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Self-bias effect: movement initiation to self-owned property is speeded for both  
approach and avoidance actions

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Running Head: Speeded initiation to self-owned property  
Key words: embodied cognition, ownership, approach-avoidance, self-prioritisation

Word Count: 9705

**1 ABSTRACT**

2 Recall of, and physical interaction with, self-owned items is privileged over items  
3 owned by other people (Constable et al, 2011; Cunningham et al, 2008). Here we investigate  
4 approach (towards the item), compared with avoidance (away from the item) movements  
5 to images of self- and experimenter-owned items. We asked if initiation time and  
6 movement duration of button-press approach responses to self-owned items are associated  
7 with a systematic self-bias (overall faster responses), compared with avoidance movements,  
8 similar to findings of paradigms investigating affective evaluation of (unowned) items.  
9 Participants were gifted mugs to use, and after a few days they completed an approach-  
10 avoidance task (Chen & Bargh, 1999; Seibt et al, 2008; Truong et al, 2016) to images of their  
11 own or the Experimenter's mug, using either congruent or incongruent movement direction  
12 mappings. There was a self-bias effect for initiation time to the self-owned mug, for both  
13 congruent and incongruent mappings, and for movement duration in the congruent  
14 mapping. The effect was abolished in Experiment 2 when participants responded based on a  
15 shape on the handle rather than mug ownership. We speculate that ownership status  
16 requires conscious processing to modulate responses. Moreover, ownership status  
17 judgements and affective evaluation may employ different mechanisms.

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## Introduction

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### *Affective evaluation and approach-avoidance movements*

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In experimental psychology paradigms, the physical features, meaning, affect and self-relevance of information all contribute to motor responses times (Cacioppo, Priester, & Bernston, 1993; Chen & Bargh, 1999; Humphreys & Sui, 2015a, b; Sparks, Cunningham & Kritikos, 2016; Strack, Martin, & Stepper, 1998). Affective evaluations show a bidirectional relationship with motor output, leading to propositions that cognitive and affective processes are embodied (Cacioppo et al., 1993; Fischer & Zwaan, 2008; Lavender & Hommel 2007; Soussignan, 2002; Strack et al, 1998; Truong, Chapman, Chisholm, Enns & Handy, 2016). For example, Cacioppo et al (1993) had participants rate Chinese ideographs. In the arm flexion condition, participants were instructed to place their palms under the table and press upwards. In the arm extension condition, they placed their palms on the table surface and pressed downwards. While performing these actions, they rated whether they liked or disliked the ideographs (experiments 1 and 2). Ideographs viewed in the flexion condition were rated more positively (better liked) than ideographs viewed in the extension condition (Cacioppo et al, 1993). In these two experiments, we investigate whether the same bidirectional motor output pattern holds for self-relevant objects.

Affective evaluations of words (pleasant - unpleasant; good - bad; simple - complex) modulate arm flexion-extension response times, as indicated in joystick approach-avoidance paradigms (Chen & Bargh, 1999; Krieglmeier et al., 2010; Seibt, Neumann, Nussinson & Strack, 2008; Zajonc, 1980). These approach-avoidance response differences fit within the

1 framework of Strack and colleagues (Körner & Strack, 2018; Strack & Deutsch, 2004), who  
2 postulated that behaviour can be attributed to reflective and impulsive processes. Reflective  
3 processes are 'higher-level' decision-making mechanisms regarding actions. Conversely,  
4 impulsive processes drive approach-avoidance actions (typically flexion and extension  
5 movements) to positive or negative stimuli. Impulsive processes can be thought of as well-  
6 established associative links related to motivation-triggered actions, are automatic, and  
7 require little or no attention (Körner & Strack, 2018; Strack & Deutsch, 2004; see also Chen  
8 & Bargh 1999).

9 Many studies report a systematic association between direction of response  
10 (approach-avoidance) and evaluation of the word (positive-negative) (Chen & Bargh, 1999;  
11 Eder & Hommel, 2013; Koch, Holland, & Knippenberg, 2008; Krieglmeyer, et al, 2010;  
12 Lavender & Hommel, 2007; van Dantzig, Pecher, & Zwaan, 2008; but see for example van  
13 Dantzig, Zeelenberg, & Pecher, 2009; Seibt et al, 2008 for an opposing view). Chen and  
14 Bargh (1999) had one group of participants evaluate and classify a word on a monitor as  
15 'good' by pushing the lever towards it and thus pulling away from the self, and 'bad' by  
16 pulling the lever away from the word and thus towards the self (incongruent condition). The  
17 second (congruent condition) group reversed this direction-evaluation mapping): words  
18 were classified as 'good' by pulling the lever towards the self and away from the word, and  
19 'bad' by pushing the lever away from the self and towards the word. Evaluation latencies  
20 were significantly faster for congruent than incongruent mappings, with faster responses  
21 when participants made movements away from 'good' words and towards the self, and  
22 moved toward 'bad' words and away from the self (Chen & Bargh, 1999). The explanation  
23 was that evaluation of a stimulus as positive or negative activates flexor muscles pulling  
24 towards the body or extensor muscles pushing away respectively (Chen & Bargh, 1999) such

1 that positive information is 'brought' towards the self while negative information is 'pushed'  
2 away. Rotteveel, Gierholz, Koch et al, (2015), conversely, directly replicated Chen and  
3 Bargh's (1999) methods and were unable to find approach-avoidance differences to the  
4 affect of word items.

5 The findings of other studies, however, indicate that the direction of differences  
6 depends on the frame of reference of the approach-avoidance movement, and can change  
7 due to task demands. Seibt et al (2008) point out that the (in)congruence of the mapping -  
8 that is, which direction is considered approach versus avoidance - depends on whether the  
9 physical self versus the item is the frame of reference of the movement. That is, the simple  
10 instruction to move towards versus away from the item, or towards versus away from the  
11 self, changes the frame of reference (Seibt et al, 2008; experiment 3). If the frame of  
12 reference is the self ('move the joystick towards / away from yourself') then approach-avoid  
13 refers to approaching or avoiding the body. Conversely, if the frame of reference is the item  
14 of information ('move the joystick towards / away from the word') then approach-avoid  
15 refers to approaching or avoiding the word on the monitor. Therefore, the frame of  
16 reference of approach-avoidance movements is in terms of the goal of the action, rather  
17 than the extensor / flexor muscles that are activated. Here we had participants move to the  
18 near or far button according to mug ownership (experiment 1) or shape on mug handle  
19 (experiment 2), so arguably the frame of reference is mug-based because the goal is to  
20 process information relating to the mug. Hence, approach implies reducing the distance  
21 between self and the mug, while avoidance implies increasing the distance.

22 Other factors, such as conscious processing of the information and hand posture, may  
23 further modulate the approach-avoidance response latency pattern. Rotteveel and Phaf  
24 (2004), investigating evaluation of emotional faces using flexion and extension movements,

1 reported that conscious processing of the emotional expressions was crucial in revealing  
2 systematic approach-avoidance differences. When focusing on gender of the face instead,  
3 approach-avoidance dissociation was not evident (Rotteveel & Phaf, 2004). Finally, Freina,  
4 Baroni, Borghi and Nicoletti (2009) showed that when the hand is holding a tennis ball  
5 latencies are faster to near reaches for positive words and far reaches for negative ones.  
6 This is possibly because with a ball, and hence a wide grasp, positive features are 'brought  
7 in' towards the self and negative ones are pushed away.

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### 9 *Self-relevance, ownership and motor control*

10 There is substantial evidence that self-relevant items are also attended to  
11 preferentially compared with non-self-relevant items. An early example of this is the work of  
12 Moray (1959) who used dichotic listening paradigms to present distinct streams of  
13 information to the two ears. Participants were instructed to attend to information  
14 presented to one ear, but personal information such as the participant's name, presented to  
15 the other ear captured attention away from the attended ear (Moray 1959). Subsequent  
16 work showed that personality traits ascribed to the self (for example, "Does [*trait*] describe  
17 you / the experimenter?") are rated more positively and recalled more accurately than traits  
18 ascribed to the Experimenter (Kuiper & Rogers, 1979; Rogers, Kuiper & Kirker, 1977),  
19 consistent with a positivity bias in self-evaluation (Greenwald, 1980). In face recognition  
20 tasks, upright and inverted self-faces are identified faster than other-owned faces (Keenan,  
21 McCutcheon, Freund-Gordon, Gallup, Sanders & Pascual-Leone, 1999).

22 Following from our earlier work on ownership (Constable, Kritikos & Bayliss, 2011;  
23 Constable, Kritikos, Lipp & Bayliss, 2014) and in line with the self-positivity bias (Greenwald,  
24 1980) and speeded responses to self-relevant information (Kuiper & Rogers, 1979; Rogers,

1 et al, 1977) we speculated that ownership could be an instantiation of positive or negative  
2 evaluation of items (for example, Morewedge, Shu, Gilbert, & Wilson, 2009). Specifically, a  
3 self-owned item might be processed as more positive than an item owned by someone else.  
4 Moreover, the work of Kahneman and Tversky (1984; Kahneman, Knetsch & Thaler, 1991)  
5 indicates that items are judged to be of greater or lesser financial value, as a function of  
6 ownership status. In related literature from consumer psychology, previously neutral,  
7 unowned items (such as pens and mugs) gifted to participants are thought to become part  
8 of the extended self (Belk, 1998). Thus, it may be that owned items become a part of the  
9 extended self, and evaluated more positively in terms of increased attractiveness (Beggan,  
10 1992) than identical items that are not owned, or owned by other people. In combination  
11 with the positivity bias in self-evaluation (Greenwald, 1980), and engagement in adaptive  
12 self-enhancement strategies (Taylor & Brown, 1988), we speculate that the self could be  
13 viewed as positive. The value or positive association of self-related items is probably distinct  
14 from a financial or monetary-type value, that is, they are intrinsically rewarding (Humphreys  
15 & Sui 2015a).

16 If self-owned items can be viewed as valenced, the principle of approach-avoidance  
17 differences in movement should apply. First, in simple grasp-lift-replace tasks with self-  
18 versus other-owned items (mugs; Constable et al, 2011; Constable et al, 2014; Holubar &  
19 Rice 2011), movement parameters of actions involving self-owned items differ from those  
20 with other-owned items. Constable et al (2011; 2014) gifted a plain white mug to  
21 participants. To promote ownership, participants decorated and then used the mug for 14  
22 days before returning to perform a simple reach-grasp-lift-replace task with their own mug,  
23 the experimenter's mug, or an unowned mug. Constable et al (2011; 2014) reported that  
24 the acceleration of the lifting phase and deceleration of the replacement phase of the self-

1 owned mugs was faster than the experimenter-owned mugs. Relevant to the approach-  
2 avoidance literature above, Constable et al. (2014) found that at the end of the lifting phase  
3 of the movement self-owned mugs were positioned closer to the self, and the  
4 experimenter-owned ones away from the self (Constable et al, 2011 Experiment 1;  
5 Constable et al, 2014). The findings suggest that there are systematic differences in the  
6 kinematic parameters that describe physical interactions with self- versus other-owned  
7 property. In this paradigm, moreover, there was some evidence that responses to other-  
8 owned mugs was suppressed: in a stimulus-response compatibility task (Constable et al,  
9 2011, Experiment 2), self- and experimenter-owned mugs were presented with handles  
10 oriented to the left or right, and participants responded to the colour (green or red)  
11 superimposed on the handle. While the typical stimulus-response compatibility effect was  
12 seen for self-owned mugs, it was suppressed for experimenter-owned mugs, perhaps  
13 indicating that the potential for action towards another's property is abolished.

14 Moreover, recent work by Truong et al (2016) brings together the concepts of  
15 approach-avoidance actions, ownership and embodied cognition. Relevant to the current  
16 study, they followed the Cunningham et al (2008) shopping paradigm, which could be  
17 characterised as having a self-centred frame of reference. Participants categorised novel,  
18 virtual shopping items as self- or experimenter-owned by pushing them away (avoidance) or  
19 pulling them towards themselves (approach; Experiment 3) to far or near locations  
20 respectively. Ownership and movement direction (away, towards) did not influence  
21 initiation (reaction) time for this sorting task. Ownership also did not influence movement  
22 duration (reach time), although movement time was faster for pushing (avoidance) actions,  
23 consistent with biomechanical constraints. Despite this, items allocated to the self that were



1 pulled towards the body (approach) were subsequently recognised better than other-owned  
2 items or items that are pushed away (Truong et al, 2016).

3           Although Truong et al (2016), reported no significant effects in reaction and reach  
4 time as a function of ownership and movement type, we believe that our paradigm  
5 modifications might lead to a detection of effects in movement parameters. Specifically, in  
6 the current experiments, we established a real (rather than virtual) ownership association  
7 and usage with items (mugs). We asked whether response latency and movement duration  
8 to self- versus other-ownership show the same dissociation as positively- and negatively-  
9 evaluated items (Chen & Bargh, 1999). We compared response times and movement  
10 duration in congruent and incongruent movement direction-ownership mappings, relative  
11 to the position of the item. We expected that there should be benefits in terms of speeded  
12 responses for the congruent mapping but a cost in terms of slowed responses for the  
13 incongruent mapping.

14           Previous studies typically have reported one measure of response, evaluation  
15 initiation time (Chen & Bargh, 1999; Lugli, Baroni, Gianelli, Borghi & Nicoletti, 2012).  
16 Conversely, Truong et al (2016) recorded both initiation (reaction) and movement duration  
17 (reach time). These parameters showed a dissociation, such that, while initiation time was  
18 unaffected by ownership and movement direction (towards, away), movement duration  
19 was faster for away (avoidance) movements, averaged over ownership status. In the present  
20 two experiments, we recorded time to lift the hand off the start button (initiation time), as  
21 well as the subsequent time to press the away-from-body or towards-body buttons  
22 (movement duration). In this way, we hoped to gain a further indication of the modulation  
23 of both initiation and movement duration times reflecting planning and execution of  
24 behavioural responses respectively (for example, Pratt & Abrams, 1994). Some work has

1 suggested that in certain tasks such as distractor interference, changes can be restricted to  
2 one measure, for example, initiation time but not duration (Kritikos, Mattingley & Breen,  
3 2004). Other work in distractor interference tasks (Pratt & Abrams, 1994) or in sequential  
4 tapping tasks (Stelmach, Worringham & Strand, 1987), however, does not indicate a clear  
5 dissociation between initiation and duration. It is possible that differences in evaluation  
6 responses are restricted to response planning which, in this task, should be weighted  
7 primarily within the initiation time, rather the movement execution phase (duration)  
8 because participants must select a flexion or extension prior to action onset.

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### Experiment 1

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In Experiment 1, participants made flexion or extension arm movements based on ownership of the mug presented on a monitor. Because they were instructed to process ownership status of the mug, it can be argued that the task has an item-based frame of reference (see Seibt et al, 2008). Therefore, we define approach movements as arm extensions towards the mug on the monitor, while avoidance movements are arm flexions away from the mug.

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Previous studies have reported evaluation latencies, that is, initiation times (Chen & Bargh, 1999; Krieglmeier et al., 2010; Zajonc, 1980). Along with their findings, the planning phase of the movement should be affected because stimulus onset of the self- or experimenter-owned mug would require selection (that is, planning) of a flexion versus extension movement, associated with an approach versus avoidance action. Thus, if response selection adds to the robust effect of privileged processing for self-owned objects, responses should be faster for the congruent compared with the incongruent mapping in

1 initiation time – that is, for approaching the self-owned mug and avoiding the Experimenter-  
2 owned mug compared with the reverse.

3 Predictions regarding expected speeding of responses and congruent-incongruent  
4 mapping for movement duration are not quite so clear, however. Given that movement  
5 planning and on-line adjustments are possible during movement execution, stimulus  
6 evaluation may continue during the execution phase of the approach-avoidance  
7 movements, and thus movement duration (MD) will follow the same cost-benefit pattern  
8 for congruent and incongruent mappings as IT. Conversely, there may be a dissociation  
9 between IT and MD: the approach-avoidance response latencies effects may depend only  
10 on initial, early exposure to and responding to the items, that is, the early phase of the  
11 movement (Pratt & Abrams, 1994), and evaluation may not impact the subsequent  
12 execution phase.

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### Method

15 Participants: To maximise the possibility of obtaining a systematic difference in  
16 performance, we included only female participants because there is evidence that females  
17 are more tuned to social cues such as gaze than males (Bayliss, di Pellegrino, & Tipper, 2005;  
18 see also Sparks, Sidari, Lyons & Kritikos, 2016; Sparks, Douglas & Kritikos, 2016). More  
19 specifically, in recent research investigating the ability to track owned items within reaching  
20 space, Scorolli, Borghi and Tummolini (2018) showed that female participants were more  
21 sensitive to ownership cues than males, particularly if the co-actors were also female. In this  
22 study, both participants and the experimenter were female.

23 Forty-nine Caucasian females (mean age = 18.75 years, SD = 1.50, range 17 – 23 years)  
24 volunteered for course credit and gave their consent to participate in the study, which was

1 cleared by the University of Queensland School of Psychology ethics committee. They were  
2 born in Australia, and English was their first language. They were self-reportedly right-  
3 handed and had normal or corrected-to-normal vision.

4 Apparatus and Stimuli: Participants were initially gifted a mug (height 8cm, rim  
5 diameter 9cm), which had either brown-and-white stripes or white spots on a blue  
6 background. They were instructed to use it, returning 6-11 days later to complete an  
7 experimental task.

8 For the approach-avoidance task (AAT), display of the stimuli and response time (RT  
9 and MD) data collection were programmed in Eprime 2.0 and displayed on a windows 19-  
10 inch (48cm) Acer AC915 colour CRT monitor (resolution 1024 X 768, refresh rate 85Hz.  
11 Participants were seated such that their eyes were 54cm from the monitor and their  
12 midsagittal axis aligned with the centre of the monitor. Responses were made on a modified  
13 QWERTY keyboard. This had all keys removed except for “~”, “0” and “/” on the numeric  
14 keyboard, because the “~” and “/” keys were equidistant (19 cm) from the 0 key. The  
15 keyboard was covered with black cloth with three white foam circles (2.5 cm diameter)  
16 attached over the position of the “~”, “0” and “/” keys, and positioned lengthwise in front of  
17 the monitor such that it was oriented along the participant’s midline axis with the space bar  
18 of the keyboard in the right hemisphere. In this arrangement, the “/” key was 52cm from the  
19 centre of the monitor, the “0” key 46 cm and “~” key 26cm (see figure 1 panel A for a  
20 diagram and panel B for an image of the apparatus). Participants started each trial with the  
21 index finger on the central “0” key, and then moved either towards the monitor or their  
22 body in response to the ownership status of the depicted mug, according to instruction.

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FIGURE 1 HERE

1 An instruction to “Get ready...” (white 18 point Arial font, on a black screen) followed  
2 by a centrally positioned white cross (18 point Arial font, on a black screen), and then a life-  
3 sized mug (height 8cm, rim diameter 9cm) were displayed on centrally on the monitor, on a  
4 black background. The image of the mug was presented such that the handle was central  
5 and aligned with the participant’s midsagittal axis.

6 Procedure: In line with our previous work on embodied ownership involving physical  
7 interaction with self- and other-owned mugs (Constable et al, 2011; 2014), we aimed to  
8 promote ownership through familiarity and usage of the mug. We postulated that the  
9 familiarity and usage would establish sensorimotor as well as semantic links between the  
10 self and the mug, as would happen with items we acquire in daily life. This, in turn, should  
11 increase the likelihood that systematic approach-avoidance effects might be revealed.

12 In the initial session, participants were allocated either the brown-and-white striped  
13 or white-on-blue spotted mug, on an alternating basis, and were told the mug was now  
14 theirs to keep forever. During this session, the Experimenter (TB) displayed the other mug  
15 held in her hand (that is, if the participant was allocated the brown-striped mug, TB  
16 displayed the blue-spotted one, and vice versa) and said that it was hers. To convince them  
17 of her ownership, the Experimenter’s mug was half-filled with water, she drank from it, and  
18 to explain the mug’s presence she said she was also participating in the experiment. When  
19 given their mug, participants were asked to use it for hot or cold drinks at least twice daily,  
20 and to tally as closely as they could the number of times they had used it each day.  
21 Participants were instructed to bring their mug and tally sheet to the second session, and  
22 then allowed to leave. (Note that due to the variability of responses, and frequent lack of  
23 responses, on this tally, this measure was not used in further analyses).

1           They returned for the second, experimental session 6-11 days later ( $M = 7.5$  days,  $SD =$   
2 0.53), and produced their mug and tally sheet. The Experimenter produced “her” mug, to  
3 reinforce experimenter-ownership as well as ensure distinction of ownership status. They  
4 were seated comfortably at the table in front of the monitor, ensuring they could move  
5 their hand and arm up and down the keyboard. They were given verbal as well as written  
6 instructions for task completion. Specifically, they were told that they would see images of  
7 either their own or the Experimenter’s mug. Participants were instructed to hold their right  
8 thumb and index finger together lightly in a ‘pinch’ grip, and that on seeing the words “Get  
9 ready...” on the monitor, they should press down on the middle button with their thumb  
10 and forefinger of the right hand touching together.

11           Participants were instructed to respond with their right hand and arm, starting from  
12 the middle button. Half the participants were instructed to lift the hand, move towards the  
13 monitor and press the button farthest from their body (approach movement) when they  
14 saw their own mug on the monitor, and to move away from the monitor and press the  
15 button closest to their body (avoid movement) when they saw the Experimenter’s mug. This  
16 was the congruent mapping. The other half of the participants were assigned the opposite,  
17 incongruent ownership-movement mapping. Each trial began with the centrally positioned  
18 “Get Ready....” instruction on a black background. This remained on the monitor until  
19 participants moved their hand to the central “0” white button and pressed it. Participants  
20 reached to one of the two button locations, and subsequently returned to the start position  
21 (middle button) when the next “Get ready...” text appeared.

22           An instruction to “Get ready...” (Arial 18 point white font) appeared centrally on the  
23 screen until the participant depressed the middle white button with the index and thumb  
24 held together. At depression of this button, a blank black screen appeared for 1506 msec

1 followed by a centrally positioned fixation cross for 506 msec (Arial 18 point white font),  
2 then by mug stimulus onset. Mug stimulus duration was 411 msec, and at its offset a blank  
3 black screen appeared and remained for 2506 msec (all timings synchronised to the refresh  
4 rate; see Figure 1 panel C).

5 The mug handle was always visible and oriented centrally. Our intention was to avoid  
6 as much as possible a potentiation of attention and action directed towards the right versus  
7 left hemispace, by orienting the handle centrally rather than to the left versus right (e.g.  
8 Tucker & Ellis, 1998). Moreover, participants only used the right hand to respond, so grasp  
9 potentiation was constant across all conditions. We reasoned that if participants used a  
10 pointing movement, the mug handle may have triggered an affordance of narrow (pinch)  
11 grip. We have shown previously that initial hand posture (pinch, spread fingers, flat palm)  
12 does influence temporal kinematics of reach-to-grasp and reach-to-point actions (Kritikos,  
13 Jackson & Jackson, 1998). More relevant to the current paradigm, Freina et al. (2009) had  
14 participants make far or near button-press responses to positive or negative words. When  
15 they used an open hand to respond, latencies were faster to far reaches for positive words  
16 and near reaches for negative words. The pattern was reversed when they reached with a  
17 tennis ball in their hand, with faster latencies to near reaches for positive words and far  
18 reaches for negative ones, possibly associated with bringing in positive features and pushing  
19 away negative ones. To hold these factors constant, we had participants perform the task  
20 using a pinch grip.

21 Participants were also instructed not to lean either elbow on the table while making  
22 the movement. Each mug (self-owned, Experimenter-owned) was presented equally often,  
23 in randomised order. During the AAT, the experimenter was seated unobtrusively behind a

1 partition 1.5m to the left of the participant. The task consisted of 100 trials across 5 blocks  
2 (that is, 20 trials per block), with a brief rest between each block.

3 On completion of the AAT, on a scale of 0 (do not like at all) to 7 (like very much),  
4 participants rated how much they liked their own and the Experimenter's mug.

5 Design: We measured initiation time (IT; time, in milliseconds, from the onset of the  
6 image of the mug to lifting of the finger from the middle start "0" key; please note: IT  
7 recording differed slightly in Experiment 2, where participants responded to a shape  
8 appearing 82 msec after mug image onset on the handle of the mug) and movement  
9 duration (MD; time, in milliseconds, from lifting of the finger from the start "0" key to  
10 depressing one of the two response keys ("~" or "/").

11 We analysed initiation time and movement duration of responses for Congruency and  
12 Ownership Status. Following an item-based frame of reference (Seibt et al., 2008), we  
13 defined congruent mapping as approaching the self-owned mug by moving the hand and  
14 arm towards the mug on the monitor and away from the body, and avoiding the  
15 Experimenter-owned mug by moving the hand and arm toward the body and away from the  
16 monitor when they saw an image of the Experimenter's mug. The difference between these  
17 two initiation times should give an index of the self-bias for congruent mapping. The  
18 incongruent mapping was the reverse: avoiding the self-owned mug by moving the hand  
19 and arm away from the mug on the monitor and towards the body, and approaching the  
20 Experimenter-owned mug by moving the hand and arm away from the body and towards  
21 the mug on the monitor. The difference between these two initiation times should give an  
22 index of the self-bias for incongruent mapping.

23 To simplify conceptualisation, analysis and graphing of the results, we calculated a  
24 'self-bias effect'. For initiation and movement duration times, we subtracted the self-trials



1 from the experimenter trials for congruent and incongruent mapping groups. That is, a  
2 positive value represents an advantage for self-trials, where as a negative value represents  
3 an advantage for experimenter trials. We conducted one-sample t-tests on these values.

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## Results and Discussion

6

Design and data analysis. We conducted one-sample t-tests on these values,  
7 separately for the congruent and incongruent mappings, to determine whether the values  
8 were significantly different from zero and thus indicative of a self-bias. We also conducted  
9 an independent samples t-test, comparing the congruent with the incongruent mapping and  
10 Bayesian analyses of the non-significant comparisons, to determine whether self-bias was  
11 significantly different between the scores of the two mappings.

12

In the Supplementary data, however, we also present a mixed-design analysis of the  
13 data (IT and MD for Experiments 1 and 2), with Ownership (self; experimenter) as the  
14 within-subjects factor and Congruency (reflecting movement direction to mug ownership  
15 status) as the between-subjects factor (approach self-mug / avoid experimenter-mug; avoid  
16 self-mug /approach experimenter-mug).

17

Data Screening. One participant forgot to bring her mug but described it to ensure she  
18 knew which one it was; her data were retained. Prior to analysis, one participant was  
19 excluded because she did not remember that the mug was permanently hers, another  
20 because she did not use her mug, and a final participant because she did not follow  
21 approach-avoidance mapping instructions for the AAT. From the remaining data, individual  
22 trials were excluded if IT was faster than 150 msec or slower than 2000 msec and we  
23 excluded three participants whose response accuracy was less than 80% correct overall.  
24 Thus 43 participants' data were included in the analysis. Of these, 21 had been randomly

1 assigned to the congruent mapping group, and 22 to the incongruent mapping group. At the  
2 end of the experiment, participants indicated that they liked their own mug more than the  
3 Experimenter's ( $M_{\text{Self-owned}} = 5.8$  range 1 -7 and  $M_{\text{Experimenter-owned}} = 4.5$  range 2 – 7  
4 respectively).

#### 5 Initiation Time (IT)

6 A t-test on approach versus avoid actions (that is, extension versus flexion) averaged  
7 over ownership status and congruence mappings across all participants showed that there  
8 was no overall difference in IT for the two types of movements ( $M_{\text{approach}} = 395.279$ ,  $M_{\text{avoid}} =$   
9  $395.911$ ,  $t(42) = .161$ ,  $p = .873$   $SD = 25.671$ ,  $SEM = 3.915$ , lower = -7.2.69 upper = 8.532).  
10 Bayesian analysis of this difference (using SPSS for PC version 25) showed the data were  
11 8.295 times more likely under the null hypothesis than the alternative ( $BF_{10} = .121$ ). Thus  
12 we felt justified in subtracting experimenter from self-own IT for the cost-benefit analyses  
13 and subsequent one-sample t-tests.

14 Based on one-sample t-tests, for the congruent mapping, there was a significant  
15 overall self-bias effect in IT for initiating actions towards the image of the self-owned mug  
16 and away from the body, and correspondingly initiating actions away from the image of the  
17 Experimenter's mug and moving towards the body,  $t(20) = 2.885$ ,  $p = .009$ , mean difference  
18 = 14.438,  $SD = 22.932$ ,  $SEM = 5.004$ , lower range= 4.000 upper range = 24.877 Cohen's  $d =$   
19 0.629 (see figure 2 panel A).

20 Similarly, for the incongruent mapping, there was a significant overall self-bias effect  
21 in IT for initiating actions away from the image of the self-owned mug and moving towards  
22 the body, and correspondingly initiating actions towards the image of the Experimenter's  
23 mug thus moving away from the body,  $t(21) = 2.791$ ,  $p = .011$ , mean = 12.548,  $SD = 24.921$ ,

1 SEM = 5.313, lower range = 3.199 upper range = 21.896 Cohen's  $d$  = 0.609 (see figure 2  
2 panel A).

3 A t-test for congruent vs incongruent mapping was not significant ( $M_{\text{Congruent}} = 14.438$   
4  $M_{\text{Incongruent}} = 12.548$  SEM = 4.495, SEM = 5.004, equal variances not assumed,  $t(41) = .281$ ,  $p$   
5 = .780 lower range = -15.482 upper = 11.701. Bayesian analysis revealed that the data were  
6 4.286 times more likely under the null hypothesis than the alternative ( $BF_{10} = 0.233$ ). This  
7 suggests there is a self-owned bias effect for IT to the self-owned mug, regardless of  
8 whether the action is towards or away from the item.

9 FIGURE 2 HERE

#### 10 Movement Duration (MD)

11 A t-test on approach versus avoid actions (that is, flexion versus extension) averaged  
12 over ownership status and congruence mappings showed that there was no overall  
13 difference in MD for the two types of movements ( $M_{\text{approach}} = 281.440$ ,  $M_{\text{avoid}} = 291.202$ ,  
14  $t(42) = 2.672$ ,  $p = .011$  SD = 23.953, SEM = 3.653, lower range= 2.390 upper range = 17.134).  
15 Bayesian analysis revealed that the data were 2.134 times more likely under the null ( $BF_{10} =$   
16 0.469). In line with the above analysis we subtracted experimenter from own MD for the  
17 cost-benefit analysis and subsequent one-sample t-tests.

18 Based on one-sample t-tests, for the congruent mapping, there was a significant self-  
19 bias effect for MD for executing actions towards the image of the self-owned mug, and  
20 away from the body and correspondingly executing an action away from the image of the  
21 Experimenter's mug and moving towards the body,  $t(20) = 2.774$ ,  $p = .012$ , mean difference  
22 = 13.795, SD = 22.789, SEM = 4.493, lower range= 3.422 upper range = 24.169 Cohen's  $d$  =  
23 .620 (see figure 2 panel B).

1 For the incongruent mapping, there was no significant overall self-bias effect for MD  
2 for executing actions away from the image of the self-owned mug and moving towards the  
3 body, and correspondingly executing actions towards the image of the Experimenter's mug  
4 and moving away from the body,  $t(21) = 1.113$ ,  $p = .278$ , mean difference = 5.912,  $SD =$   
5 24.921,  $SEM = 5.313$ , lower range = -16.961 upper range = 5.134. Bayesian analysis indicated  
6 that the data were 4.461 times more likely under the null hypothesis than the alternative  
7 ( $BF_{10} = 0.224$ ). (see figure 2 panel B).

8 A t-test for congruent vs incongruent mapping was significant ( $M_{\text{Congruent}} = -13.796$   
9  $SEM = 4.973$ ,  $M_{\text{Incongruent}} = 5.912$   $SEM = 5.313$ , equal variances not assumed,  $t(41) = 2.708$ ,  $p$   
10 = .010 lower range = -34.405 upper range = -5.009, Cohen's  $d = .423$  indicating that MD to  
11 the self-owned mug when making an avoid movement benefited performance compared  
12 with making an approach action to the self-owned mug.

13 In summary, there was a self-bias effect for initiating (IT) responses to self-owned  
14 mugs, but this was the case for both congruent and incongruent mappings, that is, for both  
15 approach and avoidance actions. There was also a self-bias effect for executing (MD)  
16 approach movements to self-owned mugs, that is, in the congruent mapping. In other  
17 words, the self-bias effect seems to be in responding to self-owned property in general, for  
18 both congruent and incongruent mappings.

19 This pattern of findings may indicate that responses to ownership for both approach  
20 and avoidance movements are generally speeded. Before we discuss this further, however,  
21 we need to consider the possibility that this lack of dissociation in responses between  
22 congruent and incongruent mappings is due to task requirements. Specifically, in  
23 Experiment 1 ownership was goal-relevant: participants needed to process ownership  
24 consciously to respond with an approach or avoidance movement. Button-press responses

1 to consciously processed self-relevant items are faster than other-relevant items  
2 (Cunningham, Brady-Van den Bos, & Turk, 2011; Sui, Sun, He & Humphreys, 2012; Sui,  
3 Rothstein & Humphreys, 2013). Approach-avoidance directional differences, conversely, are  
4 reported in tasks where affective processing is unconscious (Chen & Bargh, 1999;  
5 Krieglmeier, et al, 2010), and this conscious processing may have masked approach-  
6 avoidance differences. In Experiment 2 we altered task requirements, such that processing  
7 of ownership was implicit (unconscious), by asking participants to respond to a shape  
8 positioned on the mug's handle, rather than to the ownership of the mug

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## Experiment 2

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Rather than responding based on ownership, in this experiment participants viewed their own or the Experimenter's mug very briefly to promote implicit registration of ownership. Then, they made movements in response to a triangle or square that appeared superimposed on the handle of an image of a mug.

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If approach-avoidance systematic differences are automatic and elicited with implicit processing of ownership, then we should see a self-bias effect for responses in the congruent mapping for self-owned mugs (approach towards the self-owned mug on the monitors; avoid away from the experimenter-owned mug on the monitor; Seibt et al, 2008).

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It is possible that this will be the case for both IT and MD. Conversely, we should see a cost for responses in the incongruent mappings (avoid the self-owned mug on the monitor; approach the Experimenter-owned mug on the monitor). This will tell us if, overall, self-related information is privileged in implicit/automatic cognitive processing.

23

24

## Method

1        Participants: Thirty-four Caucasian females (mean age = 19.21 years, SD = 4.36) who  
2 had not completed Experiment 1 volunteered for course credit and gave their consent to  
3 participate in the study, cleared by the University of Queensland School of Psychology ethics  
4 committee. They were born in Australia, and English was their first language. They were  
5 self-reportedly right-handed and had normal or corrected-to-normal vision.

6        Apparatus, Stimuli, Trials and Procedure: These were largely identical to Experiment 1,  
7 except for three differences. The first difference was that the mug appeared briefly (82  
8 msec) before a small shape was superimposed on the handle. The second difference was  
9 that response direction was now mapped to the shape (triangle or square; height 2 cm,  
10 width 2 cm; see Figure 1 panel D) appearing on the handle of the mug. That is, half  
11 participants were instructed to move away from the body and press the button closest to  
12 the monitor if it was a triangle and move towards the body and away from the monitor  
13 when the shape was a square. The other half of the participants were given the opposite  
14 instruction.

15        The third difference was that mug ownership (Self, Experimenter) and movement  
16 direction- cue shape mapping was presented equally often in randomised order within each  
17 block. Thus, participants saw presentations of their mug with a triangle cue, their mug with  
18 square cue, the experimenter's mug with a triangle cue and the experimenter's mug with a  
19 square cue. The instruction to perform flexion or extension hand and arm movements to the  
20 triangle or square was counterbalanced across participants. For analysis, this was a  
21 repeated-measures design, with follow-up t-tests comparisons: we collapsed across shape  
22 categories, but divided compared across mug ownership (Self, Experimenter) and  
23 movement direction (approach, avoid). Thus, although ownership was implicit in this

1 experiment, we derived the same congruent and incongruent mappings and self-bias values  
2 as for Experiment 1.

3 An instruction to “Get ready...” appeared centrally on the screen until the participant  
4 depressed the middle white button (“0”) with the index and thumb held together. At  
5 depression of this button, a blank black screen appeared for 1506 msec, followed by a  
6 centrally positioned fixation cross for 506 msec. At fixation cross offset, the mug appeared,  
7 and 82 msec after mug onset the shape appeared on the handle of the mug for 353 msec, at  
8 which point both mug and shape offset but a blank black screen remained for 2506 msec to  
9 allow sufficient time for participants to respond (all timings synchronised to the refresh rate;  
10 see Figure 1 panel D for sequence of trial events). Note that in this experiment, the image  
11 of the mug was displayed for 82 msec, then the shape appeared on the handle of the mug  
12 to trigger movement response. Initiation time was recorded from the onset of the shape.

13 The task consisted of 100 trials across 5 blocks (that is, 20 trials per block), with a brief  
14 rest between each block. Each mug (Self, Experimenter) was presented equally often, in  
15 randomised order. During the task, the Experimenter was seated unobtrusively behind a  
16 partition 1.5 metres to the left of the participant. In contrast to Experiment 1, IT and MD (in  
17 msec) were taken from onset of the shape on the handle of the mug to lifting of the “0” key  
18 (IT) and depression of “~” or “/” keys (MD).

19 Design: We calculated a self-bias effect for initiation time and movement duration of  
20 responses for Congruency and Ownership Status, as for Experiment 1. To re-cap, we defined  
21 congruent mapping as approaching the self-owned mug on the monitor and moving away  
22 from the body from the starting midpoint, and avoiding the Experimenter-owned mug on  
23 the monitor by moving the hand and arm towards the body and away from the monitor. The  
24 incongruent mapping was the reverse: avoiding the self-owned mug on the monitor by

1 bringing the hand and arm towards the body from that midpoint, while approaching to the  
2 Experimenter-owned mug by moving the hand and arm towards the monitor. We conducted  
3 one-sample and independent samples t-tests on these values, as for Experiment 1. Positive  
4 values indicate a self-bias effect, while negative values indicate a bias away from the Self in  
5 responses. (Note: in the Supplementary data, we present a mixed-design analysis of the  
6 data).

7

## 8 **Results and Discussion**

9 Data Screening. As with experiment 1, individual trials were excluded if initiation time  
10 was faster than 150 msec or slower than 2000 msec, and we excluded data from two  
11 participants whose overall response accuracy was less than 80%. Two participants did not  
12 bring the mugs to the second session, but were able to describe their mug's design, hence  
13 their data were included in the analysis. Thus, the final number of included participants for  
14 this experiment was 32, 16 each for the congruent and incongruent mapping groups.

15 Average daily use of the mug ranged between 2.43 and 5.57 times per day ( $M = 3.66$ ,  
16  $SD = 1.06$ ). At the end of the second session, participants reported that they liked their own  
17 mug more than the Experimenter's ( $M_{\text{Self-owned}} = 5.9$  range 2-7 and  $M_{\text{Experimenter-owned}} = 4.6$   
18 range 4-7 respectively).

### 19 Initiation Time

20 A t-test on approach versus avoid actions (that is, extension versus flexion) averaged  
21 over ownership status showed that there was no overall difference in response time (IT) for  
22 the two types of movements ( $M_{\text{approach}} = 473.665$ ,  $M_{\text{avoid}} = 472.249$   $t(31) = .443$ ,  $p = .661$ ,  $SD$   
23  $= 18.102$ ,  $SEM = 3.199$ , lower range = -7.943 upper range = 5.109). Bayesian analysis  
24 revealed that the data were 6.636 times more likely under the null ( $BF_{10} = 0.150$ ). Thus we



1 felt justified in subtracting experimenter from self-owned IT for the cost-benefit analyses  
2 and subsequent one-sample t-tests (Note that: in this experiment, the image of the mug  
3 was displayed for 82 msec, then the shape appeared on the handle of the mug. Participants  
4 initiated responses on appearance of the shape. Therefore we note that in comparison to  
5 experiment 1 IT appears inflated, because it includes mug display time). Based on one-  
6 sample t-tests, for congruent mapping of movements, there was no overall self-bias effect in  
7 IT for initiating actions towards the image of the self-owned mug and away from the body,  
8 and correspondingly initiating actions away from the image of the Experimenter's mug and  
9 moving towards the body  $t(15) = .133$ ,  $p = .895$ , mean = .597, SD= 25.413, SEM = 4.492,  
10 lower range = -8.566 upper range = 9.759). Bayesian analysis revealed that the data were  
11 7.237 times more likely under the null hypothesis ( $BF_{10} = 0.138$ ). (see figure 3 panel A).

12 Similarly, in incongruent mapping, there was no overall self-bias effect in IT for  
13 initiating actions away from the image of the self-owned mug and moving towards the body,  
14 and correspondingly initiating actions towards the image of the Experimenter's mug thus  
15 moving away from the body,  $t(15) = .796$ ,  $p = .432$ , mean = 3.429, SD =24.377, SEM = 4.309,  
16 lower range= -5.359 upper range = 12.218). Bayesian analysis revealed that the data were  
17 5.375 times more likely under the null ( $BF_{10} = 0.186$ ). (see figure 3 panel A).

18 A t-test for congruent vs incongruent mapping also was not significant ( $M_{\text{Congruent}} = -$   
19 .597 SEM = 4.492,  $M_{\text{Incongruent}} = -3.4295$  SEM = 4.309,  $t(31) = .443$ ,  $p = .661$  lower range = -  
20 15.885 upper range = 10.219. Bayesian analysis indicated that the data were 6.636 times  
21 more likely under the null hypothesis than the alternative ( $BF_{10} = 0.151$ ).

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FIGURE 3 HERE

## 1 Movement Duration

2 A t-test on approach versus avoid actions (that is, flexion versus extension) averaged  
3 over ownership status showed that there was no overall difference in MD for the two types  
4 of movements ( $M_{\text{approach}} = 344.64$ ,  $SD = 80.991$ ,  $M_{\text{avoid}} = 335.464$   $SD = 71.093$ ,  $t(31) = 1.389$ ,  $p$   
5  $= .175$ ,  $SD = 37.454$ ,  $SEM = 6.621$ , lower range = -22.703 upper range = 4.304). Bayesian  
6 analysis showed a Bayes factor of 2.927, indicating inconclusive results but more support for  
7 the null ( $BF_{10} = .342$ ).

8 Based on one-sample t-tests, for congruent mapping of movements, there was no  
9 overall self-bias effect for MD for executing actions towards the image of the self-owned  
10 mug, and away from the body, and correspondingly executing an action away from the  
11 image of the Experimenter's mug and moving towards the body  $t(15) = .894$ ,  $p = .378$ , mean  
12  $= -7.179$ ,  $SD = 45.422$ ,  $SEM = 8.029$ , lower range = -23.555 upper range = 9.198). Bayesian  
13 analysis revealed that the data were 4.967 times more likely under the null ( $BF_{10} = 0.201$ ).  
14 (see figure 3 panel B).

15 Similarly, for incongruent mapping of movements, there was no overall self-bias effect  
16 for MD for executing actions away from the image of the self-owned mug and moving  
17 towards the body, and correspondingly executing actions towards the image of the  
18 Experimenter's mug and moving away from the body  $t(15) = .133$ ,  $p = .164$ , mean = 11.221,  
19  $SD = 44.521$ ,  $SEM = 7.871$ , lower range = -4.831 upper range = 27.273. ). Bayesian analysis  
20 showed a Bayes factor of 2.794 in favour of the null which would be conventionally  
21 considered inconclusive ( $BF_{10} = 0.358$ ). (see figure 3 panel B).

22 A t-test for congruent vs incongruent mapping also was not significant ( $M_{\text{Congruent}} =$   
23  $7.179$   $SEM = 8.029$ ,  $M_{\text{Incongruent}} = -11.221$   $SEM = 7.871$ ,  $t(31) = .443$ ,  $p = .175$  lower range = -

1 45.406 upper range = 8.601. Bayesian analysis indicated that the data were 2.927 times  
2 more likely under the null hypothesis than the alternative ( $BF_{10} = 0.342$ ).

3 The results from Experiment 2 indicate that ownership status (Self, Experimenter) did  
4 not influence congruent or incongruent actions when ownership was not goal-relevant, that  
5 is, was processed implicitly. There was no overall automatic benefit for response times or  
6 movement duration associated with approaching self-owned mugs and avoiding  
7 experimenter-owned ones. Similarly, there was no cost associated with approaching  
8 experimenter-owned mugs and avoiding self-owned ones.

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### General Discussion

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In these experiments, we reasoned that the self-ownership typically results in a positive affective evaluation of the item. In turn, following on from previous Approach-Avoidance Task (AAT) literature, this should result in a systematic self-bias effect in approach (towards the item) movements, compared with avoidance (away from the item) movements, while the opposite should hold for an experimenter-owned item. Participants were gifted mugs which they used for 6 to 11 days. They then returned to the lab and completed an approach-avoidance task, moving their hand and arm towards or away from images of their own or the experimenter's mug. In the congruent mapping in Experiment 1, participants were instructed to move towards (approach) the item if it was their own mug, and move away from (avoid) the item and towards themselves if it was the Experimenter's mug. In the incongruent mapping, another group of participants performed the opposite actions. Thus, processing of the ownership of the item was conscious and goal-relevant, with an item-based frame of reference.

1           There was a self-bias effect for Initiation Time (IT) to the self-owned mug, for both  
2 congruent and incongruent mappings, and for Movement Duration (MD) in the congruent  
3 mapping. That is, initiation and movement duration were speeded to self-owned mugs,  
4 regardless of the approach-avoid direction of the movement. This indicates there was no  
5 systematic difference in movement planning or execution for approach and avoidance  
6 movements based on consciously processed ownership.

7           In Experiment 2, participants responded to a shape appearing on the centrally  
8 positioned handle of the mug. Thus, while congruent and incongruent mappings were the  
9 same as Experiment 1, processing of the ownership of the item was implicit and not goal-  
10 relevant. This time, there was no evidence for a self-bias effect for responses to the Self-  
11 owned mug for either the congruent or incongruent mapping, in either IT or MD.

12           These findings raise three issues. First, responses to self-owned items are indeed  
13 privileged overall compared with responses to other-owned items. This is consistent with  
14 previous investigations of self-reference effects using button-press response tasks rather  
15 than arm flexion- extension (for example, Kuiper & Rogers, 1979; experiment 2). There was  
16 no dissociation between congruent and incongruent mappings, however, and specifically  
17 there was no indication that approach movements to self-owned mugs benefited in  
18 comparison with avoidance movements. Second, there is no firm evidence for a dissociation  
19 between planning and execution (IT vs MD) in responses to self- versus experimenter-  
20 owned mugs. Finally, findings of this task indicate that to influence behaviour ownership  
21 processing needs to be conscious and goal-relevant.

22

23 *Responses to self-owned items show an overall initiation and movement duration self-bias*  
24 *effect, but not specifically for approach movements*

1           In button-press tasks not involving flexion-extension movements, responses to self-  
2           referenced items are reportedly speeded. For example, Cunningham et al (2008; 2011)  
3           showed that accuracy was greater and responses faster for recognising self- compared with  
4           other-owned items. Sui and Humphreys (Humphreys & Sui, 2015a; Sui et al, 2012, 2013)  
5           instructed participants that one of three simple shapes (circle, square, triangle) referred to  
6           themselves, their friend or a stranger. Subsequently, each shape appeared along with the  
7           word “self”, “friend” or “stranger”, and participants indicated via button-press response  
8           whether the shape-name pair was correct or incorrect. Responses were faster when the  
9           pairing contained “self” information (Humphreys & Sui, 2015a). Consistent with the  
10          literature on self-prioritization we show that the processing of self-owned objects is  
11          privileged as indexed by initiation time. It is unclear whether response selection  
12          subsequently enhances this self-prioritization advantage because there was no evidence of  
13          modulation with reference to approach or avoidance trials. We also extend upon the self-  
14          prioritization literature by showing that self-prioritisation also applies to movement  
15          execution which could indicate that ownership influences online motor planning and  
16          execution.

17          Although in Experiment 1 responses to self-owned items were faster than to  
18          experimenter-owned ones, there was no further benefit for approaching the self-owned  
19          item and avoiding the Experimenter-owned item, or the reverse mapping. This is in contrast  
20          to expectations that there should be a benefit for responses in the congruent mapping, that  
21          is, when approach movements were made towards self-owned mugs and avoidance  
22          movements away from the experimenter-owned mugs. If one assumes self is typically  
23          construed as positive then the absence of a congruency effect is inconsistent with reports of  
24          approach-avoidance responses in affective evaluation (good – bad) tasks (Seibt et al, 2008;

1 but also Chen & Bargh, 1999; Eder & Hommel, 2013; Krieglmeyer, et al, 2010). Regarding  
2 ownership specifically, however, Truong et al (2016) also do not report clear ownership X  
3 movement direction interactions for initiation time or movement duration. It may be that  
4 ownership judgments are not comparable to affective evaluation: ownership is a category  
5 judgement (as opposed to a subjective evaluation) and thus clearly defined (either self- or  
6 other-owned) though negotiable. An item belongs to no-one, to the self or to another  
7 person(s), unless ownership is allocated or transferred accordingly. This conceptualisation of  
8 ownership is evident in very early childhood (for example, Gelman, Manczak, & Noles, 2012;  
9 Kanngiesser, Gjersoe, & Hood, 2010). Thus ownership is a concept that is developed even  
10 before language and semantics become highly elaborated (Hay, 2006; Saylor, Ganea &  
11 Vazquez, 2011).

12         Recall that in affective evaluation paradigms (described in greater detail in the  
13 Introduction) participants responded to positive and negative items by making either flexion  
14 or extension movements, away from or towards the self (Chen & Bargh, 1999; Eder &  
15 Hommel, 2013; Koch, Holland, & Knippenberg, 2008; Krieglmeyer, et al, 2010; Lavender &  
16 Hommel, 2007; Seibt et al, 2008; van Dantzig, Pecher, & Zwaan, 2008). Affective evaluation,  
17 however, engages different cognitive processes, and can be superimposed on to ownership.  
18 Indeed, it is a common experience that we own an item we do not like very much, and we  
19 like items that do not belong to us until we purchase or otherwise acquire them – the retail  
20 sector of the economy is based on this. More importantly, previously neutral items *become*  
21 more positive by being allocated to the self, that is, becoming owned even in a virtual  
22 capacity, as indicated by the mere ownership and endowment effects (Kahneman et al.,  
23 1991). Other-owned or unowned items may not necessarily be rated as negative, however;  
24 they are only relatively less positive than the self-owned items. Therefore, the visuomotor

1 system may engage with owned items in a fundamentally different manner to affectively  
2 valenced stimuli because the salient factor is ownership rather than valence.

3 It is possible that hand-based responses to ownership are faster than responses based  
4 on affective evaluations, reducing the likelihood that clear approach-avoidance differences  
5 would emerge. We note that our latencies are comparable to those reported by Truong et al  
6 (2016) for ownership. Conversely, the affective evaluation latencies (comparable to our  
7 initiation time) reported by Chen and Bargh (1999) were in the order of up to approximately  
8 2000 msec in Experiment 1, and about 1200msec in the Rotteveel et al (2015) attempted  
9 replication. RTs were approximately 690 msec in Experiment 2 of Chen and Bargh, and  
10 about 570msec in the Rotteveel et al (2015) attempted replication. Seibt et al (2008;  
11 experiment 3) report latencies of between 720 and 820msec with an item-based frame of  
12 reference. These are all considerably longer than the IT reported here. The initiation time  
13 latencies reported by Markman and Brendl (2005) are also considerably longer than ours.  
14 Conversely, release times for arm flexions and extensions reported by Rotteveel and Phaf  
15 (2004) for evaluation of emotional faces are about 500 msec.

16 One methodological issue is that in this task there were only two items to base this  
17 decision, compared with the multiple words of Chen and Bargh (1999) or virtual shopping  
18 items of Truong et al (2016). In the surprise recall tasks of Cunningham, Turk et al which  
19 involve about 144 previously presented self- or other-owned items, however, median  
20 response times were rather lower than Chen and Bargh, at approximately 1000 msec or less  
21 (Cunningham, Turk, Macdonald & Macrae, 2008). Although it is difficult to draw conclusions  
22 from this essentially different recognition task, it does suggest that including multiple items  
23 may slow responses compared with only two in the current task.

1           As regards the extent to which the self-owned mug was liked, there is some indication  
2 in Constable et al (2014, experiment 3) that preference (that is, liking but not owning) for an  
3 item is associated with subtly different embodied behaviours (motor output) than  
4 ownership. Constable et al (2014) had participants select from an array of six differently-  
5 painted mugs not painted by the participant. They were instructed that they would use this  
6 mug for a short period, while completing the lifting task. The experimenter selected another  
7 mug from the same array. Using this preferred but unowned mug, there was a trend for  
8 participants to position their selected mug closer to themselves at the peak of the lifting  
9 movement, compared with the mug selected by the experimenter. Thus there may well be  
10 an overlap in the way behaviour manifests in terms of preference and ownership. A possible  
11 paradigm for future studies may involve participants bringing in a certain number and type  
12 of already-owned items.

### 13 *Responses to self-owned items impact planning and execution of movements*

14           Previous studies have typically reported on initiation response times (Chen & Bargh,  
15 1999; Koch et al, 2008; Krieglmeyer, et al, 2010; Seibt et al, 2008; but see Truong et al,  
16 2016), corresponding to the planning of the movement (Pratt & Abrams, 1994). Here, we  
17 reported on IT and MD, corresponding to response selection and execution (Pratt & Abrams,  
18 1994). We did not observe a clear dissociation between IT and MD in Experiment 1. There  
19 was an overall self-bias effect in IT (that is, processes up to and including movement  
20 planning) for approach and avoidance responses to self-owned mugs, and a benefit in MD  
21 (movement execution) to self-owned mugs for approach movements. In Experiment 2, there  
22 was no self-bias effect for either IT or MD.



1           Truong et al (2016) also recorded IT and MD (reaction and reach time). The reported  
2 pattern of findings for their two parameters was inconsistent across relevant experiments.  
3 In Experiment 1, IT trended towards being faster, and MD was significantly faster to self-  
4 owned items. In Experiment 3 there was no main effect for ownership or movement  
5 direction in IT, but MD was faster for self- than other-owned items, and faster for away  
6 (avoidance) movements (Truong et al. 2016).

7           Thus at this point, the parsimonious interpretation is that, under the type of  
8 conditions of the current Experiment 1, where ownership is consciously processed and is  
9 goal relevant (see below), both initiation and execution of movement are susceptible to  
10 alteration depending on ownership status.

#### 11    *Conscious, goal-relevant processing of ownership*

12           In previous tasks showing speeded approach (compared with avoid) responses, affect  
13 evaluation (like-dislike, good-bad) is goal-relevant and requires that participants consciously  
14 process the items. Similarly, in Truong et al (2016) and the present Experiment 1, processing  
15 of self- versus experimenter-owned items was also conscious and goal-relevant, showing a  
16 self-bias for self-owned items. In other research reporting an advantage for responses to  
17 self-referenced items, the responses are button-presses, not involving approach-avoidance  
18 (flexion-extension) movements (Cunningham et al, 2008; Sui et al, 2012). In the Cunningham  
19 et al recognition memory tasks, ownership is explicitly processed in the initial basket  
20 allocation part of the paradigm (Cunningham et al, 2008, 2011), although it is not goal-  
21 relevant or explicit in the subsequent memory task. The self-other shape-name pairs of the  
22 Sui and Humphreys paradigm (Humphreys & Sui, 2015a; Sui et al, 2012, 2013) are also

1 explicitly processed, and owned mugs only show a benefit in information processing when  
2 explicitly processed (Constable, Welsh, Huffman & Pratt, 2019).

3       When cognitive evaluation is unconscious and not referenced to self versus other  
4 distinctions, there is evidence that flexion movements are associated with faster responses  
5 to positive items, while extensions are associated with faster responses to negative ones  
6 (Chen & Bargh, 1999, experiment 2), although Rotteveel et al (2015) did not replicate these  
7 findings. Moreover, Rameson, Satpute and Lieberman (2010) showed that similar brain  
8 areas (including ventromedial and medial prefrontal cortex, and amygdala) activate during  
9 both explicit and implicit processing of self-relevant images. Conversely, in the present  
10 Experiment 2, when ownership evaluation was implicit and thus and goal-irrelevant, there  
11 were no evident differences in responses to self- versus experimenter-owned mugs, for  
12 either approach or avoid movements. Likewise, Rotteveel and Phaf (2004, experiment 2)  
13 found that when participants were categorising face stimuli on the basis of gender rather  
14 than emotion, there were no significant differences between flexion and extension response  
15 times. This suggests that arm flexion and extension (corresponding to approach and  
16 avoidance) may not be clearly an automatic, non-conscious response to evaluations of  
17 affect, similar to our conclusions regarding ownership. In the framework of Strack and  
18 colleagues (Körner & Strack, 2018; Strack & Deutsch, 2004) we speculate that the current  
19 findings are consistent with reflective rather than impulsive processes, because they  
20 indicate involvement of conscious processing. What is clear is that instructions and task  
21 requirements may have a major consequence for task performance.

22       In these experiments we attempted to hold constant familiarity and usage of the  
23 items, as well as visual and physical (colour, design) and volumetric (shape, size, weight)

1 features. One line of future work is asking participants to provide images of their own  
2 'loved' mugs or other precious items for use in the experiment. This would mean that  
3 positive evaluation of the mug has become strongly associated with the mug (Greenwald,  
4 Banaji, Rudman, Farnham, Nosek, & Mellott, 2002), and automatic. Under these  
5 circumstances a difference in approach-avoid movements may be detected even when  
6 participants are responding to the shape on the handle rather than to the ownership.

7 Future work could also address the debate about what approach-avoidance  
8 movement differences achieve in terms of the interactions between self and information in  
9 the environment. Neumann and Strack (2000) had participants respond by finger button-  
10 press but not flexion-extension of the arm to positive or negative words on a monitor. The  
11 words were presented within concentric circles that appeared to loom or recede, giving the  
12 sensation of approaching or moving away. Button-press responses were faster to positive  
13 words that appeared to be looming (approaching) and to negative words that appeared to  
14 be receding. This suggests that the systematic differences in response times may not be due  
15 to flexion-extension 'pushing away' and 'bringing towards' of negative and positive  
16 information, but may indicate an adjustment of the distance of valenced information from  
17 the self.

18

19 In summary, we found there is a self-bias effect for response times to self- compared  
20 with other-owned items. There is no specific bias, however, for congruent action mappings  
21 (approaching the self-owned items while avoiding experimenter-owned ones), over  
22 incongruent mappings. We speculate, therefore, that processing ownership status is not  
23 comparable to affective evaluation. Moreover, this pattern was evident only when

1 ownership was consciously processed and goal-relevant, rather than implicit. Finally, under  
2 these task requirements, there was no evident dissociation between initiation and  
3 movement duration times.  
4

1 **Acknowledgements**

2 This work was supported by Australian Research Council Discovery Project grant

3 DP130100253 to Ada Kritikos.

4

1 **Conflict of Interest**

2 The authors declare they have no conflicts of interest.

3

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22  
23 **Figure legends**

1

2 Figure 1: Panel A: Apparatus (keyboard and computer monitor) and distances between  
3 eyes, computer monitor, and keyboard response buttons for Experiments 1 and 2. Panel B:  
4 image of the actual apparatus. Panels C and D: trial event sequences for Experiments 1 and  
5 2 respectively.

6

7

8 Figure 2: Self-bias values (with standard error bars), Experiment 1 (responding to mug  
9 ownership), for Initiation Time (panel A). Values for the self-bias were significantly different  
10 from 0 in both the congruent and incongruent approach-avoidance mappings ( $p = .009$  and  
11  $p = .011$  respectively). For Movement Duration (panel B), values for the self-bias (with  
12 standard error bars) were significantly different from 0 in the congruent mapping ( $p = .012$ ),  
13 but not the incongruent approach-avoidance mapping ( $p = .278$ ).

14

15

16 Figure 3: Self-bias values (with standard error bars), Experiment 2 (responding to a  
17 shape on the mug handle), for Initiation Time (panel A). Values for the Self-bias were not  
18 significantly different from 0 for either the congruent or incongruent approach-avoidance  
19 mappings ( $p = .895$  and  $p = .432$  respectively). For Movement Duration (panel B), values for  
20 the self-bias (with standard error bars) were also not significantly different from 0 for either  
21 the congruent or incongruent approach-avoidance mappings ( $p = .378$  and  $p = .164$   
22 respectively).

23