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## Abstract

Human survival depends on identifying targets potentially capable of engaging in meaningful social connection. Using sets of morphed images created from animate (human) and inanimate (doll) faces, we found converging evidence across two studies showing that the motivation to connect with other people systematically alters the interpretation of the physical features that signal that a face is alive. Specifically, in their efforts to find and connect with other social agents, individuals who feel socially disconnected actually decrease their thresholds for what it means to be alive, consistently observing animacy when fewer definitively human cues are present. From an evolutionary perspective, overattributing animacy may be an adaptive strategy that allows people to cast a wide net when identifying possible sources of social connection and maximize their opportunities to renew social relationships.

## Keywords

social perception, motivation, face perception, loneliness, interpersonal relationships

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Social relationships are a vital aspect of human life (Baumeister & Leary, 1995). Failure to satisfy the need for close social connections is associated with a host of mental and physical health problems, including increased stress hormones (Adam, Hawkley, Kudielka, & Cacioppo, 2006) and increased blood pressure (Hawkley, Masi, Berry, & Cacioppo, 2006), as well as depression and suicidal tendencies (Cacioppo, Hughes, Waite, Hawkley, & Thisted, 2006).

Feeling disconnected from other people activates the desire to replenish social connections and motivates social behaviors aimed at accomplishing this goal (DeWall, Baumeister, & Vohs, 2008). Past research has demonstrated that compared with socially connected people, socially disconnected individuals more readily and accurately identify social information (Gardner, Pickett, & Brewer, 2000; Gardner, Pickett, Jefferis, & Knowles, 2005; Pickett, Gardner, & Knowles, 2004), are more sensitive to emotional intonation (Pickett et al., 2004), and display a greater desire to make new friends and work cooperatively with other people (Maner, DeWall, Baumeister, & Schaller, 2007). This pattern

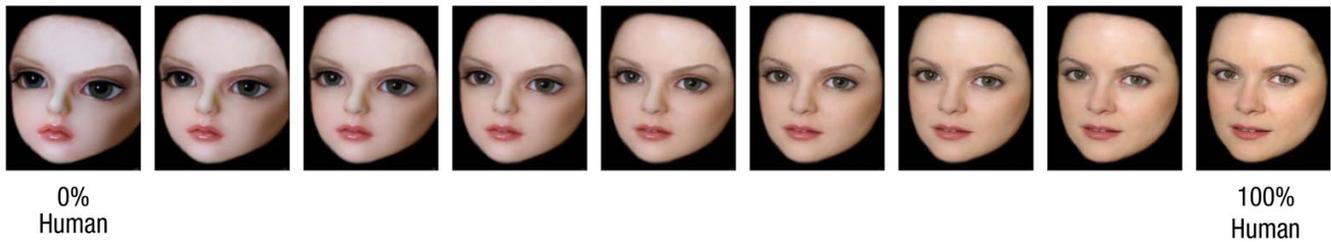
highlights the overarching goal of reestablishing connections with other people.

Engaging in social encounters requires efficiently detecting targets in the environment that are potentially capable of meaningful mental connection (e.g., another living human). Indeed, humans are preferentially tuned to detect other faces (Langton, Law, Burton, & Schweinberger, 2008; Ro, Russell, & Lavie, 2001) and discriminate carefully between faces that are alive and those that are not (Looser, Guntupalli, & Wheatley, 2013; Looser & Wheatley, 2010; Wheatley, Weinberg, Looser, Moran, & Hajcak, 2011). However, when connection with other humans is deemed impossible, the drive to fulfill this motivation may manifest itself in the attribution of mental states to nonhuman entities, such as gadgets and pets (Epley, Akalis, Waytz, & Cacioppo, 2008).

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**Fig. 1.** Example continuum of morph stimuli used in the two studies.

We suggest that when the motivation for social connection is unfulfilled, individuals may require less bottom-up evidence to detect the most basic of social cues: whether a face is alive. From this perspective, as other people become more motivationally relevant to perceivers, the threshold at which physical cues signal that a face is alive should be lowered and relaxed. To date, the putative relationship between motivation for social connection and biases in animacy detection has not been empirically tested. In the two studies reported here, we used both chronic and situational measures of social disconnection to test the hypothesis that feeling greater motivation to seek out social connections would prompt people to more readily perceive animacy in their environment.

## Study 1

### Method

**Participants.** Thirty undergraduates (22 female, 8 male; age range = 18–21 years) were recruited for Study 1 and paid for their participation. Responses from 1 participant indicated a clear misunderstanding of the response labels, so this individual was excluded from all analyses. Participants gave consent in accordance with the guidelines set by the Committee for the Protection of Human Subjects at Dartmouth College. Sample sizes for both studies were determined on the basis of the studies reported in Looser and Wheatley (2010).

**Stimuli.** Stimuli consisted of animacy morphs from Looser and Wheatley (2010). Morphs were created by combining inanimate faces (e.g., dolls, statues) with comparable human faces, which resulted in sets of images ranging from 0% human to 100% human. Study 1 employed images selected from nine points spaced across these morph continua, including the spectrum end points (see Fig. 1). Ten unique face identities (five male, five female) were used, for a total of 90 morphs. All faces were resized to  $416 \times 500$  pixels and placed onto a black background.

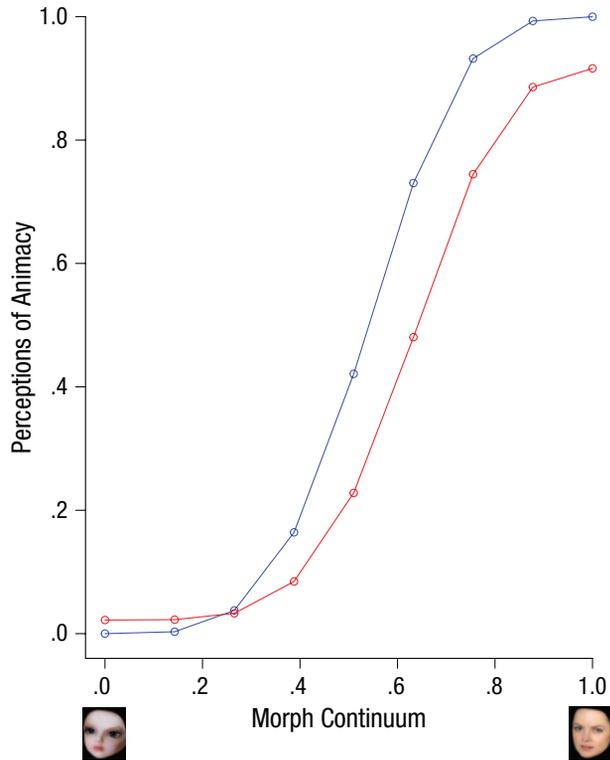
**Experimental design.** Each trial began with participants clicking a “start” button located in the bottom center of the screen. Once clicked, a face appeared, and participants were instructed to categorize that face as either “animate” or “inanimate” by clicking the corresponding label located at either the top-left or top-right corner of the screen. Faces were presented in a random order, and the location of the labels on the screen was counterbalanced across participants. Before the experiment began, participants completed eight practice trials to ensure familiarity with the instructions and computer software. The practice trials were identical to the experimental trials, with the exception that unique face identities were used for the animacy morphs in the practice trials.

Immediately following the task, all participants filled out the Need to Belong (NTB) Scale (Leary, Kelly, Cottrell, & Schreindorfer, 2013), a 10-item questionnaire designed to assess an individual’s desire for social connections. Participants indicated the degree to which each statement (e.g., “I want other people to accept me”) applied to them, using a scale from 1 (*strongly disagree*) to 5 (*strongly agree*). The NTB Scale demonstrated adequate reliability in this sample ( $\alpha = .78$ ).

### Results and discussion

Scores on the NTB Scale ranged from 21 to 43 (possible range: 10–50;  $M = 32.2$ , 95% CI = [29.7, 34.7]), with higher scores signaling greater desire for social connection. As an initial step to examine whether motivation for social connection systematically biased perceptions of animacy, we analyzed each participant’s categorization performance using a standard psychometric approach (see Yssaad-Fesselier & Knoblauch, 2006). Individual psychometric functions (e.g., Fig. 2), representing the proportion of animate categorizations across the 9-point morph continuum,  $P(c)$ , were constructed for each participant using the following equation:

$$P(c) = \gamma + (1 - \gamma - \lambda) \left( 1 - e^{-(c/\alpha)^\beta} \right)$$



**Fig. 2.** Psychometric functions depicting perceptions of animacy (proportion of faces categorized as animate) at each point along the morph continuum. The functions shown are for individual participants from Study 1 who scored approximately 1 *SD* above (blue line) and 1 *SD* below (red line) the mean on the Need to Belong Scale (Leary, Kelly, Cottrell, & Schreindorfer, 2013).

The psychometric functions were modeled using the Weibull function, and certain starting parameters—for example, the steepness of the curve ascent ( $\beta$ ) and the upper ( $\lambda$ ) and lower ( $\gamma$ ) asymptotes of the function—were adjusted on a participant-by-participant basis to achieve the best fit between the model and the data (using maximum-likelihood estimates). From these functions, we calculated threshold parameters ( $\alpha$ ) for each participant. This parameter provided a quantitative measure of the point at which participants began consistently observing animacy, with lower thresholds indicating detection of animacy when fewer distinctly human features were present.

On average, participants reached this threshold when faces were 68.9% human (95% CI = [64.6, 73.2], range = 53.0–99.8). These values are consistent with prior work revealing that faces must contain significantly more than 50% human features to be considered alive (Hackel, Looser, & Van Bavel, 2014; Looser & Wheatley, 2010). As predicted, threshold parameters varied as a function of individual differences in desire for social connections. Specifically, increasing desire for social connections (i.e., higher NTB scores) was associated with decreasing

threshold parameters,  $r(29) = -.37$ , 95% CI = [–.65, –.01] (see Fig. 3a). That is, individuals highly motivated to seek out social connections were more likely to perceive animacy with fewer human cues. NTB scores accounted for 14% of the variance in threshold parameters.

From these functions, we also calculated the point of subjective equality (PSE), which represents the point at which a face was equally likely to be deemed animate or inanimate, for each participant. PSEs were strongly correlated with threshold parameters,  $r(29) = .999$ , and maintained the same inverse relationship with NTB scores,  $r(29) = -.36$ , 95% CI = [–.64, .01].

## Study 2

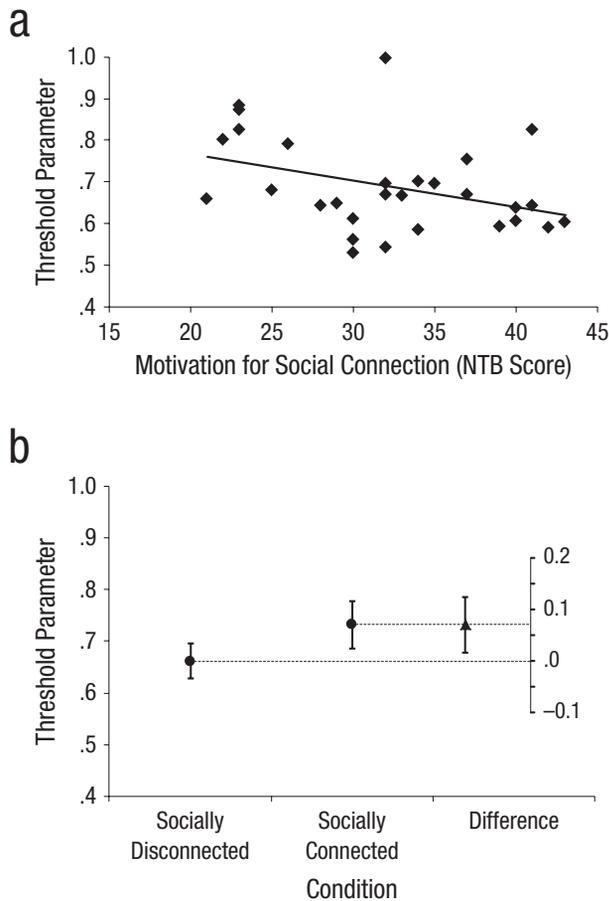
In Study 1, we demonstrated that individual differences in the desire for social connections predict sensitivity to animacy cues in a face. In Study 2, we used an experimental manipulation to demonstrate a causal link between motivation for social connection and biases in animacy detection.

## Method

**Participants.** Forty-nine undergraduates were recruited for Study 2. Seven participants were dropped from final analyses, either because of experimenter error during the practice trials ( $n = 2$ ) or because the threshold for animacy detection was never reached, which made it impossible to calculate usable threshold parameters ( $n = 5$ ). This resulted in a final sample of 42 participants (33 female, 9 male; age range = 18–21 years). Participants received course credit in exchange for their participation. All participants gave consent in accordance with the guidelines set by the Committee for the Protection of Human Subjects at Dartmouth College.

**Experimental design.** To manipulate motivation for social connection, we employed a modified version of the future-alone-versus-future-belonging paradigm, which has been used extensively to induce feelings of social loss and disconnection (e.g., Baumeister, Twenge, & Nuss, 2002; DeWall et al., 2008; DeWall, Maner, & Rouby, 2009; Epley et al., 2008; Powers, Wagner, Norris, & Heatherton, 2013; Twenge, Baumeister, Tice, & Stucke, 2001).

We told participants that this study was investigating the relationship between personality and categorical perception. Participants first completed a computerized version of the Eysenck Personality Questionnaire (Eysenck & Eysenck, 1975), and we subsequently provided them with feedback ostensibly derived from their answers. In reality, feedback was randomly assigned prior to the experimental session. One group of participants ( $n = 22$ ) were told that their future lives would be isolated and



**Fig. 3.** Results from Study 1 and Study 2. The scatter plot (with best-fitting regression line) in (a) shows threshold parameters from Study 1 participants plotted as a function of their scores on the Need to Belong (NTB) Scale (Leary, Kelly, Cottrell, & Schreindorfer, 2013). The graph in (b) shows mean threshold parameters from Study 2 as a function of social-connection condition. The difference between the group means is depicted on the floating axis. Error bars represent 95% confidence intervals.

lonely (socially disconnected), whereas the other group ( $n = 20$ ) were told that their lives would be filled with long-lasting, stable relationships (socially connected). For increased believability, the feedback also included personality descriptions typically believed by the average person (i.e., the *Barnum effect*; Snyder, Shenkel, & Lowery, 1977), as well as two statements regarding self-esteem and social skills tailored to each participant (based on self-report information obtained in a mass survey). Immediately after receiving feedback, participants completed a 24-item mood questionnaire (Vohs & Heatherton, 2001) using a scale from 1 (*strongly disagree*) to 4 (*strongly agree*), so we could assess the effectiveness of the manipulation.

Participants then completed the same face-categorization task used in Study 1. To reduce potential confusion regarding the meaning of the response labels, we

instructed participants this time to categorize each face as simply “alive” or “not alive.” The rest of the experimental protocol was identical to that of Study 1. At the end of the study, all participants were thoroughly debriefed regarding the fictitious nature of the feedback they had received.

## Results and discussion

Analysis of the 24-item mood questionnaire revealed that socially disconnected participants reported being in a more negative mood ( $M = 54.8$ , 95% CI = [48.9, 60.6]) than socially connected participants ( $M = 47.0$ , 95% CI = [41.4, 52.6]). The estimated difference between the means was 7.8 (95% CI = [-0.15, 15.7]), which is not a large effect. However, prior work using this paradigm has consistently failed to find any effects of generalized negative mood (e.g., Baumeister et al., 2002; Maner et al., 2007; Twenge et al., 2001), and even when differences in mood were observed, they did not mediate any of the reported effects (e.g., DeWall et al., 2009; Powers et al., 2013).

As in Study 1, we fit individual psychometric functions and calculated threshold parameters for each participant. Similarly to Study 1, threshold parameters ranged from .522 to .910 ( $M = .694$ , 95% CI = [.666, .724]). Examination of the extent to which social disconnection affected threshold parameters revealed that socially disconnected individuals displayed lower threshold parameters ( $M = .661$ , 95% CI = [.627, .695]) than socially connected individuals ( $M = .732$ , 95% CI = [.686, .777]). The estimated difference between the means was .07, 95% CI = [.02, .13], Cohen's  $d = 0.83$  (see Fig. 3b). That is, social disconnection lowers the threshold for animacy detection by approximately 7%. Though the numerical value of this shift is relatively small, Cohen's  $d$  indicates that this is a large effect. This shift in perceptions of animacy suggests that social disconnection prompts individuals to be less stringent than socially connected individuals when attributing animacy to potential social contacts. Again, PSEs were strongly correlated with threshold parameters,  $r(42) = .999$ , and were similarly modulated by social disconnection, estimated mean difference = .07, 95% CI = [.02, .12].

## General Discussion

As a social species, humans' ability to sustain meaningful relationships with other people is critical for survival. Engaging in social encounters necessitates efficiently detecting targets in the environment capable of making meaningful mental connections (Heatherton, 2011; Wheatley, Kang, Parkinson, & Looser, 2012). Across two studies, we showed that the motivation to connect with other people systematically biases this perceptual ability. Compared with individuals who felt socially connected, individuals characterized by a chronic desire for social

connections (Study 1), or those who have these needs momentarily heightened through an experimental manipulation (Study 2), were consistently more likely to say a morphed face was alive.

People seem to be exceptionally conservative in their judgments of animacy. Prior work revealed that the physical features of a face must be predominately human (i.e., significantly toward the human end of the morph continuum) in order for people to attribute the qualities of life and mind (Looser & Wheatley, 2010). In the present studies, we showed that increasing the motivational relevance of other people reliably reduces the amount of humanness a face must contain to be considered alive. From an evolutionary perspective, people who can more readily detect animacy can cast a wider net when identifying possible sources of social connection, which thereby allows these individuals to maximize opportunities for renewing social relationships. Though refinement of these judgments may follow as realistic sources of affiliation are parsed (Maner et al., 2007), the initial perceptual bias we have demonstrated suggests that overattributing animacy may be a fundamentally adaptive strategy.

The ability to perceive that people have minds capable of conscious thought (e.g., mind perception) has been identified as a close proxy of animacy (Looser & Wheatley, 2010). Effective and harmonious interactions among social-group members require the capacity to recognize and infer the contents of the thoughts of other people (Frith & Frith, 2001; Heatherton, 2011). Considered in this light, our findings suggest that social disconnection may similarly influence the extent to which people engage in mental-state attribution. Indeed, increased attempts to accurately decode what other people are thinking and feeling could facilitate attempts at social reconnection (Heatherton, 2011).

More broadly, these implications contribute to the conceptualization of mind perception as a dynamic process in which contextual information and motivational states interact with bottom-up visual cues to affect an individual's ability to understand the thoughts and feelings of others. Consistent with this reasoning, prior studies have documented modulation of mind perception in the presence of other social motivations, including dehumanization (Waytz & Epley, 2012), social identity (Hackel et al., 2014), and out-group threat (Hackel et al., 2014). Moreover, the consistency between the precise threshold shift we report here (approximately 7%) and those documented in prior studies investigating mind perception (between 4% and 8%; Hackel et al., 2014) underscores the reliability of the influence of basic social motives on perceptions of life and mind.

The need for social interaction is a pervasive and powerful human drive. Across two studies, we uncovered converging evidence demonstrating that the motivation

for social connection reliably alters the interpretation of the physical features in a face that signal animacy and the presence of another mind. Given the physical and psychological consequences associated with the lack of social relationships (Baumeister & Leary, 1995), overattributions of animacy when social contacts are lacking may be a fundamentally adaptive strategy.

### Author Contributions

K. E. Powers, J. B. Freeman, T. Wheatley, and T. F. Heatherton designed the research; K. E. Powers and A. L. Worsham performed the research; K. E. Powers analyzed the data and drafted the manuscript; and A. L. Worsham, J. B. Freeman, T. Wheatley, and T. F. Heatherton provided critical revisions. All authors approved the final version of the manuscript for submission.

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### Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

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