IN PRESS – JOURNAL OF EXPERIMENTAL PSYCHOLOGY: LEARNING, MEMORY, AND COGNITION

Running Head: Self and Ownership

Exploring the Self-Ownership Effect: Separating Stimulus and Response Biases

Marius Golubickis,[1] Johanna K. Falben,[1] William A. Cunningham,[2] C. Neil Macrae[1]

[1]School of Psychology, University of Aberdeen, Aberdeen, Scotland, UK
[2]Department of Psychology, University of Toronto, Toronto, Canada

Address Correspondence To:

Marius Golubickis
School of Psychology
University of Aberdeen
King's College
Aberdeen AB24 3FX
Scotland, UK

Email: marius.golubickis.10@aberdeen.ac.uk

Abstract

Although ownership is acknowledged to exert a potent influence on various aspects of information processing, the origin of these effects remains largely unknown. Based on the demonstration that self-relevance facilitates perceptual judgments (i.e., the self-prioritization effect), here we explored the possibility that ownership enhances object categorization. The results of two experiments supported this prediction. Compared with items owned by a stranger (Expt. 1) or best friend (Expt. 2), those owned by the self were classified most rapidly (i.e., self-ownership effect) in an object-categorization task. To establish the basis of this effect, the processes underlying task performance were interrogated using a hierarchical drift diffusion model (HDDM) approach. Results of these analyses revealed that self-ownership was underpinned by a response bias (i.e., starting point of evidence accumulation). These findings explicate the origin of the ownership effect during object processing.

Keywords: self, ownership, decision-making, social cognition, drift diffusion model

Exploring the Self-Ownership Effect: Separating Stimulus and Response Biases

Influencing core aspects of social-cognitive functioning, the self is a pivotal psychological construct. It guides cognition and action, shapes interpersonal relations, and provides stability and continuity to the flux of subjective experience (Baars, 1988; Gallagher, 2000; James, 1890; Kihlstrom & Klein, 1994; Neisser, 1988). As William James (1890) adroitly observed, the self lies at the center of mental life. Reflecting its fundamental status, the self is a topic that has fascinated scholars for centuries and continues to stimulate research and theorizing from diverse sections of the scientific community (e.g., Baumeister, 1998; Boyer, Robbins, & Jack, 2005; Conway & Pleydell-Pearce, 2000; Gallagher, 2000; Gillihan & Farah, 2005; Heatherton, 2011; Heatherton, Macrae, & Kelley, 2004; James, 1890; Kilhstrom & Klein, 1994; Klein, Rozendal, & Cosmides, 2002; Markus & Nurius, 1986; Markus & Wurf, 1987). In recent years, this work has focused on two interrelated issues: (i) how the self influences cognition and decision-making; and (ii) identifying the neural correlates of self-referential thought (e.g., Blakemore & Robbins, 2012; Conway, 2005; Conway & Pleydell-Pearce, 2000; Heatherton, 2011; Heatherton et al., 2004; Mezulis, Abramson, Hyde, & Hankin, 2004; Sali, Anderson, & Courtney, 2016; Sheppard, Malone, & Sweeny, 2008; Wagner, Haxby, & Heatherton, 2012). The message that emerges from this body of research is unequivocal — self-relevance exerts a potent influence on stimulus processing (Baumeister, 1998; Conway & Pleydell-Pearce, 2000; Heatherton, 2011; Humphreys & Sui, 2015; Sui & Humphreys, 2015; Truong & Todd, in press). Quite how these effects arise, however, remains a matter of continued empirical scrutiny.

Self-Reference and Memory

Although self-relevance is acknowledged to impact a range of cognitive outcomes (Baumeister, 1998; Heatherton et al., 2011; Mezulis et al., 2004), most work has investigated memory function, specifically how self-referencing (i.e., associating items with the self) influences recognition and recall (Conway, 2005; Conway & Pleydell-Pearce, 2000; Heatherton et al., 2004; Symonds & Johnson, 1997). Inspection of the attendant literature reveals a consistent finding. When recollecting the past, self-referential encoding affords material a reliable memorial benefit, the so-called *self-reference effect* (SRE, see Kelley et al., 2002; Macrae, Moran, Heatherton, Banfield, & Kelley, 2004; Maki & McCaul, 1985; Rogers, Kuiper, & Kirker, 1977; Symonds & Johnson, 1997). For example, following a task in which participants are required to rate the extent to which personality characteristics are descriptive of the self and others (e.g., celebrity, best friend), items (i.e., traits) encoded in the context of the self are typically advantaged in memory (i.e., self > other, see Rogers et al., 1977; Symonds & Johnson, 1997). This SRE has been attributed to the operation of accessible and elaborative self-constructs that serve to enrich stimulus representations, hence memory performance (e.g., Johnson, Hashtroudi, & Lindsay, 1993; Klein & Loftus, 1988; Mather, Shafir, & Johnson, 2003; Symons & Johnson, 1997).

Importantly, the effects of self-referencing extend beyond the instructed evaluation of personality characteristics (cf. Kelley et al., 2002; Rogers et al., 1977). A substantial body of evidence reveals that ownership exerts comparable influence on judgment and memory. Specifically, owned (vs. not owned) objects are treated as psychological extensions of the self (Beggan, 1992; James, 1890), such that their appraisal is distorted by a host of self-serving biases (Belk, 1988, 1991, 2014). For example, exemplified by the 'mere ownership' effect, objects randomly assigned to the self (i.e., owned but not chosen by self) are deemed to be more desirable (Beggan, 1992; Belk, 1988, 1991) and valuable (i.e., endowment effect, Kahneman, Knetsch, & Thaler, 1991; Knetsch & Sinden, 1984; Morewedge & Giblin, 2015) than identical objects with no prior self-association. In addition, consistent with the SRE (Symons & Johnson, 1997), ownership also impacts memory performance. Numerous studies have documented a memorial advantage for items owned by the self (vs. other people), even when the basis of ownership is arbitrary and transient (e.g., Cloutier & Macrae, 2008; Cunningham, Brady-van den Bos, & Turk, 2011; Cunningham, Turk, Macdonald, & Macrae, 2008;

Cunningham, Vergunst, Macrae, & Turk, 2013; Sparks, Cunningham, & Kritikos, 2016; Turk et al., 2013; Turk, van Bussel, Waiter, & Macrae, 2011; van den Bos, Cunningham, Conway, & Turk, 2010).

Self-Relevance and Object Categorization

Whilst significant benefits undoubtedly accrue from the enhanced memorability of items owned by the self (Conway, 2005; Conway & Pleydell-Pearce, 2000), self-referencing likely exerts influence much earlier in the processing stream (Dunning & Balcetis, 2013), thereby setting the stage for subsequent judgmental and memorial biases. Take, for example, object categorization. Interaction with a complex environment necessitates that an important psychological function of the self is to classify objects based on their personal significance (e.g., mine vs. not mine; useful vs. useless; goal-relevant vs. goal-irrelevant, Berlad & Pratt, 1995; Constable, Kritilos, & Bayliss, 2011; Constable, Kritikos, Lipp, & Bayliss, 2014; Fischler, Jin, Boaz, Perry, & Childers, 1987; Folmer & Yingling, 1997; Gray, Ambady, Lowenthal, & Deldin, 2004; Miyakoshi, Nomura, & Ohira, 2007; Müller & Kutas, 1996; Turk et al., 2013). One's possessions are an obvious case in point, as evidenced by the fact that even young children understand the concept of ownership and afford it significant social capital (Fasig, 2000; Furby, 1980; Hay, 2006). When the costs of appropriating other people's belongings (e.g., glass of wine) can be considerable (e.g., an unseemly altercation in the bar), the ability to discriminate items that one owns (even transiently) from items that one does not (i.e., objects owned or assigned to other people) is an invaluable skill (Constable et al., 2011, 2014). As such, one might expect self-relevance (i.e., ownership) to facilitate object categorization.

Recent research by Sui, Humphreys and colleagues corroborates the contention that perceptual processing is sensitive to the self-relevance of stimuli (Humphreys & Sui, 2015; Sui & Humphreys, 2015). In an associational-learning paradigm, Sui, He, and Humphreys (2012) initially required participants to couple arbitrary geometric shapes with person-labels (e.g., circle = you, triangle = best friend, square = stranger). Afterwards, in a perceptual-matching task (i.e., do the shape and label go together?), judgments were fastest (and most accurate) for stimulus pairs associated with the self (vs. friend or stranger), a phenomenon they dubbed the *self-prioritization effect* (Sui et al., 2012; Sui, Liu, Moverach, & Humphrey, 2013). Sui and Humphreys (2015) further proposed that self-relevance triggers prioritized processing by enhancing the perceptual salience of stimuli (see also Humphreys & Sui, 2015). What this work reveals is that self-association is sufficient to facilitate the perceptual processing of otherwise meaningless items, at least under certain conditions (i.e., perceptual matching task).

Notwithstanding numerous demonstrations of the self-prioritization effect (e.g., Sui et al., 2012, 2013), it is somewhat unusual for geometric shapes to serve as a proxy for the self (or indeed any other social target) during everyday social-cognitive functioning. It remains to be seen, therefore, whether self-prioritization extends to objects encountered and associated with the self under more naturalistic processing conditions. Object ownership provides such a context (Cunningham et al., 2008, 2013; Sparks et al., 2016). Interacting with objects (e.g., mugs, pens, forks) — some of which are owned by self, others of which are not — is a ubiquitous facet of daily life. It may be easier therefore for people to categorize objects they either own or have been assigned (even arbitrarily) than identical items that belong (or have been assigned) to someone else (Ashby, Dickert, & Glöckner, 2012; Cunningham et al., 2008). But if this is the case, how exactly does ownership (i.e., self-relevance) facilitate task performance (Humphreys & Sui, 2015; Sui & Humphreys, 2015)? Based on the assumption that perception is cognitively penetrable (e.g., Changizi & Hall, 2001; Clark, 2013; Dunning & Balcetis, 2013; Fecteau & Munoz, 2006; Goldstone, 1995; Lupyan, 2015; Lupyan & Ward, 2013; Shams, Kamitani, & Shimojo, 2002; Watanabe & Shimojo, 2001), Humphreys and Sui (2015) contend that self-relevance impacts the perceptual operations that underpin decision-making (Humphreys & Sui, 2015). In the context of object ownership, this suggests that self-owned (vs. other-owned) items should benefit from enhanced perceptual processing, such as faster information uptake (i.e., evidence gathering) during decisional processing. That is, a bias in stimulus processing underpins the self-ownership effect (White & Poldrack, 2014).

It is entirely conceivable, however, that self-relevance could affect other aspects of decision-making, notably response-related processes that are involved when objects are initially encountered (Ditto & Lopez, 1992; Firestone & Scholl, 2016; Pylyshyn, 1999). For example, response biases may operate via the asymmetric setting of thresholds regarding the quantity of information that is required prior to the elicitation of a judgment, such that less evidence is required for responses to the self (i.e., mine) than other people (i.e., yours). Egocentrism would precipitate such an effect. If people initially assume that everything belongs to them (see Epley, Morewedge, & Keysar, 2004), then a response bias could also drive the enhanced categorization of self-owned (vs. other-owned) objects (Firestone & Scholl, 2016; White & Poldrack, 2014). Of theoretical importance, therefore, is the ability to decompose task performance and isolate the specific cognitive pathway (or pathways) through which ownership influences object categorization. In the context of binary decision tasks (e.g., self vs. other), drift diffusion models provide just such an opportunity (see Ratcliff, 1978; Ratcliff & Rouder, 1998; Ratcliff, Smith, Brown, & McKoon, 2016; Voss, Nagler, & Lerche, 2013; Voss, Rothermund, & Brandtstädter, 2008; Voss, Rothermund, & Voss, 2004; Voss & Voss, 2007; Voss, Voss, & Lerche, 2015; Wagenmakers, 2009).

Decomposing the Self-Ownership Effect

Drift diffusion models decompose behavioral data (i.e., response times & accuracy) into a set of latent parameters that represent the cognitive processes underlying decision-making (Ratcliff, 1978; Ratcliff & Rouder, 1998; Voss et al., 2013, 2015). A variant of continuous sampling approaches, these models assume that information is continuously gathered during a decision phase until sufficient evidence is acquired to initiate a response. A schematic depiction of the model is provided in Figure 1. The model describes evidence accumulation unfolding over time and fits accuracy and response-time distributions. The duration of the diffusion process is known as the decision time and the diffusion process itself can be characterized by several parameters (Voss et al., 2004, 2013, 2015).

Insert Figure 1 About Here

The drift rate (*v*) estimates the speed and quality of information acquisition (i.e., larger drift rate = faster information uptake), thus is interpreted as a measure of stimulus processing during decision-making (White & Poldrack, 2014). Estimates of drift rate are important in the current context given the contention that self-relevance enhances perceptual processing (Humphreys & Sui, 2015; Sui & Humphreys, 2015). What this implies is that, during decision-making, drift rates should be higher for self-owned than not-owned (i.e., owned by other people) objects. Threshold (i.e., boundary) separation (*a*) estimates the distance between the two decision thresholds (i.e., owned-by-self vs. owned-by-other) and defines how much information is considered before a judgment is made. The starting point (*z*) defines the position between the response thresholds (*a*) at which information accumulation begins. If *z* is not centered between the thresholds (i.e., $z = 0.5$), this indicates an a priori bias in favor of the response closer to the starting point (i.e., less information is required to reach the preferred threshold). If a response bias underpins the self-ownership effect (e.g., people are predisposed to respond ‘mine’), *z* should be closer to the response threshold for self than other (White & Poldrack, 2014). Finally, the duration of all non-decisional processes is given by the additional parameter t_0, which is taken to indicate biases in stimulus encoding and response execution (see Voss, Voss, & Klauer, 2010).

In any particular task context (e.g., ownership paradigm), there are two ways in which the decision process can be biased. These pertain to how a stimulus is processed and how a response is generated, with each reflecting a different underlying component of decisional processing (Voss et al., 2004, 2013, 2015; White & Poldrack, 2014). Whereas variation in stimulus processing affects the evidence that is extracted from the item under consideration (i.e., a stimulus bias), adjustments in response preparation influence how much evidence is required before a specific judgment is made (i.e., a response bias). The theoretical value of diffusion modeling resides in its ability to separate these distinct forms of bias (Voss et al., 2004, 2008, 2013, 2015). Accordingly, the current data were submitted to a hierarchical drift diffusion model (HDDM) analysis (Wiecki, Sofer, & Frank, 2013).

Experiment 1

The goal of Experiment 1 was to explore the effects of self-relevance on object categorization — specifically, the emergence of a self-ownership effect during decision-making. In a modified ownership task (Cunningham et al., 2008), participants were presented with items (i.e., pencils or pens) that ostensibly belonged either to the self or a stranger. Their task was simply to classify the objects (i.e., owned-by-self vs. owned-by-stranger) as quickly and accurately as possible. We expected an ownership effect to emerge (Sui et al., 2012, 2013), such that responses would be faster to self-owned than stranger-owned items. To identify the processes underlying the self-ownership effect, data were interrogated using a HDDM analysis (Wiecki et al., 2013). Of theoretical interest was establishing the extent to which the self-ownership effect is based on a stimulus bias (i.e., rate of information uptake, v), a response bias (i.e., starting value, z) or both biases (White & Poldrack, 2014).

Participants and Design

Thirty-four undergraduates (7 male, M_{age} = 20.91, *SD* = 2.02) took part in the research.[1] All participants had normal or corrected-to-normal visual acuity. Four participants (3 female & 1 male) failed to follow the instructions by responding with invalid key presses, thus were excluded from the analyses. Informed consent was obtained from participants prior to the commencement of the experiment and the protocol was reviewed and approved by the Ethics Committee at the School of Psychology, University of Aberdeen. The experiment had a single factor (Ownership: self vs. stranger) repeated measures design.

Stimulus Materials and Procedure

Participants arrived at the laboratory individually, were greeted by an experimenter, seated in front of a desktop computer, and informed that the experiment comprised an object-categorization task featuring two categories of objects, pencils and pens. Next, participants were told that, prior to the commencement of the task, the computer had randomly assigned one category of object to them (i.e., owned-by-self) and the other category of object to a stranger (i.e., owned-by-stranger). That is, participants owned all the items (i.e., pencils or pens) from one of the categories, and a stranger owned all the items from the other category. They then pressed the spacebar on the keyboard and text appeared revealing who had been assigned the pencils and pens, respectively (i.e., you = pen, stranger = pencil). Assignment of the objects to self and stranger was counterbalanced across the sample. The experimenter then explained that, on the computer screen, participants would be presented with a series of pictures of individual pencils and pens and their task was simply to report (via a button press), as quickly and accurately as possible, whether the item belonged to them (i.e., self) or a stranger. Responses were given using two buttons on the keyboard (i.e., N & M). Key-response mappings were

[1] Based on a medium effect size (Cunningham et al., 2008), G*Power (*d* = .50, α = .05, power = 80%) revealed a requirement of 34 participants for each experiment (i.e., Expts. 1 & 2).

counterbalanced across participants and the labels ‘mine’ and ‘stranger’ were located above the relevant response buttons.

Each trial began with the presentation of a central fixation cross for 1000 ms, followed by the picture of a pencil or pen for 100 ms. After each object was presented, the screen turned blank until participants reported the owner of the item (i.e., self or stranger). Following each response, the fixation cross re-appeared and the next trial commenced. The two categories of stimuli comprised photographs of 28 unique objects (14 pencils & 14 pens) that were taken from Google images and edited using Photoshop CS6, such that each pencil or pen was oriented obliquely from the left-bottom to the right-top corner. Images were 140 x 140 pixels in size, greyscale, and matched for luminance. Participants initially performed 18 practice trials, followed by two blocks of 112 trials in which all stimuli occurred equally often (i.e., 4 times per block) in a random order. In total, there were 224 trials, with 112 trials in each condition (i.e., self-owned trials vs. stranger-owned trials). On completion of the task, participants were debriefed, thanked, and dismissed.

Results

Object Categorization

To explore the effects of ownership on object categorization, participants’ mean reaction times were submitted to paired samples *t*-test (one-tailed). This revealed that responses were faster to self-owned (M = 522 ms, SD = 79 ms) than stranger-owned (M = 542 ms, SD = 80 ms) items ($t(29) = 3.17$, $p = .002$, $d = .58$). In addition, a comparable Bayesian analysis was conducted to ascertain the strength of support for the experimental hypothesis (Dienes, 2011). A one-sided test using a Cauchy prior width of 1.0 (see Rouder, Speckman, Sun, Morey, & Iverson, 2009) yielded a Bayes Factor (BF_{10}) of 18.71, indicating strong evidence for the experimental hypothesis (Jeffreys, 1961; Wagenmakers, Wetzels, Borsboom, & van der Maas, 2011). A paired samples *t*-test (one-tailed) revealed no difference in accuracy between self-owned (*M* = .93, *SD* = .09) and other-owned (*M* = .92, *SD* = .08) items ($t(29) = 0.82$, $p = .208$, $BF_{10} = 0.26$).

Diffusion Modeling

To establish the contribution of stimulus (*v*) and response (*z*) biases to the observed self-ownership effect (White & Poldrack, 2014), data were submitted to a HDDM analysis. HDDM is an open-source software package written in Python for the hierarchical Bayesian estimation of drift diffusion model parameters (Wiecki et al., 2013). This approach assumes that the model parameters for individual participants are random samples drawn from group-level distributions and uses Bayesian statistical methods to estimate all parameters at both the group- and individual-participant level (Vandekerckhove, Tuerlinckx, & Lee, 2011). An advantage of this approach is that it is robust at recovering model parameters when less data (i.e., experimental trials) are available (Wiecki et al., 2013). Models were response coded, such that the upper threshold corresponded to a 'mine' response, the lower threshold to a 'stranger' response. Separate drift rates (*v*) were estimated for self and stranger trials (i.e., positive values = drift rate on self-owned trials, negative values = drift rate on stranger-owned trials). A single starting value (*z*) was allowed to vary between the thresholds, such that $z = 0.5$ indicates no bias (i.e., the starting point is located at the midpoint between the thresholds). Separate non-decisional processes (t_0) were estimated for self and stranger trials. Bayesian posterior distributions were modeled using a Markov Chain Monte Carlo (MCMC) with 10,000 bootstraps (following 1,000 burn in samples). Outliers (5% of trials) were removed by the HDDM software (Ratcliff & Tuerlinckx, 2002). In this model, a bias could be mapped on to the drift rate (*v*), indicating a stimulus bias; or the position of the starting point (*z*), indicating a response bias (Voss et al., 2008).

Insert Table 1 About Here

To determine the adequacy of this model, three additional models were tested for comparison. For the first two models, only the drift parameter (*v*) or starting point (*z*) was allowed to vary. For the third model, drift rate (*v*) and starting point (*z*) were allowed to vary. As can be seen in Table 1, the model that included all three parameters yielded the best fit (i.e., lowest DIC value). The DIC was adopted as it is routinely used for hierarchical Bayesian model comparison (Spiegelhalter, Best, Carlin, & van der Linde, 1998). As diffusion models were fit hierarchically rather than individually for each participant, a single value was calculated for each model that reflected the overall fit to the data at the participant- and group-level. Lower DIC values favor models with the highest likelihood and least number of parameters. Interrogation of the posterior distributions revealed evidence of a response bias during object classification (see Figure 2). Specifically, comparison of the observed starting value ($z = .67$) with no bias (i.e., $z = 0.5$) yielded very strong evidence of an a priori response bias to the self ($p_{\text{Bayes}}(\text{bias} > 0.5) < .001$)[2]. To investigate whether evidence accumulation (i.e., *v*) was faster for items owned by the self ($M = 3.71$) than a stranger ($M = -3.53$), the negative drift rates on the latter trials were first multiplied by -1 (see Figure 3). The resultant analysis revealed insufficient evidence for a difference between self-owned and stranger-owned items ($p_{\text{Bayes}}(\text{self} > \text{stranger}) = .230$), which was also the case for non-decisional processes (t_0 - respective *M*s: 250ms vs. 260 ms, $p_{\text{Bayes}}(\text{self} < \text{stranger}) = .159$).

Although the three-parameter model was established as best fitting the data (i.e., lowest DIC values), statistical tests on drift rate (*v*) and non-decision time (t_0) revealed no differences between

[2] Bayesian *p* values quantify the degree to which the difference in the posterior distribution is consistent with the hypothesis that the parameter is greater for self-owned than stranger-owned items. For example, a Bayesian *p* of .15 indicates that 85% of the posterior distribution supports the hypothesis.

self-owned and stranger-owned items. This suggests that separate values for *v* and t_0 are unnecessary and the model that allows only the starting value (*z*) to vary between the response thresholds should yield the best fit. It is worth noting, however, that DIC favors models with greater complexity, hence should be used with caution (Plummer, 2008). As such, to further evaluate the best fitting model, a standard model comparison procedure used in Bayesian parameter estimation — Posterior Predictive Check (PPC) — was performed (e.g., Matzke, Love, Wiecki, Brown, Logan, & Wagenmakers, 2013). For each of the models, the posterior distributions of the estimated parameters were used to simulate data sets, which subsequently were compared to the observed data. The Mean Squared Error (MSE) was calculated to quantitatively evaluate how well each model could reproduce (i.e., fit) the key data patterns (i.e., RT and accuracy for self-owned and stranger-owned trials). Lower average MSE values indicate less deviance between the predicted (i.e., simulated) and actual (i.e., observed) data. As can be seen in Table 1, the model that only allowed starting point (*z*) to vary yielded the lowest MSE.[3] This provides further evidence that the self-ownership effect is underpinned by a response bias.

Insert Figures 2 & 3 About Here

Discussion

Experiment 1 provided evidence that ownership influences the speed of object categorization. Compared with pencils or pens owned by a stranger, identical self-owned items elicited faster

[3] Across ownership conditions, the difference in mean accuracy between the simulated and actual data sets was extremely small (*M* = 0.1%), nevertheless the entire distributions yielded a sizeable misfit (MSE = .21). This suggests that the best fitting model (i.e., *z*) was either over or underestimating aspects of the accuracy distributions, which may derive from the error rates observed across conditions. No such misfit was found on RTs.

classification times. This corroborates the demonstration that self-relevance impacts decision-making (Sui et al., 2012, 2013). In exploring the origin of this ownership effect, the results of a HDDM analysis were informative (Voss et al., 2008; Wiecki et al., 2013). Specifically, ownership mapped on to only the response (i.e., starting value, *z*) parameter of the diffusion model, thereby revealing that participants favored responses to the self (vs. stranger) prior to gathering information during the decision-making process. In other words, the self-ownership effect was underpinned by a response bias (White & Poldrack, 2014).

Experiment 2

Although the results of Experiment 1 are enlightening, a caveat is in order. This pertains to the task conditions under which the benefits of self-referential processing were observed (i.e., self vs. stranger). At least in the memory domain, processing is routinely advantaged when the self is compared with a non-intimate other (e.g., celebrity, politician) or a complete stranger (Kelley et al., 2002; Macrae et al., 2004; Maki & McCaul, 1985; Rogers et al., 1977). In contrast, when the target of comparison is an intimate other (e.g., parent, best friend, spouse) the benefits of self-referencing are sometimes reduced, an effect that has been attributed to the familiarity of the target (Symons & Johnson, 1997). It remains to be seen, therefore, whether the effects observed in Experiment 1 would be sustained under conditions in which the self is contrasted with an intimate other (e.g., best friend). Accordingly, we explored this issue in our next experiment. Again, in an ownership paradigm, participants classified objects that ostensibly belonged either to the self or another person. On this occasion, however, the other person was the participant’s best friend. As before, data were submitted to a HDDM analysis to elucidate the processes underlying decision-making during object categorization (Wiecki et al., 2013).

Participants and Design

Thirty-four undergraduates (5 male, M_{age} = 19.47, SD = 1.26) took part in the research. All participants had normal or corrected-to-normal visual acuity. Two participants (2 females) failed to follow the instructions by responding with invalid key presses, thus were excluded from the analyses. Informed consent was obtained from participants prior to the commencement of the experiment and the protocol was reviewed and approved by the Ethics Committee at the School of Psychology, University of Aberdeen. The experiment had a single factor (Ownership: self vs. friend) repeated measures design.

Stimulus Materials and Procedure

Participants arrived at the laboratory individually, were greeted by an experimenter, seated in front of a desktop computer, and informed that the experiment comprised an object-categorization task featuring pencils and pens. The task closely followed Experiment 1, but with an important modification. Specifically, participants were told that the computer had randomly assigned one of the categories of object to them (i.e., owned-by-self) and the other category of object to their best friend (i.e., owned-by-friend). At this point, each participant was asked to give the name of her or his best friend. They then pressed the spacebar on the keyboard and text appeared revealing who had been assigned the pencils and pens, respectively (i.e., you = pen, best friend = pencil). As in Experiment 1 responses were given using two buttons on the keyboard (i.e., N & M), with the labels ‘mine’ and ‘friend’ located above the relevant buttons. On completion of the task, participants were debriefed, thanked, and dismissed.

Results

Object Categorization

To explore the effects of ownership on object categorization, participants' mean reaction times were submitted to paired samples *t*-test (one-tailed). This revealed that responses were faster to self-owned (M = 566 ms, SD = 95 ms) than friend-owned (M = 593 ms, SD = 110 ms) items ($t(31) = 2.80$, $p = .004$, $d = .49$). In addition, a comparable Bayesian analysis was conducted to ascertain the strength of support for the experimental hypothesis (Dienes, 2011). A one-sided test using a Cauchy prior width of 1.0 (Rouder et al., 2009) yielded a BF_{10} of 8.23, indicating substantial evidence for the experimental hypothesis (Jeffreys, 1961; Wagenmakers et al., 2011). A paired samples *t*-test (one-tailed) revealed no difference in accuracy between self-owned (M = .91, SD = .09) and other-owned (M = .91, SD = .08) items ($t(31) = 0.08$, $p = .534$, $BF_{10} = 0.13$).

Diffusion Modeling

To establish the contribution of stimulus (v) and response (z) biases to the observed self-ownership effect, data were submitted to a HDDM analysis (Wiecki et al., 2013). As in Experiment 1, to determine the adequacy of this model, three additional models were tested for comparison. The model that included all three parameters yielded the best fit (i.e., lowest DIC value, see Table 1). Interrogation of the posterior distributions revealed evidence of a response bias during object categorization (see Figure 4). Specifically, comparison of the observed starting value ($z = .64$) with no bias (i.e., $z = 0.5$) yielded very strong evidence of a pre-potent response bias to the self ($p_{\text{Bayes}}(\text{bias} > 0.5) < .001$). To investigate whether evidence accumulation (i.e., v) was faster for items owned by the self (M = 3.17) than a friend (M = -3.00), the negative drift rates on the latter trials were first multiplied by -1 (see Figure 5). The resultant analysis revealed insufficient evidence for a difference between self-owned and friend-owned items ($p_{\text{Bayes}}(\text{self} > \text{stranger}) = .235$), which was also the case for non-decisional processes (t_0 - respective *M*s: 270 ms vs. 280 ms, ($p_{\text{Bayes}}(\text{self} < \text{stranger}) = .266$).

As in Experiment 1, the three-parameter model was established as best fitting (i.e., lowest DIC values) the data. Again, however, statistical tests on drift rate (*v)* and non-decision time (t_0) revealed no differences as a function of ownership. Accordingly, we conducted posterior predictive checks to further evaluate the best fitting model. As can be seen in Table 1, the model that only allowed starting point (*z*) to vary yielded the lowest MSE.[4] This provides further evidence that the self-ownership effect reflects the operation of a response bias.

Insert Figures 4 & 5 About Here

Discussion

Experiment 2 furnished further evidence that ownership influences object processing. Compared with pencils or pens owned by a friend, identical self-owned items elicited faster classification times, thereby demonstrating a self-prioritization effect on object categorization (Sui et al., 2012, 2013). Replicating Experiment 1, this ownership effect was underpinned by a response bias. Specifically, participants favored responses to the self (vs. friend) prior to gathering information during the decision-making process.

General Discussion

An extensive literature has revealed the effects of self-referential processing on cognition and decision-making (Baumeister, 1998; Blakemore & Robbins, 2012; Conway, 2005; Heatherton, 2011; Mezulis et al., 2004; Sheppard et al., 2008). When memory is the outcome of interest, items paired

[4] As in Experiment 1, the difference between simulated and actual average accuracy was extremely small (*M* = 0.5%), however the entire distributions yielded a sizeable misfit (MSE = .20). No such misfit was found on RTs.

with — or owned by — the self are easier to remember than identical stimuli associated with other people (e.g., Cunningham et al., 2008, 2013; Kelley et al., 2002; Maki & McCaul, 1985; Rogers et al., 1977; Sparks et al., 2016; Turk et al., 2011). Put simply, self-relevance facilitates memory function (Conway, 2005; Conway & Pleydell-Pearce, 2000). Extending this line of inquiry, recent research has revealed a pervasive self-prioritization effect in aspects of perceptual processing (e.g., perceptual matching), such that association with self (vs. friend and stranger) facilitates the processing of otherwise meaningless geometric shapes (Golubickis et al., in press; Humphreys & Sui, 2015; Sui et al., 2012; Sui & Humphreys, 2015; Sui et al., 2013, 2014).

Further developing research of this kind (see also Macrae, Visokomogilski, Golubickis, Cunningham, & Sahraie, 2017; Truong, Roberts, & Todd, 2017), here we demonstrated the effects of ownership on object categorization. Across two experiments, a consistent pattern of results was observed. First, ownership facilitated object classification whether the target of comparison was a stranger (Expt. 1) or best friend (Expt. 2). Second, drift diffusion modeling revealed that this self-ownership effect was underpinned by a response bias (i.e., starting value, *z*) operating prior to the accumulation of evidence during the object-categorization task (Voss et al., 2004, 2013, 2015; Wiecki et al., 2013; White & Poldrack, 2014). In this respect, the current work resonates with recent attempts to elucidate how self-referential processing integrates perception and memory (see Sui & Humphreys, 2015). In particular, how the benefits of self-relevance (i.e., self-enhancement effects) extend to perceptual decision-making. By facilitating the binding of material in perception and memory, self-relevance is believed to bias information processing at various scales of inquiry (Humphreys & Sui, 2015; Truong & Todd, 2017). As Sui and Humphreys contend, “Self-reference provides a form of associative ‘glue’ for perception, memory, and decision making, and through this acts as a central mechanism in information processing (2015, p. 719).

Influences on Ownership

According to a clutch of recent theoretical articles, self-prioritization during stimulus processing is a perceptual phenomenon (Humphreys & Sui, 2015; Sui & Humphreys, 2015). Endorsing the viewpoint that perception can be modified by characteristics of the observer — including desires, values, and goals (e.g., Clark, 2013; Collins & Olson, 2014; Dunning & Balcetis, 2013; Lupyan, 2015; Vetter & Newen, 2014) — self-relevance (e.g., ownership) is believed to exert a comparable influence on stimulus processing. According to Humphreys and Sui (2015), through reciprocal connections between regions of the prefrontal (i.e., vMPFC) and temporal (i.e., posterior STS) cortices, a Self-Attention Network (SAN) serves to enhance the visual salience of self-relevant stimuli (see also Kim & Johnson, 2012, 2015; Turk et al., 2011). In other words, self-relevance modulates perception. Critically, however, not everyone would agree with this conclusion. Instead, a rival viewpoint suggests that self-relevance potentially influences non-perceptual stages of the decision-making process, notably the adoption of different response criteria when judging self-relevant (vs. non-relevant) information (i.e., perception is cognitively impenetrable, see Firestone & Scholl, 2016; Pylyshyn, 1999).

Given these contrasting positions, a primary objective of the current research was to explore the extent to which stimulus (i.e., perceptual) and response (i.e., judgmental) processes contribute to the emergence of the self-ownership effect using a HDDM analysis (Wieki et al., 2013). In this respect the current results were revealing. The self-ownership effects observed in both Experiments 1 and 2 corresponded to a shift in the starting point of evidence accumulation (i.e., z), but no change in the rate at which evidence was extracted from the stimuli (i.e., drift v). That is, ownership moderated information-sampling requirements (i.e., self > other) prior to evidence gathering — a pre-potent response bias (Wiecki et al., 2013).[5] At least in the context of ownership and object categorization

[5] Although it is supposed that z is established prior to information sampling, it should be noted that the drift diffusion model does not make strong temporal claims regarding when in the decisional process threshold setting (including starting point) occurs (Ratcliff et al., 2016).

therefore, the current results fail to support the contention that self-relevance modulates the perceptual component of decisional processing (Humphreys & Sui, 2015; Sui & Humphreys, 2015).

Response biases commonly arise for a couple of reasons: stimulus probability and reward (see White & Poldrack, 2014). Manipulations of response expectancy provide a priori information that one outcome is more likely than another, resulting in a higher starting value for the frequent response. Similarly, shifting stimulus reward also moderates starting values, such that participants are biased toward rewarding (vs. unrewarding) stimuli (Ashby, 1983; Bogacz, Brown, Moehlis, Holmes, & Cohen, 2006; Diederich & Busemeyer, 2006; Simen et al., 2009; van Ravenzwaaij, Mulder, Tuerlinckx, & Wagenmakers, 2012; White, Ratcliff, Vasey, & McKoon, 2010). Interestingly, and of relevance to the current investigation, self-relevance has been shown to trigger reward in a quite different way (Northoff & Hayes, 2011). In a recent article, Krigolson, Hassall, Balcom, and Turk (2013) demonstrated that, in addition to self-relevant stimuli (i.e., items owned by self), self-relevant responses (i.e., trials on which a ‘self’ response is made) are also rewarding. Specifically, in the context of a gambling task in which participants could win or lose prizes for either themselves or someone else, Krigolson et al. (2013) revealed that the medial frontal reward system was only activated during trials (i.e., bets) accompanied by a self-relevant response. This effect, moreover, emerged regardless of the outcome (i.e., win or lose) of each trial. In other words, self-relevant (vs. other-relevant) responses were rewarding.

Reflecting the operation of an egocentric bias, it is possible that participants in the current investigation were similarly predisposed toward the response option that was most rewarding (i.e., mine), hence the higher starting value for responses to the self than either a stranger or best friend. Although egocentrism is most strongly associated with early childhood (Perner, 1991; Wimmer & Perner, 1983), adults continue to think and behave in a self-centric manner. Indeed, one intriguing suggestion is that all that separates children from adults are corrective processes that counteract the effects of egocentrism. That is, it is not that adults are less self-centered than children, it is simply that they are better able to correct their initial egocentric reactions (Epley & Gilovich, 2004; Epley et al., 2004). In early childhood, egocentrism and ownership go hand in hand (Cunningham et al., 2012). From the age of around 18-24 months, children begin to use possessive pronouns (notably, mine), and by 4 years have a well-established understanding of ownership (Hay, 2006). Indeed, disputes over ownership account for a significant proportion of sibling and peer conflicts (Furby, 1980; Ramsey, 1987). In the current work, the drift diffusion analysis provided evidence indicative of adult egocentrism. Specifically, the higher starting value (z) for responses to the self (vs. others) suggests that participants initially assumed all the objects belonged to them, only later adjusting this belief (hence the slowed response times to other-owned items).

Culture and Ownership

Rooted in different patterns of self-construal (i.e., independent vs. interdependent), cultural factors (i.e., individualistic vs. collectivist) have been shown to exert significant influence on the products of self-referential processing, including the ownership effect (Markus & Kitayama, 2010; Sparks et al., 2016). Whereas Western cultures emphasize the extent to which the self differs from others (i.e., independent self-construal), Asian cultures highlight how closely the self is interconnected with other people (i.e., interdependent self-construal), particularly family members (Markus & Kitayama, 1991). A consequence of this interconnectedness is that the SRE in memory is often attenuated, or completely eliminated, among East Asians (Zhu & Zhang, 2002; Zhu, Zhang, Fan, & Han, 2007). Interestingly, the self-ownership effect displays similar cultural variability. In recent work, Sparks et al. (2016) incidentally assigned objects (i.e., articles commonly available in a shopping center) to the self and various others (e.g., best friend, mother) then measured participants' memory for the items. As expected, Westerners showed the typical benefit of self-referencing, such that self-owned (vs. other-owned) items were most memorable (Cunningham et al., 2008; van den Bos et al., 2010), an effect that emerged regardless of the identity of the other targets (i.e., mother, friend, stranger). For

Asian participants, in contrast, the benefits of self-referencing were either eliminated (Expt. 1) or completely reversed (i.e., mother > self, Expt. 2). This then raises an interesting and important question, how exactly does culture influence ownership?

To date, cultural differences in self-referential processing have been traced to the manner in which objects are perceived (Kitayama & Uskul, 2011). Whereas Westerners predominantly process objects in an elemental, piecemeal way, Asians typically adopt a more holistic strategy whereby they exhibit greater sensitivity to the context in which items are embedded (Chua, Boland, & Nisbett, 2005; Kitayama, Duffy, Kawamura, & Larsen, 2003; Masuda & Nisbett, 2001, Miyamoto, Nisbett, & Masuda, 2006). As a result of these differences in perceptual style (i.e., analytic vs. holistic), Asians forge weaker connections between objects and the self, hence the benefits of self-referential processing are weakened or abolished (Gutchess, Welsh, Boduroĝlu, & Park, 2006; Sparks et al., 2016). Of theoretical interest, here we identified a quite different pathway through which culture may potentially impact self-referential cognition — the response-related criteria that Western and Asian participants adopt during decision-making. In particular, by minimizing the psychological distance between the self and intimate others (Heine & Ruby, 2010; Markus & Kitayama, 2010), Asians may adopt different response thresholds during decision-making. Alternatively, if perceptual styles underpin cultural differences in the emergence of the self-ownership effect (Masuda & Nisbett, 2001, Miyamoto et al., 2006), then one would expect the rate of information uptake (i.e., drift rate) to vary between Western and Asian participants. Using drift diffusion modeling to decompose the parameters underlying decision-making (Wiecki et al., 2013), future research should explore this issue.

Conclusion

Although ownership is acknowledged to exert a potent influence on stimulus processing, the origin of this effect remains largely unknown. Based on the demonstration that self-relevance facilitates perceptual decision-making (Humphreys & Sui, 2015; Sui et al., 2012; Sui & Humphreys, 2015), here we showed that ownership enhances object categorization. Compared with items owned by others (e.g., stranger, best friend), those owned by the self were classified most rapidly in an object-categorization task. However, drift diffusion modeling revealed that this self-ownership effect originated in the operation of a response rather than stimulus bias (cf. Humphreys & Sui, 2015) — specifically, a preference to respond mine (vs. stranger or friend) prior to the accumulation of decision-relevant evidence (White & Poldrack, 2014). What remains to be seen, however, is the extent to which these effects extend to self-referential cognition in other task contexts and among different groups of participants.

References

Ashby, F. G. (1983). A biased random walk model for two choice reaction times. *Journal of Mathematical Psychology*, *27*, 277-297.

Ashby, N. J., Dickert, S., & Glöckner, A. (2012). Focusing on what you own: Biased information uptake due to ownership. *Judgment and Decision Making*, *7*, 254.

Baars, B. J. (1988). *A cognitive theory of consciousness*. New York: Cambridge University Press.

Baumeister, R. F. (1998). The self. In D.T. Gilbert, S.T. Fiske, & G. Lindzey (Eds.), *Handbook of social psychology* (4th ed., pp. 680-740). New York: McGraw-Hill.

Beggan, J. K. (1992). On the social nature of nonsocial perception: The mere ownership effect. *Journal of Personality and Social Psychology*, *62*, 229-237.

Belk, R. W. (1988). Possessions and the extended self. *Journal of Consumer Research*, *15*, 139-168.

Belk, R. W. (1991). The ineluctable mysteries of possessions. *Journal of Social Behavior and Personality*, *6*, 17-55.

Belk, R. W. (2014). The extended self unbound. *Journal of Marketing Theory and Practice*, *22*, 133-134.

Berlad, I., & Pratt, H. (1995). P300 in response to the subject's own name. *Electroencephalography and Clinical Neurophysiology*, *96*, 472-474.

Blakemore, S. J., & Robbins, T. W. (2012). Decision-making in the adolescent brain. *Nature Neuroscience*, *15*, 1184-1191.

Bogacz, R., Brown, E., Moehlis, J., Holmes, P., & Cohen, J. D. (2006). The physics of optimal decision making: A formal analysis of models of performance in two-alternative forced-choice tasks. *Psychological Review*, *113*, 700-765.

Boyer, P., Robbins, P., & Jack, A. I. (2005). Varieties of self-systems worth having. *Consciousness and Cognition*, *14*, 647-660.

Changizi, M. A., & Hall, W. G. (2001). Thirst modulates a perception. *Perception*, *30*, 1489-1497.

Chua, H. F., Boland, J. E., & Nisbett, R. E. (2005). Cultural variation in eye movements during scene perception. *Proceedings of the National Academy of Sciences*, *102*, 12629-12633.

Clark, A. (2013). Whatever next? Predictive brains, situated agents, and the future of cognitive science. *Behavioral and Brain Sciences*, *36*, 181-204.

Cloutier, J., & Macrae, C. N. (2008). The feeling of choosing: Self-involvement and the cognitive status of things past. *Consciousness and cognition*, *17*, 125-135.

Collins, J. A., & Olson, I. R. (2014). Knowledge is power: How conceptual knowledge transforms visual cognition. *Psychonomic Bulletin & Review*, *21*, 843-860.

Constable, M. D., Kritikos, A., & Bayliss, A. P. (2011). Grasping the concept of personal property. *Cognition*, *119*, 430-437.

Constable, M. D., Kritikos, A., Lipp, O. V., & Bayliss, A. P. (2014). Object ownership and action: The influence of social context and choice on the physical manipulation of personal property. *Experimental Brain Research*, *232*, 3749-3761.

Conway, M. A. (2005). Memory and the self. *Journal of Memory and Language*, *53*, 594-628.

Conway, M. A., & Pleydell-Pearce, C. W. (2000). The construction of autobiographical memories in the self-memory system. *Psychological Review*, *107*, 261-288.

Cunningham, S. J., Brady-van den Bos, M., & Turk, D. J. (2011). Exploring the effects of ownership and choice on self-memory biases. *Memory*, *19*, 449-461.

Cunningham, S. J., Turk, D. J., Macdonald, L. M., & Macrae, C. N. (2008). Yours or mine? Ownership and memory. *Consciousness and Cognition*, *17*, 312-318.

Cunningham, S. J., Vergunst, F., Macrae, C. N., & Turk, D. J. (2013). Exploring early self-referential memory effects through ownership. *British Journal of Developmental Psychology*, *31*, 289-301.

Diederich, A., & Busemeyer, J. R. (2006). Modeling the effects of payoff on response bias in a perceptual discrimination task: Bound-change, drift-rate-change, or two-stage-processing hypothesis. *Perception & Psychophysics*, *68*, 194-207.

Dienes, Z. (2011). Bayesian versus orthodox statistics: Which side are you on? *Perspectives on Psychological Science*, *6*, 274-290.

Ditto, P. H., & Lopez, D. F. (1992). Motivated skepticism: Use of differential decision criteria for preferred and nonpreferred conclusions. *Journal of Personality and Social Psychology*, *63*, 568-584.

Dunning, D., & Balcetis, E. (2013). Wishful seeing: How preferences shape visual perception. *Current Directions in Psychological Science*, *22*, 33-37.

Dunovan, K. E., Tremel, J. J., & Wheeler, M. E. (2014). Prior probability and feature predictability interactively bias perceptual decisions. *Neuropsychologia*, *61*, 210-221.

Epley, N., & Gilovich, T. (2004). Are adjustments insufficient? *Personality and Social Psychology Bulletin*, *30*, 447-460.

Epley, N., Morewedge, C., & Keysar, B. (2004). Perspective taking in children and adults: Equivalent egocentrism but different correction. *Journal of Experimental Social Psychology*, *40*, 760-768.

Fasig, L. G., (2000). Toddlers' understanding of ownership: Implications for self-concept development. *Social Development*, *9*, 370-382.

Fecteau, J. H., & Munoz, D. P. (2006). Salience, relevance, and firing: A priority map for target selection. *Trends in Cognitive Sciences*, *10*, 382-390.

Firestone, C., & Scholl, B. J. (2016). Cognition does not affect perception: Evaluating the evidence for 'top-down' effects. *Behavioral and Brain Sciences*, *39*, 1-77.

Fischler, I., Jin, Y. S., Boaz, T. L., Perry, N. W., & Childers, D. G. (1987). Brain potentials related to seeing one's own name. *Brain and Language*, *30*, 245-262.

Folmer, R. L., & Yingling, C. D. (1997). Auditory P3 responses to name stimuli. *Brain and Language*, *56*, 306-311.

Furby, L. (1980). The origins and early development of possessive behavior. *Political Psychology*, *2*, 30-42.

Gallagher, S. (2000). Philosophical conceptions of the self: Implications for cognitive science. *Trends in Cognitive Sciences*, *4*, 14-21.

Gillihan, S. J., & Farah, M. J. (2005). Is self special? A critical review of evidence from experimental psychology and cognitive neuroscience. *Psychological Bulletin*, *131*, 76.

Goldstone, R. L. (1995). Effects of categorization on color perception. *Psychological Science*, 298-304.

Golubickis, M., Falben, J. K., Sahraie, A., Visokomogilski, A., Cunningham, W. A., & Sui, J., & Macrae, C. N. (in press). Self=prioritization and perceptual matching: The effects of temporal construal. *Memory & Cognition*.

Gray, H. M., Ambady, N., Lowenthal, W. T., & Deldin, P. (2004). P300 as an index of attention to self-relevant stimuli. *Journal of Experimental Social Psychology*, *40*, 216-224.

Gutchess, A. H., Welsh, R. C., Boduroĝlu, A., & Park, D. C. (2006). Cultural differences in neural function associated with object processing. *Cognitive, Affective, & Behavioral Neuroscience*, *6*, 102-109.

Hay, D. F. (2006). Yours and mine: Toddlers’ talk about possessions with familiar peers. *British Journal of Developmental Psychology*, *24*, 39-52.

Heatherton, T. F. (2011). Neuroscience of self and self-regulation. *Annual Review of Psychology*, *62*, 363-390.

Heatherton, T. F., Macrae, C. N., & Kelley, W. M. (2004). A social brain sciences approach to studying the self. *Current Directions in Psychological Science*, *13*, 190-193.

Heine, S. J., & Ruby, M. B. (2010). Cultural psychology. *Wiley Interdisciplinary Reviews: Cognitive Science*, *1*, 254-266.

Humphreys, G.W., & Sui, J. (2015). Attentional control and the self: The self-attention network (SAN). *Cognitive Neuroscience*, *7*, 5-17.

James, W. (1890). *The principles of psychology*. New York: Henry-Holt & Co.

Jeffreys, H. (1961). *Theory of probability*. Oxford: Clarendon Press.

Johnson, M. K., Hashtroudi, S., & Lindsay, D. S. (1993). Source monitoring. *Psychological Bulletin*, *114*, 3-28.

Kahneman, D., Knetsch, J. L., & Thaler, R. H. (1991). Anomalies: The endowment effect, loss aversion, and status quo bias. *The Journal of Economic Perspectives*, *5*, 193-206.

Kass, R. E., & Raftery, A. E. (1995). Bayes factors. *Journal of the American Statistical Association*, *90*, 773-795.

Kelley, W. M., Macrae, C. N., Wyland, C. L., Caglar, S., Inati, S., & Heatherton, T. F. (2002). Finding the self? An event-related fMRI study. *Journal of Cognitive Neuroscience*, *14*, 785-794.

Kihlstrom, J. F., & Klein, S. B. (1994). The self as a knowledge structure. In R.S Wyer & T.K. Srull (Eds.), *Handbook of social cognition* (2nd ed., Vol. 2, pp. 153-208). Mahwah, NJ: Erlbaum.

Kim, K., & Johnson, M. K. (2012). Extended self: Medial prefrontal activity during transient association of self and objects. *Social Cognitive and Affective Neuroscience, 7*, 199-207.

Kim, K., & Johnson, M. K. (2015). Distinct neural networks support the mere ownership effect under different motivational contexts. *Social Neuroscience*, *10*, 376-390.

Kitayama, S., & Uskul, A. K. (2011). Culture, mind, and the brain: Current evidence and future directions. *Annual Review of Psychology*, *62*, 419-449.

Kitayama, S., Duffy, S., Kawamura, T., & Larsen, J. T. (2003). Perceiving an object and its context in different cultures: A cultural look at new look. *Psychological Science*, *14*, 201-206.

Klein, S. B., & Loftus, J. (1988). The nature of self-referent encoding: The contributions of elaborative and organizational processes. *Journal of Personality and Social Psychology*, *55*, 5-11.

Klein, S. B., Rozendal, K., & Cosmides, L. (2002). A social-cognitive neuroscience analysis of the self. *Social Cognition*, *20*, 105-135.

Knetsch, J. L., & Sinden, J. A. (1984). Willingness to pay and compensation demanded: Experimental evidence of an unexpected disparity in measures of value. *The Quarterly Journal of Economics*, *99*, 507-521.

Krigolson, O. E., Hassall, C. D., Balcom, L., & Turk, D. (2013). Perceived ownership impacts reward evaluation within medial-frontal cortex. *Cognitive, Affective, & Behavioral Neuroscience*, *13*, 262-269.

Lupyan, G. (2015). Cognitive penetrability of perception in the age of prediction: Predictive systems are penetrable systems. *Review of Philosophy and Psychology*, *6*, 547-569.

Lupyan, G., & Ward, E. J. (2013). Language can boost otherwise unseen objects into visual awareness. *Proceedings of the National Academy of Sciences*, *110*, 14196-14201.

Macrae, C. N., Visokomogilski, A., Golubickis, M., Cunningham, W. A., & Sahraie, A. (2017). Self-relevance prioritizes access to visual awareness. *Journal of Experimental Psychology: Human Perception and Performance*, *43*, 438-443.

Macrae, C. N., Moran, J. M., Heatherton, T. F., Banfield, J. F., & Kelley, W. M. (2004). Medial prefrontal activity predicts memory for self. *Cerebral Cortex*, *14*, 647-654.

Maki, R. H., & McCaul, K. D. (1985). The effects of self-reference versus other-reference on the recall of traits and nouns. *Bulletin of the Psychonomic Society*, *23*, 169-172.

Markus, H. R., & Kitayama, S. (1991). Culture and the self: Implications for cognition, emotion, and motivation. *Psychological Review*, *98*, 224.

Markus, H. R., & Kitayama, S. (2010). Cultures and selves: A cycle of mutual constitution. *Perspectives on Psychological Science*, *5*, 420-430.

Markus, H., & Wurf, E. (1987). The dynamic self-concept: A social psychological perspective. *Annual Review of Psychology*, *38*, 299-337.

Markus, H. R., & Nurius, P. (1986). Possible selves. *American Psychologist*, *41*, 954-969.

Matzke, D., Love, J., Wiecki, T. V., Brown, S. D., Logan, G. D., & Wagenmakers, E. J. (2013). Release the BEESTS: Bayesian estimation of ex-Gaussian stop-signal reaction time distributions. *Frontiers in Psychology*, *4*: 918. doi: 10.3389/fpsyg.2013.00918.

Masuda, T., & Nisbett, R. E. (2001). Attending holistically versus analytically: Comparing the context sensitivity of Japanese and Americans. *Journal of Personality and Social Psychology*, *81*, 922-934.

Mather, M., Shafir, E., & Johnson, M. K. (2003). Remembering chosen and assigned options. *Memory & Cognition, 31*, 422-433.

Mezulis, A. H., Abramson, L. Y., Hyde, J. S., & Hankin, B. L. (2004). Is there a universal positivity bias in attributions? A meta-analytic review of individual, developmental, and cultural differences in the self-serving attributional bias. *Psychological Bulletin*, *130*, 711-747.

Miyakoshi, M., Nomura, M., & Ohira, H. (2007). An ERP study on self-relevant object recognition. *Brain and Cognition*, *63*, 182-189.

Miyamoto, Y., Nisbett, R. E., & Masuda, T. (2006). Culture and the physical environment: Holistic versus analytic perceptual affordances. *Psychological Science*, *17*, 113-119.

Morewedge, C. K., & Giblin, C. E. (2015). Explanations of the endowment effect: An integrative review. *Trends in Cognitive Sciences*, *19*, 339-348.

Müller, H. M., & Kutas, M. (1996). What's in a name? Electrophysiological differences between spoken nouns, proper names and one's own name. *NeuroReport*, *8*, 221-225.

Neisser, U. (1988). Five kinds of self-knowledge. *Philosophical Psychology*, *1*, 5-59.

Northoff, G., & Hayes, D. J. (2011). Is our self nothing but reward? *Biological Psychiatry*, *69*, 1019-1025.

Perner, J. (1991). *Understanding the representational mind*. Cambridge, MA: Bradford Books/MIT Press.

Plummer, M. (2008). Penalized loss functions for Bayesian model comparison. *Biostatistics*, *9*, 523-539.

Pylyshyn, Z. (1999). Is vision continuous with cognition? The case for cognitive impenetrability of visual perception. *Behavioral and Brain Sciences*, *22*, 341-365.

Ramsey, P. G. (1987). Possession episodes in young children's social interactions. *Journal of Genetic Psychology*, 148, 315-324.

Ratcliff, R. (1978). A theory of memory retrieval. *Psychological Review, 85*, 59-108.

Ratcliff, R., & Rouder, J. N. (1998). Modeling response times for two-choice decisions. *Psychological Science*, *9*, 347-356.

Ratcliff, R., & Tuerlinckx, F. (2002). Estimating parameters of the diffusion model: Approaches to Dealing with contaminant reaction times and parameter variability. *Psychonomic Bulletin & Review*, *9*, 438-481

Ratcliff, R., Smith, P. L., Brown, S. D., & McKoon, G. (2016). Diffusion decision model: current issues and history. *Trends in cognitive sciences*, *20*, 260-281.

Rogers, T. B., Kuiper, N. A., & Kirker, W. S. (1977). Self-reference and the encoding of personal information. *Journal of Personality and Social Psychology*, *35*, 677-688.

Rouder, J. N., Speckman, P. L., Sun, D., Morey, R. D., & Iverson, G. (2009). Bayesian t-tests for accepting and rejecting the null hypothesis. *Psychonomic Bulletin & Review*, *16*, 225-237.

Shams, L., Kamitani, Y., & Shimojo, S. (2002). Visual illusion induced by sound. *Cognitive Brain Research*, *14*, 147-152.

Sheppard, J., Malone, W., & Sweeny, K. (2008). Exploring causes of the self-serving bias. *Social & Personality Compass*, *2*, 895–908.

Simen, P., Contreras, D., Buck, C., Hu, P., Holmes, P., & Cohen, J. D. (2009). Reward rate optimization in two-alternative decision making: empirical tests of theoretical predictions. *Journal of Experimental Psychology: Human Perception and Performance*, *35*, 1865-1897

Sparks, S., Cunningham, S. J., & Kritikos, A. (2016). Culture modulates implicit ownership-induced self-bias in memory. *Cognition*, *153*, 89-98.

Sui, J., & Humphreys, G. W. (2015). The integrative self: How self-reference integrates perception and memory. *Trends in Cognitive Sciences*, *19*, 719-728.

Sui, J., He, X., & Humphreys, G. . (2012). Perceptual effects of social salience: Evidence from self-prioritization effects on perceptual matching. *Journal of Experimental Psychology: Human Perception and Performance*, *38*, 1105-1117.

Sui, J., Liu, M., & Mevorach, C., & Humphreys, G. W. (2013). The salient self: The left intra-parietal sulcus responds to social as well as perceptual salience after self-association. *Cerebral Cortex*, *4*, 1060-1068.

Symons, C. S., & Johnson, B. T. (1997). The self-reference effect in memory: A meta-analysis. *Psychological Bulletin*, *121*, 371-394.

Truong, G., & Todd, R. M. (in press). SOAP Opera: Self as Object and Agent in Prioritizing Attention. *Journal of Cognitive Neuroscience*.

Truong, G., Roberts, K. H., & Todd, R. M. (2017). I saw mine first: A prior-entry effect for newly acquired ownership. *Journal of Experimental Psychology: Human Perception and Performance*, *43*, 192-205.

Turk, D. J., Brady-van den Bos, M., Collard, P., Gillespie-Smith, K., Conway, M. A., & Cunningham, S. J. (2013). Divided attention selectively impairs memory for self-relevant information. *Memory & Cognition*, *41*, 503-510.

Turk, D. J., Van Bussel, K., Waiter, G. D., & Macrae, C. N. (2011). Mine and me: Exploring the neural basis of object ownership. *Journal of Cognitive Neuroscience*, *23*, 3657-3668.

van den Bos, M., Cunningham, S. J., Conway, M. A., & Turk, D. J. (2010). Mine to remember: The impact of ownership on recollective experience. *The Quarterly Journal of Experimental Psychology*, *63*, 1065-1071.

van Ravenzwaaij, D., Mulder, M. J., Tuerlinckx, F., & Wagenmakers12, E. J. (2012). Do the dynamics of prior information depend on task context? An analysis of optimal performance and an empirical test. *Frontiers in Psychology*, 3:132. doi: 10.3389/fpsyg.2012.00132.

Vandekerckhove, J., Tuerlinckx, F., & Lee, M. D. (2011). Hierarchical diffusion models for two-choice response times. *Psychological Methods*, *16*, 44-62.

Vetter, P., & Newen, A. (2014). Varieties of cognitive penetration in visual perception. *Consciousness and Cognition*, *27*, 62-75.

Voss, A., & Voss, J. (2007). Fast-dm: A free program for efficient diffusion model analysis. *Behavior Research Methods*, *39*, 767-775.

Voss, A., Nagler, M., & Lerche, V. (2013). Diffusion models in experimental psychology. *Experimental Psychology*, *60*, 385-402.

Voss, A., Rothermund, K., & Brandtstädter, J. (2008). Interpreting ambiguous stimuli: Separating perceptual and judgmental biases. *Journal of Experimental Social Psychology*, *44*, 1048-1056.

Voss, A., Rothermund, K., & Voss, J. (2004). Interpreting the parameters of the diffusion model. *Memory & Cognition*, *32*, 1206-1220.

Voss, A., Voss, J., & Klauer, K. C. (2010). Separating response-execution bias from decision bias: Arguments for an additional parameter in Radcliff's diffusion model. *British Journal of Mathematical and Statistical Psychology*, *63*, 539-555.

Voss, A., Voss, J., & Lerche, V. (2015). Assessing cognitive processes with diffusion model analyses: A tutorial based on fast-dm-30. *Frontiers in Psychology*, 6:336. doi:10.3389/fpsyg.2015.00336.

Wagenmakers, E. J., Wetzels, R., Borsboom, D., & van der Maas, H. L. (2011). Why psychologists must change the way they analyze their data: the case of psi: comment on Bem (2011). *Journal of Personality and Social Psychology*, *100*, 426-432.

Wagenmakers, E. J. (2009). Methodological and empirical developments for the Ratcliff diffusion model of response times and accuracy. *European Journal of Cognitive Psychology*, *21*, 641-671.

Wagner, D. D., Haxby, J. V., & Heatherton, T. F. (2012). The representation of self and person knowledge in the medial prefrontal cortex. *Wiley Interdisciplinary Reviews: Cognitive Science*, *3*, 451-470.

Watanabe, K., & Shimojo, S. (2001). When sound affects vision: Effects of auditory grouping on visual motion perception. *Psychological Science*, *12*, 109-116.

White, C. N., & Poldrack, R. A. (2014). Decomposing bias in different types of simple decisions. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *40*, 385.

White, C. N., Ratcliff, R., Vasey, M. W., & McKoon, G. (2010). Using diffusion models to understand clinical disorders. *Journal of Mathematical Psychology*, *54*, 39-52.

Wieki, T. V., Sofer, I., & Frank, M. J. (2013). HDDM: Hierarchical Bayesian estimation of the drift-diffusion model in python. *Frontiers in Neuroinformatics*, *7*:14. doi: 10.3389/fninf.2013.00014.

Wimmer, H., & Perner, J. (1983). Beliefs about beliefs: Representation and constraining function of wrong beliefs in young children's understanding of deception. *Cognition*, *13*, 103-128.

Zhu, Y., & Zhang, L. (2002). An experimental study on the self-reference effect. *Science in China Series C: Life Sciences*, *45*, 120-128.

Zhu, Y., Zhang, L., Fan, J., & Han, S. (2007). Neural basis of cultural influence on self-representation. *Neuroimage*, *34*, 1310-1316.

Table 1. Deviance Information Criterion (DIC) and Mean Squared Error (MSE) Values for Each Model (Experiments 1 & 2).

			DIC		MSE	
Model	Vary between stimuli	Fixed	Expt.1	Expt. 2	Expt.1	Expt. 2
1	v	t_0, z	-5769	-3320	.025	.032
2	z	t_0, v	-6275	-3711	.024	.030
3	v, z	t_0	-6247	-3816	.029	.036
4	v, z, t_0	-	-6320	-3935	.030	.036

Note. v = drift rate, z = starting point, t_0 = non-decision processes. Fixed z indicates centred starting value between the thresholds (z = .5). A DIC difference of 2 is positive evidence for a model, greater than 10 is strong evidence for a model (Kass & Raftery, 1995). Lower MSE values are indicative of better model fit.

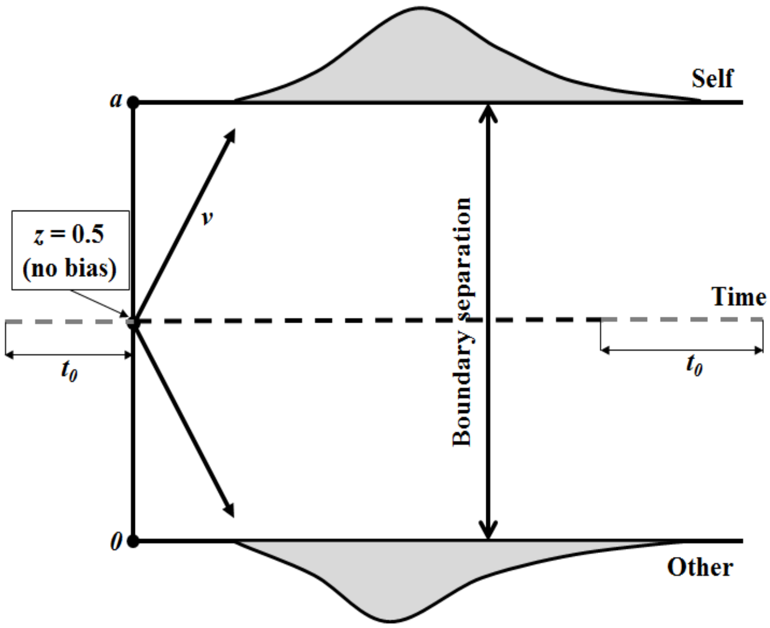

Figure 1. Schematic version of the diffusion model adapted from Voss et al. (2013, p. 4). An information gathering process begins at starting point *z* and continues with a mean slope *v* until it reaches an upper (*a*) or lower (*0*) threshold. Non-decision processes (t_0) reflect how much time elapses before/after the decision process. The process durations and outcomes vary from trial to trial because of random noise. Outside the threshold boundaries the response distributions are shown.

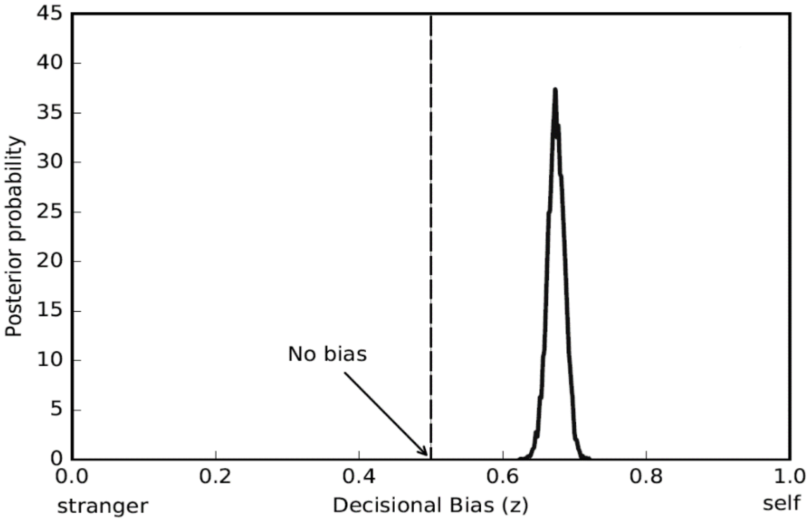

Figure 2. Mean posterior distribution of starting point (*z*) - Expt. 1.

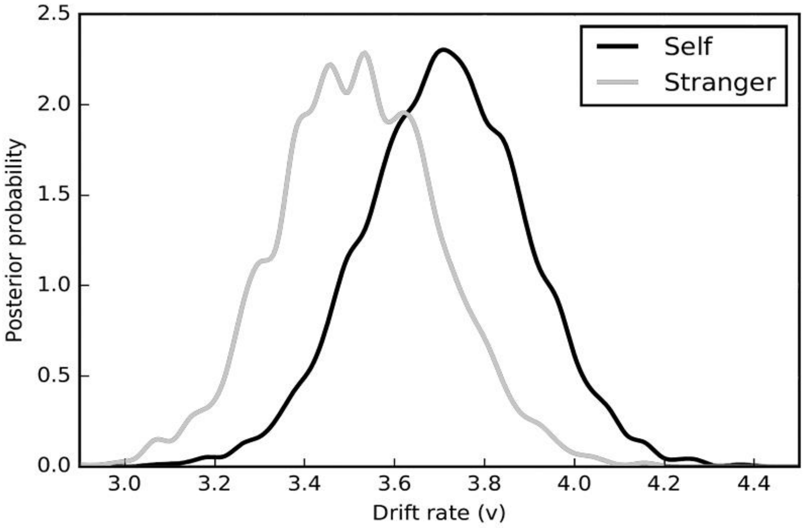

Figure 3. Mean posterior distributions of drift rate (*v*) on self and stranger trials (Expt. 1). Drift rates for stranger have been multiplied by -1.

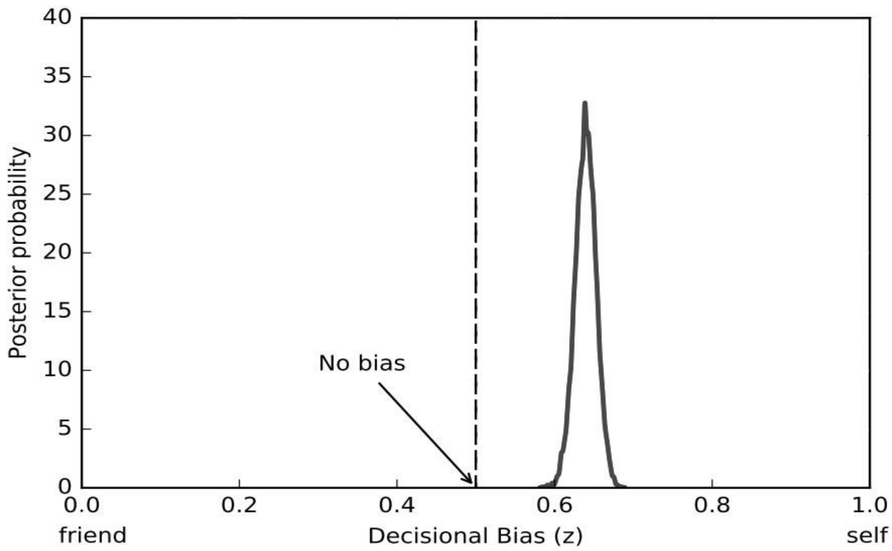

Figure 4. Mean posterior distribution of starting point (*z*) - Expt. 2.

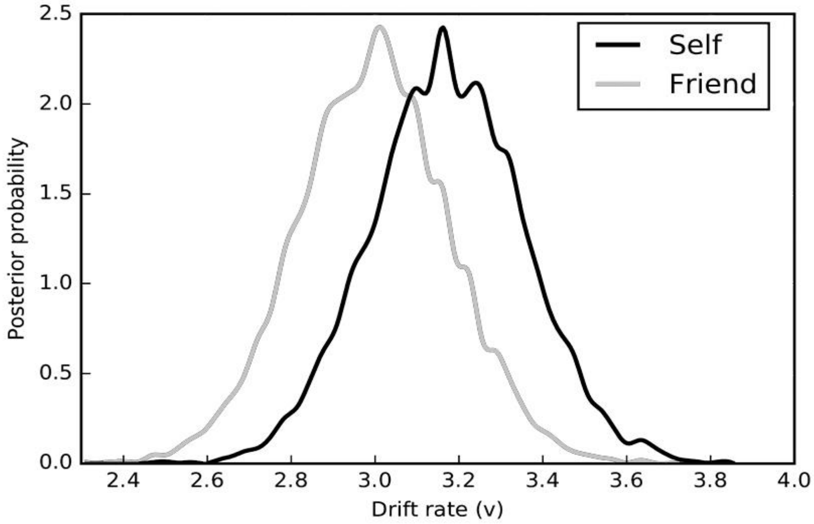

Figure 5. Mean posterior distributions of drift rate (*v*) on self and friend trials (Expt. 2). Drift rates for friend have been multiplied by -1.