

THE BROOMS IN FANTASIA: NEURAL CORRELATES OF ANTHROPOMORPHIZING OBJECTS

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People show medial prefrontal cortex and superior temporal sulcus (STS) activation when making dispositional attributions to other people (Harris, Todorov, & Fiske, 2005) under conditions predicted by Kelley's (1972) ANOVA model. Here, participants make dispositional attributions to entire categories of objects under similar conditions; they also show greater activity in STS (implicated in perceiving trajectory) and bilateral amygdala (implicated in vigilance). Initial STS activity is greater to object categories while later amygdala activity is greater to specific objects. Self-reported anthropomorphizing predicts both STS activity to object categories and amygdala activity to specific objects. Anthropomorphizing object categories (versus single objects) resembles dispositional inferences.

Objects in action sometimes appear alive. In the cartoon *Fantasia*, brooms come to life and dance with the apprentice before adopting murderous intentions. Animation appeared even in early experimental psychology, demonstrating that people effortlessly attribute human states to non-human objects engaged in nonrandom motion (Heider & Simmel, 1944). Attributing intent is not reserved simply for targets that people generally believe have internal mental states, namely human beings. Indeed, other species do have personalities and are attributed dispositions (Gosling, 2001; Gosling, Kwan, & John, 2003). Therefore, we hypothesize that people make dispositional attributions to objects engaged in action, thereby assuming intent, that is, stable internal states guiding behavior.

Making a dispositional attribution is a unique mental inference. A dispositional attribution assigns a stable trait that guides behavior (Jones, 1979). People infer dispositions effortlessly, even from thin-slices of behavior (Ambady & Rosenthal, 1993; Dunning, Meyerowitz, & Holzberg, 1989). This causal reasoning led Fritz Heider (1958) to describe people as naïve scientists and to outline attribution theory. Kelley's (1972) ANOVA-styled model described specifically how people make

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dispositional attributions based on information about others' behavior. Relevant patterns of behavior include (a) consensus—frequency of the behavior across people, (b) distinctiveness—frequency of the actor's behavior targeting this entity uniquely, and (c) consistency—frequency of the actor directing this behavior to this entity across circumstances. Certain combinations lead to dispositional attributions (McArthur, 1972). In particular, low consensus (hardly anyone else does it), low distinctiveness (the actor does it to all relevant entities), and high consistency (the actor always does it to this entity) together facilitate attributing the behavior to the actor's disposition.

However, dispositional attributions often ignore consensus information (Fiske & Taylor, 2008). Thus even if most people perform a behavior, a dispositional attribution often still attaches to a specific person for the behavior. In contrast to the usual individuated *low-consensus* dispositional attribution, a *high-consensus* dispositional attribution does not distinguish the specific person from all people. This dispositional attribution concerns more a feature of people than a unique social target. Because the more normative low-consensus dispositional attribution guides behavior toward a specific person (Jones, 1979), then dispositional attribution to people under high consensus behavior is less often discussed. Nevertheless, it does occur, implicating whole categories of people. Behavior toward a group relies on stereotypes (Fiske, 1998)—stable traits that (participants think will describe all group members.) This cognitive process abets perceived outgroup homogeneity—a failure to distinguish among group members (Simon & Mummendey, 1990). We suggest this provides a link to the level at which people sometimes anthropomorphize objects.

Anthropomorphizing objects may occur more readily when *high* consensus information is available because specific objects tend not to be distinguished as individual objects apart from their category of objects. People may typically distinguish whole categories of objects as behaving certain ways because different types of objects have different uses. We agree that people more often make dispositional attributions to specific people; thus distinguishing people as individuals. But a single object often may not be treated with the same cognitive individuality because usually there is often no need to distinguish every single object as a unique entity. Therefore, we predict that when people make dispositional attributions to objects, they may do so to both *high-consensus* and *low-consensus* object behavior. In other words, brooms in general sweep, and even a single evil animated broom rapidly morphs into an army of like-minded brooms.

NEURAL CORRELATES OF ANTHROPOMORPHISM

According to many behavioral studies, including several in this special issue, people anthropomorphize objects. Here, we address when dispositional attributions attach to objects, and whether these attributions rely on the same neural network as dispositional attributions to people. Previous research specifies the medial prefrontal cortex (MPFC) and superior temporal sulcus (STS) as neural structures involved in dispositional attribution to people, regarding behavior relevant to emotion, accomplishment, and opinion (Harris, Todorov, & Fiske, 2005). The MPFC is generally implicated in social cognition (Amodio & Frith, 2006), but the MPFC is not as active to objects (Harris, McClure, Van den Bos, Cohen, & Fiske, 2007; Mitchell, Heatherton, & Macrae, 2004). Therefore, when people anthropomorphize—attribute human charac-

teristics and mental states—to non-human agents, then the process may rely more on the STS, a part of this person perception network.

The STS responds to what might be called trajectory/intent, activating to: biographical motion, eye gaze, and intent in person perception (Haxby, Gobbini, Montgomery, 2004), simple animations (Blakemore, Boyer, Paohot-Clouard, Meltzoff, Segebarth, & Decety, 2003), complex intentional movement patterns (Castelli, Happe, Frith, & Frith, 2000), and point-light walkers (Heberlein, Adolphs, Tranel, & Damasio, 2004). This suggests that the STS as a trajectory/intent component of the person perception network may be involved in anthropomorphizing objects. When people attribute intent and human characteristics to shapes in nonrandom coordinated motion (Heider & Simmel, 1944), this anthropomorphism suspends the belief that the non-human entity lacks a mind to guide its behavior. Objects can inspire Theory of Mind (ToM), mentalizing processes that consider a person's mind (Frith & Frith, 2001).

In addition, the amygdala activates during certain social categorical processing (Harris & Fiske, 2007; Hart et al., 2000; Lieberman, Hariri, Jarcho, Eisenberger, & Bookheimer, 2005; Phelps et al., 2000; Wheeler & Fiske, 2005); it may also be involved in anthropomorphizing categories of objects. The amygdala becomes more active when participants perceive people by some social categories such as race (Harris & Fiske, 2007; Hart et al., 2000; Lieberman et al., 2005; Phelps et al., 2000; Wheeler & Fiske, 2005), compared to when participants perceive people as familiar individuals. Generally, the amygdala is implicated in fear conditioning in both animals (LeDoux, 1998) and people (Phelps, 2006), and meta-analyses provide converging evidence for its role in fear (Murphy, Nimmo-Smith, & Lawrence, 2003; Phan, Wager, Taylor, & Liberzon, 2002). More broadly, the amygdala tends to activate to emotionally salient stimuli, suggesting vigilance (Whalen, 1998). Most relevant here, this sub-cortical region also activates when people infer trustworthiness—an assessment of good or ill intent (Winston, Strange, O'Doherty, & Dolan, 2002).

In sum, we hypothesize that participants make both high- and low-consensus dispositional attributions to objects because they rarely distinguish individual objects. We also hypothesize that the STS (for trajectory/intent) and amygdala (for vigilance) activate in dispositional attribution to objects. Finally, we predict that participant self-reported anthropomorphism relates to neural activity in these regions.

METHOD

PARTICIPANTS

Twelve Princeton University undergraduates participated in the study for course credit. Participants reported no abnormal neurological conditions, head trauma, or brain lesions. All participants were right-handed, had normal or corrected vision, were native English speakers, and provided informed consent. Mean age was 19.2 years, with 7 women, and 5 ethnic minorities.

STIMULI

Participants saw a target sentence describing the action of an object: (1) The broom sat on the window sill, (2) The pen rolled off the table, (3) The glass fell off the chair, and (4) The paper lay on the grass. Participants then received additional information that conveyed (a) the consensus, either high (*almost all other*) or low (*hardly any other*), (b) the distinctiveness, either high (*does not . . . on any other*) or low (*also . . . on every other*), and (c) the consistency, either high (*in the past . . . would almost always*) or low (*in the past . . . would almost never*).¹

Scanning Parameters

All fMRI scanning was conducted at Princeton's Center for the Study of Brain, Mind, and Behavior, which uses a 3.0 Tesla Siemens Allegra head-dedicated MR scanner. A Dell computer presented the stimuli projected to a screen mounted at the rear of the scanner bore. Stimuli reflected through a series of mirrors, which participants viewed while supine. Responses were recorded using bimanual fiber-optic response pads. Prior to the functional echo planar image (EPI) acquisitions, subjects received a short series of structural MRI scans to allow for subsequent functional localization. These scans took approximately 12 minutes and included: (1) a brief scout for landmarking; and (2) a high-resolution whole-brain MPRAGE sequence for later localization and intersubject registration. Functional imaging then proceeded using an EPI sequence that allowed for whole-brain coverage in a relatively short period of time (32 3mm axial slices; 1mm gap, TR: 2 sec; TE: 30 msec). In-plane resolutions were 3mm × 3mm (196mm FOV, 64 × 64 matrix).

PROCEDURE

The method repeated the Harris et al. (2005) paradigm (see Figure 1), itself a version of the McArthur (1972) paradigm. The four sentences were paired with the eight combinations of additional information conveying high or low consensus, high or low distinctiveness, or high or low consistency information. We used action sentences instead of emotions, accomplishments, or opinions because objects engage in action, but do not experience emotion, have accomplishments or opinions. The sentences were presented using the computer display program E-prime. The task required participants to make an attribution to the target sentence based on the additional information. All participants practiced the task on a dummy set of object sentences before scanning.

We employed a repeated measure design inside the scanner. Each target sentence was presented once along with each of the eight combinations of additional information across two runs, 16 presentations per run (see Figure 1). A sentence never appeared more than twice per run and was paired with each information combination only once. A run consisted of a fixation cross for two seconds before presenta-

1. That is, *low-consensus* dispositional combination reads: The pen fell off the table. *Hardly any other* pens fall off the table; the pen *also* falls off *every other* table; *in the past*, the pen *would almost always* fall off the table. A *high-consensus* dispositional combination substitutes: *Almost every other* pen falls off the table; the pen *also* falls off *every other* table; *in the past*, the pen *would almost always* fall off the table (italics added).

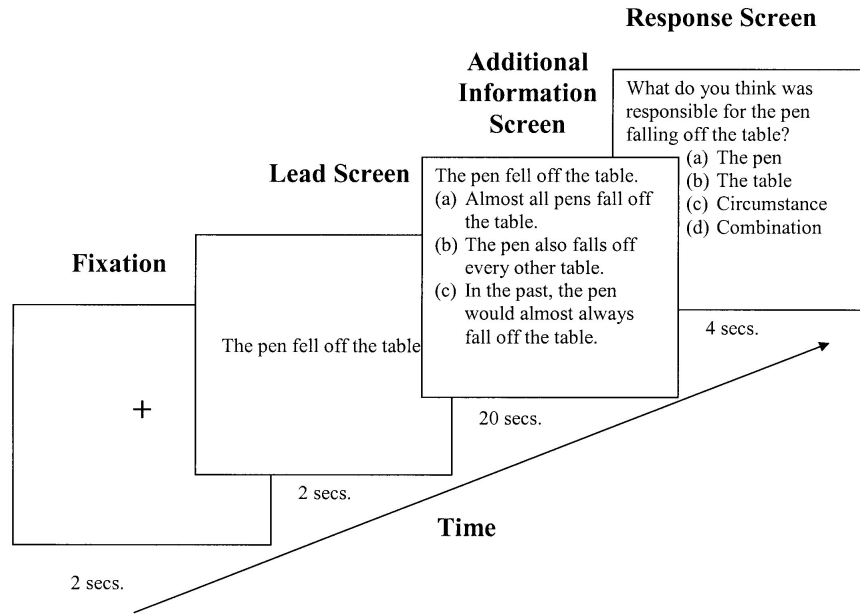


FIGURE 1: One sentence run. Each participant saw the above sequence of stimuli. The object and the action appears after a fixation cross. The consensus, distinctiveness, and consistency information appears in the additional information screen. Finally, behavioral data is collected in the response screen. This sequence repeated for each object, behavior, and information combi-

tion of the lead screen with the target sentence for two seconds. The target sentence was at the top of the additional information screen that followed and contained the additional information about the behavior. This screen remained for 20 seconds. Participants indicated with a button press during the 20-second period when they provided the attribution. They were instructed before scanning to think about their response while the additional information screen was still displayed, even after indicating the moment when the answer judgment was made. Participants were next asked to make the attribution to either the object,² the entity acted upon, circumstance, or a combination of factors. This response screen appeared for four seconds. All sentences were randomly displayed within each run, and run order was randomized for each participant.

After the scanning session, participants were asked to report on a 1–7 Likert scale the degree to which they anthropomorphized the objects, the ease of making the attributions, and their confidence in their attribution.³ Participants were next probed for suspicion; none were suspicious. They were then thoroughly debriefed, given course credit, and thanked.

2. The object described in the sentence (e.g., the pen), as well as the entity acted upon (e.g., the table), was always specified, as illustrated in the example: "The pen fell off the table."

3. The experimenter's instructions were: "Now please fill out these three quick questions. Tell us how much you anthropomorphized the objects, or thought of them as people, how easy the task of making the attributions to the objects was, and your overall confidence in your decisions."

PREPROCESSING

Both image preprocessing and statistical analysis used Brain Voyager QX. Before statistical analysis, image preprocessing consisted of: (1) slice acquisition order correction; (2) 3D rigid-body motion correction; (3) voxelwise linear detrending across time; and (4) temporal bandpass filtering to remove low and high frequency (scanner and physiology related) noise. Distortions of EPI images were corrected with a simple affine transformation. Functional images were registered to the structural images and interpolated to cubic voxels. After coregistering participants' structural images to a standard image using a 12-parameter spatial transformation, their functional data were similarly transformed, along with a standard moderate degree of spatial smoothing (Gaussian 8 mm FWHM).

DATA ANALYSIS

Data were analyzed using the general linear model available on the Brain Voyager QX software package. We first performed exploratory analyses, where a series of regressions examined BOLD brain activity to each of the eight combinations of information resulting from consensus \times distinctiveness \times consistency. We computed contrast maps for the eight 7:1 contrasts (one cell versus the other seven), always averaged across the four sentences and 12 participants; these contrasts examined the signal change within the relevant regions significantly activated in the LLH combination information that led to a low-consensus dispositional attribution.⁴ We chose this cell because of its crucial role in dispositional inference. These regressors included the entire 20 seconds when the additional information screen was displayed. In addition, we report the average signal change value of all the clusters of voxels that overlay the neural region of interest, and provide the coordinates at the center of this cluster, not maximum values. Random effects analyses were performed on all imaging data. All data are presented with their coordinates based on a standard system (Talairach & Tournoux, 1988).

Additionally, we conducted region of interest (ROI) analyses. That is, we extracted the average signal change for each participant within a cluster of voxels to each of the eight combinations of information over the 20 seconds when the additional information was displayed. This resulted in a dependent variable that measures neural activity to each information combination in each region of interest. The ROIs focused on clusters of voxels significantly activated in the initial exploratory analysis to the LLH information, because LLH is the combination previously shown to elicit dispositional attribution (Harris et al., 2005; McArthur, 1972). We computed $2 \times 2 \times 2$ repeated measures ANOVAs on each cluster. We also created a series of linear regression models with this neural activity as the outcome variable, and either neural activity from other regions or the self-report measures collected after scanning as predictors.

4. We examined neural activity during presentation of the low-consensus dispositional attribution because previous research identified neural regions involved in dispositional attribution with this contrast (Harris et al., 2005).

RESULTS

BEHAVIORAL RATING DATA

Participants make dispositional attributions to objects at a rate well above the chance rate (12.5%) given low consensus, low distinctiveness, and high consistency information (LLH; 70.88%) and high consensus, low distinctiveness, and high consistency information (HLH: 27.13%; see Figure 2). This replicates the previous pattern to people (Harris et al., 2005; McArthur, 1972) and confirms the first hypothesis: Participants make dispositional attributions to objects in the same information combinations as they do for people. Participants made all attributions in seven seconds or less.

A repeated measures ANOVA reveals main effects for consensus, $F(1, 11) = 46.62$, $p < .05$, partial $\eta^2 = .81$, distinctiveness, $F(1, 11) = 36.45$, $p < .05$, partial $\eta^2 = .77$, and consistency, $F(1, 11) = 21.03$, $p < .05$, partial $\eta^2 = .66$. All two-way interactions are also significant: consensus \times distinctiveness, $F(1, 11) = 19.96$, $p < .05$, partial $\eta^2 = .65$, consensus \times consistency, $F(1, 11) = 8.50$, $p < .05$, partial $\eta^2 = .47$, and distinctiveness \times consistency, $F(1, 11) = 8.12$, $p < .05$, partial $\eta^2 = .43$. This fits more dispositional attributions in the HLH and LLH information combinations. The three-way interaction is not significant, $F(1, 11) = 1.55$, $p = .24$.

NEURAL DATA

Exploratory Analyses to Select ROIs. Recall that we predicted attribution-related activity in the amygdala and STS. The LLH, low-consensus, specific object attribution condition, indicated further analyses for both regions. The 7:1 contrast shows significantly more activity in bi-lateral *amygdala*, left— $t(11) = 2.91$, $p < .01$; 90 voxels, at $x = -23$, $y = -6$, $z = -9$; right— $t(11) = 2.92$, $p < .01$; 84 voxels, at $x = 27$, $y = -7$, $z = -11$; see Figure 3a) and the right *STS* $t(11) = 2.91$, $p < .01$; 84 voxels, at $x = 37$, $y = 1$, $z = -22$; (see Figure 4a). Significant neural activity is defined at $p < .01$ and at least 10 contiguous voxels.⁵ Both the STS and amygdala activity overlap with the neural findings for social cognition, but the lack of MPFC activity does not overlap. This suggests that dispositional attribution draws on different neural systems for objects and people. Nevertheless, the STS and amygdala do overlap, so we analyzed regions of interest and regressions.

Region of Interest (ROI) Analyses: STS. A time-course analysis reveals significantly more activity to the HLH *high-consensus* (object category) dispositional attribution over the entire 20 seconds, peaking in the first seven seconds (see Figure 4b). This fits the behavioral data showing the HLH information combination significantly more often leading to dispositional attribution than chance. In our prior research, only LLH showed STS effects for people. Here, when participants first receive the information, the STS is more active to categories of objects.

A repeated measure ANOVA reveals a significant main effect of consensus, $F(1, 11) = 7.79$, $p < .05$, partial $\eta^2 = .42$. No other main effects or interactions are significant. This suggests that high consensus activates the STS more than low consensus information. If the STS is activated in trajectory, a correlate of intent, then it suggests

5. Marginally significant activity occurs at $.10 > p > .01$. The LHL condition shows marginally more activity in the MPFC, $t(11) = 2.83$, $p = .02$; 2 voxels, at $x = 1$, $y = 53$, $z = 22$.

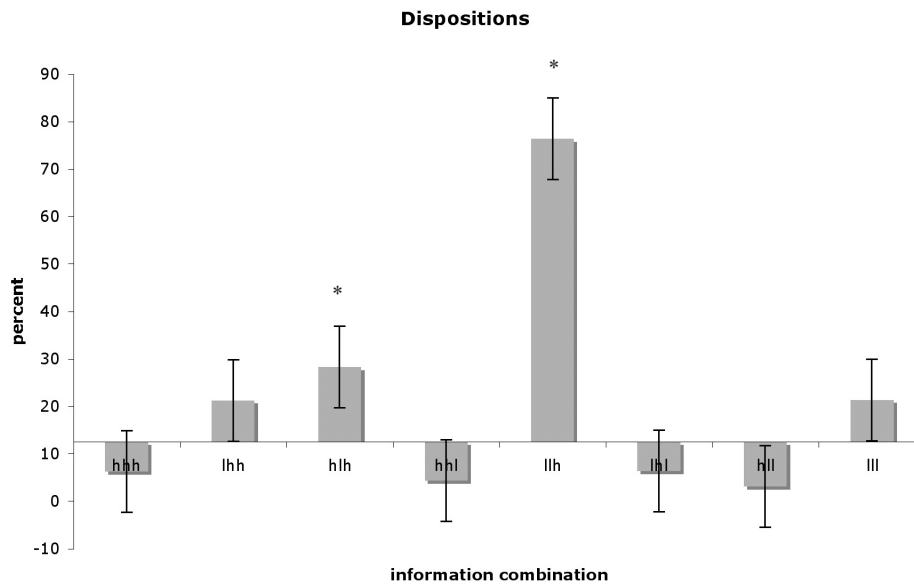


FIGURE 2. Dispositional attributions to objects. Dispositional attributions to objects when different combinations of information were displayed. The x-axis is at chance (12.5%); * indicates significantly different from chance.

that categories of objects engaged in the same behavior lead to greater inferences of trajectory/intent (Almost all pens roll off the table.).

Region of Interest (ROI) Analyses: Amygdala. The amygdala activity fits its prior activations in inferring intent, categorical processing, and certain kinds of affective responding. Time-course analyses of both amygdalae reveal that activity to LLH, low-consensus (specific object) dispositional attribution peaks late, in the last five seconds the information is on the screen (see Figures 3b & 3c). This suggests that the amygdala responses occur after the attributions have already been made, and may reflect activity in response to the attributions. As a result, we focus on the last five seconds of amygdala activity.

A significant main effect of consensus, $F(1,11) = 37.74, p < .05$, partial $\eta^2 = .77$ in *left amygdala* voxels shows lower consensus leads to more activity. This suggests that the idiosyncratic behavior of a single object activates the amygdala (Why does only this strange broom sit on the window sill?). The next step, examining the relationship between self-reported measures, activity in the initial STS response, and this late amygdala response suggests why the amygdalae are responding late to specific dispositional attributions.⁶

6. Also, a significant interaction—consensus \times consistency ($F(1, 11) = 8.92, p < .05$, partial $\eta^2 = .45$)—shows that low consensus, high consistency object behavior activates the area. A significant interaction of consensus \times consistency information, $F(1, 11) = 6.52, p < .05$, partial $\eta^2 = .37$, shows that low consensus, high consistency object behavior also activates the *right amygdala*. A marginally significant main effect of consensus, $F(1, 11) = 3.80, p = .08$, partial $\eta^2 = .26$ shows that low consensus information is higher in the (late) amygdala response.

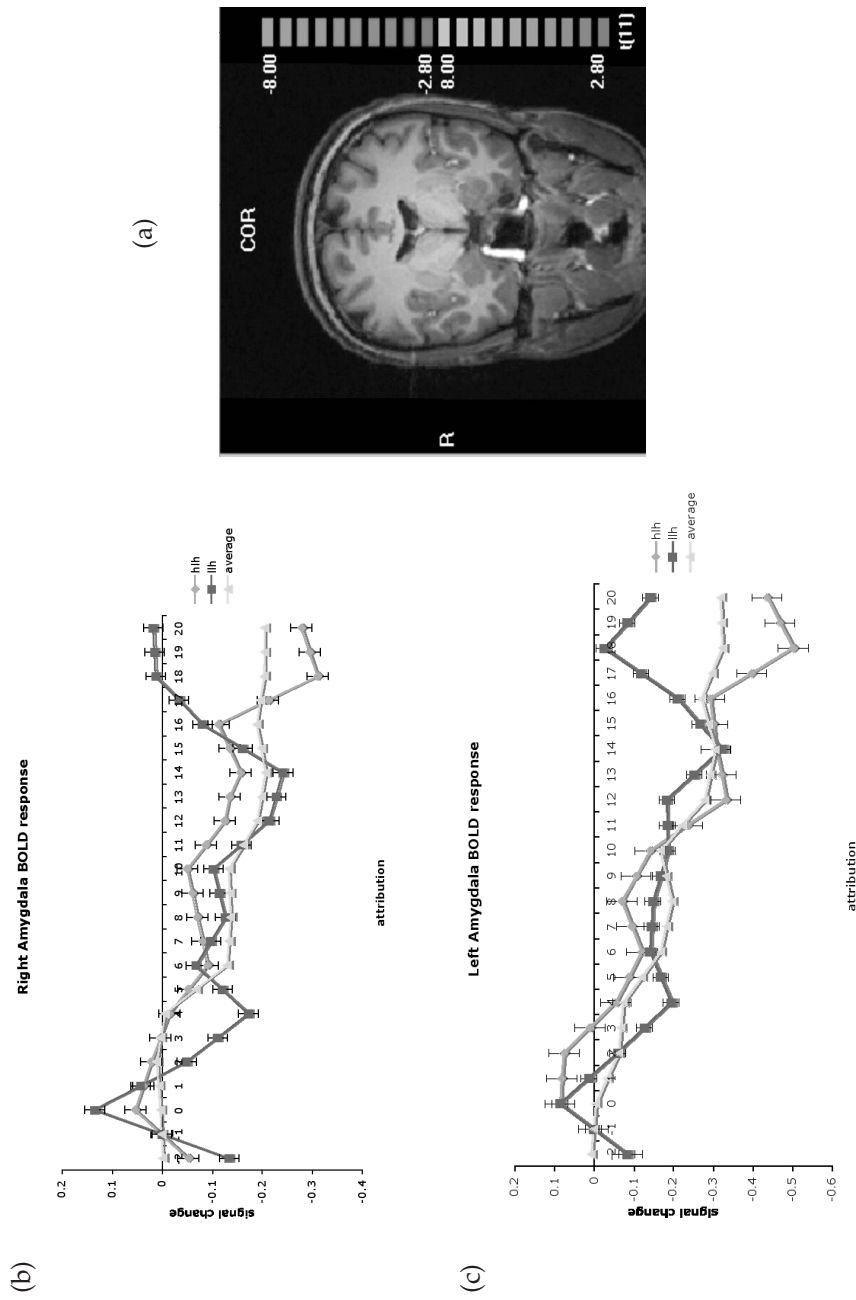


FIGURE 3. Neural response in left and right amygdala, showing (a) significant voxels and (b) & (c) time course over the 20 second period displaying the additional information screen.

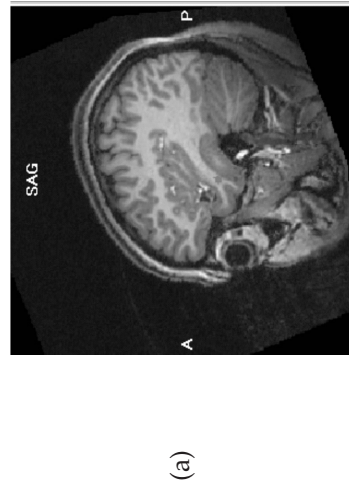
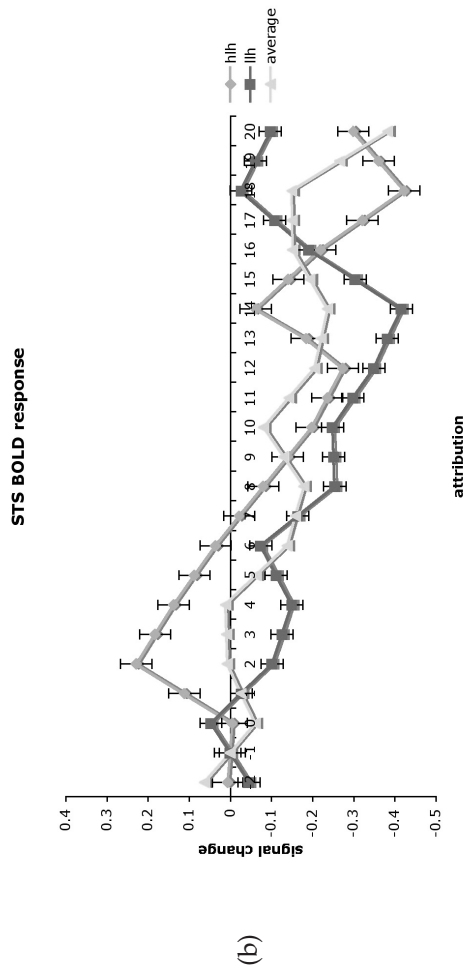


FIGURE 4. Neural response in left and right amygdala, showing (a) significant voxels and (b) & (c) time course over the 20 second period displaying the additional information screen. Neural response in STS, showing (a) significant voxels and (b) & (c) time course over the 20 second period displaying the additional information screen.

REGRESSIONS

Regressions tested whether self-reported anthropomorphism in the experiment as a whole, an individual difference measure, relates to neural activity. We entered ease of dispositional attribution, confidence in attributions, and anthropomorphism (how much the objects were generally thought of as a person) for each type of attribution as first-level predictors in regressions; neural activity from the ROIs during the LLH and HLH conditions as outcome variables.⁷

The first two regression models tested the self-report variables as predictors of *left amygdala* activity during the final seconds of high consensus (HLH) and low consensus (LLH) dispositional attribution information presentation. One model marginally predicts activity to *high consensus* dispositional attribution (HLH) in the last five seconds in the left amygdala voxels, $F(3, 7) = 2.77, p = .12$. Of the self-report variables, only reported anthropomorphism marginally predicts this left amygdala activity to the high consensus dispositional attribution, $t(11) = 2.25, p = .06; \beta = .64$. This suggests the *more* participants report anthropomorphizing, the *greater* their left amygdala activity during the last five seconds when high-consensus information is displayed. No other significant effects emerged for other information combinations. It suggests that *greater anthropomorphism increases the late amygdala response to categories of objects*.

The second pair of regression models tested the self-report variables as predictors of *right amygdala* activity during the final seconds of high consensus (HLH) and low consensus (LLH) dispositional attribution information presentation. There were no significant effects.

Finally, a pair of regression models tested the relationship between the self-report measures on the initial seven seconds of *STS activity* for dispositional attributions to categories (HLH) and specific objects (LLH). One model significantly predicts activity during the initial seven seconds of STS activity for *high consensus* HLH dispositional attribution, $F(3,7) = 4.74, p < .05$. Again, only anthropomorphism significantly predicts this STS activity during high consensus dispositional attribution, $t(11) = 3.23, p < .05; \beta = .78$: the *more* participants reported anthropomorphizing, the *greater* their initial STS activity during the initial seven seconds when high consensus information was on the screen. There are no significant effects for specific object dispositional attributions. This suggests that *greater self-reported anthropomorphism predicts activity in STS for dispositional attributions only to categories of objects*. Paired with the earlier result—*greater anthropomorphism increasing the late left amygdala response to categories of objects*—this suggests that anthropomorphizing entire object categories (an army of brooms) activates both vigilance and trajectory/intent systems.

DISCUSSION

All hypotheses received support: Participants did make dispositional attributions to objects, STS and amygdala did activate to these attributions, and self-reported anthropomorphism as an individual difference predicts neural activity. Specifi-

7. These items (ease of dispositional attributions, confidence in attributions, and reported anthropomorphism) as a scale have a weak $\alpha = .65$. Moderate inter-correlations range from $r = .28$ to $.48$. Since the three are not redundant, we treated them as independent constructs.

cally, participants make dispositional attributions to objects at above-chance levels when either high or low consensus is added to low distinctiveness and high consistency information, the same conditions under which they attribute dispositions to people. Here, people make dispositional attributions to both categories of objects (HLH) and specific objects (LLH). Also, in exploratory neural analyses, both STS and amygdala show greater overall activation for dispositional attributions to specific objects. However, more sensitive time-course analyses reveal initial STS activation for dispositional attributions to entire categories of objects, while the amygdala shows a late response to specific objects. Anthropomorphism predicts both early STS and late amygdala activity to object categories.

Although individual differences in anthropomorphism predict neural activity, the neural patterns do not replicate neural patterns of dispositional inferences to people in one important respect, namely the lack of medial prefrontal cortex (MPFC) activation, a staple of social cognition studies and a clear result for both LLH (low consensus, specific person) and HLH (high consensus, all people) conditions in our previous work. This points to differences in thinking about the mind of a person versus an object, even though people may imagine categories of objects having trajectories or even intent. One can imagine an army of brooms menacing the sorcerer's apprentice, without thinking about their minds as humanly complex.

The difference between low-consensus attributions to specific objects and high-consensus attributions to categories of objects appears in the amygdala. Other social neuroscience research that implicates the amygdala in social categorical processing also shows that this neural area is moderated by familiarity, either through repetition or habituation (Hart et al., 2000), or prior familiarity (Phelps et al., 2000). Perhaps then specific objects to which we make dispositional attributions tend to be familiar. Our own computers, cars, and even pens receive the endowment effect (Thaler, 1980) and as such may not be especially emotionally arousing when anthropomorphized. But dispositional attribution to categories of object may lead to emotional arousal because this may be unfamiliar behavior by a group of objects. One sheet of paper lying on the grass, or a single pen rolling off a table does occasionally occur, but a lot of paper or a lot of pens all engaged in the same action may lead to increased vigilance because it is strange.

Familiarity also plays a role in the complimentary cognitive process dehumanization. Social neuroscience research shows that extreme outgroups that do not elicit a complex social emotion and do not elicit MPFC activity above a fixation baseline (Harris & Fiske, 2006). Like the basic emotion disgust, this dehumanized perception is characterized by a failure to think about the minds of these social targets. Familiarity moderates this effect (Harris, 2007).

Anthropomorphism may differ depending on the category level of the target. Though this paper is not an initial demonstration of intentional agency to objects, it is an initial demonstration of dispositional attributions to objects using the same criteria as dispositional attributions to people. We show dispositional anthropomorphism of objects, different from attributing intent. Nonwestern societies attribute intent to nature, a multifaceted collection of objects. This anthropomorphism engenders awe, fear, and respect in people. These forms of anthropomorphism may be just as common as the anthropomorphism of nonnatural objects such as personal items—cars and computers (Reeves & Nass, 1996). Nevertheless, we suggest that despite its comparable frequency, anthropomorphism of object categories may be an unsettling process.

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