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# Effectance Motivation: Unpredictability and Uncontrollability in the Anthropomorphism Strategy

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26 control and more positive evaluations under high predictability. Together, these findings  
27 advance anthropomorphism models by providing discriminant evidence that lacking both  
28 control and predictability uniquely compel anthropomorphic attributions to re-establish  
29 effectance. Imposing familiar mental models appears to serve a compensatory function when  
30 interfacing with nonhuman entities, regulating uncertainty by bolstering perceived agency  
31 alongside comprehension. Elucidating such psychological processes carries practical  
32 implications for designing transparent and relatable, yet objectively unreliable, AI systems.

33

34 **Keys words:** predictability, control, anthropomorphism, need for closure.

35

## 36 1. Introduction

37 Anthropomorphism, the attribution of human characteristics to non-human agents, has  
38 received much attention in recent years due to the rise of new technologies such as social robots  
39 and artificial intelligence (AI) to facilitate interaction with these machines and make it "more  
40 natural" [1]. This process involves attributing human-like appearance and behaviors (i.e.,  
41 superficial characteristics) as well as mind and emotions (i.e., essential characteristics) to non-  
42 human entities [2, 3, 4]. Faced with a non-human agent, attributing human characteristics to it  
43 serves an adaptive function: understanding and anticipating its actions.

44 According to the SEEK model (Sociality, Effectance, and Elicited Agent Knowledge)  
45 proposed by Epley and colleagues [3], anthropomorphism satisfies *effectance motivation*—a  
46 fundamental psychological need for control and predictability in one's environment [5, 6].  
47 Predictability refers to the ability to anticipate outcomes based on patterns, whereas control  
48 describes the capacity to influence or modify a situation directly. For example, while artificial  
49 intelligence systems may behave unpredictably due to "black box" algorithms, they can still  
50 offer users control through adjustable parameters. Conversely, deterministic systems might be  
51 predictable but resist direct intervention by users. Understanding this distinction is crucial, as  
52 predictability and control are often conceptually conflated, despite evidence suggesting they  
53 operate as independent constructs [7, 8, 9].

54 The present study builds on prior work, particularly by Waytz et al. [7], who demonstrated  
55 that unpredictability in technological gadgets' actions increases anthropomorphic inferences.  
56 However, their work did not separate predictability from control, treating them as  
57 interdependent facets of effectance motivation. To address this gap, the current research  
58 investigates the distinct roles of control and predictability in shaping anthropomorphic  
59 attributions. By distinguishing these constructs, this study aims to refine our understanding of  
60 how humans compensate for uncertainty when interacting with non-human entities.

61

## 62 **1.1. Predictability, control, and uncertainty**

63 Predictability is the one ability to anticipate an outcome whether the person can influence  
64 or not the outcome [7] while perceiving control is to believe that one could significantly change  
65 a situation [10], but also to see the world as structured, ordered, and above all, non-chaotic [11].  
66 It's probably because perception of control and predictability can both linked with feelings of  
67 uncertainty [12] that some researchers do not conceive control without prediction (e.g., [13,  
68 14]; “they will not be easy to separate” [15], p. 58), arguing that a stimulus cannot be  
69 controllable if it is not predictable [16]. However, Geer and Maisel [17] have shown that effects  
70 of control are not the effects of control-prediction interaction. In that direction, others argue  
71 that predictability and control have often been confused [18, 19]. Sometimes, predictability can  
72 even be conceived as a determinant of control. However, according to Miller [20], this variable  
73 does not always influence the perception of control. Although these factors seem to lead to  
74 similar effects (e.g., reduce negative affects), they seem to function independently [9, 18, 21].  
75 To illustrate this independence, Burger and Akin [18] give the example of a person who is ill  
76 and has a high perception of control over his/her recovery by doing what is necessary (e.g.,  
77 taking medication), but a low perception of prediction over when he/she will be cured. It seems  
78 that predictability would be future oriented while control would pertain to the immediate  
79 experience.

80

## 81 **1.2. Anthropomorphism as a compensation strategy**

82 People expect to interact effectively (i.e., control) with their environment [22], and to  
83 anticipate (i.e., predictability) other actions. Because non-human technologies can initially  
84 appear uncontrollable and unpredictable, anthropomorphism serves an important psychological

85 function. By imbuing machines with perceived autonomy and intentions, people satisfy their  
86 basic need to impose structure and agency onto their surroundings [3, 11, 23, 24].

87 When perceptions of control or predictability are threatened, uncontrolled uncertainty  
88 activates unpleasant emotions in the amygdala and prefrontal cortex [25]. A variety of  
89 compensatory strategies then emerge to regain a sense of mastery, such as increased beliefs in  
90 powerful external entities like God [26]. Crucially, anthropomorphizing non-human agents  
91 represents an efficient way to quickly assimilate them into understandable social schemas [1].

92 Seeing autonomy and intentionality in technologies allows for control through imagined  
93 social influence over their "mental states", reducing uncertainty-induced anxiety [27]. The  
94 motivation to maintain perceptions of control has been well-documented across cultures and  
95 disciplines [11, 28, 29, 30]. Landau and colleagues' [11] framework positions  
96 anthropomorphism specifically as a compensatory control strategy, restoring feelings of  
97 structure and agency through imbuing the environment with perceived intentionality.

98

### 99 **1.3. Role of dispositional variables in anthropomorphism**

100 There is substantial individual variability in propensity to anthropomorphize non-human  
101 entities [31]. For instance, personality traits like the need for closure, the need for cognition  
102 have been linked to differences in anthropomorphic reasoning [3, 32].

103 The need for closure reflects an orientation towards rapidly resolving uncertainty through  
104 hypothesis generation and validation [33]. This drive can encourage simplistic, target-general  
105 attributions that fuel anthropomorphism through accessibly human schemas rather than target-  
106 specific analysis [34]. As such, high need for closure individuals may be more prone to  
107 anthropomorphize due to a preference for expedient uncertainty reduction over nuanced  
108 understandings [32]. In addition, the need for control reflects discomfort with ambiguity and a  
109 motivation for structured, ordered perceptions [35]. Those higher in this trait therefore seek to

110 comprehend their environment in predictable, agentic terms amenable to perceived influence.  
111 The strategic attribution of human characteristics would be a strategy to satisfy this regulatory  
112 need, suggesting heightened anthropomorphism under conditions of uncertainty.

113

#### 114 **1.4. Overview**

115 In the present study we were interested in distinguished predictability and control. In one  
116 of their studies Waytz et al. [7] show that the effectance motivation - by manipulating  
117 (un)predictability - increases the attribution of anthropomorphic inferences to different  
118 technological gadgets (e.g., the technological gadget is perceived as having intentions, a  
119 conscience, etc.). Because perceptions of control and predictability are often confused, the  
120 present study proposes a variant which requires participants to judge technological gadgets that  
121 could produce predictable *versus* unpredictable actions and from which the activation was  
122 controllable *versus* uncontrollable. We hypothesized that participants would anthropomorphize  
123 technological gadgets more when they perceive a lack of control over their activation than when  
124 they perceive the possibility to control their activation (H1). this hypothesis is consistent with  
125 the literature suggesting that anthropomorphism is a compensation control strategy. In the same  
126 way, because unpredictability leads to a motivation to understand [7, 36] participants would  
127 anthropomorphize more gadgets presented with unpredictable actions than those with  
128 predictable actions (H2). Finally, we expected, as a reinforcement effect, that when gadgets are  
129 described as uncontrollable and unpredictable that anthropomorphic inferences would be more  
130 prominent (H3). In exploratory approach, a dispositional variable such as the need for closure  
131 was included to observe individual differences in the anthropomorphism strategy.

132

## 133 **2. Method**

### 134 **2.1. Methodological overview**

135 This study draws conceptual inspiration from Waytz and colleagues [7] experiment  
136 examining effects of controllability and predictability on anthropomorphism. In their  
137 "Unpredictable Gadgets" study, participants evaluated 30 technological devices that varied in  
138 whether their actions were predictable (i.e., within user control) or unpredictable (i.e., outside  
139 user control). Greater perceived control over and predictability of devices respectively predicted  
140 higher ratings of anthropomorphism, supporting the role of effectance motivation.

141 The current study aims to replicate and extend Waytz and colleagues [7] seminal work by  
142 orthogonally manipulating two key dimensions - a device's predictability (i.e., predictability of  
143 its actions) and controllability (i.e., whether its activation is within the user's control). This  
144 permit investigating interactive effects between perceived control and predictability on  
145 anthropic reasoning. Additionally, by incorporating relevant individual differences shown to  
146 moderate anthropomorphism like need for closure, the study endeavors to propose an enhanced  
147 model linking effectance motivation more comprehensively to strategic anthropic inferences.

148

## 149 **2.2. Participants**

150 The sample consists of 107 participants ( $N_{\text{women}} = 53$ )<sup>1</sup> from an English recruitment platform  
151 (Prolific Academic) in exchange for 7.40£ per hour (for details of participants characteristics,  
152 see Table 1). Participants completed the online survey through a 2, Control (High vs. Low) x  
153 2, Predictability (High vs. Low) within-participants design. The sample size was calculated  
154 with G\*power software and the original study's effect size ( $\alpha = .05$ ,  $\beta = .80$ ,  $\eta^2 = .51$ ). Thus,  
155 the recommended minimum size of sample was 50.

156

## 157 **Table 1**

---

<sup>1</sup> For technical reasons, the age of participants was not requested. However, age, sex and education were not considered in the analyses. These variables were included in this study only to describe the sample. In addition, the average age of participants on the Prolific platform is less than 40 years old (e.g., Study 1:  $M = 31.5$ ,  $SD = 11$ , Study 2:  $M = 35.7$ ,  $SD = 13$  [37];  $M = 37.2$ ,  $SD = 14.01$  [38]).

158 *Details of sample characteristics (N = 107)*

Characteristics	n (%)
<b>Gender</b>	
Female	53 (52.5)
Male	48 (47.5)
Missing value	6
<b>Education</b>	
Less than high school degree	4 (3.9)
High school graduate 'high school diploma or equivalent	14 (13.7)
Some college but not degree	25 (24.5)
Associate degree in college (2-year)	9 (8.8)
Bachelor's degree in college (4-year)	26 (25.5)
Master's degree	22 (21.6)
Doctoral degree	2 (2.0)
Professional degree (JD, MD)	0 (0)
Missing value	5

159

160 **2.3. Procedure**

161 The procedure is almost identical to Waytz and colleagues [7]. The study was presented as  
 162 being interested in the opinions of consumers regarding devices that are in production. First,  
 163 participants completed the dispositional variables as the Mini-IPIP scale (20-items, [39])<sup>2</sup> and  
 164 then the Need for Closure scale (15-items, [40]). In a second phase, all participants were  
 165 exposed to 30 technological gadgets. The 30 technological gadgets are presented with their  
 166 name, a brief description and not one rule, as in the original study, but two. These rules present  
 167 how the devices work. It allows to make devices appear as having an *activation* either highly  
 168 or lowly controllable by the user, and on the other hand, having *actions* either highly or lowly  
 169 predictable. These gadgets were presented one after the other at random, and in one of the four

<sup>2</sup> As part of an exploratory approach, participants personality traits using the Mini-IPIP scale (20-items [39]) were assessed before the NFC scale. Correlations between Mini-IPIP and NFC, anthropomorphism and attractiveness are available in the supplementary material on OSF: <https://osf.io/pzg9r/>

170 experimental conditions (High Control/High Predictability vs. High Control/Low Predictability  
171 vs. Low Control/High Predictability vs. Low Control/Low Predictability). For example<sup>3</sup>:

172           **“Clocky**

173           Clocky is an alarm clock that looks like a furry animal and operates in a way that  
174           makes it difficult to repeatedly press snooze in the morning.

175           You can control Clocky activation (*High control condition*). You can program  
176           Clocky so that when you press snooze, Clocky either runs away from you or it  
177           jumps on top of you. This device is activated on demand, but you cannot control its  
178           response to pressing snooze (*Low predictability condition*).”

179 For each of the 30 technological gadgets, participants were asked to indicate their degree of  
180 perception of control over the device (1 item, [7]), the degree of anthropomorphism (2 items,  
181 [7]) and the degree of attractiveness (1 item, [7])<sup>4</sup>. At the end of the study, participants were  
182 asked to complete socio-demographic data (gender, level of education). In all, participants  
183 completed 157 items and the averaged completion time was estimated at 15 minutes.

184

185           **2.4. Measures**

186           *Need for closure*. The short version of Need for Closure scale [40] was completed at the  
187 beginning of the study. This scale assesses individual differences on how much a person may  
188 prefer any answer rather than ambiguity [41]. Indeed, people with a high need for closure would  
189 prefer predictability and structure, and would be uncomfortable with ambiguity [42]. This one-  
190 dimensional scale ( $\alpha = .84$ ) consists of 15-items (e.g., “I find that a well ordered life with regular

---

<sup>3</sup> All technological gadgets (i.e., name, description and variation in the four different experimental conditions) are available on OSF: <https://osf.io/pzg9r/>

<sup>4</sup> Following Waytz et al. [7], participants were also asked to assess the gadgets on their efficiency. However, participants' answers on this variable were not available on Qualtrics. The item does not present in the datasets was therefore not analyzed.

191 hours suits my temperament.”) with a 7-point Likert scale from 1-Strongly disagree to 7-  
192 Strongly agree.

193 *Perception of control, anthropomorphism, and attractiveness.* As in the original study  
194 [7] the perceived control is assessed through an item on 7-point Likert scale (from 1-Not at all  
195 to 7-Very much). Participants indicated in which extent they could control each gadget (i.e.,  
196 “To which extent do you think you can control that device?”). Concerning anthropomorphism,  
197 it is measured with two items from [7] ( $\alpha = .89$ ) on 7-point Likert scale (from 1-Not at all to 7-  
198 Very much). These items assess to which extent participants reported the gadget have “a mind  
199 of its own”, “intentions” (e.g., “This gadget has a mind of its own”). It is to mention, in the  
200 original study, authors also included the items “free will”, “consciousness” and “experience  
201 emotions”. We restricted the items to two for practical reasons regarding the experiment  
202 duration and cost. Finally, participants reported the extent to which they found the gadgets  
203 attractive on the same scale (i.e., “This gadget is attractive”, on 7-point Likert scale from 1-Not  
204 at all to 7-Very much).

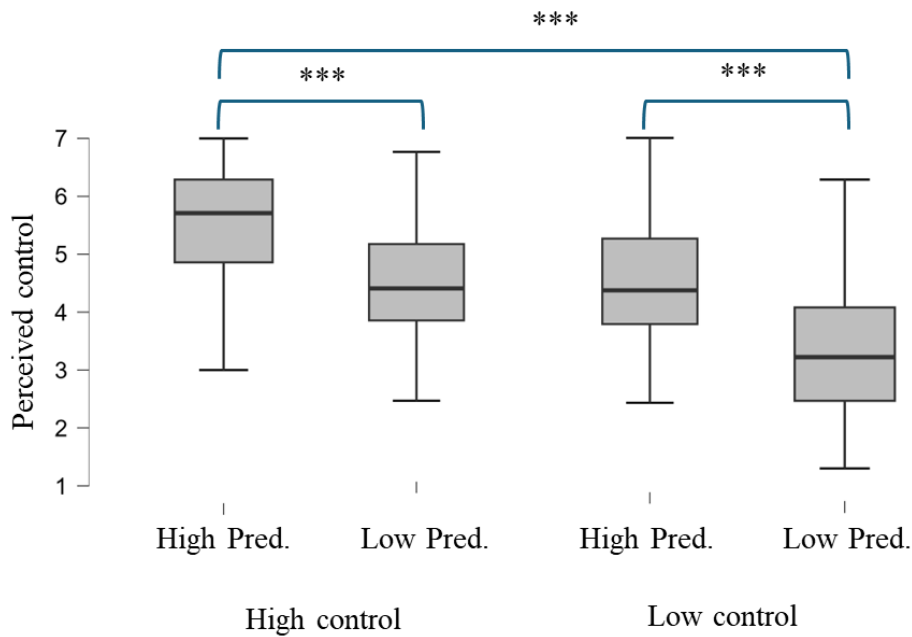
205

### 206 **3. Results**

#### 207 **3.1. Perceived control: manipulation check**

208 We first conducted a repeated measures ANOVA, including the Control (High vs Low) and  
209 Predictability (High vs Low) as within independent variable and the level of perceived control  
210 as DV.

211 While the results showed a non-significant interaction Control\*Predictability,  $F(1, 106) =$   
212  $.32, p = .577, n^2p < .01$ , participants declared higher perceived control in high control condition,  
213  $F(1, 106) = 178.13, p < .001, CI 95\% [.94, 1.27], n^2p = .63$  compared to low control condition,  
214 and in high predictability condition,  $F(1, 106) = 200.26, p < .001, CI 95\% [1.10, 1.47], n^2p =$   
215  $.65$ , compared to low predictability condition (see Figure 1).



217

218 **Figure 1.** Perceived control as the function of the control (high vs. low) and predictability  
 219 (high vs. low) conditions.

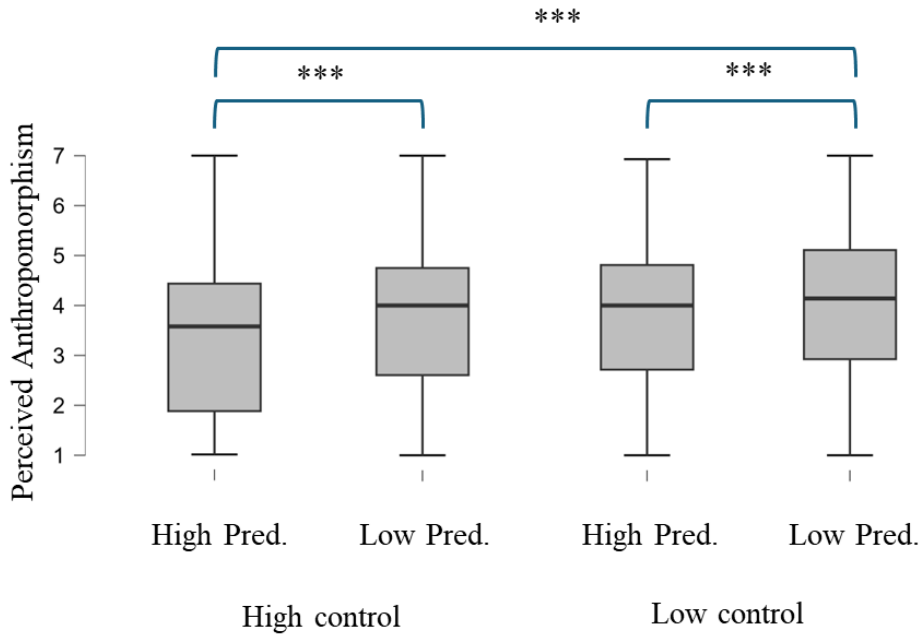
220

### 221 3.2. Anthropomorphism

222 To test whether anthropomorphism increased in high vs. low control and predictability  
 223 conditions, we conducted a repeated measures ANOVA, including the Control (High vs. Low)  
 224 and Predictability (High vs. Low) as within independent variable and the level of  
 225 anthropomorphism as DV.

226 The interaction term Control\*Predictability was non-significant,  $F(1, 106) = 3.19, p = .077,$   
 227  $n^2p = .03$ . However, results showed that, in the low control condition (compared to high  
 228 control), participants attributed higher anthropomorphism to objects,  $F(1, 106) = 26.70, p <$   
 229  $.001, CI 95\% [.20, .43], n^2p = .22$ . Also, in the low predictability condition, participants  
 230 attributed higher level of anthropomorphism to objects compared to the high predictability  
 231 condition,  $F(1, 106) = 25.76, p < .001, CI 95\% [.17, .38], n^2p = .20$  (see Figure 2).

232



233

234 **Figure 2.** Level of anthropomorphic attributions as the function of the control (high vs. low)  
 235 and predictability (high vs. low) conditions.

236

### 237 3.3. Attractiveness

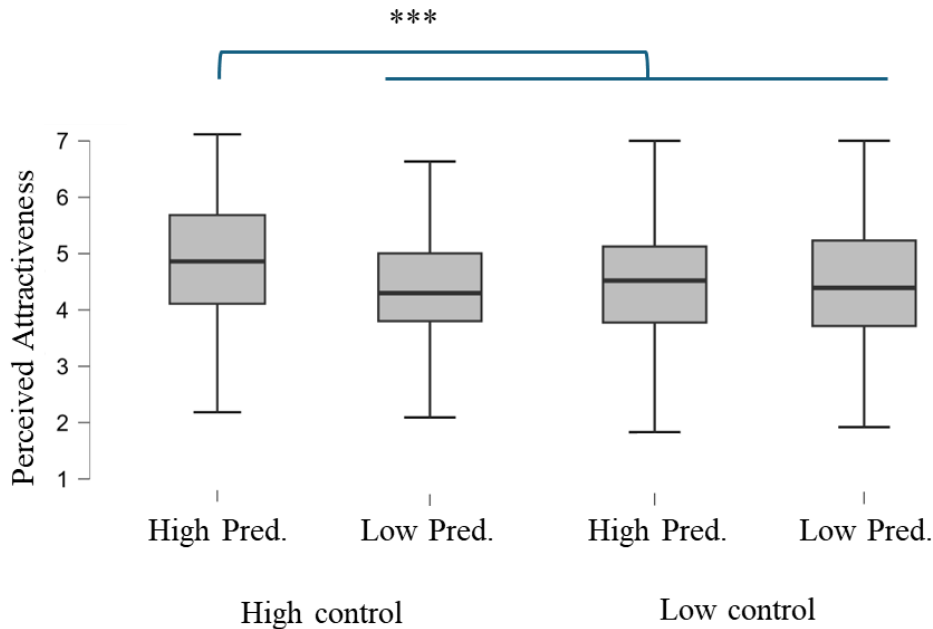
238 We further tested to what extent the level of control and predictability effected the  
 239 attractiveness of objects. To do so, we conducted a repeated measures ANOVA, including the  
 240 Control (High vs. Low) and Predictability (High vs. Low) as within independent variable and  
 241 the level of attractiveness as DV.

242 Interestingly, we found a significant interaction Control\*Predictability,  $F(1, 106) = 13.63$ ,  
 243  $p < .001$ ,  $\eta^2 p = .12$ . Contrasts with Holm correction showed that participants declared higher  
 244 attractiveness to objects in high control and high predictability condition compared to all other  
 245 condition averaged<sup>5</sup>,  $t(106) = 5.70$ ,  $p < .001$ , CI 95% [.75, 1.55], while there was no difference  
 246 between the other conditions (all  $p_s > .900$ ) (see Figure 3).

<sup>5</sup> Detailed post-hoc contrasts with Holm correction showed that participants declared higher attractiveness in the high (control)/high (predictability) condition compared to the Low/High,  $t(106) = 4.32$ ,  $p < .001$ , CI 95% [.13, .55], High/Low,  $t(106) = 5.22$ ,  $p < .001$ , CI 95% [.21, .65], Low/Low conditions,  $t(106) = 4.42$ ,  $p < .001$ , CI 95% [.15, .61]. All the other contrasts failed to reach significance (all  $p_s > .900$ ).

247 Results also showed a main effect on control,  $F(1, 106) = 622, p = .014, CI\ 95\% [.03, .27],$   
248  $n^2p = .06,$  and predictability,  $F(1, 106) = 13.84, p < .001, CI\ 95\% [.11, .36], n^2p = .12.$

249



250

251 **Figure 3.** Level of attractiveness as the function of the control (high vs low) and predictability  
252 (high vs low) conditions.

253

254 It is also to mention that attractiveness and anthropomorphism were strongly correlated,  $r = .61,$   
255  $p < .001, CI\ 95\% [.48, .72].$

256

### 257 3.4. Need for closure

258 We further investigated to what extend participants' need for closure could moderate the  
259 significant differences observed in the previous analysis. We therefore conducted separated  
260 regression analyses to test the moderating weight of the individual need for closure score on the  
261 control and predictability effect on perceived control, anthropomorphism, and attractiveness,  
262 and the on the Control\*Predictability effect on attractiveness.

263 Results showed no significant moderation by the need for closure on the effect of control  
264 on perceived control,  $t(106) = 1.83$ ,  $p = .070$ , CI 95% [-.02, .39],  $R^2_{adj} = .02$ , and  
265 anthropomorphism,  $t(106) = -.25$ ,  $p = .806$ , CI 95% [-.33, .26],  $R^2_{adj} = .01$ . The same was true  
266 for the effect of predictability on anthropomorphism,  $t(106) = .54$ ,  $p = .592$ , CI 95% [-.23, .41],  
267  $R^2_{adj} = .01$ . Also results failed to reach significance regarding the effect of control,  $t(106) = 1.05$ ,  
268  $p = .298$ , CI 95% [-.02, .44],  $R^2_{adj} = .01$ , and the control\*predictability,  $t(106) = 1.05$ ,  $p = .298$ ,  
269 CI 95% [-.14, .44],  $R^2_{adj} = .01$ , on attractiveness.

270 However, results showed that the higher the need for closure, the higher the perceived  
271 control in high (vs. low) predictability condition,  $t(106) = 2.08$ ,  $p = .040$ , CI 95% [.01, .37],  
272  $R^2_{adj} = .03$ . Also, the higher the need for closure, the higher the attractiveness in high (vs. low)  
273 predictability condition,  $t(106) = 2.58$ ,  $p = .011$ , CI 95% [.08, .60],  $R^2_{adj} = .05$ .

274

#### 275 **4. Discussion**

276 Effectance motivation, defined as the desire for control and predictability coupled with a  
277 drive for sociability, is a core component of anthropomorphism models [3]. However, in their  
278 exploration of the effects of effectance motivation on anthropomorphic inferences, Waytz et al.  
279 [7] operationalized it exclusively through predictability. This approach likely stems from the  
280 traditional view, following Seligman [14], that control and predictability are inherently  
281 intertwined. In contrast, this study assumes that control and predictability function  
282 independently [18], and our findings strongly support this distinction.

283 As hypothesized, a lack of control over the activation of technological gadgets  
284 significantly increased anthropomorphic attributions (H1 supported). Similarly, a lack of  
285 predictability in gadget behavior also heightened anthropomorphic inferences (H2 supported).  
286 These findings confirm the results of Waytz et al. [7], which showed that unpredictability

287 increases anthropomorphic attributions, while adding a novel theoretical dimension: the  
288 discomfort arising from a lack of control contributes independently to anthropomorphism.

289 Our results revealed that, while both control and predictability influence  
290 anthropomorphism, their effects did not interact. This supports the conclusions of Geer and  
291 Maisel [17], Burger and Arkin [18], and others advocating for the conceptual separation of these  
292 constructs. For example, Nickels et al. [9, 43] describe "predictionless control" as scenarios in  
293 which individuals possess control without predictability. Cramer et al. [44] illustrate this with  
294 the case of a foreigner ordering food from a menu in an unfamiliar language: the individual has  
295 control over the order but cannot predict the dish that will be served. More broadly, the concept  
296 of control remains ambiguous and multifaceted, as highlighted by Skinner [22], who  
297 documented the numerous terms, definitions, and operationalizations related to the notion of  
298 control.

299 Contrary to our third hypothesis (H3), the combination of low control and low  
300 predictability did not lead to an additive effect on anthropomorphism. Instead, participants rated  
301 gadgets in this condition as less attractive. This finding aligns with research in human-machine  
302 interaction, which shows that the perception of control over a machine significantly influences  
303 user attitudes and acceptance, such as the intention to use it [8, 45]. Similarly, the predictability  
304 of a machine's actions may enhance perceptions of security during interactions [46].  
305 Consequently, a gadget perceived as both uncontrollable and unpredictable is unlikely to be  
306 accepted or used and may even be perceived as threatening due to its unfamiliarity. Moreover,  
307 the significant interaction effect observed for attractiveness suggests that attractiveness  
308 judgments may represent a composite evaluative dimension, integrating both functional  
309 reliability and emotional appeal. When both control and predictability are high, users not only  
310 experience a greater sense of agency but also benefit from the reassuring nature of predictable  
311 interactions, leading to enhanced aesthetic evaluations. In contrast, while the absence of control

312 or predictability independently prompts compensatory anthropomorphic attributions, such  
313 conditions do not suffice to yield positive attractiveness judgments. This divergence  
314 underscores that attractiveness may depend on the simultaneous fulfillment of both affective  
315 comfort and cognitive satisfaction, highlighting its unique sensitivity to the interplay between  
316 control and predictability.

317 Finally, we hypothesized that individuals with a higher need for closure would exhibit  
318 greater anthropomorphism of unpredictable or uncontrollable gadgets, driven by their stronger  
319 desire to impose coherent and agentic explanations under conditions of uncertainty. However,  
320 need for closure did not significantly moderate the effects of control or predictability on  
321 anthropomorphism. This lack of moderation could stem from the study's online context or the  
322 hypothetical nature of the gadget descriptions, which may not have sufficiently activated  
323 participants' intolerance of ambiguity. Additionally, the Need for Closure scale itself may not  
324 fully capture this construct's complexity. Future studies should consider employing  
325 experimental manipulations of need for closure or alternative measurement tools to address  
326 these limitations.

327 Despite these results, need for closure was associated with higher perceived control and  
328 greater attractiveness in high (vs. low) predictability conditions. This suggests that individuals  
329 with a strong preference for structured, ordered information may be more sensitive to  
330 predictability when evaluating technological gadgets. While need for closure did not directly  
331 moderate anthropomorphism, its influence on evaluations of predictable stimuli highlights the  
332 need to consider both cognitive and affective dimensions in anthropic reasoning.

333 While the present study provides valuable insights into the distinct roles of predictability  
334 and control in anthropomorphic reasoning, it is not without limitations. First, the reliance on  
335 hypothetical technological gadgets may have constrained participants' real-world applicability  
336 of responses. Although this approach allowed for experimental control, it may not fully capture

337 the complexity and emotional engagement of interactions with actual devices. Future studies  
338 should include real-world interactions with physical or digital systems to enhance ecological  
339 validity.

340 Second, the measurement of anthropomorphism relied on self-reported items that, while  
341 validated, may be subject to social desirability bias or introspective inaccuracies. Utilizing  
342 complementary methods such as behavioral observations or physiological measures could  
343 provide a more nuanced understanding of anthropomorphic tendencies.

344 Third, the lack of a significant interaction effect between control and predictability on  
345 anthropomorphism suggests the need for further exploration. It is possible that the manipulation  
346 of these variables did not fully capture their complexities, or that additional factors, such as  
347 perceived agency or trust, moderated their effects. Future work could expand upon these  
348 findings by incorporating a broader range of contextual and dispositional variables.

349 Additionally, while the Need for Closure scale provided useful insights into individual  
350 differences, it did not significantly moderate the key effects as hypothesized. This could be  
351 attributed to the limited sensitivity of the scale in an online experimental context. Alternative  
352 measures or experimental manipulations of need for closure may yield more robust evidence of  
353 its moderating role.

354 Finally, the sample, though diverse, consisted primarily of participants from a single online  
355 platform. This homogeneity may limit the generalizability of the findings across different  
356 populations or cultural contexts. Expanding the sample to include participants from varied  
357 demographic and cultural backgrounds would strengthen the external validity of the results.

358

## 359 **5. Conclusion**

360 This study replicated and extended previous findings, showing that anthropomorphism  
361 increases for unpredictable and uncontrollable non-human agents. Critically, we demonstrated

362 that these effects operate independently, reinforcing the conceptual distinction between  
363 perceived control and predictability. These results provide robust evidence that  
364 anthropomorphism satisfies effectance motivation by compensating for deficits in control and  
365 predictability, offering new insights into the psychological mechanisms underpinning anthropic  
366 reasoning.

367 Our findings highlight that lacking control and lacking predictability each contribute unique  
368 variance to anthropomorphism. When technological devices behaved unpredictably,  
369 participants attributed humanlike autonomy and intentions to them. Similarly, deficient control  
370 elicited compensatory anthropomorphism, even when the devices' actions were predictable.  
371 These results emphasize the multifaceted nature of effectance motivation: anthropomorphism  
372 functions not only to enhance comprehension but also to restore perceived agency in uncertain  
373 environments.

374

375 These insights align with emerging neuroscience perspectives on anthropomorphism,  
376 particularly those grounded in predictive processing frameworks. Imposing familiar  
377 anthropomorphic mental models helps resolve prediction errors and compensates for control  
378 deficiencies, addressing violations of expectations related to efficiency and intentionality.  
379 Anthropomorphism thus serves as a cognitive strategy for regulating uncertainty and  
380 maintaining a sense of mastery.

381 The practical implications of these findings are significant. The differential effects of  
382 control versus predictability suggest that user-centered AI and robotic design should prioritize  
383 transparent and interpretable functionality over merely predictable behavior. Additionally,  
384 fostering a sense of co-agency during human-machine interactions may discourage excessive  
385 anthropomorphism that could undermine objectivity or inflate user expectations. Striking a

386 balance between relatable and reliably non-human interfaces is crucial for advancing human-  
387 machine collaboration in a manner that is both functional and psychologically adaptive.

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389

### **Declarations**

390 **Ethical Statement:** This research was conducted in accordance with the Declaration of  
391 Helsinki.

392 **Open Science Statement:** The study materials and data have been deposited on the  
393 Open Science Framework: <https://osf.io/pzg9r/>

394 **Data availability:** The study data can be directly accessed at <https://osf.io/pzg9r/>

395 **Authors contributions:** D.D and N.S contributed to the study conception and design.  
396 Data collection and analyses were performed by N.S, and funds for the participants  
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