**Insufficient evidence of a positive association between chronic loneliness and anthropomorphism: Replication and extension Registered Report of Epley et al. (2008)**

Qinyu Xiao

Department of Occupational, Economic, and Social Psychology, Faculty of Psychology, University of Vienna, Vienna, Austria

qinyu.xiao@univie.ac.at

ORCID: 0000-0002-9824-9247

Mahmoud M. Elsherif

University of Leicester, United Kingdom

[mahmoud.medhat.elsherif@gmail.com](http://mahmoud.medhat.elsherif@gmail.com)

ORCID: 0000-0002-0540-3998

#Hoi Yan Chu, #Ming Chun Tang, #Ting Hin Angus Wong, #Yiming Wu

University of Hong Kong, Hong Kong S.A.R., China

u3547750@connect.hku.hk / u3547750@outlook.com

mctang20@connect.hku.hk / alantmc3902@gmail.com

u3547269@connect.hku.hk / anguswong1022@gmail.com

wym98@connect.hku.hk / wendy.wu.hku@gmail.com

#Christina Pomareda

University of Birmingham, United Kingdom

CXP997@bham.ac.uk

ORCID: 0000-0001-7386-297X

^Gilad Feldman

University of Hong Kong, Hong Kong S.A.R., China

gfeldman@hku.hk / giladfel@gmail.com

ORCID: 0000-0003-2812-6599

# Contributed equally, joint third author

^ Corresponding author

## Author contribution

Hoi Yan Chu, Ming Chun Tang, Ting Hin Angus Wong, and Yiming Wu developed the study concept and wrote the initial Stage 1 Registered Report draft under the supervision of Qinyu Xiao and Gilad Feldman. Mahmoud Elsherif, Christina Pomareda, and Qinyu Xiao finalized the Stage 1 submission with editing by Gilad Feldman. Gilad Feldman performed pre-registration after in-principle acceptance and collected data. Qinyu Xiao wrote the initial Stage 2 draft. Mahmoud Elsherif provided feedback, and Gilad Feldman reviewed it for submission. Gilad Feldman acquired funding, administered the project, and curated the data.

**Declaration of conflict of interest**

The authors declared no potential conflicts of interest concerning the authorship and/orpublication of this article.

**Corresponding author**

Gilad Feldman, Department of Psychology, University of Hong Kong, Hong Kong S.A.R., China; gfeldman@hku.hk.

**Rights**

CC-BY or equivalent license is applied to the AAM arising from this submission. ([clarification](https://bit.ly/rrs-primer))

## Contributor roles taxonomy

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Role** | **Qinyu Xiao** | **Mahmoud Elsherif** | **H.Y.C., M.C.T., T.H.W., & Y.W.** | **Christina Pomareda** | **Gilad Feldman** |
| Conceptualization |  |  | X |  | X |
| Pre-registration | X |  | X | X |  |
| Data curation |  |  |  |  | X |
| Formal analysis | X | X |  |  |  |
| Funding acquisition |  |  |  |  | X |
| Investigation | X | X | X |  |  |
| Pre-registration peer review / verification | X | X |  | X | X |
| Data analysis peer review / verification | X | X | X | X |  |
| Methodology | X | X | X |  |  |
| Project administration |  |  |  |  | X |
| Resources |  |  |  |  | X |
| Supervision | X |  |  |  | X |
| Validation | X | X |  |  | X |
| Visualization | X | X |  |  |  |
| Writing – original draft | X |  |  |  |  |
| Writing – review and editing | X | X |  |  | X |

# PCI-RR Study Design Table

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Question | Hypothesis | Sampling plan | Analysis plan | Rationale for deciding the sensitivity of the test for confirming or disconfirming the hypothesis | Interpretation given different outcomes | Theory that could be shown wrong by the outcomes |
| What is the relationship between loneliness and anthropomorphism? | Loneliness is positively associated with anthropomorphism (because higher loneliness implies stronger sociality motivation). | We conducted *a priori* power analysis based on existing effect size estimates. We further enlarged this sample size given our budget. The final sample size is over 2 times the required sample size suggested by our power analysis (assuming a power of .95 for detecting existing effect sizes in the literature). | Pearson correlation (loneliness/free will belief and each of the anthropomorphism measures) | Based on effect sizes reported in previous, conceptually similar studies | If we fail to find a positive relationship between loneliness and anthropomorphism, it could be because: (1) the three-factor theory does not apply in this study context; (2) the anthropomorphism measure(s) are not valid; (3) the sample size is not large enough (the true effect size is too small). | Three-factor theory of anthropomorphism (Epley et al., 2007) |
| What is the relationship between free will belief and anthropomorphism? | Free will belief is associated with anthropomorphism (but we don’t know in which direction). | This is an extension. As such, we do not have a sampling plan for testing this hypothesis. | Not Applicable | An association in either direction is possible given the literature and our reasoning (see manuscript for details). | Not Applicable |
| What is the relationship between perceived controllability of non-human objects and anthropomorphism of them? | Perceived controllability is negatively associated with anthropomorphism (because the former is positively associated with effectance motivation). | This is an extension. As such, we do not have a sampling plan for testing this hypothesis. | Linear mixed-effects models (predicting anthropomorphism with perceived controllability and covariates) | Not Applicable | Same as in Q1 | Three-factor theory of anthropomorphism (Epley et al., 2007) |

# Abstract

Human beings have a fundamental need to connect with others. Epley, Akalis, et al. (2008) found that people higher in chronic loneliness had a stronger tendency to anthropomorphize non-human objects, presumably for fulfilling unmet needs for social connection. In this Registered report, we conducted a replication of Epley, Akalis, et al. (2008): based on the setup of their Study 1, we examined the correlations between loneliness and anthropomorphism of technological gadgets (original Study 1) and pets (original Study 3) and belief in supernatural beings (original Study 2), with a large U.S. online sample recruited from MTurk using CloudResearch (*n* = 885 after exclusions). Meanwhile, we extended the replication by examining the association between belief in free will and anthropomorphism. We found weak-to-no empirical support for the original finding that self-reported chronic loneliness was positively related to anthropomorphism. However, our evidence supports that the perceived controllability of gadgets negatively predicts their anthropomorphism and that free will belief is positively associated with belief in and anthropomorphism of supernatural beings. Study materials, data, and analysis scripts are available at <https://osf.io/2sb7x/>.

*Keywords*: anthropomorphism, free will belief, loneliness, replication, Registered Report

# Insufficient evidence of a positive association between chronic loneliness and anthropomorphism: Replication and extension Registered Report of Epley et al. (2008)

Human beings have a fundamental need for social connection (Baumeister & Leary, 1995), and this need motivates people to socialize when they feel lonely. Yet, very often, one has no immediately available others to connect with. At such times, it has been proposed that people *anthropomorphize* their surroundings (i.e., attributing the behavioral characteristics and mental states of humans to non-human objects) as an alternative way to satisfy their sociality needs (Epley, Akalis, et al., 2008; Epley, Waytz, et al., 2008; Epley et al., 2007). In this research, we revisited the positive association between anthropomorphism and sociality motivation (as proxied by the level of chronic loneliness) by replicating Epley, Akalis, et al. (2008), one of the first empirical investigations providing evidence for this association. In the following, we briefly introduce the theoretical background of the sociality motivation–anthropomorphism association, outline our motivation for conducting this replication, and present an overview of our replication study and our extensions to it.

## Three-factor theory of anthropomorphism

The most influential account of anthropomorphism as a psychological phenomenon is the three-factor theory (Epley et al., 2007). It suggests that people anthropomorphize a non-human target (1) when it elicits accessible knowledge about human beings (e.g., when the target has a human-like “face”), (2) when motivated to understand, explain, predict, and control their surroundings, and (3) when motivated to establish social connections and affiliations. In other words, *elicited agent knowledge*, *effectance motivation* (White, 1959), and *sociality motivation* are three key determinants of anthropomorphic tendency. These general determinants can affect anthropomorphism via specific dispositional, situational, developmental, and cultural factors. For instance, individual differences in chronic loneliness—a dispositional variable—were found to be positively associated with anthropomorphic tendencies (Epley, Akalis, et al., 2008, Study 1; Epley, Waytz, et al., 2008, Study 1). Temporarily induced social disconnection—a situational variable—can also increase anthropomorphism (Epley, Akalis, et al., 2008, Studies 2 and 3). Because both chronic loneliness and temporary social disconnection create a sociality motivation, they increase anthropomorphism via the same determinant.

## Replication target and motivation for replication

In this research, we attempted to replicate Epley, Akalis, et al. (2008). Study 1 of the article measured participants’ anthropomorphism (i.e., the extent to which targets have “a mind of its own,” “intentions,” “consciousness,” etc.) toward a series of technological gadgets, several non-anthropomorphic ratings of the gadgets (e.g., attractiveness), and their chronic loneliness levels (with a short 3-item scale from Hughes et al., 2004). The study found that anthropomorphism and loneliness were positively correlated after non-anthropomorphic ratings were controlled for. Study 2 used an experimental approach and manipulated social connection by suggesting to participants that they would either end up lonely in their lives or be strongly socially connected, ostensibly based on their responses to a personality questionnaire (Twenge et al., 2001). It was found that those induced to feel socially disconnected had stronger beliefs in supernatural agents (e.g., God, ghosts), regardless of their baseline levels of religiosity. Finally, Study 3 induced socially disconnected, fearful, or neutral feelings (in a control condition) in participants by having them watch emotionally laden video clips. Participants then reported their beliefs in supernatural agents (like in Study 2), chose adjectives that best described their pets from a given list, and noted down what they saw from a series of ambiguous figures. It was found that participants in the social disconnection condition reported higher beliefs in supernatural beings and chose more anthropomorphic adjectives (e.g., thoughtful, considerate) to describe their pets than those in the fear and control conditions. In contrast, participants in the fear condition detected more faces from ambiguous figures than those in the other two conditions. According to the authors, this finding illustrated that the observed anthropomorphism effects were “not simply produced by any negative emotional state,” but specifically by a feeling of loneliness, or social disconnection (Epley, Akalis, et al., 2008). Overall, their results supported the idea that sociality motivation increases anthropomorphism.

Later studies have largely corroborated these findings. Both self-rated and temporarily induced loneliness were found to be positively associated with anthropomorphizing a wide range of non-human targets, including smartphones, computers, animals, and robots (Eyssel & Reich, 2013; Shin & Kim, 2020; Wang, 2017), and preferences for anthropomorphized targets, such as consumer product brands (Chen et al., 2017). There is also preliminary evidence suggesting that a lack of social connection may account for the particularly strong anthropomorphic tendencies in people with autistic traits (Caruana et al., 2021) and hoarding behaviors (Burgess et al., 2018; Neave et al., 2015).

Despite this body of evidence, we decided to replicate Epley, Akalis, et al. (2008) for three reasons: (1) the article has had a high impact in the field of social perception (about 900 citations on Google Scholar as of February 2024), (2) the studies had relatively small sample sizes (total *N* = 176 for three separate studies), and (3) later replications found mixed evidence.

For instance, Open Science Collaboration (2015) reported a partial replication of the original Studies 2 and 3, which failed to find support for the original results. The replication found insufficient evidence that participants assigned to a social disconnection condition (vs. control or fear condition) believed in supernatural beings and anthropomorphized their pets more (see <https://osf.io/m5a2c> for the replication report). Nevertheless, these results should be interpreted cautiously, because the study might not have successfully manipulated participants’ emotional experiences: participants assigned to the social disconnection condition did not report feeling lonelier than those in the other conditions; also, those assigned to the fear condition did not report feeling more fearful. The replication also had a small sample size (81 participants in three between-subjects conditions). Given that a two-tailed independent-samples *t*-test with 27 data points per sample would have .80 power to only detect effects larger than *d* = 0.78, an untypically large effect in social psychology (Jané et al., 2024), this replication was probably underpowered.

In a conceptual replication with a larger sample (*n* under analysis = 178), Bartz et al. (2016) randomly assigned participants to recall relationships with either a close other or an acquaintance and found that chronic loneliness positively predicted the anthropomorphism of technological gadgets regardless of experimental condition, *r*partial = .17. Also, those who recalled a close relationship (vs. relationship with an acquaintance) anthropomorphized the gadgets less after chronic loneliness was controlled for, *r*partial = −.15. There was, however, no support for any of these effects on anthropomorphism of participants’ pets. In addition, the reported effect sizes in this conceptual replication were much smaller than those in the original studies. It is worth noting that, like the Open Science Collaboration (2015) replication, Bartz et al. (2016) might not have had sufficient power to detect weak effects. With 178 participants, one has about .63 power to detect a *r*partial = .17 in a two-tailed test for a coefficient in a multiple regression model with four predictors, as in Bartz et al.’s analysis. Had the study been sufficiently powered, they would likely have obtained much smaller *p*-values than those reported, which were just below the .05 significance threshold (Simonsohn et al., 2014).

Given the impact of the original findings, the mixed evidence from and the limitations of previous (conceptual and direct) replications, we attempted a close high-power replication of the three studies reported in Epley, Akalis, et al. (2008). More specifically, we used the original Study 1’s design as a base and included anthropomorphism measures from Studies 2 and 3. This setup is useful in addressing concerns about sample differences: with a large sample completing different anthropomorphism measures in one study, different replication results of these measures cannot be explained by any difference in sample characteristics. It is also powerful for drawing inferences about differences between the measures. For instance, while the loneliness–anthropomorphism association can remain consistent across measures, individual participants may not respond to these measures consistently; if this happens to be the case, future research should investigate the source of such inconsistency, and what makes a measure appropriate for assessing anthropomorphism. We have published replication projects with similar setups, which provided critical insights into differences between measures and studies (e.g., Adelina & Feldman, 2021; Xiao et al., 2021; Yeung & Feldman, 2022).

## Extensions

Extensions are minor additions to replication studies that can potentially provide further insights into the phenomena under investigation. We introduced several extensions to our replication.

### Anthropomorphism of supernatural beings

First, we assessed the anthropomorphism of common supernatural beings in addition to the belief measure from the original Studies 2 and 3. If lonelier people have a stronger general tendency to anthropomorphize, they may also attribute more human characteristics to supernatural beings. Epley, Akalis, et al. (2008) found that feelings of social disconnection led participants to indicate a stronger belief in supernatural agents. Stronger beliefs in these agents, however, may not go hand in hand with perceptions of more human attributes. Hence, we included a measure of anthropomorphism of supernatural beings to test the association between loneliness and anthropomorphism more directly. This extension also provided us with one more category of anthropomorphism targets to examine how robust the association is across different target categories.

### Belief in free will

Second, we explored potential associations between anthropomorphism and free will lay beliefs. Belief in free will is the generalized belief that humans are free from internal and external constraints across situations and captures a core aspect of human agency (Feldman, 2017; Lam, 2021; Nanakdewa et al., 2021). There are two competing hypotheses about the relationship between free will belief and anthropomorphism. On the one hand, a stronger belief in free will implies an overall stronger tendency to attribute free will to others. This might extend to non-humans, especially when they are already perceived to have some degree of agency, thus predicting stronger anthropomorphism. On the other hand, many consider free will to be uniquely about human beings (Feldman, 2017), thinking that humans possess agency (i.e., the capacity to act independently of constraints, make free choices, and take responsibility) but non-humans do not. A stronger belief in free will may thus be associated with a subjectively sharper distinction between humans and non-humans and predict weaker anthropomorphism. Some theorized that our concept of free will evolved out of humans’ complex social networks: we believe we have free will because only as such can we inhibit our instinctual impulses for satisfying our immediate needs, follow cooperative rules that serve the long-term interest of the majority, and integrate ourselves into our cultural surroundings (Baumeister et al., 2011). There is some evidence that belief in free will is positively associated with prosocial behaviors, dispositional gratitude, and importantly, a sense of belongingness (Baumeister et al., 2009; MacKenzie et al., 2014; Moynihan et al., 2017). Based on this evidence, and assuming that sociality needs are positively associated with anthropomorphism, free will belief should be negatively associated with anthropomorphic tendency.

To test these competing hypotheses, we measured free will belief as an extension. To the best of our knowledge, no study has explicitly tested the link between free will belief and anthropomorphism, making this extension worthy of adding.

### Controllability

As the final extension, we measured the perceived controllability of the technological gadgets used in the original Study 1. The three-factor theory suggests that the motivation to predict and control one’s surroundings (i.e., effectance motivation) enhances anthropomorphism (Epley et al., 2007). Corroborating this idea, Waytz et al. (2010) found that people anthropomorphized gadgets perceived to be relatively unpredictable more than their predictable counterparts. Although we aimed primarily to replicate the association between sociality motivation and anthropomorphism, that Epley, Akalis, et al. (2008) and Waytz et al. (2010) used the same gadgets and the low cost of including just one additional item measuring perceived controllability made it cost-effective to also try conceptually replicating Waytz et al.’s (2010) finding. We expected that the more participants found the gadgets uncontrollable, the more they would anthropomorphize those gadgets.

# Methods

We determined our sample size based on previous findings. Epley, Akalis, et al. (2008, Study 1) observed a correlation of *r*(18) = .53 between loneliness and anthropomorphism of technological gadgets. This effect size was probably an overestimate, being much larger than common effect sizes in social psychology (Jané et al., 2024) and those obtained in later replications (e.g., Bartz et al., 2016). Bartz et al. (2016) found loneliness to predict anthropomorphism with a small-to-medium effect size (*r*partial = .17) when non-anthropomorphic ratings of targets (e.g., strength, efficiency, attractiveness), participants’ gender, and experimental condition (recalling a close other vs. an acquaintance) were controlled for. Our power analysis with G\*Power (Faul et al., 2007) suggested that we would need 439 participants to detect this effect size with a linear multiple regression model that has two predictors (i.e., loneliness and non-anthropomorphic ratings), assuming a desired power of .95 and an alpha of .05 (see supplemental materials for details about this analysis). Since effect sizes in the literature are mostly overestimates (Button et al., 2013), we decided to err on the side of caution and collect a much larger sample of 1,000 participants, the maximum allowed by our budget, which ensures that we have good power to detect potentially small effect sizes and provide a more accurate effect size estimate. Meanwhile, a large sample size can also help compensate for failed attention checks and make well-powered moderator analyses possible (e.g., examining whether the order of measures has an effect).

## Participants

A total of 1,091 participants born and currently residing in the United States started our Qualtrics survey on Amazon Mechanical Turk via CloudResearch (Litman et al., 2017). A total of 1,002 participants completed the survey, and 885 (*M*age = 44.43, *SD*age = 12.97, age ranged from 20 to 91; nine preferred not to disclose age) remained in our sample after exclusion (please refer to the supplemental materials for the pre-registered exclusion criteria), including 462 males (52.2%), 411 females (46.4%), five with non-binary gender identification (0.6%), and seven preferring not to disclose their gender (0.8%). We compensated each participant US$1.50, which was pre-determined based on the U.S. minimum federal wage of $7.25 per hour. The average completion time as calculated by CloudResearch was 14.63 minutes for a small-sample pretest (30 participants) and 11.20 minutes for the rest of the data collection; medians were 10.73 and 10.00 minutes, respectively.

## Design

The study was correlational. There were two predictor variables: (1) dispositional or chronic loneliness and (2) belief in free will, and four outcome variables: (1) anthropomorphism of gadgets (from the original Study 1), (2) belief in supernatural beings (from the original Study 2), (3) anthropomorphism of supernatural beings (an extension), and (4) anthropomorphism of pets (from the original Study 3). Unless otherwise specified, we randomized the order of items in the measurements that we used; we labeled only the endpoints with text anchors as well as numbers, whereas the middle options only had numeric labels.

### Predictor variables

#### Replication: Chronic loneliness

To assess loneliness, instead of the three-item short loneliness scale (Hughes et al., 2004) used in Epley, Akalis, et al.’s (2008) Study 1, we used the longer, more frequently used, and more comprehensive UCLA Loneliness Scale (Russell, 1996), which nonetheless includes the three items of the shorter scale. Although this was a deviation, the replication part was not affected since it would be possible to conduct the same analyses as in the original study using only those three items. The UCLA Loneliness Scale has 20 items including, for example, “How often do you feel left out,” and “How often do you feel shy.” Participants responded to these items on a 4-point scale (1 = *Never*, 2 = *Rarely*, 3 = *Sometimes*, 4 = *Always*), and we averaged the responses to obtain an overall loneliness score (α = .96, ω*u* = .96). Higher scores reflect greater loneliness. We also made an average composite measure of the three items in the shorter scale (Hughes et al., 2004; α = .89, ω*u* = .89). To differentiate the two composite scores, we will refer to them as the UCLA measure and the Short measure respectively henceforth.

#### Extension: Belief in free will

We measured participants’ belief in free will with the Free Will Subscale from the Free Will Inventory (Nadelhoffer et al., 2014). Participants indicated their agreement with five items (e.g., “People always have the ability to do otherwise”) on a 7-point scale (1 = *Strongly disagree*, 2 = *Disagree*, 3 = *Somewhat disagree*, 4 = *Neither agree nor disagree*, 5 = *Somewhat agree*, 6 = *Agree*, 7 = *Strongly agree*). The responses were averaged for an overall index of free will belief (α = .91, ω*u* = .91).

#### Attention checks

The UCLA Loneliness Scale and the Free Will Subscale each had an attention check item embedded in them. These check items asked participants to select a certain response option. As preregistered, we excluded participants who failed any of these checks. Adding attention checks was a deviation since none were included in the original study. However, they are low-cost and efficient in helping protect scale validity, identify unserious respondents, and as such, improve data quality (Berinsky et al., 2014; Kung et al., 2018; Shamon & Berning, 2020). As such, we decided to deviate and include them.

### Outcome variables

#### Technological gadgets

Participants read about four technological gadgets (e.g., “Clocky is a wheeled alarm clock that looks like a furry animal and operates in a way that makes it difficult to repeatedly press snooze in the morning. When you press snooze, Clocky either runs away from you or jumps on top of you so that you must get up to turn it off.”) and rated each on five anthropomorphic measures (i.e., the extent to which the gadget has “a mind of its own,” “intentions,” “free will,” and “consciousness,” as well as “experience emotions”; α = .88–.93 for the four gadgets; ω*u* = .89–.93), three non-anthropomorphic measures (i.e., “strong,” “efficient,” and “attractive”; α = .62–.72; ω*u* = .64–.72), and one extension measure on perceived controllability (i.e., “can be controlled”) on 7-point scales (0 = *Not at all*, 6 = *Very much*). We calculated anthropomorphic and non-anthropomorphic composite measures by taking the average of the item scores, first within each gadget and then across all four gadgets (i.e., these composites were grand means).

#### Supernatural beings

Participants indicated the extent to which they believed in six supernatural beings (ghosts, angels, miracles, curses, the Devil, and God) on a 7-point scale (0 = *Not at all*, 6 = *Very much*).[[1]](#footnote-2) We calculated a composite measure for belief in supernatural beings by averaging responses to these six items (α = .92, ω*u* = .93). Participants also rated the extent to which a ghost, an angel, the Devil, and God “experiences emotions,” “has consciousness,” “has intentions,” “has a mind of its own,” and “has free will” (7-point scale; 0 = *Not at all*, 6 = *Very much*). We took the grand average of the ratings on these five items to form a measure of anthropomorphism of supernatural beings (α = .97–.99 and ω*u* = .97–.99 for the four supernatural beings).

Participants also reported whether they believed in God (binary; yes or no) and were then split into believers (*n* = 540) and non-believers (*n* = 345). Believers reported their level of religiosity on a 5-point scale (1 = *Very slightly*, 5 = *Extremely*). Non-believers did not see this question.

#### Pets

Participants were asked to think of a pet that they either owned or were familiar with and to provide some basic information about the pet. Then, participants picked three traits that they thought best described the pet from a list of 14, including three anthropomorphic traits that are related to social connection (thoughtful, considerate, and sympathetic), four anthropomorphic traits that are less related to social connection (embarrassable, creative, devious, and jealous), and seven non-anthropomorphic traits (aggressive, agile, active, energetic, fearful, lethargic, and muscular). We recorded the proportions of traits selected from each category as outcome measures.[[2]](#footnote-3)

## Procedure

Participants provided their consent in the beginning, read an outline of this study, and answered screener questions that asked about their ability and willingness to participate in the study. If they did not answer these questions affirmatively, their session would be terminated. This helped us screen out those who tended to randomly click through surveys. Participants then completed the predictor and outcome measures. The measures were separated into five blocks as per the sections above, and the blocks were presented in random orders. In the end, participants completed a funneling section and provided their demographic information.

Randomizing the order of measures was a deviation because the original study presented them in a fixed order: the loneliness measure always appeared after the gadget anthropomorphism task. We consider randomizing the order a strength of our study that enables us to address any concerns related to the order of measures. With our large sample size, we could test possible order effects, and this might bring additional insights into the design of this study.

## Deviations

We summarized our deviations from the original study in the supplemental materials (Table S3). We classified our replication of Study 1 as a *very close replication* with conceptual replications of Studies 2 and 3 as extensions on top of the Study 1 design, based on LeBel et al.’s (2018) criteria (summarized in Table S1).

## Hypotheses

In line with the original study, we hypothesized that loneliness is positively associated with anthropomorphism. As for extensions, we also predicted that free will is associated with anthropomorphism (though we did not make predictions about its direction) and that the perceived controllability of targets is negatively associated with anthropomorphism. We noted the hypotheses more specifically in Table 1. There, next to the hypotheses, we also noted the relevant key statistics from our analyses and concluded whether the hypotheses received support from our data.

## Open practices statement

We provided all materials, data, and analysis scripts at <https://osf.io/2sb7x/>. This project received *Peer Community In Registered Report* Stage 1 in-principle acceptance (<https://rr.peercommunityin.org/articles/rec?id=181>; <https://osf.io/by89c/>) after which we created a frozen pre-registration version of the entire Stage 1 packet (<https://osf.io/92b8d/>; December 3, 2022) and proceeded to data collection (January 16, 2023). [To be updated after Stage 2 endorsement:] It has then gone through peer review and is officially endorsed by Peer Community In Registered Reports ([Endorsement citation]; [Endorsement link]). We confirm that all measures, exclusions, and analyses conducted for this investigation have been reported, and data collection was completed before any formal analysis. We also report no deviations from the Stage 1 protocol. This Registered Report was written using the Registered Report template by Feldman (2023).

Table 1
*List of hypotheses and relevant key statistics*

| **No.** | **Hypothesis** | **Key statistics** | **Support** |
| --- | --- | --- | --- |
| H1a | Loneliness is positively correlated with anthropomorphic ratings of gadgets. | *r*(883) = .02 [−.04, .09] | (UCLA) | No |
| *r*(883) = .04 [−.02, .11] | (Short) |
| H1b | Loneliness is positively correlated with non-anthropomorphic ratings of gadgets. | ***r*(883) = −.08 [−.15, −.02]** | (UCLA) | No |
| *r*(883) = −.02 [−.09, .05] | (Short) |
| H1c | Loneliness is positively correlated with anthropomorphic ratings of gadgets after non-anthropomorphic ratings are controlled for. | ***r*partial = .07 [.01, .14]** | (UCLA) | Mixed |
| *r*partial = .06 [−.01, .12] | (Short) |
| H1d | Loneliness is positively correlated with the proportion of social connection-related traits selected by participants to describe their pets. | *r*(883) = −.02 [−.09, .04] | (UCLA) | No |
| H1e | Loneliness is positively correlated with belief in supernatural beings. | ***r*(883) = −.11 [−.17, −.04]** | (UCLA) | No |
| H1f | Loneliness is positively correlated with the anthropomorphism of supernatural beings. | *r*(883) = −.05 [−.12, .01] | (UCLA) | No |
| H2a\* | Free will belief is positively correlated with anthropomorphic ratings of gadgets. | *r*(883) = .05 [−.02, .12] | No |
| H2b | Free will belief is positively correlated with non-anthropomorphic ratings of gadgets. | ***r*(883) = .08 [.01, .14]** | Yes |
| H2c | Free will belief is positively correlated with anthropomorphic ratings of gadgets after non-anthropomorphic ratings are controlled for. | *r*partial = .02 [−.05, .08] | No |
| H2d | Free will belief is positively correlated with the proportion of social connection-related traits selected by participants to describe their pets. | ***r*(883) = .07 [.00, .13]** | Yes |
| H2e | Free will belief is positively correlated with belief in supernatural beings. | ***r*(883) = .23 [.16, .29]** | Yes |
| H2f | Free will belief is positively correlated with the anthropomorphism of supernatural beings. | ***r*(883) = .16 [.10, .23]** | Yes |
| H3a | Free will belief is negatively correlated with anthropomorphic ratings of gadgets. | *r*(883) = .05 [−.02, .12] | No |
| H3b | Free will belief is negatively correlated with non-anthropomorphic ratings of gadgets. | ***r*(883) = .08 [.01, .14]** | No |
| H3c | Free will belief is negatively correlated with anthropomorphic ratings of gadgets after non-anthropomorphic ratings are controlled for. | *r*partial = .02 [−.05, .08] | No |
| H3d | Free will belief is negatively correlated with the proportion of social connection-related traits selected by participants to describe their pets. | ***r*(883) = .07 [.00, .13]** | No |
| H3e | Free will belief is negatively correlated with belief in supernatural beings. | ***r*(883) = .23 [.16, .29]** | No |
| H3f | Free will belief is negatively correlated with the anthropomorphism of supernatural beings. | ***r*(883) = .16 [.10, .23]** | No |
| H4 | Perceived controllability of gadgets negatively predicts anthropomorphic ratings after non-anthropomorphic ratings are controlled for. | ***b* = −0.09 [−0.10, −0.07]** | Yes |
| *Note*. H2s and H3s were essentially competing hypotheses because we did not make predictions about the direction of the associations between free will belief and the outcome measures. Bolded statistics are significant at .05 level. The lower and upper bounds of 95% confidence intervals are indicated in square brackets. \*: Analyzing the full sample led to qualitatively different results. |

# Results

We report here the results based on the sample after exclusion (*n* = 885; see the supplementary materials for exclusion criteria). We conducted the same analyses with the full sample and documented the results in a separate analysis file shared on OSF. We noted below wherever the results meaningfully diverged. We used the statistical computing language *R* (R Core Team, 2023) and the following *R* packages/collections of packages for data processing and analysis: *cocor* (Diedenhofen & Musch, 2015), *correlation* (Makowski et al., 2020), *datawizard* (Patil et al., 2022), *ggstatsplot* (Patil, 2021), *lme4* (Bates et al., 2015), *lmerTest* (Kuznetsova et al., 2017), *MBESS* (Kelley, 2007), *psych* (Revelle, 2024), *rstatix* (Kassambara, 2023), and *tidyverse* (Wickham et al., 2019).

## Loneliness and anthropomorphism

### Gadgets

#### Confirmatory analyses.

Table 2 presents the descriptive statistics and the zero-order Pearson correlation matrix for the key variables in this study (see also Figure 1). Chronic loneliness was weakly correlated with anthropomorphic ratings of gadgets, *r*(883) = .02, 95% CI [−.04, .09], *p*one-sided = .261 for the UCLA measure and *r*(883) = .04, 95% CI [−.02, .11], *p*one-sided = .111 for the Short measure. Contrary to our prediction and the original finding, loneliness (UCLA measure) correlated negatively with non-anthropomorphic ratings of gadgets, *r*(883) = −.08, 95% CI [−.15, −.02], *p* = .014; the correlation was still negative but not statistically significant for the Short measure, *r*(883) = −.02, 95% CI [−.09, .05], *p* = .565. Controlling for non-anthropomorphic ratings, we found loneliness to be positively associated with the anthropomorphism of gadgets; the association was statistically significant for the UCLA measure, *r*partial = .07, 95% CI [.01, .14], *p* = .031, but not for the Short measure, *r*partial = .06, 95% CI [−.01, .12], *p* = .082. Overall, we found weak-to-no evidence that loneliness was positively associated with the anthropomorphism of technological gadgets, regardless of whether non-anthropomorphic ratings were controlled for or not. We could not reject the null in favor of H1a and H1b, and the evidence for H1c was mixed.

#### Exploratory analyses.

We did not find evidence that the order in which participants completed the tasks (gadget anthropomorphism task first, as in the original study, or the UCLA Loneliness Scale first) affected the relationship between gadget anthropomorphism and loneliness. Regressing gadget anthropomorphism on loneliness (UCLA measure) and a task order factor (deviation contrast coding), we did not find an interaction, *b* = 0.16, 95% CI [−0.04, 0.36], *p* = .126. Loneliness (UCLA) also did not predict gadget anthropomorphism, *b* = 0.04, 95% CI [−0.07, 0.14], *p* = .488. Nonetheless, after we included non-anthropomorphic ratings in the regression model, a three-way interaction emerged, *b* = 0.22, 95% CI [0.08, 0.36], *p* = .003. We then analyzed separately those who completed the gadget task before the loneliness scale and those who completed the two in the reversed order. We did not find that loneliness (UCLA) predicted anthropomorphism in either subsample, *b* = 0.25, 95% CI [−0.03, 0.52], *p* = .077 and *b* = −0.20, 95% CI [−0.52, 0.12], *p* = .217. We found no evidence that the first-order Pearson correlations between gadget anthropomorphism and loneliness (UCLA) differed in these two subsamples (gadget task first: *r*(449) = −.03, *p* = .544; loneliness scale first: *r*(432) = .07, *p* = .124), Fisher’s *z* = −1.52, *p* = .128.

Considering that most participants did not anthropomorphize the gadgets so much (*M* = 0.63 for anthropomorphic ratings on a 0-to-6 scale), we checked the robustness of the results by conducting a Spearman’s rank correlation between loneliness (UCLA) and anthropomorphic ratings. We still found little evidence of a correlation, ρ = .06, 95% CI [.00, .13], *p* = .056 (however, the same analysis on the full sample revealed a significant correlation, ρ = .07, 95% CI [.01, .13], *p* = .023).

Figure 1
*Key correlations*



Table 2
*Descriptives and Pearson correlation matrix for key variables*

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | ***M*** | ***SD*** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| 1. Loneliness (UCLA) (1–4) | 2.15 | 0.69 | (.96) |  |  |  |  |  |  |  |
| 2. Loneliness (short) (1–4) | 2.19 | 0.84 | **.88** | (.89) |  |  |  |  |  |  |
| 3. Belief in free will (1–7) | 4.94 | 1.28 | **−.27** | **−.27** | (.91) |  |  |  |  |  |
| 4. Gadget anthropomorphism (0–6) | 0.63 | 1.06 | .02 | .04 | .05 | (.89–.93) |  |  |  |  |
| 5. Gadget non-anthropomorphism (0–6) | 2.67 | 1.17 | **−.08** | −.02 | **.07** | **.50** | (.64–.72) |  |  |  |
| 6. Pet anthropomorphism (0–1) | 0.22 | 0.26 | −.02 | −.01 | **.07** | **.10** | **.12** | n/a |  |  |
| 7. Belief in supernatural beings (0–6) | 2.53 | 1.96 | **−.11** | −.04 | **.23** | **.25** | **.32** | **.09** | (.93) |  |
| 8. Anthropomorphism of supernatural beings (0–6) | 3.22 | 2.03 | −.06 | .00 | **.16** | **.20** | **.30** | **.08** | **.74** | (.97–.99) |
| *Notes*. Gadget anthropomorphism: anthropomorphic ratings of technological gadgets; gadgets non-anthropomorphism: non-anthropomorphic ratings of technological gadgets; pet anthropomorphism: proportion of social connection-related traits selected for describing participants’ pets well. If applicable, Omega coefficients (ω*u*) are shown on the diagonal in parentheses. Bolded correlation coefficients are significant at *α* = .05 level. *M* = Mean, *SD* = standard deviation. |

### Pets

#### Confirmatory analyses.

Contrary to H1d, loneliness (UCLA) was negatively correlated with the proportion of social connection-related anthropomorphic traits that participants considered describing their pets well, *r*(883) = −.02, 95% CI [−.09, .04], *p* = .495.

### Supernatural beings

#### Confirmatory analyses.

Contrary to H1e, loneliness (UCLA) was negatively associated with belief in supernatural beings, *r*(883) = −.11, 95% CI [−.17, −.04], *p* = .001. Loneliness (UCLA) was also negatively—but non-significantly—correlated with the anthropomorphism of supernatural beings, *r*(883) = −.05, 95% CI [−.12, .01], *p* = .103. Thus, we did not find sufficient evidence for H1f.

#### Exploratory analyses.

We explored whether the association between loneliness and belief in or anthropomorphism of supernatural beings depends on whether one believed in God or not. To this end, we regressed either belief in or anthropomorphism of supernatural beings on loneliness (either UCLA or Short) and the binary measure of whether participants believed in God (treatment coding: 0 = *no*, 1 = *yes*). Additionally, only for those participants who indicated that they believed in God (*n* = 540), we regressed the two dependent measures on loneliness (either UCLA or Short) and religiosity (5-point scale). In none of these regression models did we find evidence for an interaction. As such, there was little evidence that a belief in God or religiosity moderates the association between loneliness and belief in or anthropomorphism of supernatural beings.

## Free will belief and anthropomorphism

### Gadgets

*Confirmatory analyses*.

Participants’ belief in free will was weakly correlated with their anthropomorphic ratings of gadgets, *r*(883) = .05, 95% CI [−.02, .12], *p* = .133. We found a positive correlation between free will belief and non-anthropomorphic ratings of gadgets, *r*(883) = .08, 95% CI [.01, .14], *p* = .025. We did not find evidence that belief in free will was positively associated with gadget anthropomorphism when non-anthropomorphic ratings were controlled for, *r*partial = .02, 95% CI [−.05, .08], *p* = .657. Overall, we did not find sufficient evidence for any relationship between gadget anthropomorphism and belief in free will.

*Exploratory analyses*.

We created a gadget anthropomorphism composite measure without the “free will” item and conducted the same analyses as above. We found a correlation between free will belief and gadget anthropomorphism of almost the same size, *r*(883) = .05, 95% CI [−.02, .12], *p* = .137. Again, we found no evidence that the two were correlated when non-anthropomorphic ratings were controlled for, *r*partial = .01, 95% CI [−.05, .08], *p* = .680.

### Pets

We found a positive correlation between participants’ belief in free will and pet anthropomorphism (i.e., the proportion of anthropomorphic traits related to social connections that were selected), *r*(883) = .07, 95% CI [.00, .13], *p* = .046.

### Supernatural beings

#### Confirmatory analyses.

We found evidence for a positive correlation between participants’ belief in free will and their belief in supernatural beings, *r*(883) = .23, 95% CI [.16, .29], *p* < .001, and likewise, a positive correlation between free will belief and anthropomorphism of supernatural beings, *r*(883) = .16, 95% CI [.10, .23], *p* < .001.

#### Exploratory analyses.

We again removed the “free will” item from the composite measure of anthropomorphism of supernatural beings. We found a roughly equal correlation between belief in free will and anthropomorphism of supernatural beings, *r*(883) = .16, 95% CI [.09, .22], *p* < .001.

## Perceived controllability and anthropomorphism

The three-factor theory of anthropomorphism suggests that the motivation to understand and control our surroundings leads to anthropomorphism (Epley et al., 2007). With the extension measure of “perceived controllability” in the gadget anthropomorphism task, we tested whether the perceived controllability of gadgets was negatively associated with their anthropomorphism. For this purpose, and considering that the data are fully crossed (i.e., all participants evaluated all gadgets), we built a series of linear mixed-effects models with the *lme4* (Bates et al., 2015) and the *lmerTest* (Kuznetsova et al., 2017) R packages. Our full model included anthropomorphic mental-state ratings of gadgets as the outcome variable and perceived controllability and non-anthropomorphic ratings as predictors. We included both random intercepts and slopes for the predictors on participant and gadget levels (Baayen et al., 2008). Degrees of freedom were approximated with Satterthwaite’s method.

We preregistered the following steps to simplify the model in case of non-convergence: (1) remove random slopes for gadgets; (2) remove random slopes for participants; (3) remove random intercepts for gadgets; and (4) remove random intercepts for participants (which would result in a fixed-effects model). We also compared the first model that converged with simpler models in terms of their fit to determine whether the more parsimonious models would be preferable.

We settled on the model with random intercepts for both gadgets and participants, which had a significantly better fit than the model without random intercepts for gadgets (i.e., after Step 3). We found a negative fixed effect of perceived controllability, *b* = −0.09, 95% CI [−0.10, −0.07], *t*(3534) = −11.92, *p* < .001, and a positive fixed effect of non-anthropomorphic ratings, *b* = 0.19, 95% CI [0.16, 0.21], *t*(3534) = 16.00, *p* < .001. Thus, we found evidence for a negative association between perceived controllability and gadget anthropomorphism, which provides support for the three-factor theory of anthropomorphism.

## Evaluating replication results

We evaluated the replication outcomes based on the criteria proposed by LeBel et al. (2019). As shown in Table 3, overall, the current findings were inconsistent with the original results. We therefore conclude that we failed to replicate the original findings.

Table 3
*Evaluating replication outcomes based on LeBel et al.’s (2019) criteria*

|  |  |  |  |
| --- | --- | --- | --- |
| Finding | Original result | Replication result | Interpretation |
| Loneliness is positively correlated with anthropomorphic ratings of gadgets. |
|  | *r*(18) = .53, 95% CI [.11, .79] | *r*(883) = .02, 95% CI [−.04, .09] | (UCLA) | No signal – inconsistent |
| *r*(883) = .04, 95% CI [−.02, .11] | (Short) | No signal – inconsistent |
| Loneliness is positively correlated with non-anthropomorphic ratings of gadgets. |
|  | *r*(18) = .25, 95% CI [−.22, .62] | *r*(883) = −.08, 95% CI [−.15, −.02] | (UCLA) | Signal – inconsistent, negative effect |
| *r*(883) = −.02, 95% CI [−.09, .05] | (Short) | No signal – inconsistent\* |
| Loneliness is positively correlated with anthropomorphic ratings of gadgets after non-anthropomorphic ratings are controlled for. |
|  | *r*(17) = .49, 95% CI [.06, .77] | *r*partial = .07, 95% CI [.01, .14] | (UCLA) | Signal – inconsistent, smaller |
|  |  | *r*partial = .06, 95% CI [−.01, .12] | (Short) | No signal – inconsistent |
| *Note*. \*LeBel et al. (2019) did not provide an interpretation category for this replication outcome (that consistent with the original, no signal was detected, but the confidence interval of the replication estimate did not cover the original estimate). Based on existing categories we believe it is appropriate to categorize this outcome as “no signal – inconsistent.” |

# Discussion

We conducted a replication of Study 1 in Epley et al. (2008) with a much larger and more diverse sample. We did not find sufficient evidence for a robust positive association between chronic loneliness and anthropomorphic tendency across the different measures of both constructs: loneliness was only correlated with anthropomorphic ratings of gadgets in the expected direction when non-anthropomorphic ratings were controlled for, and only when it was measured with the 20-item UCLA scale (but not with the Short 3-item scale); the size of the correlation was nevertheless small (*r*partial = .07). For the other correlations involving loneliness that we expected to detect, some were tiny and statistically non-significant, while others were statistically significant but in a different direction than expected.

While there is relatively more evidence for a positive correlation between free will belief and different measures of anthropomorphic tendency (pets, belief in supernatural beings, and anthropomorphism of supernatural beings), the sizes of these correlations differed in a way such that it is reasonable to infer free will belief has more to do with “supernatural beings” rather than “anthropomorphism.” Indeed, free will belief was correlated with belief in supernatural beings at *r* = .23 and anthropomorphism of supernatural beings at *r* = .16, but with weaker effect for anthropomorphism of pets at *r* = .07. Thus, we consider this as limited evidence for an association between belief in free will and anthropomorphism. In support of the three-factor theory of anthropomorphism (Epley et al., 2007), however, we found evidence that perceived control is negatively related to anthropomorphism.

Three additional findings deserve attention. First, loneliness was correlated negatively and moderately with belief in free will (*r* = −.27). This echoes previous findings showing that a stronger free will belief is linked with a heightened sense of belongingness (e.g., Moynihan et al., 2017). Second, participants’ level of anthropomorphism of technological gadgets in this investigation was nearly at the floor, with a mean of 0.63 and a standard deviation of 1.06 on a 0-to-6 scale. The relevant null findings might thus partially be attributed to the low variance in participants’ responses in the gadget anthropomorphism task (though because no descriptive statistics were reported in the original article, we could not assess how different the responses were between the studies). This low variance could be because as time has changed, the technological gadgets used in the original study do not appear advanced and are now commonplace, therefore evoking less effectance motivation. To overcome this limitation, we could use gadgets or technological products that are more up-to-date and people perceive they have less control over, such as (at the time of this writing) the humanoid robots produced by Boston Dynamics or artificial intelligence powered by large language models.

While acknowledging that using the original gadgets—but not ones that reflect state-of-the-art technology—might have contributed to the replication failure, we emphasize that replicators often face a dilemma of updating original materials when those materials are assumed to be time-specific (Chandrashekar & Feldman, 2024): if replicators do not update the original study materials and fail to replicate the original finding, evaluators can argue that the materials were outdated and the decision not to update led to the failure; if replicators update the materials and still fail, evaluators can argue that the update was not appropriate and led to the failure (or that the study is no longer a replication). Both arguments are easy to make, and they can often be legitimate. However, when used to devalue replication studies, they suffer from strong hindsight and outcome biases (i.e., the replicators should have anticipated the consequence of their decisions to update/not update; Chen et al., 2021; successful replications are likely considered trivial regardless of update decisions), are often empirically untestable, and if used on a scale, hinder the development of a literature free of publication bias. We suggest evaluators refrain from evaluating *single* replication studies with these arguments, particularly when the outcomes are already known. Instead, it would be beneficial to take a meta-analytical view and study how these design factors systematically affect the evidence for a claim on a sufficiently large, bias-free literature (Cumming, 2014). This literature should welcome replications of all sorts.

Finally, the different measures assumed to capture anthropomorphic tendency were correlated with each other at most only modestly, with the strongest being that between the anthropomorphic ratings of gadgets and belief in supernatural beings (*r* = .25). This raises the question of whether one can draw valid conclusions about the relationship between loneliness and anthropomorphic tendency based on any of these measures.

We note two limitations of the current replication attempt. First, and as aforementioned, to have a faithful direct replication, we used materials from the original study. These materials—the gadgets in particular—can be considered outdated, and that could be one reason why people mostly did not anthropomorphize the targets. Therefore, our findings suggest that it is important for future research on anthropomorphism to carefully choose the targets of anthropomorphism, ensuring a sufficient level of variance in participants’ responses. Second, this study, as well as the original, are correlational, meaning the results do not directly establish that sociality motivation leads to anthropomorphism. We thus call for high-powered replications of experimental studies, ideally in the form of Registered Reports, where feelings of loneliness are manipulated and anthropomorphism is examined as a downstream consequence. Relatedly, considering that Epley et al.’s (2007) three-factor theory of anthropomorphism has a strong focus on motivation, situational loneliness may predict anthropomorphism better than chronic or dispositional loneliness.

In summary, our direct replication of Epley et al. (2008) with a large sample failed to find robust evidence for a positive association between chronic loneliness and anthropomorphism. This failure was further complicated by issues such as floor responses and low intercorrelations among different measures originally thought to tap on anthropomorphism. Given the prominence of the three-factor theory (Epley et al., 2007), our findings call for more direct and conceptual replication to establish the link between sociality motivation and anthropomorphism, importantly, with well-validated anthropomorphism measures. Based on our extension, we found a non-trivial positive association between belief in free will and belief in, and anthropomorphism of, supernatural beings. We speculate that this is because people who hold supernatural beings tend *not* to think of the world as operating under mechanistic, materialistic, and/or reductionist principles, all of which are linked to determinism in philosophical discussions. Future studies can continue exploring the implications of these associations.

# References

Adelina, N., & Feldman, G. (2021). Are past and future selves perceived differently from present self? Replication and extension of Pronin and Ross (2006) temporal differences in trait self-ascription. *International Review of Social Psychology*, *34*(1), 29. <https://doi.org/10.5334/irsp.571>

Baayen, R. H., Davidson, D. J., & Bates, D. M. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language*, *59*(4), 390–412. <https://doi.org/10.1016/j.jml.2007.12.005>

Bartz, J. A., Tchalova, K., & Fenerci, C. (2016). Reminders of social connection can attenuate anthropomorphism: A replication and extension of Epley, Akalis, Waytz, and Cacioppo (2008). *Psychological Science*, *27*(12), 1644–1650. <https://doi.org/10.1177/0956797616668510>

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, *67*(1), 1–48. <https://doi.org/10.18637/jss.v067.i01>

Baumeister, R. F., Crescioni, A. W., & Alquist, J. L. (2011). Free will as advanced action control for human social life and culture. *Neuroethics*, *4*, 1–11. <https://doi.org/10.1007/s12152-010-9058-4>

Baumeister, R. F., & Leary, M. R. (1995). The need to belong: Desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin*, *117*(3), 497–529. <https://doi.org/10.1037/0033-2909.117.3.497>

Baumeister, R. F., Masicampo, E. J., & DeWall, C. N. (2009). Prosocial benefits of feeling free: Disbelief in free will increases aggression and reduces helpfulness. *Personality and Social Psychology Bulletin*, *35*(2), 260–268. <https://doi.org/10.1177/0146167208327217>

Berinsky, A. J., Margolis, M. F., & Sances, M. W. (2014). Separating the shirkers from the workers? Making sure respondents pay attention on self-administered surveys. *American Journal of Political Science*, *58*(3), 739–753. <https://doi.org/10.1111/ajps.12081>

Burgess, A. M., Graves, L. M., & Frost, R. O. (2018). My possessions need me: Anthropomorphism and hoarding. *Scandinavian Journal of Psychology*, *59*(3), 340–348. <https://doi.org/10.1111/sjop.12441>

Button, K. S., Ioannidis, J. P. A., Mokrysz, C., Nosek, B. A., Flint, J., Robinson, E. S. J., & Munafò, M. R. (2013). Power failure: Why small sample size undermines the reliability of neuroscience. *Nature Reviews Neuroscience*, *14*, 365–376. <https://doi.org/10.1038/nrn3475>

Caruana, N., White, R. C., & Remington, A. (2021). Autistic traits and loneliness in autism are associated with increased tendencies to anthropomorphise. *Quarterly Journal of Experimental Psychology*, *74*(7), 1295–1304. <https://doi.org/10.1177/17470218211005694>

Chandrashekar, S. P., & Feldman, G. (2024). On the process and value of direct close replications: Reply to Shafir and Cheek (2024) commentary on Chandrashekar et al. (2021). <https://osf.io/rvpzf/>

Chen, J., Kwan, L. C., Ma, L. Y., Choi, H. Y., Lo, Y. C., Au, S. Y., Tsang, C. H., Cheng, B. L., & Feldman, G. (2021). Retrospective and prospective hindsight bias: Replications and extensions of Fischhoff (1975) and Slovic and Fischhoff (1977). *Journal of Experimental Social Psychology*, *96*, 104154. <https://doi.org/10.1016/j.jesp.2021.104154>

Chen, R. P., Wan, E. W., & Levy, E. (2017). The effect of social exclusion on consumer preference for anthropomorphized brands. *Journal of Consumer Psychology*, *27*(1), 23–34. <https://doi.org/10.1016/j.jcps.2016.05.004>

Cumming, G. (2014). The new statistics: Why and how. *Psychological Science*, *25*(1), 7–29. <https://doi.org/10.1177/0956797613504966>

Diedenhofen, B., & Musch, J. (2015). cocor: A comprehensive solution for the statistical comparison of correlations. *PLOS ONE*, *10*(4), e0121945. <https://doi.org/10.1371/journal.pone.0121945>

Epley, N., Akalis, S., Waytz, A., & Cacioppo, J. T. (2008). Creating social connection through inferential reproduction: Loneliness and perceived agency in gadgets, Gods, and greyhounds. *Psychological Science*, *19*(2), 114–120. <https://doi.org/10.1111/j.1467-9280.2008.02056.x>

Epley, N., Waytz, A., Akalis, S., & Cacioppo, J. T. (2008). When we need a human: Motivational determinants of anthropomorphism. *Social Cognition*, *26*(2), 143–155. <https://doi.org/10.1521/soco.2008.26.2.143>

Epley, N., Waytz, A., & Cacioppo, J. T. (2007). On seeing human: A three-factor theory of anthropomorphism. *Psychological Review*, *114*(4), 864–886. <https://doi.org/10.1037/0033-295X.114.4.864>

Eyssel, F., & Reich, N. (2013). Loneliness makes the heart grow fonder (of robots)—On the effects of loneliness on psychological anthropomorphism. *2013 8th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*, 121–122. <https://doi.org/10.1109/HRI.2013.6483531>

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G\*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175–191. <https://doi.org/10.3758/BF03193146>

Feldman, G. (2017). Making sense of agency: Belief in free will as a unique and important construct. *Social and Personality Psychology Compass*, *11*(1), e12293. <https://doi.org/10.1111/spc3.12293>

Feldman, G. (2023). Registered Report Stage 1 manuscript template. <https://doi.org/10.17605/OSF.IO/YQXTP>

Hughes, M. E., Waite, L. J., Hawkley, L. C., & Cacioppo, J. T. (2004). A short scale for measuring loneliness in large surveys: Results from two population-based studies. *Research on Aging*, *26*(6), 655–672. <https://doi.org/10.1177/0164027504268574>

Jané, M., Xiao, Q., Yeung, S., Ben-Shachar, M. S., Caldwell, A., Cousineau, D., Dunleavy, D. J., Elsherif, M., Johnson, B., Moreau, D., Riesthuis, P., Röseler, L., Steele, J., Vieira, F., Zloteanu, M., & Feldman, G. (2024). Guide to Effect Sizes and Confidence Intervals. <http://dx.doi.org/10.17605/OSF.IO/D8C4G>

Kassambara, A. (2023). *rstatix: Pipe-friendly framework for basic statistical tests* (Version 0.7.2). [https://CRAN.R-project.org/package=rstatix](https://CRAN.R-project.org/package%3Drstatix)

Kelley, K. (2007). Methods for the Behavioral, Educational, and Social Sciences: An R package. *Behavior Research Methods*, *39*, 979–984. <https://doi.org/10.3758/BF03192993>

Kung, F. Y. H., Kwok, N., & Brown, D. J. (2018). Are attention check questions a threat to scale validity? *Applied Psychology*, *67*(2), 264–283. <https://doi.org/10.1111/apps.12108>

Kuznetsova, A., Brockhoff, P. B., & Christensen, R. H. B. (2017). lmerTest package: Tests in linear mixed effects models. *Journal of Statistical Software*, *82*(13), 1–26. <https://doi.org/10.18637/jss.v082.i13>

Lam, A. (2021). *Folk conceptions of free will: A systematic review and narrative synthesis of psychological research* [Master’s dissertation, University of Liverpool]. <https://doi.org/10.31234/osf.io/nuyjw>

LeBel, E. P., McCarthy, R. J., Earp, B. D., Elson, M., & Vanpaemel, W. (2018). A unified framework to quantify the credibility of scientific findings. *Advances in Methods and Practices in Psychological Science*, *1*(3), 389–402. <https://doi.org/10.1177/2515245918787489>

LeBel, E. P., Vanpaemel, W., Cheung, I., & Campbell, L. (2019). A brief guide to evaluate replications. *Meta-Psychology*, 3. <https://doi.org/10.15626/mp.2018.843>

Litman, L., Robinson, J., & Abberbock, T. (2017). TurkPrime. com: A versatile crowdsourcing data acquisition platform for the behavioral sciences. *Behavior Research Methods*, 49(2), 433-442. <https://doi.org/10.3758/s13428-016-0727-z>

MacKenzie, M. J., Vohs, K. D., & Baumeister, R. F. (2014). You didn’t have to do that: Belief in free will promotes gratitude. *Personality and Social Psychology Bulletin*, *40*(11), 1423–1434. <https://doi.org/10.1177/0146167214549322>

Makowski, D., Ben-Shachar, M. S., Patil, I., & Lüdecke, D. (2020). Methods and algorithms for correlation analysis in R. *Journal of Open Source Software*, *5*(51), 2306. <https://doi.org/10.21105/joss.02306>

Moynihan, A. B., Igou, E. R., & van Tilburg, W. A. P. (2017). Free, connected, and meaningful: Free will beliefs promote meaningfulness through belongingness. *Personality and Individual Differences*, *107*, 54–65. <https://doi.org/10.1016/j.paid.2016.11.006>

Nadelhoffer, T., Shepard, J., Nahmias, E., Sripada, C., & Ross, L. T. (2014). The free will inventory: Measuring beliefs about agency and responsibility. *Consciousness and Cognition*, *25*, 27–41. <https://doi.org/10.1016/j.concog.2014.01.006>

Nanakdewa, K., Bulchand, D., Chen, J., Chia, R.-J., Lim, V., Ong, C. W., Savani, K., & Feldman, G. (2021). *Outcomes associated with believing in free will: Meta-analysis Registered Report* [Registered Report Stage 1]. <http://doi.org/10.13140/RG.2.2.36383.92327/2>

Neave, N., Jackson, R., Saxton, T., & Hönekopp, J. (2015). The influence of anthropomorphic tendencies on human hoarding behaviours. *Personality and Individual Differences*, *72*, 214–219. <https://doi.org/10.1016/j.paid.2014.08.041>

Open Science Collaboration. (2015). Estimating the reproducibility of psychological science. *Science*, *349*(6251), aac4716. <https://doi.org/10.1126/science.aac4716>

Patil, I. (2021). Visualizations with statistical details: The ‘ggstatsplot’ approach. *Journal of Open Source Software*, *6*(61), 3167. <https://doi.org/10.21105/joss.03167>

Patil, I., Makowski, D., Ben-Shachar, M. S., Wiernik, B. M., Bacher, E., & Lüdecke, D. (2022). datawizard: An R package for easy data preparation and statistical transformations. *Journal of Open Source Software*, *7*(78), 4684. <https://doi.org/10.21105/joss.04684>

R Core Team. (2023). *R: A language and environment for statistical computing* (Version 4.3.2). R Foundation for Statistical Computing. <http://www.R-project.org/>

Revelle, W. (2024). *psych: Procedures for psychological, psychometric, and personality research* (Version 2.4.1). Northwestern University. [https://CRAN.R-project.org/package=psych](https://CRAN.R-project.org/package%3Dpsych)

Russell, D. W. (1996). UCLA Loneliness Scale (Version 3): Reliability, validity, and factor structure. *Journal of Personality Assessment*, *66*(1), 20–40. <https://doi.org/10.1207/s15327752jpa6601_2>

Shamon, H., & Berning, C. C. (2020). Attention check items and instructions in online surveys with incentivized and non-incentivized samples: Boon or bane for data quality? *Survey Research Methods*, *14*(1), 55–77. <https://doi.org/10.18148/srm/2020.v14i1.7374>

Shin, H. I., & Kim, J. (2020). My computer is more thoughtful than you: Loneliness, anthropomorphism and dehumanization. *Current Psychology*, *39*(2), 445–453. <https://doi.org/10.1007/s12144-018-9975-7>

Simms, L. J., Zelazny, K., Williams, T. F., & Bernstein, L. (2019). Does the number of response options matter? Psychometric perspectives using personality questionnaire data. *Psychological Assessment*, *31*(4), 557–566. <https://doi.org/10.1037/pas0000648>

Simonsohn, U., Nelson, L. D., & Simmons, J. P. (2014). P-curve: A key to the file-drawer. *Journal of Experimental Psychology: General*, *143*(2), 534–547. <https://doi.org/10.1037/a0033242>

Twenge, J. M., Baumeister, R. F., Tice, D. M., & Stucke, T. S. (2001). If you can’t join them, beat them: Effects of social exclusion on aggressive behavior. *Journal of Personality and Social Psychology*, *81*(6), 1058–1069. <https://doi.org/10.1037/0022-3514.81.6.1058>

Wang, W. (2017). Smartphones as social actors? Social dispositional factors in assessing anthropomorphism. *Computers in Human Behavior*, *68*, 334–344. <https://doi.org/10.1016/j.chb.2016.11.022>

Waytz, A., Morewedge, C. K., Epley, N., Monteleone, G., Gao, J.-H., & Cacioppo, J. T. (2010). Making sense by making sentient: Effectance motivation increases anthropomorphism. *Journal of Personality and Social Psychology*, *99*(3), 410–435. <https://doi.org/10.1037/a0020240>

White, R. W. (1959). Motivation reconsidered: The concept of competence. *Psychological Review*, *66*(5), 297–333. <https://doi.org/10.1037/h0040934>

Wickham, H., Averick, M., Bryan, J., Chang, W., McGowan, L. D., François, R., Grolemund, G., Hayes, A., Henry, L., Hester, J., Kuhn, M., Pedersen, T. L., Miller, E., Bache, S. M., Müller, K., Ooms, J., Robinson, D., Seidel, D. P., Spinu, V., … Yutani, H. (2019). Welcome to the tidyverse. *Journal of Open Source Software*, *4*(43), 1686. <https://doi.org/10.21105/joss.01686>

Xiao, Q., Zeng, S., & Feldman, G. (2021). Revisiting the decoy effect: Replication and extension of Ariely and Wallsten (1995) and Connolly, Reb, and Kausel (2013)‎. *Comprehensive Results in Social Psychology*, *4*(2), 164–198. <https://doi.org/10.1080/23743603.2021.1878340>

Yeung, S. K., & Feldman, G. (2022). Revisiting the temporal pattern of regret in action versus inaction: Replication of Gilovich and Medvec (1994) with extensions examining responsibility. *Collabra: Psychology*, *8*(1), 37122. <https://doi.org/10.1525/collabra.37122>

1. The original article used a 10-point scale (1 = *Not at all*, 10 = *Very much*). To avoid confusion and to minimize the mental effort in switching between scales with different numbers of options, we decided to deviate from the original and use the same 7-point scale as in the gadget task. Research has shown that this change is unlikely to result in a psychometric disadvantage for the measure (e.g., Simms et al., 2019). [↑](#footnote-ref-2)
2. A similar measure in the literature (e.g., Epley, Waytz, et al., 2008) asked participants to rank the traits in terms of how well each describes their pets. The average rank of each category of traits was then correlated with participants’ loneliness. Epley, Waytz, et al. (2008) found a significant negative association between loneliness and the average rank assigned to social connection-related traits, *r*(164) = −.18, *p* = .02. The associations between loneliness and the average ranks of the other two types of traits were not statistically significant. [↑](#footnote-ref-3)