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An unforgettable apple: Memory and attention for forbidden objects

Grace Truong · David J. Turk · Todd C. Handy

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Abstract Are we humans drawn to the forbidden? From jumbo-sized soft drinks to illicit substances, the influence of prohibited ownership on subsequent demand has made this question a pressing one. We know that objects that we ourselves own have a heightened psychological saliency, relative to comparable objects that are owned by others, but do these kinds of effects extend from self-owned to "forbidden" objects? To address this question, we developed a modified version of the Turk shopping paradigm in which "purchased" items were assigned to various recipients. Participants sorted everyday objects labeled as "self-owned", "other-owned," and either "forbidden to oneself" (Experiment 1) or "forbidden to everyone" (Experiment 2). Subsequent surprise recognition memory tests revealed that forbidden objects with high (Experiment 1) but not with low (Experiment 2) self-relevance were recognized as well as were self-owned objects, and better than other-owned objects. In a third and final experiment, we used event-related potentials (ERPs) to determine whether self-owned and self-forbidden objects, which showed a common memory advantage, are in fact treated the same at a neurocognitive–affective level. We found that both object types were associated with enhanced cognitive analysis, relative to other-owned objects, as measured by the P300 ERP component. However, we also found that self-forbidden objects uniquely triggered an enhanced response preceding the P300, in an ERP component (the N2) that is sensitive to more rapid, affect-related processing. Our findings thus suggest that, whereas self-forbidden objects share a common cognitive signature with self-owned objects, they are unique in being identified more quickly at a neurocognitive level.

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Going back to Eve and the apple, the idea that we have a particular affinity for "forbidden fruit" is a common and recurring theme throughout history, art, and literature. The allure of things that we cannot have seems to capture our imaginations and attention. Yet, is this really the case? Like Eve, are we really drawn to things we are forbidden to have?

Here we framed the question empirically from the perspective of object ownership. In particular, previous research has demonstrated attentional and memorial advantages for objects owned by the self relative to objects owned by others. When dyads were shown pictures of objects ostensibly "owned" by one member of the dyad or the other, subsequent recognition was greater for self-owned than for other-owned objects (Cunningham, Turk, Macdonald, & Macrae, 2008). This memory boost for self-owned objects was later replicated using more explicit measures of recall (Cunningham, van den Bos, & Turk, 2011; van den Bos, Cunningham, Conway, & Turk, 2010) and has been extended to subjective preferences and assessments of worth. For example, Huang, Wang, and Shi (2009) found that possessions assigned to self-ownership are implicitly preferred to possessions assigned to other-ownership in an Implicit Association Test (IAT). Areas related to attentional and reward processing show higher activation to self-owned objects (Turk, van Bussel, Brebner, et al., 2011a; Turk, van Bussel, Waiter, & Macrae, 2011b). Furthermore, sellers of objects value self-owned items (e.g., chocolate, mugs) significantly more than potential buyers do, a finding known as the *endowment effect* (Kahneman, Knetsch, & Thaler, 1990; Knetsch, 1989).

Importantly, ownership over objects in these studies was determined during the experiments themselves, thus eliminating the potential influences of familiarity and history interacting with some objects relative to others. This suggests that ascribing ownership in the moment may confer special processing independent of other relevant factors, a consequence often referred to as the "mere ownership" effect (Beggan, 1992; Gawronski, Bodenhausen, & Becker, 2007). That is, self-owned objects appear to sit atop a cognitive processing hierarchy, relegating other-owned objects to lower levels of attention, memory, and hedonic preference. Given this conclusion, in our study we addressed whether "forbidden" objects, or objects that we are specifically denied from owning, may have a comparable effect on cognition. In light of the common perception that, like Eve, we are in fact drawn to things that we "cannot" have, it seems that they might.

Support for this possibility has come from work on reactance theory. As described by S. S. Brehm and Brehm (1981), when one's choices are threatened or circumscribed, one may experience feelings of arousal known as "reactance," and act to reduce this reactance by restoring a feeling of choice or freedom. Implications of reactance have been shown for objects that have been restricted or limited in some way. Research regarding warning labels on unhealthy foods (Bushman, 1998) and violent video games (Bijvank, Konijn, Bushman, & Roelofsma, 2009) has been consistent with the idea that making objects forbidden increases their subjective value. Despite falling on the opposite side of the ownership dichotomy, forbidden objects appear to parallel self-owned objects in terms of their relative valuations. Does this parallel exist for other behaviors, such as memory? Does being "forbidden" alter our psychological relationship with an object in a manner that is categorically distinct from a simple mine/not mine dichotomy? To address these questions, we first examined whether rendering objects forbidden confers a memory advantage similar to that for self-owned objects (Exp. 1). Next, after establishing that forbidden objects are recognized at levels comparable to those found with self-ownership, we then examined whether self-referential encoding acts a possible mechanism for the forbidden effect, given its importance in more typical ownership paradigms (Exp. 2). Using a paradigm adapted from Cunningham et al. (2008), participants viewed objects assigned to various categories: "mine" (self-ownership), "yours/not mine" (other-ownership), and a third, novel category, "cannot have" (or forbidden). A subsequent recognition test assessed memory for objects in each of these categories.

Experiment 1

Method

Participants A group of 36 undergraduate students (29 women, seven men) recruited through a university human subject pool completed the experiment in exchange for partial course credit (age: M = 20.70 years, SD = 3.48). All had normal or corrected-to-normal vision and no history of neurological problems, and all provided written informed consent at the beginning of the study.

Stimuli and paradigm The stimulus set included 210 digital images of frequently purchased everyday items (e.g., raspberries, milk, pasta). Each image was 250 × 250 pixels and contained a photograph of the item on a white background. Half (105) of the images were randomly selected for use during the sorting task and were equally divided between the three ownership categories. For the sorting task, a colored border around each image was used to cue ownership category. The borders were 25 pixels wide and were blue, red, and black for self-owned, other-owned, and forbidden items, respectively. The remaining, noncued items were used as foils for the subsequent memory test. All images were presented on a computer monitor.

Participants completed a sorting task, followed by a memory test. During the first task, participants were told that they would be sorting items that belonged to them (self-owned), belonged to the experimenter (other-owned), or could not belong to them (forbidden), and that the ownership category would be denoted by a colored border presented around the image. Participants were verbally quizzed before beginning the sorting task to ensure correct construal of the ownership conditions (e.g., objects with a black border could not be owned by the participant *specifically*, rather than being unable to be owned by anyone *in general*). During explanation of the categories, the experimenter did not use the word "forbidden," but instead described the objects with a black border as "objects you cannot own/have," minimizing potential allusions to taboo or illegal objects. On each trial, an object was presented in the middle of the computer screen, at first by itself (for a variable interval of 400–600 ms) and then surrounded by a colored border indicating ownership category (for a variable interval of 800–1,200 ms). Upon seeing the cue, participants were required to "sort" the item via a buttonpress. As such, the paradigm was an adaptation of the "shopping" paradigm used by Cunningham et al. (2008) and by Turk, van Bussel, Brebner, et al. (2011a), but rather than a "shopping" task, it was a more general "sorting" task.

After completing the sorting task, participants were given a surprise recognition "old/new" memory test. All of the items from the sorting task and 105 similar but previously unseen items were presented sequentially in a randomized order. Participants indicated whether they recognized the image from the sorting task ("old" and recognized) or not ("new" and not recognized or not previously seen) via buttonpress. The item remained on screen until the participant responded or until 5 s had elapsed, at which point the next trial would begin. Participants were encouraged to guess on trials if they were uncertain.

Results

Participants' object recognition scores for each ownership category were calculated as the percentages of "old" objects correctly identified as having previously been seen, out of the total number of old objects presented. Foils ("new" items) were not divided by ownership category, and thus category-specific false alarm rates could not be determined. Rather, the average overall false alarm rate was 23 %. As is shown in Fig. 1, recognition for self-owned objects and forbidden objects appeared to be higher than recognition for other-owned objects. This was confirmed by a repeated measures analysis of variance (ANOVA), which revealed a main effect of ownership category, $F(2, 70) = 5.30$, $p = .007$, $\eta_p^2 = .13$. Post-hoc analyses via Tukey's HSD test revealed that self-owned objects were recognized better than other-owned objects, $\Delta = 5.73$, with 95 % confidence interval ($CI_{.95}$) = [1.68, 9.81], $p = .007$. Forbidden objects were also recognized better than other-owned objects, $\Delta = 4.48$ with $CI_{.95}$ = [0.85, 8.10], $p = .015$. Recognition did not differ significantly between self-owned and forbidden objects ($p = .48$). On average, participants responded very conservatively, selecting "old" for only 34 % of objects across all trials, which is lower than the 50 % that would be expected at chance.

Discussion

The results from Experiment 1 replicated previous findings showing greater memory for self-owned versus other-owned items. More importantly, however, it demonstrated a parallel effect for forbidden items relative to other-owned items. What drives this cognitive advantage? One possibility is that the allusion to limitations of choice induced reactance-like arousal, leading to increased stimulus processing. Another, but not mutually exclusive, possibility is that enhanced memory for forbidden objects is driven by the same mechanism proposed to drive enhanced memory for self-owned objects, namely the self-reference effect (SRE).

The *self-reference effect* refers to the memory benefit arising from self-referent encoding strategies relative to other-referent strategies (Rogers, Kuiper, & Kirker, 1977; Symons & Johnson, 1997), even when the encoding is incidental (Bower & Gilligan, 1979; Ganellen & Carver, 1985). Klein and Loftus (1988) suggested that the self promotes greater elaborative and organizational processing; associations with the self may be more deeply encoded as well as more easily retrieved. Accordingly, much research on ownership has identified self-relevance or self-referential processing as a primary factor in ownership-related effects (Morewedge, Shu, Gilbert, & Wilson, 2009; Serbun, Shih, & Gutchess, 2011; Turk, van Bussel, Brebner, et al., 2011a; van den Bos et al., 2010).

The forbidden objects of Experiment 1 may have triggered self-referential processing in much the same way as self-owned objects because they were always described as things "you" could not have, rather than things "no one" could have. If self-relevance plays a role in increasing attention for forbidden objects, one might expect that a decrease in self-relevance would lead to a decrease in attention to the same objects. In Experiment 2, the self-relevance of forbidden objects was attenuated by altering the description from "you cannot have" to "no one can have." Recognition memory was assessed for objects that were self-owned, other-owned, and forbidden to everyone. We predicted that objects forbidden to everyone would elicit the same level of recognition as other-owned objects, with both being lower than the level for self-owned objects.

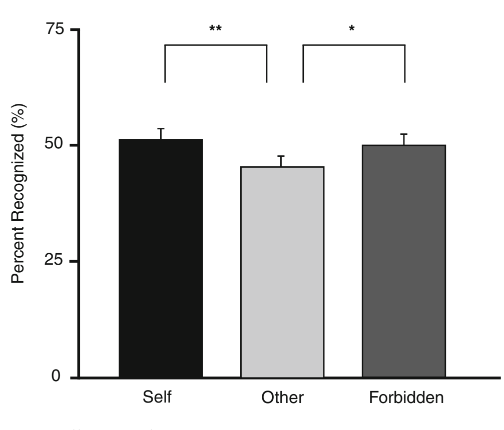

Fig. 1 Percentage recognition scores as a function of category for Experiment 1. Error bars represent standard errors of the means

Experiment 2

Method

Participants A group of 37 undergraduate students (26 women, 11 men) recruited through a university human subject pool completed the experiment in exchange for partial course credit (age: $M = 21.03$ years, $SD = 2.64$).

Stimuli and paradigm The stimuli and experimental procedures exactly mirrored Experiment 1, with the following exception: To reduce the self-relevance of the "forbidden" object category, it was described to participants as "objects that could not be owned *by anyone*" (i.e., were forbidden to everyone). Participants were verbally quizzed prior to the sorting task to ensure that these ownership categories were understood.

Results

Participants' object recognition scores for each ownership category were calculated in the same way as in Experiment 1.

The average overall false alarm rate was 24.73 %. As is shown in Fig. 2, recognition of self-owned objects remained high relative to that of other-owned objects, whereas recognition of forbidden objects dropped. A repeated measures ANOVA revealed a main effect of ownership category, $F(2, 72) = 4.04$, $p = .022$, $\eta_p^2 = .10$. Post-hoc analyses via Tukey's HSD test revealed that self-owned objects were recognized better than other-owned objects, $\Delta = 5.24$ with $CI_{.95} = [1.41, 9.06]$, $p = .009$. Self-owned objects were also recognized better than objects forbidden to everyone, $\Delta = 4.39$ with $CI_{.95} = [0.31, 8.47]$, $p = .036$. Recognition between other-owned and forbidden objects did not differ significantly ($p = .68$). Again, participants responded conservatively, selecting "old" for only 40 % of items across all trials.

Discussion

Replicating the findings in Experiment 1, self-owned objects were recognized better than other-owned objects. Furthermore, as predicted, self-owned objects were recognized better than objects that were forbidden to everyone. The reduction of the memory boost for forbidden objects from Experiment 1 (forbidden to self) to Experiment 2 (forbidden to everyone) is consistent with the extant literature on the self-reference effect, which states that enhanced item-specific and relational processing afforded to the self leads to greater recall (Klein, 2012).

When forbidden objects are no longer explicitly self-relevant, the memorial advantage that they share with self-owned objects also disappears, despite the objects still being "forbidden." The pattern of results across the first two experiments suggests that self-referential encoding is indeed a possible mechanism driving the "forbidden" effect, and that it may affect recognition above and beyond any potential reactance caused by choice reduction alone. Although such findings shed light on the nature of forbidden objects, it does not suffice to conclude that self-owned and forbidden (to self) objects are necessarily treated the same cognitively. Nor does it follow that self-referential encoding is the only means by which encoding of forbidden objects is intensified. These two categories may not parallel each other neurocognitively, and dissociations between forbidden and self-owned (and other-owned) objects may emerge during different stages of processing. To explore these possibilities, in Experiment 3 we measured the event-related potentials (ERPs) elicited by cues indicating self-ownership, other-ownership, and forbidden ownership.

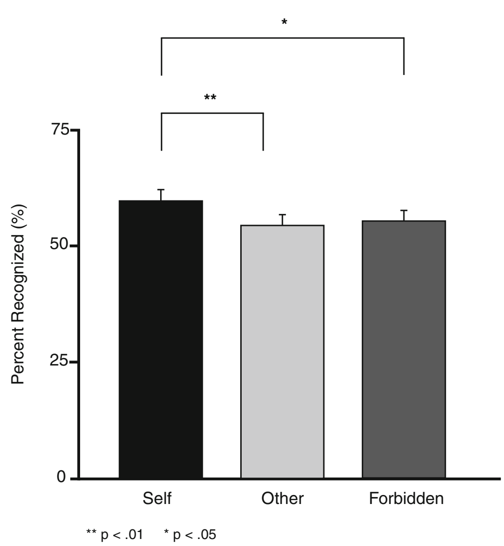

Fig. 2 Percentage recognition scores as a function of category for Experiment 2. Error bars represent standard errors of the means

Of particular interest in Experiment 3 was the P300 ERP component, a large positive wave emerging 300–400 ms after the presentation of a stimulus that is proposed to index attentional resources devoted to context updating (for reviews, see Patel & Assam, 2005; Polich, 2007). Critically, previous research has shown that the P300 is sensitive to self-relevant information such as one's name or face (e.g., Berlad & Pratt, 1995; Ninomiya, Onitsuka, Chen, Sato, & Tashiro, 1998; Tacikowski & Nowicka, 2010; Zhao, Wu, Zimmer, & Fu, 2011), as well as to stimuli less explicitly recognized as self-relevant, such as one's own handwriting (A. Chen et al., 2008), home province (J. Chen et al., 2011), and other autobiographical information (Gray, Ambady, Lowenthal, & Deldin, 2004).

More recently, Turk, van Bussel, Brebner, at el. (2011a) employed a modified "shopping" paradigm to present participants with common everyday objects, and then informed them via a colored border cue that an object was either self-owned or other-owned. ERPs time-locked to the presentation of the ownership cues showed that self-ownership cues elicited greater P300s than did other-ownership cues. Furthermore, attention to the periphery, as indexed by P1 amplitudes, decreased during self- but not other-ownership cues. This experiment was a departure from previous ERP studies on self-relevance because it assigned self-relevance status immediately after object presentation, whereas the aforementioned experiments relied on previously established biographical information. By eliminating the confound of prior history/interaction with the stimuli, Turk, van Bussel, Brebner, et al. found that attentional benefits for self-relevant items could be generated almost instantly upon assignment to self-ownership, an attentional ERP equivalent to the "mere ownership" effect.

Accordingly, in Experiment 3, participants viewed frequently purchased everyday items on a computer screen during an ostensible ownership-category "sorting" task. After the initial item presentation, the items were presented again with a colored border around the image. The border's color signified the ownership category (self, other, or forbidden to self), to which the participant responded via buttonpress. We predicted that the amplitude of the P300 ERP component would be significantly greater for self-ownership cues relative to other-ownership cues, as was found in Turk, van Bussel, Brebner, et al. (2011a). Given the importance of self-relevance to the "forbidden" effect at the recognition memory level, as revealed by Experiments 1 and 2, we also predicted that the P300 component would be significantly greater for forbidden-ownership cues relative to other-ownership cues, as well.

Experiment 3

Method

Power analysis A power calculation was conducted using G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) for the P300 component time-locked to the ownership cues. Although the effect in Turk, van Bussel, Brebner, et al. (2011a) was moderate in size ($\eta_p^2 = .31$), we chose a more conservative effect size ($\eta_p^2 = .10$) in order to determine an appropriate sample size. Within our chosen sample size (as follows) and effect size, the power ($1 - \beta$) was approximately .80.

Participants A group of 19 participants (11 women, eight men; 17 right-handed) completed the experiment in exchange for $15 (age: $M = 21.89$ years, $SD = 2.18$).

Stimuli The stimulus set consisted of the same 210 digital images used in Experiments 1 and 2. A total of 70 images were assigned per ownership category (self-owned, other-owned, or forbidden to self); ownership category was randomly assigned and again denoted by a colored border. The paradigm for this study was adapted from Turk, van Bussel, Brebner, et al. (2011a), and closely resembled the "sorting" tasks from Experiments 1 and 2. Participants "sorted" items into ownership categories upon cueing by a colored border and responded by buttonpress. Each item was presented in the center of a computer screen for 400–600 ms and was presented again, but with a colored border, for 800–1,400 ms, at which point participants responded. The on-screen duration for stimuli was randomly varied to prevent temporal habituation to stimulus onset. The ERP analysis was time-locked to the onset of the ownership cues.

Electrophysiological recording All electroencephalographic (EEG) activity was recorded relative to the CMS electrode, amplified (BioSemi Active 2 system) with a band-pass of 0.1–30 Hz (half-amplitude cutoffs), and digitized online at a sampling rate of 256 samples per second. In order to correct for and/or remove events relating to eye movements offline, electrooculograms (EOGs) were recorded using electrodes below the right eye and on the outer canthi of both the left and right eyes. Finally, electrodes were recorded from the left and right mastoids; offline, all EEG signals were re-referenced to their average. Prior to this re-referencing, computerized artifact rejection was performed offline to eliminate trials with detectable eye movements (>1º), blinks, muscle potentials, and amplifier blocking. Across participants, approximately 11 % of trials were rejected on the basis of these artifacts. For each participant, EEG was segmented for remaining events into 1,000-ms epochs, starting 200 ms prior to event onset. These epochs were sorted by condition, signal-averaged, digitally low-pass Gaussian filtered (26.5-Hz half-amplitude cutoff), and baseline corrected to remove any linear slow-wave drifts prior to group-averaging for statistical analyses and illustration (–200- to 0-ms prestimulus baselines).

Results

Since self-relevance has been found to reveal itself most robustly across a number of functional domains over cortical midline structures (Northoff et al., 2006), and since we sought to replicate the self-versus-other P300 difference found in Turk, van Bussel, Brebner, et al. (2011a), in addition to predicting a similar difference for forbidden versus other, our ERP analysis focused a priori on parietal midline electrodes. Visual inspection of the ERP waveforms indicated possible effects of object condition in both the P300 and the preceding N2 component. Accordingly, both were statistically analyzed. As in Turk, van Bussel, Brebner, et al.'s study, accuracy was not analyzed, as participants performed at ceiling.

N2 The N2 ERP component can be seen as a function of cue in Fig. 3. We conducted an omnibus repeated measures ANOVA that included Ownership Cue ("self" vs. "other" vs. "forbidden") as a factor. As is reported in Table 1, mean amplitudes were measured at electrodes CPz, P1, Pz, P2, and POz over a 50-ms time window (250–300 ms postcue) centered on the approximate N2 peak in the grand-averaged waveforms. We found a significant main effect of cue, $F(2, 36) = 8.22$, $p = .001$, $\eta_p^2 = .31$. Post-hoc pairwise comparisons revealed that N2 mean amplitudes were larger for "forbidden" than for "self" cues ($p = .005$) and for "forbidden" than for "other" cues ($p = .001$). The amplitudes for "self" versus "other" cues did not differ ($p = .15$).

P300 Visual inspection of the P300 waveform revealed morphological differences that varied by time and cue (Fig. 3). To more accurately account for the temporal nuances of the P300 waveform across conditions, we conducted an omnibus repeated measures ANOVA with

Fig. 3 Event-related potential responses to ownership cues for Experiment 3

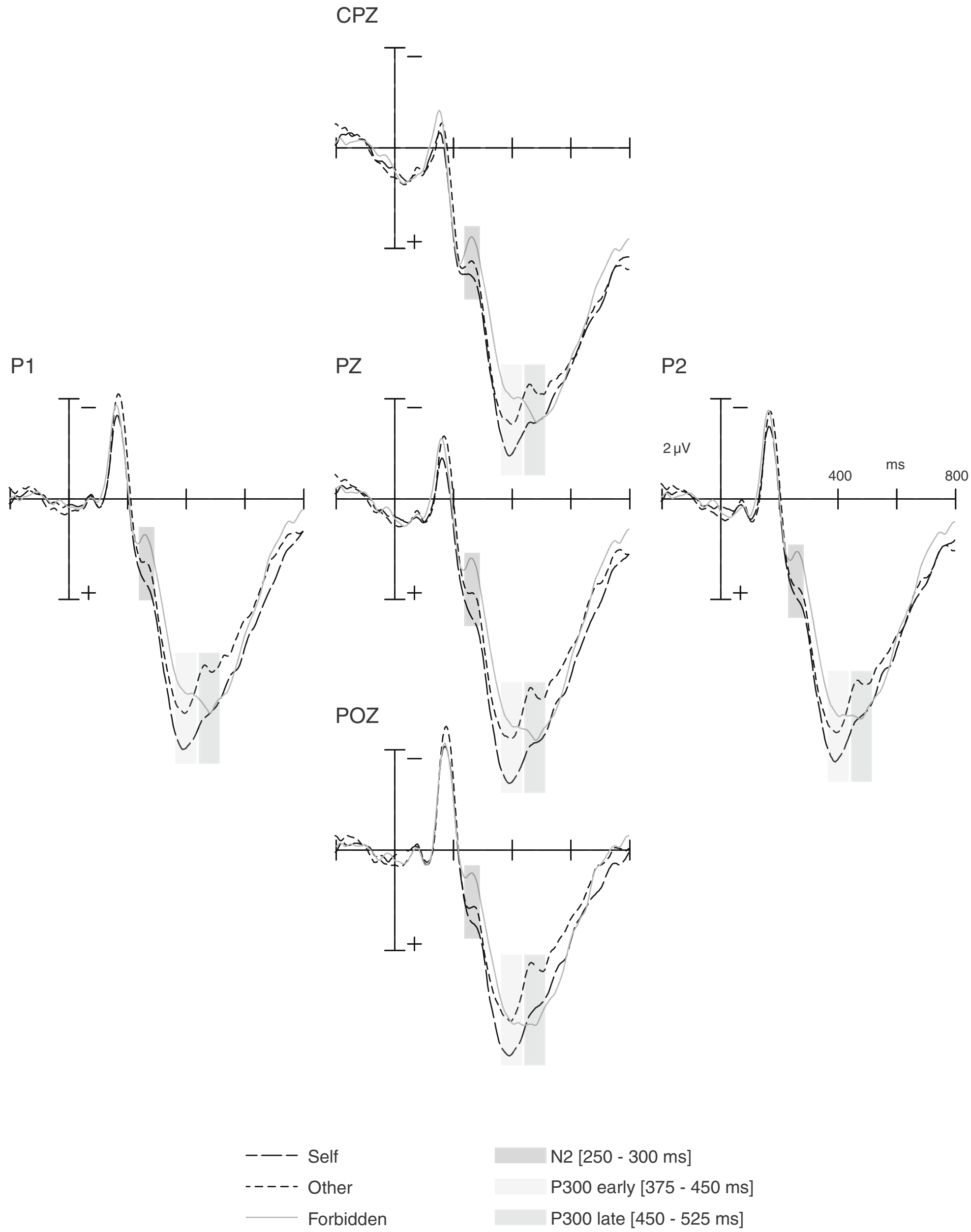

Table 1 Experiment 3: Mean amplitudes (in microvolts) in the N2 time frame at selected electrode sites as a function of ownership category

Electrode	Ownership Category		
	Self	Other	Forbidden
CPz	2.73 (0.54)	2.46 (0.49)	1.99 (0.46)
P1	1.85 (0.45)	1.46 (0.40)	0.94 (0.35)
Pz	2.51 (0.45)	2.03 (0.40)	1.41 (0.38)
P2	2.16 (0.44)	1.92 (0.37)	1.28 (0.35)
POz	1.54 (0.44)	1.26 (0.35)	0.65 (0.33)

Standard errors are in parentheses.

the factors Ownership Cue and Time Window (375–450 ms vs. 450–525 ms postcue). As is reported in Table 2, mean amplitudes were examined for each time window at electrodes CPz, P1, Pz, P2, and POz. We found a significant Time × Cue interaction, $F(2, 36) = 9.50$, $p = .002$, $\eta_p^2 = .35$, as well as a marginal main effect of cue, $F(2, 36) = 3.60$, $p = .07$, $\eta_p^2 = .17$. Post-hoc pairwise comparisons for the late window revealed that the mean P300 amplitude was larger for "self" than for "other" cues ($p = .006$) and for "forbidden" than for "other" cues ($p = .041$). The mean amplitudes for "self" versus "forbidden" cues did not differ significantly ($p = .93$). Waveforms in the early window did not differ ($p = .051$ for both "self" vs. "other" and "self" vs. "forbidden," $p = .85$ for "other" vs. "forbidden").

Table 2 Experiment 3: Mean amplitudes (in microvolts) in P300 time frames (early and late) at selected electrode sites as a function of ownership category

Electrode	Ownership Category		
	Self	Other	Forbidden
CPz			
Early	5.90 (0.61)	5.28 (0.49)	4.97 (0.50)
Late	5.41 (0.57)	4.82 (0.53)	5.34 (0.52)
P1			
Early	4.81 (0.53)	3.99 (0.34)	3.89 (0.37)
Late	4.22 (0.50)	3.35 (0.36)	4.10 (0.38)
Pz			
Early	5.45 (0.54)	4.53 (0.43)	4.51 (0.40)
Late	4.81 (0.54)	3.88 (0.48)	4.66 (0.41)
P2			
Early	4.99 (0.55)	4.39 (0.42)	4.28 (0.37)
Late	4.27 (0.55)	3.65 (0.46)	4.24 (0.41)
POz			
Early	3.89 (0.56)	3.12 (0.44)	3.42 (0.36)
Late	3.13 (0.59)	2.33 (0.43)	3.35 (0.40)

Standard errors are in parentheses.

Discussion

At 250–300 ms poststimulus, the “forbidden” cue elicited a greater negative deflection (N2) relative to both the “self” and “other” cues. The “self” and “other” cues did not differ significantly during this time window. Analysis of the P300 revealed different responses to the ownership cues as a function of time window. Although the early window appeared to show the “self” cues dissociating from the remaining two categories, this was not supported statistically. Analysis of the late window revealed an enhanced P300 for self-ownership cues and “forbidden” cues relative to other-ownership cues, a finding consistent with the first and second experiments as well as with Turk, van Bussel, Brebner, et al. (2011a), since P300 amplitudes are greater when self-referencing is engaged. Taking the N2 and P300 findings together, it appears that being “forbidden” is indeed distinct from being “self-owned,” and furthermore, can be distinguished more quickly than ownership category. Nevertheless, a commonality between these conditions was manifest in the P300, a frequent indicator of self-referent processing.

What explains the dissociation of “forbidden” from the other ownership categories at the N2? One possibility is that it could signify a greater emotional response. Being told that we cannot have something, even if it is not something particularly fascinating or desirable, may feel threatening or objectionable. Enhanced negativity in the 200- to 300-ms time window has been found when participants read emotional relative to neutral words (Herbert, Pauli, & Herbert, 2011; Kissler, Herbert, Peyk, & Junghofer, 2007) or see negatively emotional relative to neutral pictures (Ma, Wang, Wang, Wang, & Wang, 2010). An early posterior negativity was also found when emotional words were presented during a grammatical decision task, suggesting incidental and automatic encoding of valence (Kissler, Herbert, Winkler, & Junghofer, 2009). The pre-P300 negativity has been shown to be particularly sensitive to negative stimuli. Balconi and Pozzoli (2012) demonstrated that the N2 is greater when viewing angry as compared with neutral and happy faces. There may even be degree-dependent modulation of the N2 for unpleasant pictures (Yuan et al., 2012). The forbidden cue thus may evoke a rapid negative emotional response before ownership or self-relevance is processed.

Although we found a functional dissociation between the N2 and P300 in terms of how the different ownership conditions affected the two components, previous research has suggested that these components may reflect a common set of underlying processes (Folstein & van Petten, 2008). To examine this possibility in the present data, and to provide additional insight into the shared versus distinct neurocognitive aspects of our three ownership conditions, we plotted the scalp topographies of each component (N2, early P300, and late P300) as a function of condition (Fig. 4). Specifically, the mean voltage measurements within each of the three time windows analyzed above were converted into topographic maps by means of a spherical spline interpolation algorithm (Perrin, Pernier, Bertrand, & Echallier, 1989). Visual inspection of these topographies supports two general conclusions. First, although the absolute voltage values changed, within each ownership condition, the topographic distributions of voltage minima and maxima remained relatively consistent across the three ERP time windows. As such, this would be consistent with a common set of ERP-generating dipoles for the N2 and P300 data within each condition. Second, although all topography plots show voltage maxima at or near the midline parietal locations analyzed in the ERP waveforms, additional topographic features clearly dissociated the conditions. The “mine” and “forbidden” conditions shared a left occipital/temporal maximum that was absent in the “other” condition. Likewise, over the right central/frontal scalp sites we observed a maximum in the “mine” condition and a minimum in the “other” condition, with no corresponding feature in the “forbidden” condition. This not only supports our conclusion that self-owned and self-forbidden objects share certain neurocognitive features, as discussed below, but that self-forbidden objects are nevertheless qualitatively distinct in terms of how we process them neurally.

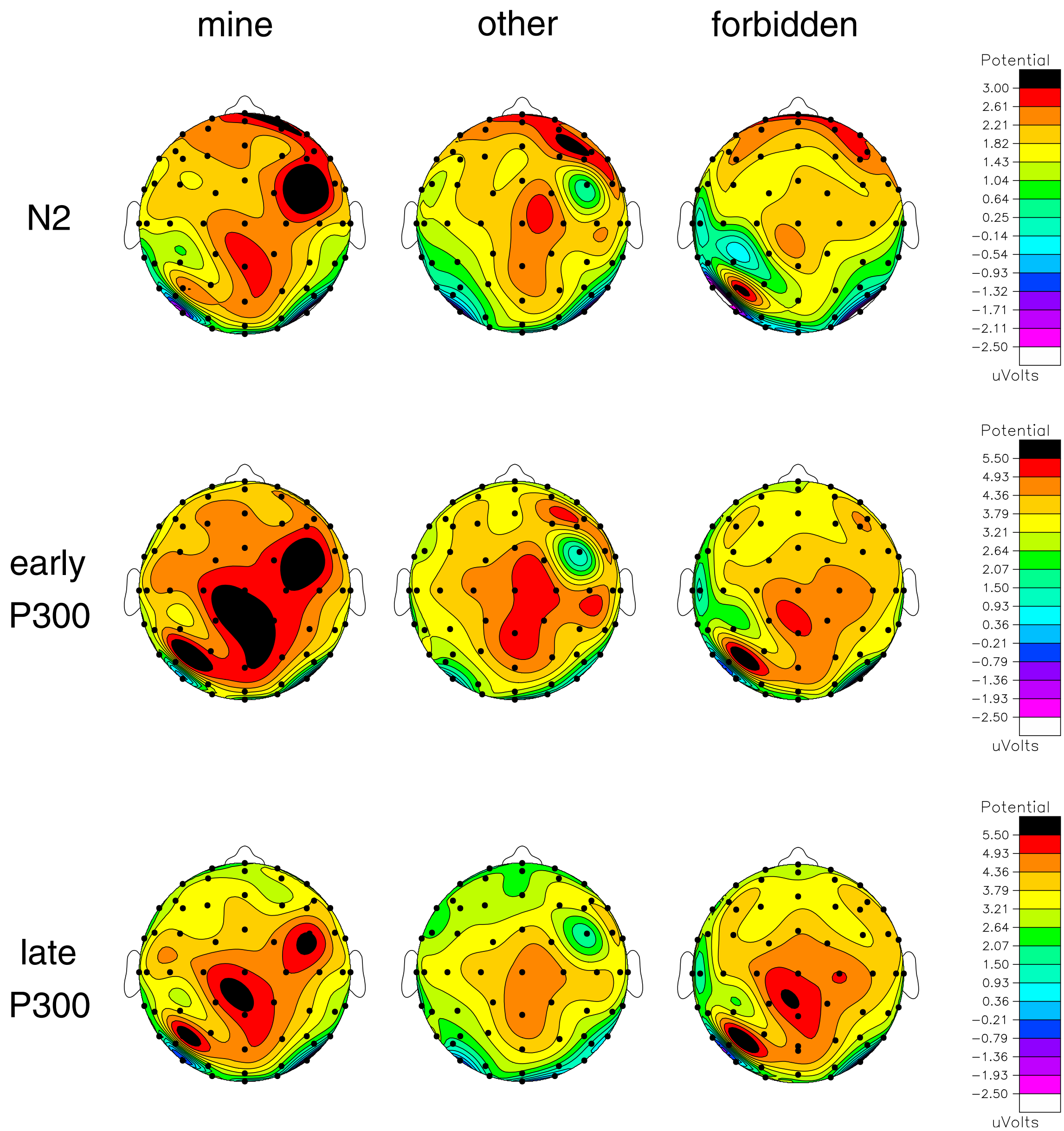

Fig. 4 Topography maps pertaining to the ownership cues for the N2 (250–300 ms), early P300 (375–450 ms), and late P300 (450–525 ms) time windows

General discussion

Over the course of three experiments, we examined memorial and event-related potential changes relating to the psychological concept of "forbidden" objects. In the first two experiments, we found evidence that objects labeled as being forbidden to oneself are later recognized as well as objects labeled as being self-owned (i.e., "mine), whereas objects labeled as being forbidden to everyone are later recognized significantly less, producing recognition rates equivalent to those for objects labeled as being other-owned (i.e., "not mine" or "other"). A third experiment revealed greater amplitudes for self-owned and forbidden but not for other-owned objects in a waveform widely associated with self-relevance. It also demonstrated that the "forbidden" category was distinguished from the "mine"/"other" categories at the N2 component, a waveform linked with emotional stimuli.

How do the present results advance our understanding of ownership? Whereas previous research had focused on the numerous biases in favor of self-owned objects, the present study highlights the importance of considering objects that lie outside of self-ownership. Belk (1988) argued that our possessions are extensions of ourselves and that objects are not just things but clues to our very identities. If we take the present findings as evidence that forbidden objects engage self-referential processing similarly to self-owned objects, this may suggest that objects reflect not just who we are, but also who we cannot be. Furthermore, singling out objects not simply as unowned but as *unable* to be owned defies the mine/other dichotomy and, as our ERP data imply, triggers an emotional response. Forbidden objects show that ownership is more complex than a two-fold choice and that objects outside self-ownership can hold varying degrees of self-relevance.

We postulated that the relationship that an object has with the self, or perhaps the relationship that the self has with an object, influences how much attention is allotted to that object, and consequently impacts how strongly the representation of that object is encoded in memory. Although this argument is not a new one, in the present work we sought to expand on it by hypothesizing that an object that was not self-owned could still exhibit this relationship. In so far as self-referential encoding and recognition memory for forbidden objects positively covaried from Experiment 1 to Experiment 2, this postulation was supported, and it was further reinforced by our ERP evidence in Experiment 3. That such a relationship between a nonowned object and the self could be established at the moment of person–object introduction implies that the "mere ownership" effect could be generalized to exist as a "mere self-relevance" effect. To wit, the apple that cannot be mine is just as "me" as if it were my own.

The present results appear to be consistent with theoretically similar constructs such as thought suppression and social exclusion. As was made prominent by Wegner, Schneider, Carter, and White (1987), the attempt to suppress certain "target" thoughts (most famously, a white bear) does not lead to a successful reduction in those thoughts, but rather to a surge of target thoughts during and/or after the period of suppression (for a review, see Wenzlaff & Wegner, 2000). From this perspective, the target thought is construed as being forbidden but cognitively surfaces frequently. Likewise, the presentation of a forbidden object increases rather than decreases attention to said object.

Relatedly, despite the absence of an explicit induction of negative emotion, the ERP results closely mirror neuroimaging work on social exclusion (e.g., Otten & Jonas, 2012). Event-related potentials recorded during modified "Cyberball" manipulations have shown N2 as well as P300 modulations (Gutz, Küpper, Renneberg, & Niedeggen, 2011; Themanson, Khatcherian, Ball, & Rosen, 2012). Specifically, when participants are temporarily excluded from play during a game of virtual "catch," N2 and P300 amplitudes significantly increase. In this respect, the present research and the Cyberball paradigm both utilize an externally imposed "forbidden" aspect to owning or exercising agency over the ball. Consequently, both may be eliciting negative affect and feelings of self-relevance (i.e., being singled out).

In comparing the present research with previous work on forbidden objects, it is interesting to note the methodological differences between warning label studies and the present one. For the former, the labels specified an outstanding attribute of the forbidden objects (e.g., a video game was particularly violent) and/or the consequences of owning the forbidden option (e.g., "fatty cream cheese will increase your risk of heart disease"), whereas in the latter we did not mention special qualities about the forbidden objects at all. Despite not having these distinguishing features, forbidden objects in the present study were still recognized as well as were self-owned objects. This is consistent with J. W. Brehm, Stires, Sensenig, and Shaban's (1966) study showing that a middle-ranked music record was subsequently rated as being more attractive when it was forbidden. It also suggests that the "forbidden" label alone is sufficient for increased processing.

Moving forward, it will be critical to consider potential moderators to the forbidden effect, including various individual differences between participants and the psychological qualities of the objects. For example, certain cultural groups do not express the self-referencing effect as strongly, and therefore may not exhibit typical ownership effects or the "forbidden" effect. Maddux et al. (2010) examined the endowment effect in East Asians and Westerners and found a reduction in the effect in East Asians and in participants primed for interdependent self-construal. Similar manipulations might also reduce the memory advantage for self-owned and forbidden objects. Conversely, the objects in a stimulus set themselves may increase or decrease the extent to which the forbidden effect is observed. Item valence has been shown to moderate the endowment effect (Brenner, Rottenstreich, Sood, & Bilgin, 2007). Furthermore, evidence from the present experiments and other neuroimaging work (Kensinger, 2007; Steinmetz & Kensinger, 2009) has indicated that negative or arousing stimuli may increase memory accuracy. A stimulus set comprised completely of unattractive or emotionally arousing objects might erase categorical differences in memory.

In conclusion, when considered relative to objects in other ownership categories, forbidden objects are recognized as much as self-owned objects and more than other-owned objects, but not when the "forbidden" category is explicitly described to apply to everyone. ERPs associated with the "forbidden" category show mean amplitudes for the P300 equal to those for the self-ownership category and greater than those for the other-ownership category, echoing the role of self-relevance. However, the greater N2 amplitudes that we found only for the "forbidden" category point toward a dissociation of "forbidden" from the classic "mine"/"other" ownership dichotomy. Future research should investigate other factors relevant to this effect.

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