug, how masculine/feminine the design appeared and also how much effort they felt had been given to the design. On the basis of these ratings, six mugs were selected as being the most neutral in terms of liking and effort. Of these six mugs, three fell on the masculine end of the scale and three fell on the feminine end of the scale (Appendix 1 provides the ratings for each mug used). The six mugs that were selected plus a blank mug were used in the experiment (see Fig 4).

Fig 4. The 6 painted mugs and the blank mug used in Experiment 3. From left, Mug 1, Mug 2, Mug 3, Mug 4, Mug 5, Mug 6 and the blank mug.

Design & Procedure.

The design and procedure of the experimental session was identical to Experiments 1 and 2, except for how the mugs were selected. The six painted mugs were arranged pseudo-randomly between participants in a row on the table. Participants were asked to "choose a mug to use in the experiment today". The experimenter then also chose a mug from the array, which was always one of two mugs (Mug 4 or 5). The experimenter then said "we will also use this blank mug for the experiment today" while presenting the blank mug to the participant. Infra-red reflective markers were then attached to the participant and the 3 selected mugs. The experiment then proceeded as usual (Experiments 1 & 2) with the experimenter standing to the right of the participant. Upon completing the lifting phase of the experiment, participants were asked to identify the mug they selected and the mug the experimenter selected from an array of the six original mugs, to ensure they had remembered their choice. All participants were able to correctly identify which mug they had chosen and which mug the experimenter had chosen. They were then asked how much they liked each of the three mugs used in the experiment on a 10-point scale.

Results

One participant's data was removed before analysis due to a high number of recording errors (10%). Other individual trials with recording errors (0.54%) were removed before analysis. On average participants took 662ms

(*SD* = 227ms) to initiate movement towards the mug after hearing the tone. The entire action took 1947ms (*SD* = 458ms), with the mug in flight for 951ms (*SD* = 242ms). After testing, all participants identified the mug they chose and the mug the experimenter chose correctly. Huynh-Feldt corrections were applied where appropriate.

Mug Ratings.

There was a significant effect of mug on participant's ratings, $F(1.78, 62.22) = 32.69$, $MSE = 3.13$, $p < .001$, $\eta_p^2 = .48$. The participant's chosen mug was rated higher (7.03) than both the experimenter's chosen mug (6.39, $t(35) = 2.14$, $p = .04$, $d_z = .36$) and the blank mug (4.01, $t(35) = 7.02$, $p < .001$, $d_z = 1.17$). The comparison between the experimenter's chosen mug and the blank mug also reached significance, $t(35) = 5.46$, $p < .001$, $d_z = .91$. This suggests that participant's did, indeed, have a preference for the mug they chose as compared to the others they were lifting during the testing phase.

Spatial Manipulation.

Contrary to Experiments 1 and 2, no main effect of 'Mug Type' on '*x* at *z*-max' was observed, $F(2,70) = 1.553$, $MSE = 4.08$, $p = .219$, $\eta_p^2 = .042$. A trending effect of 'Mug Type' on '*y* at *z*-max' was obtained, $F(1.49,52.14) = 3.26$, $MSE = 11.45$, $p = .06$, $\eta_p^2 = .085$ (see Fig 2c). Planned comparisons revealed that the participant's chosen mug drifted toward the participant during lift (18.2 mm) significantly further than the experimenter's chosen mug (16.8 mm, $t(35) = 2.73$, $p = .01$, $d_z = .45$) and a trended towards significance with the blank mug (16.7 mm, $t(35) = 1.81$, $p = .08$, $d_z = .30$). The blank and experimenter's chosen mug did not differ significantly, $t(35) = .21$, $p = .84$, $d_z = .03$.

Dynamic Manipulation.

A significant effect of 'Mug Type' on 'Peak acceleration during lift' was obtained, $F(1.74,60.74) = 14.49$, $MSE = 8020400$, $p < .001$, $\eta_p^2 = .293$. The experimenter's chosen mug and the participant's chosen mug did not differ significantly, $t(35) = .826$, $p = .415$, $d_z = .14$ (see Fig 3c). The blank mug reached a lower acceleration (9502mm/s^2) compared with the experimenter's chosen mug (12043mm/s^2, $t(35) = 4.53$, $p < .001$, $d_z = .75$) and the participant's chosen mug (12660 mm/s^2, $t(35) = 5.92$, $p < .001$, $d_z = .99$). There was a significant effect of 'Mug Type' on deceleration, $F(1.68,58.82) = 12.57$, $MSE = 15789464$, $p < .001$, $\eta_p^2 = .264$. Mirroring the acceleration data, the blank mug reached a lower peak deceleration (8716mm/s^2) compared with the Experimenter's chosen mug (12232mm/s^2, $t(35) = 4.93$, $p < .001$, $d_z = .82$) and the participant's chosen mug (12623mm/s2, $t(35) = 5.01$, $p < .001$,

d_z =.83). The Experimenter's chosen mug and the Participant's chosen mug did not differ significantly, $t(35) = .374$, p =.711, d_z =.06.

Discussion

The findings from Experiments 1 and 2 may not have been purely due to the ownership status of the mugs, but contaminated by differential preferences we hold for objects that we own. To establish the extent to which mere choice (and thereby preference) influences the kinematics of mug lifts, we removed the ownership manipulation. A manipulation check confirmed that participants did like their chosen mug more than the other mugs they lifted during the experiment. Contrary to previous experiments, no differences in rightward drift were observed between the mugs. There was a significant difference associated with both acceleration during lift and deceleration during the placement of the mug, however, this difference was due to the blank mug. The only effect obtained in previous experiments that remained was '*y* at *z*-max', with participant's drawing the mug they had chosen closer towards their body compared to the other mugs. Further, for measures on which we failed to replicate previously found effects (*x* at *z*-max, acceleration and deceleration), we collected a sufficient sample size to detect effects of the same magnitude as those obtained by Constable et al. (2011), $d_z s$ = .86 – 1.11 at the recommended .80 level (Cohen 1988).

In Constable et al. (2011) we suggested that the '*y* at *z*-max' effect could be due to an over learned 'drinking' motor response. This explanation, however, is not consistent with finding the same effect in response to a preference manipulation. Therefore, we suspect that this may be an approach response to objects we like, whether owned, or not. On the other hand, the effects obtained in Experiments 1 and 2 associated with '*x* at *z*-max', 'Lift height', and 'Peak acceleration during lift' seem to be independent from preference.

General Discussion

Over three experiments, we have replicated and extended the findings associated with ownership related effects. These studies show that the previously described (Constable et al. 2011) kinematic effects pertaining to differences in ownership status are context dependent and dissociable from each other (see Fig 5). Importantly, this is the first evidence directly implicating ownership as a variable that alters cognitive processing, distinct from preference.

Measure	E1-Replication	E2- Owner Absent	E3- Choice Only	Comment
Y at *z*-max	✓	✓	✓	Preference effect/approach action, dissociated from ownership and motor learning
X at *z*-max	✓	✓	✗	Ownership effect/avoidance action, sensitive to other-owned objects
Peak Acceleration	✓	✗	✗	Ownership effect, sensitive to owner presence
Peak Deceleration	✗	✗	✗	Failed to replicate observation of Constable et al. (2011)

Fig 5 Indication of whether the critical comparison between the Participant's own/chosen mug and the Other owned/chosen mug was replicated (tick) or failed to replicate (cross) across experiments and the possible underlying process involved in the effect

In general, measures of interest ('*x* at *z*-max', '*y* at *z*-max' and 'peak acceleration during lift') reflected the operation of distinct cognitive mechanisms. Given that '*x* at *z*-max' was the only measure of interest exclusively linked with ownership in the experiments presented here, and previous research (see Constable et al. 2011), we suggest that it is a valid and robust representation of embodiment of the social construct of ownership. '*Y* at *z*-max' was the only measure that consistently produced the same pattern of results throughout the three experiments, one of which did not involve ownership. As such, it is difficult to make an argument that the inducement of ownership is required to elicit effects associated with a drift towards the participant. Regarding acceleration, however, differences between the mugs were absent when the owner of the object was absent. As we failed to replicate the previously reported (Constable et al. 2011) pattern of results associated with deceleration we interpret the acceleration data with caution. It may suggest that when participants were in the presence of the owner in Experiment 1 they were taking extra care with the experimenter's mug, perhaps as a conflict prevention strategy, although this is speculative.

Rightward drift during lift

Looking at '*x* at *z*-max' more closely, in Experiment 1 we addressed the alternative hypothesis that mugs drift towards their owner during lift. The experimenter's mug drifted further towards the right as compared to both the participant's mug and the unowned mug. The location of the experimenter, however, did not interact with mug type. The most parsimonious explanation of the data, therefore, is that the effect represents a general reticence to interact with other people's property rather than the participant moving the owned object towards its owner.

The same pattern of results for '*x* at *z*-max' was observed when the owner of the 'other owned' object was absent (Experiment 2). Therefore, this measure is robust to socially related environmental changes. This indicates that the social construct of ownership is embodied within the motor system and prompts automatic motor processing even in the absence of a visible need to account for other people's property. The pattern of results in Experiment 2 provides further evidence disqualifying the idea that the mugs travel towards their owner during lift as the owner was not present. We propose instead that this pattern of movement is a result of a general avoidance process. Overall, the pattern of results associated with this measure provides a strong case for the notion that *ownership* alters visuomotor processing beyond a conscious goal of developing, smoothing, and maintaining interpersonal relationships, reflecting automatic approach and avoidance processes.

Proximity to the body during lift

Across all three experiments the participant's own (Experiments 1 & 2), or chosen (Experiment 3) mug, drifted further towards the participant's body during lift compared with the other (Experimenter's, Confederate's, or Experimenters chosen) mug or the blank mug. Constable and colleagues (2011) previously suggested that this may be associated with an over-learned motor process. The fact that this measure produces the same pattern of results when participants have had no prior exposure to the mugs and there is no difference in familiarity between the three mugs they lift (Experiment 3), suggests that this is not the case. Rather, it is consistent with a preference for, or a positive connotation associated with, the participant's own or chosen mug as compared with the others. This explanation concurs with previous research on the approach/avoidance effect (Chen and Bargh 1999; Lugli et al. 2012; Markman and Brendl 2005; van Dantzig et al. 2008) showing that positive words or positively connoted objects elicit faster response times when the action involves pulling a lever or mouse towards the body while negative words or negatively connoted objects elicit a faster response time when the action involves pushing the lever or mouse away. The attribution of ownership (Experiments 1 & 2) and the act of choosing an object (Experiment 3) may construe otherwise neutral objects as being positive and favorable (as in the mere-ownership effect, Beggan 1992) via a common mechanism that is special neither to ownership or choice.

Acceleration associated with lifting actions

In Experiment 1, participants reached higher peak acceleration during the lift phase of the movement with their own mug compared with the experimenter's mug and the unowned mug. No difference was observed, however, when the owner of the other object was absent from the room during testing. Therefore, the differences observed in

Experiment 1 may reflect a bias to be seen to take care of other people's things or a means to maintain social connections by avoiding conflicts only when those individuals are present. There was a significant difference observed in Experiment 3 but this difference was associated with the blank mug reaching a lower peak acceleration rather than any difference between chosen mugs.

As acknowledged by James (1890) distinguishing between 'me' and 'mine' is not trivial. The items that surround us form a vital part of our identity (Belk 1988; Cram and Paton 1993; Dittmar 1992; Kroger and Adair 2008). We often choose to posses items on the basis of how well they align with our current (or desired) identity as a means of developing, maintaining or repairing it (Belk 1988; Gao et al. 2009; Sivanathan and Pettit, 2010). Our property, however, is also likely to play a direct role in shaping our identity once it is in our possession. For example, Chiou and Chao (2011) caution that using cheaper, generic products may lead to lower self-worth. Likewise, Belk (1988) discusses a range of cases whereby the unintentional loss of possessions causes substantial amounts of grief and results in a diminished sense of self. Given the importance possessions have to our sense of self, it is not surprising that we are acutely aware of our own property. But the data presented here also demonstrate that we implicitly account for other people's property and this process is reflected in the way we act upon objects in our immediate surroundings.

The series of experiments we present here provides further evidence to suggest the visuomotor system accounts for the socially relevant construct of ownership. The attribution of meaning to owned objects alters our behaviors in a subtle and contextually driven way. The data provide a strong case for the inhibition of action towards other people's property, which may, with future research, prove to be associated with an individual's ability to navigate through an inherently social world. We also demonstrate that preference cannot account for these ownership related effects. Moreover, ownership independently contributes to differences in individual's motoric interactions with objects. The methodological approach presented here may also provide a new means of investigating the developmental trajectory of ownership cognition and how this alters an individual's perception of and interactions with important socially relevant objects.

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Appendix 1A

Table 1

Mean ratings (liking, masculinity/femininity, effort) of the six painted mugs used in Experiment 3 provided by 22 independent raters.

	Liking *M (SD)*	Masculinity/Femininity *M (SD)*	Effort *M (SD)*
Mug 1	5.27(1.32)	4.32(1.09)	2.41(0.59)
Mug 2	5.73(2.00)	4.41(0.80)	2.50(0.67)
Mug 3	5.14(1.61)	5.05(1.70)	3.09(0.43)
Mug 4	5.73(1.58)	5.86(0.83)	2.50(0.51)
Mug 5	5.09(1.77)	6.91(1.31)	2.59(0.59)
Mug 6	5.86(1.78)	3.86(1.13)	2.73(0.55)

Notes. Liking and Masculinity/Femininity were both rated on a 9 point Likert Scale. 1 = Strongly dislike or Highly Masculine, 9 = Strongly like or Highly Feminine. Effort was rated in terms of 1 = No effort invested, 2 = Not much effort was invested, 3 = A moderate amount of effort was invested, 4 = A large amount of effort was invested.