International Journal of Social Robotics (2022) 14:1013–1024
https://doi.org/10.1007/s12369-021-00848-9

# "I Have to Praise You Like I Should?" The Effects of Implicit Self-Theories and Robot-Delivered Praise on Evaluations of a Social Robot

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Accepted: 19 November 2021 / Published online: 23 January 2022


**Abstract**

Recent research suggests that implicit self-theories—a theory predicated on the idea that people's underlying beliefs about whether self-attributes, such as intelligence, are malleable (incremental theory) or unchangeable (entity theory), can influence people's perceptions of emerging social robots developed for everyday use. Other avenues of research have identified a close link between ability and effort-focused praise and the promotion of individual implicit self-theories. In line with these findings, we posit that implicit self-theories and robot-delivered praise can interactively influence the way people evaluate a social robot, after a challenging task. Specifically, we show empirically that those endorsing more of an entity theory, indicate more favorable responses to a robot that delivers ability praise than to one that delivers effort praise. In addition, we show that those endorsing more of an incremental theory, remain largely unaffected by either praise type, and instead evaluate a robot favorably regardless of the praise it delivers. Together, these findings expand the state-of-the-art, by providing evidence of an interactive match between implicit self-theories and ability, and effort-focused praise in the context of a human-robot interaction.

**Keywords** Implicit self-theories · Mindset · Human–robot interaction · Social robotics · Praise · Effort-ability

## 1 Introduction

Implicit self-theory, implicit theories, or, more colloquially 'mindset theory', asserts that individual's underlying beliefs about whether self-attributes (e.g., personality and intelligence) are malleable (incremental theory) or are unchangeable (entity theory) causally affect motivation [14] and behavior [27], with the largest effects occurring in situations that involve challenges and setbacks [98].

Ample research suggests that feedback and praise, particularly, effort (i.e., hard work) and ability (i.e., intelligence) praise, may foster implicit self-theories from an early age on (see [46], for review ).

Additionally, there is a longstanding and growing evidence base that suggests implicit self-theory exerts its effect on a wide array of self-attributes and downstream variables [26,81]. These range from intelligence [12,33,85], personality [17,35], morality [16,53], emotions [58,91], and relationships [59,60,75], to evaluations of marketing messages [55,100], brands [67,79], technology [39,45,89] and financial decisions [71,82].

Consistent with these findings, we have recently reported in this journal, the first empirical evidence of the influence of implicit self-theories on people's perception of emerging social robots developed for everyday use [3].

In this article, we build on, and substantially extend, our previous work by examining the effect of implicit self-theories on people's responses to a robot that praises for ability (i.e., intelligence), and for effort (i.e., hard work), after completing a difficult reading and comprehension task.

We expect, and find evidence that entity theorists, who seek flattering external validation regarding their capabilities, and are liable to becoming defensive in the face of challenges [12,52,76], evaluate a social robot as more intelligent and likable after receiving ability praise (i.e., praise for intelligence) than effort praise (i.e., praise for hard work). By contrast, incremental theorists, who orient towards developing their abilities, and exert greater effort when facing challenges [25,29], are unaffected by praise type. Hence, incremental

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theorists' ratings of the robot did not differ between conditions.

## 1.1 Theoretical Framework and Hypotheses

### 1.1.1 Implicit Self-Theories and Praise

As noted, implicit self-theories are underlying beliefs people hold about the malleability or fixedness of self-attributes (e.g., intelligence, personality). A substantial body of research suggests there are two kinds of implicit self-theories held by individuals: the incremental theory and the entity theory.[1] Those who hold an incremental self-theory (incremental theorists) assume that self-attributes are mutable and amenable to change through self-development efforts, practice, and education. Incremental theorists are driven to develop their ability (i.e., learning goals; [34]). Accordingly, they are prone to seeking out learning opportunities [12], and tend to be more learning-oriented [35]. Consequently, they are better able to adapt to situational change, challenges, and setbacks, relative to entity theorists [33].

In contrast, those who hold an entity theory (entity theorists) assume that self-attributes are largely fixed and unsusceptible to change [30]. In consequence, they are driven to validate their competence and/or avoid looking incompetent (i.e., performance goals; [34]). Thus, they are prone to seeking out situations and cues that provide favorable external evidence of their capabilities [77,78]. Furthermore, entity theorists, compared to incremental theorists, are more risk-averse [82], sensitive to negative evaluations [52], and display more helpless reactions in the face of failure [98].

Clearly, an exhaustive review of implicit self-theory is not feasible here (but see[31], for review), however, five key characteristics bear mentioning. Firstly, each theory occurs with equal frequency within most populations [14,70]. Secondly, the differences in implicit self-theory are most salient under conditions of challenge or when facing setbacks [98]. Third, although implicit self-theories are moderately stable [32,85] and can be measured as an individual difference variable [64], they can also be temporarily altered,[2] via experimental stimuli such as scientific articles [10,51] and video media [68], in order to assess the causal role the theories play [70]. Fourth, these contrasting self-theories appear to affect a vast spectrum of human motivation, perception, and behavior [27,64,68,85]. Finally, many of the consequences of one's implicit self-theory appear to operate outside of one's awareness [99].

Crucially, a long tradition of research has consistently found that implicit self-theories arise from, and are related to, ability and effort-focused praise (e.g., [56,66,80]).

In a landmark study by Mueller and Dweck [72], fifth-grade children worked on a set of challenging tasks and were subsequently praised, first with outcome praise ("Wow, you did very well on these problems. You got [number of problems] right. That's a really high score.") The children were informed that of the problems they had answered they had solved at least 80%. This was followed by one of two types of praise–ability (e.g., "You must be smart at these problems."), and effort (e.g., "You must have worked hard at these problems.") A control condition received the initial outcome praise only. Next, the children were given a set of problems of increased difficulty, of which most failed. According to Mueller and Dweck [72], the children who were praised for their ability viewed their intelligence as innate. Accordingly, they rejected a hard task, in favor of an easier task that, presumably, would pose no threat to their intelligence. Contrastingly, the children praised for their effort viewed their intelligence as something that could be developed. Thus, this group chose a hard task rather than an easier task in order to learn from it.

Since this study,[3] researchers have continued to find support for the interrelationship of implicit self-theories and ability, and effort-focused praise (e.g., [18,47,66]).

For example, Gunderson et al. examined parents' use of ability and effort praise in the presence of their children aged 1–3 years. They demonstrated that parents' use of effort praise predicted children's incremental theory of intelligence 5 years later [44]. Furthermore, in a study conducted by Pomerantz and Kempner [80], parents of 8–10 year-olds were interviewed on a daily basis, in order to track their use of ability and effort-focused praise. Upon assessing the children's implicit self-theories 6 months later, they found that frequent use of ability praise predicted children's entity self-theory.

To be sure, this relationship is well demonstrated using child samples. However, as other researchers have noted, only a handful of studies have examined how ability praise and effort praise interact with implicit self-theories in adult samples, thus warranting further research (see [96]).

[1] Although people tend to endorse one self-theory more than the other, there is some evidence that people may hold implicit self-theories somewhere between the entity and the incremental theory [30,50,54].

[2] It should be noted, that this is a well-used and well-cited practice, employed in the bulk of existing implicit self-theories research (see [30, 52,64,100]). Furthermore, research has repeatedly demonstrated that experimentally induced self-theories' bias preferences in accordance with those found in studies measuring individuals' chronic implicit self-theories as an individual difference factor [70].

[3] One might note that, like other seminal works, the Mueller and Dweck [72] study, has been subjected to some criticism in recent years (e.g., [43]). Primarily, with respect to issues of replication and generalizability [65]. However, many of these criticisms have now been addressed (see [98]).

#### 1.1.2 HRI and Praise

Research on praise in HRI has been conducted from different perspectives. Some work has focused on: investigating how humans attribute praise and punishment to robots [6,7], robot-delivered praise for increasing user motivation [37,86], self-efficacy [101], as well as personalized robot praise toward children [88] and older adults [93]; other work has evaluated the role of praise in game-based interactions [2] and nurturing praise in a therapy context [92], and still other research has examined the relationship between robot-delivered praise, trust, and compliance [40].

Despite progress made, it seems particularly interesting that there is scant scholarly research on the role of ability-focused or effort-focused praise in the field. This is a surprising omission given that this form of praise is one of the most extensively researched praise types in the educational and psychological literatures (see [13,19,61]), not to mention it has received attention from researchers in adjacent fields such as Human–Computer Interaction (e.g., [95]).

That said, to the best of our knowledge, there is one published study to date that has (partially) explored the association between effort-focused praise and implicit self-theory. In particular, Davidson et al. [20] conducted an unsupervised longitudinal study whereby children interacted with either a Computer Aided Learning (CAL) system that administered effort-focused praise via headphones or one that delivered the same praise via a social robot. This study found that children who received effort-related praise from the social robot had a significant increase in their incremental self-theory score, compared to those who received praise from the CAL system.

However, even though this single study sheds at least some light on the effect of effort-focused praise and implicit self-theory in HRI, it is hampered by several limitations. Firstly, the researchers examined only a single praise type (effort) on a single implicit self-theory dimension (incremental). In addition, it did not investigate the role of implicit self-theories in shaping attributions and behavior per se, therefore people's evaluations of a robot post-task were not examined. Moreover, this study used a relatively small sample (44 participants), composed of children (aged 6–10 years old), and it reported a few inclusive findings.

As such, it is unknown whether one's implicit self-theory orientation and robot delivered-praise can interactively determine one's evaluation of a robot. Accordingly, the study reported herein was designed to empirically investigate this issue.

#### 1.1.3 Hypotheses

As indicated above, entity theorists' basic assumption that traits are fixed leads them to devalue effort and constantly seek validation [30,34], praise [73] and favorable judgments about their performance [77]. According to Dweck [28] entity theorists' sense of worth rests on demonstrating these traits (see also, [12,27]). Relatedly, those endorsing an entity theory are also more likely to describe their ideal romantic partner as a person who would bolster their fixed qualities (i.e., praise them).

In contrast, incremental theorists prefer romantic partners that will encourage their development (see [28]). Furthermore, incremental theorists are motivated by confronting a challenge, learning, and developing their ability [55,70,85]. Moreover, they are not generally content with gaining favorable competence feedback about themselves [30,68]. Hence, given that incremental theorists are inclined to value effort, and self-monitor their own progress [30,68], external praise that provides flattering extrinsic validation of their capabilities is likely to carry less meaning for incremental theorists than entity theorists.

Finally, it seems pertinent to note that we have recently found that incremental theorists, evaluate robots favorably regardless of how a robot is positioned (in this case, servant, or assistant; [3]).

Considering all the above, entity theorists would be expected to be more partial to a robot that praises for ability than one that praises for effort. Additionally, we should expect incremental theorists to be relatively unaffected by either effort or ability-focused praise, and, in turn, rate the robot favorably in both conditions. Stated formally:

**Hypothesis 1 (H1):** Entity theorists will evaluate the robot as more (versus less) likable after receiving ability (versus effort) praise.
**Hypothesis 2 (H2):** Incremental theorists will evaluate the robot as higher (versus lower) in likability after receiving both effort and ability praise.
**Hypothesis 3 (H3):** Entity theorists will evaluate the robot as more (versus less) intelligent after receiving ability (versus effort) praise.
**Hypothesis 4 (H4):** Incremental theorists will evaluate the robot as higher (versus lower) in intelligence after receiving both effort and ability praise.

## 2 Method

The study hypotheses and analysis plan were pre-registered and may be accessed via the Open Science Framework (OSF): https://osf.io/54nhk/. The study took place in May 2021. Data collection took place over the course of 5 days.[4]

[4] It is important to make clear that in our pre-registration we declared that we had started the data collection process at the time of pre-registration. This, however, pertained only to the recruitment

The experimental procedure was reviewed and approved by the Human Research Ethics Committee of the University of Canterbury (HEC 2020/130).

### 2.1 Recruitment

Participants were recruited via social media postings, recruiting websites; and numerous posters, flyer drops, and word of mouth around the University of Canterbury and the surrounding community. All advertisements indicated that the study was designed to investigate the suitability of a robot as a "test marker" (e.g., marking tests and exams in order to support educators) in the context of a reading and multiple-choice exercise. The robot test marker context allowed us to inconspicuously carry out the theory inductions, as well as to give participants credible robot praise on a plausibly challenging task. Sample recruitment materials are available at https://osf.io/z5x8s/ and https://osf.io/tqxcp/.

Inclusion criteria comprised (1) Participants 18 years or older with fluent English and basic reading and comprehension skills, and (2) no experience with robotics and/or any expertise in AI (e.g., data science and machine learning). Past research suggests that some forms of technical expertise and experience with robotics, both independently and in combination, have positive and moderating effects on people's attitudes toward, and acceptance of, social robots (see [21,24,62,63]). Therefore, it is reasonable to presume that the inclusion of such individuals may have potentially produced distorted findings.

### 2.2 Design

We used a 2 (implicit self-theory: entity vs. incremental theory) ×2 (ability vs. effort praise) between-subjects factorial design. The study was performed in two steps. In the first step, participants' implicit self-theories of intelligence were manipulated impelling some toward an incremental theory and others toward an entity theory. During the second step, we administered a difficult reading and comprehension task on which participants were told they did well. Participants were then presented with either effort or ability praise. We then measured participants' likability and perceived intelligence scores regarding the robot. Participants were randomized into four conditions: (1) entity theory/effort praise, (2) entity theory/ability praise, (3) incremental theory/effort praise, and (4) incremental theory/ability praise. The experiment was conducted by one of two experimenters (both male) who were dressed professionally and wore the same clothing. Both experimenters followed a detailed script. See https://osf.io/j4mvg/ for the full script.

Footnote 4 continued
component. In other words, we had not at that time conducted any of the research described herein.

### 2.3 Participants

A total of 101 adults participated for a $10 gift card. One participant was precluded from analyses a-priori on the basis of failing to answer the manipulation check correctly. Thus, the sample used for analyses comprised 100 participants (53 female, 44 male, 3 with no gender reported) from Christchurch, New Zealand. They ranged in age from 18 to 73 years old ($M = 28.4$, $SD = 15.3$). All participants had a high-school education, and 31% reported having either an undergraduate degree or a postgraduate degree.

### 2.4 Materials

#### 2.4.1 Implicit Self-Theory Manipulation

Participants were randomly assigned to read one of two scientific *Psychology Today* articles adapted from Bergen [10], endorsing either an incremental (e.g., "up to eighty-eight percent of a person's intelligence is due to environmental factors."), or entity (e.g., "up to eighty-eight percent of a person's intelligence is due to genetic factors") theory of intelligence. This priming stimuli is commonly used and well-validated in implicit self-theory research (see [10,52,53,87]). After reading their respective articles, participants were asked to (a) summarize the main point of the article in no more than three sentences, and (b) complete the implicit theory of intelligence measure—which served as a manipulation check—described later in Sect. 2.6.

#### 2.4.2 Task Materials

A challenging reading test was set based on [76], for which praise was later given. The rationale for this was to provide a challenging stimulus because the effects of implicit self-theory are most pronounced under conditions of challenge or difficulty [83]. In particular, participants were given 3 min to read an excerpt from Freud's *The Interpretation of Dreams*. Following Nussbaum and Dweck [76] the text was chosen to be reasonably perplexing and the 3 min time limit was purposely insufficient so as to allow for minimal comprehension. Furthermore, participants were instructed to answer five multiple-choice questions associated with the passage. To ensure the participants felt uncertain of their performance and thus found the robot-delivered praise to be somewhat credible, the questions and answers were designed to be vague and ambiguous.

#### 2.4.3 Manipulation of Praise

Drawing, in part, on the procedure outlined by Mueller and Dweck [72], we manipulated the praise the robot administered. Specifically, the robot informed all participants that they had performed well (e.g., "Wow, you did very well"). It is worthwhile emphasizing here, that all participants were explicitly told they had been successful in terms of their task performance. (In other words, the praise was delivered right after a supposedly successful performance on a difficult task). Following the outcome praise, participants were told that they had 60% of the questions correct.[5] They subsequently heard one of two types of praise from the robot: some were praised for their effort (e.g., "You must have worked hard at these questions" and "Interesting, the pattern indicates that you tend to put in a lot of effort when faced with challenges, would that be right? Just answer yes or no"). Whereas others were praised for their ability (e.g., "You must be smart at these questions" and "Interesting, the pattern indicates that you tend to rely on your intelligence when faced with challenges, would that be right? Just answer yes or no"). Additionally, when the experimenter re-entered the room and asked the robot how the test went, the robot replied, "Overall, the participant has done well at these questions, although this participant is not one of the top performers, the pattern indicates they are quite a hard worker". Alternatively, the robot said, "Overall, the participant has done well at these questions, although this participant is not one of the best performers, the pattern indicates they are quite smart". It is important to point out that the justification for having the robot repeat the praise is based on prior work suggesting that robots need to deliver feedback multiple times in order for it to register as meaningful [37]. See https://osf.io/cs42y/ and https://osf.io/yu37e/ for video examples of both conditions.

### 2.5 Procedure

Participants were tested individually in a small room with a round flat desk. Each participant was briefed about the nature of the study and inroduced to the social robot (A humanoid NAO[6]V5 from Softbank Robotics; see Fig. 1). The robot was seated on a table in front of the participant for the duration of the experiment (see Fig. 2).

After providing consent, and completing a brief demographics questionnaire (age, gender, education), participants were given a 1 page document that described the robot's supposed intelligent reasoning capabilities (a PDF version is

**Fig. 1** The robot used in this study: a NAO V5 by SoftBank robotics

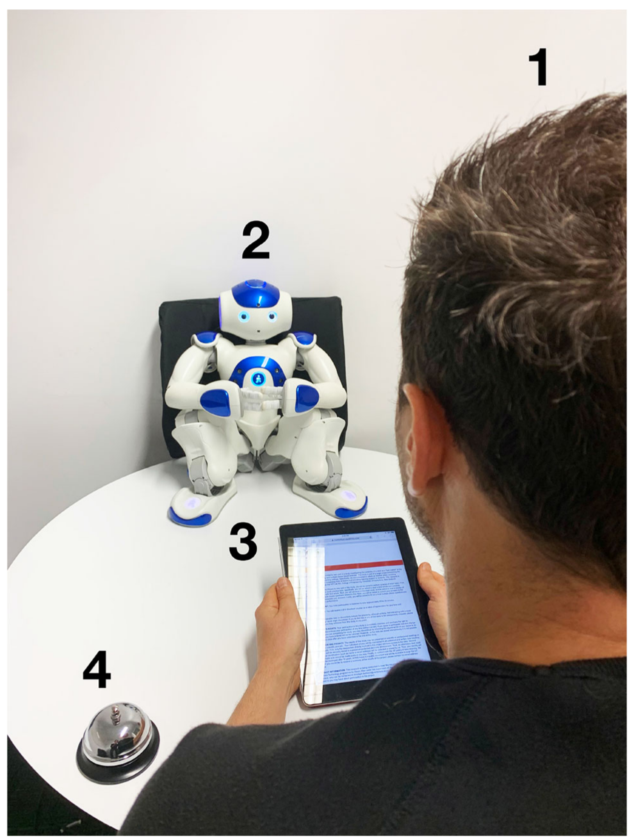


**Fig. 2** Experimental setup with the following components: (1) Participant, (2) NAO robot, (3) iPad, and (4) Bell

[5] We used 60% instead of 80% adopted by Muller and Dweck [72], because there were only 5 questions used in the study described herein. Therefore, we reasoned that 60% (3/5) was more tenable than 80% (4/5) with respect to participants' estimation of their own performance.

[6] https://www.softbankrobotics.com/emea/en/nao.

available at https://osf.io/zjvap/). This aspect of the cover story was designed to ensure that participants perceived the robot praise as well-reasoned, rather than simply a pre-programmed response (which, in fact, it was).

Participants were then instructed to complete a pre-study task, in which their implicit self-theories were manipulated (described above in Sect. 2.4.1). Specifically, they were told they had 6 min to read a short article on an iPad, and two and a half minutes to complete some questions associated with that article. At this point, they were informed that the study was about assessing the robot, not them. Further, they were told that their answers would be automatically converted to a special NAO code.[7] They were then informed that after they had answered the questions, they were to hold the iPad up in front of the robot's eyes and wait until the robot said, "OK got it".

When they had completed the pre-study task, participants were told that they would advance to the primary study task. They were subsequently advised that they would have 3 min to read a section of text and 2 min to answer some questions associated with that text (described in Sect. 2.4.2). Additionally, they were told not to worry if the text didn't appear to make sense at first, as it had been selected purely because the content and the data produced, would be a suitable challenge for the robot to assess. Once again, participants were advised that the purpose of the study was to assess the robot, not them. The participant was then told that their answers would be converted to a NAO code, as in the pre-study task and they would be required to hold it up to the robot's eyes until it says, "OK got it". They were also advised that the experimenter would leave the room until the participant had finished, so as not to distract them. As well, the participant was instructed to ring the bell when the robot told them to do so. The experimenter then left the room.

After they had completed the study task, participants presented the NAO code to the robot. At this point, the robot ostensibly scanned the test and delivered the praise manipulation, as described in Sect. 2.4.1. After delivering this praise, the robot thanked the participant for their participation and told them to ring the bell. Afterward, the experimenter entered the room and asked the robot how the test went, to which the robot replied with either effort or ability-related praise. The robot then asked if it should go into standby mode, the experimenter replied, "Yes", and then informed the participant that the robot could no longer see or hear them. This was done to encourage participants' candid feedback. Next, participants completed the measures described later in Sect. 2.6. After completing these items, participants were informed that the study was over, and debriefed. In keeping with the debriefing procedure used by Nussbaum and Dweck [76], special care was taken to expound the fictitious nature of the theory induction article. In particular, the fact that intelligence is understood to have both malleable and stable qualities [29]. Finally, participants were compensated for their participation, informally probed for suspicion,[8] then dismissed.

## 2.6 Measures

### 2.6.1 Manipulation Check

We used the six-item Implicit Theories of Intelligence Scale (ITIS; [27]) as a manipulation check for participants' implicit self-theories. This is a well-established procedure for checking the effectiveness of primed implicit self-theories (see [64,68,82]). This scale has three items that measure incremental beliefs (e.g., "You have a certain amount of intelligence, and you really can't do much to change it") and three that measure entity theory beliefs (e.g., "You can always greatly change how intelligent you are"). Participants provided responses using a 6-point Likert scale (1 = strongly disagree, 6 = strongly agree). The incremental items were then reverse scored, and a mean score calculated for all six items, with high scores representing greater endorsement of an incremental theory of intelligence. The internal consistency of this measure was excellent ($\alpha = 0.95$, $M = 2.84$, $SD = 1.48$).

### 2.6.2 Perceived Intelligence

Perceived intelligence was assessed using the five-item Perceived Intelligence sub-scale of the Godspeed Questionnaire Series (GQS; [8]). Responses were made using a 5-point scale (e.g., 1 = Unintelligent, 5 = Intelligent, and 1 = Ignorant, 5 = Knowledgeable). This scale has been used in previous research to measure people's impression of robots post-interaction (e.g., [15,42,49]), particularly NAO robots (see [97]). This measure exhibited excellent internal consistency in our sample ($\alpha = 0.90$, $M = 3.97$, $SD = 0.95$).

### 2.6.3 Likability

Likability was assessed with the five-item Likability subscale of the GQS [8]. Participants provided responses using a 5-point scale (e.g., 1 = Dislike, 5 = Like, and 1 = Unfriendly, 5 = Friendly). The internal consistency of this measure was excellent ($\alpha = 0.93$, $M = 4.13$, $SD = 0.93$).

[7] A NAO code or "Naomark" is a circular symbol specific to the NAO robot. The robot is able to detect, and respond to this symbol (see http://doc.aldebaran.com/2-1/naoqi/vision/allandmarkdetection.html).

[8] None of the participants reported suspicion about any aspect of the study.

# 3 Results

The dataset for this study can be found at https://osf.io/j69nv/.

## 3.1 Main Analyses

### 3.1.1 Manipulation Check

An independent sample t-test on the ITIS indicated that participants who received the entity theory article scored higher on entity theory ($M = 1.66, SD = 1.13$) than those who received the incremental theory article ($M = 3.93, SD = 0.729$), $t(98) = -12, p < .001$), thus, our implicit self-theory manipulation was successful.[9]

### 3.1.2 Perceived Intelligence

We used a 2 (implicit self-theory) ×2 (praise) between-subjects ANOVA on perceived intelligence. Results revealed a significant interaction between implicit self-theory and praise on perceived intelligence ($F(1, 96) = 24.0, p < .001$). Follow-up planned comparisons showed that participants who were primed with entity theory demonstrated higher perceived intelligence scores for the robot when praised for ability ($M = 4.26, SD = 0.606$) versus effort ($M = 2.96, SD = 1.26$), $t(96) = 5.855, p < .001, d = 1.69(95\%CI[1.06, 2.31])$. However, results for participants manipulated to believe in incremental self-theory showed no significant difference between ability ($M = 4.20, SD = 0.534$) and effort-focused praise on ratings of perceived intelligence ($M = 4.41, SD = 0.447$), $t(96) = -.974, p = .765, d = -0.27(95\%CI[-0.82, 0.28])$. Given these results, hypotheses H3 and H4 were supported (see Fig. 3).

### 3.1.3 Likeability

A similar ANOVA test on participant's ratings of likability was also conducted. As expected, a significant interaction between implicit self-theory and praise on ratings of likability was observed ($F(1, 96) = 5.30, p = .024$). Planned comparison results revealed that for entity theorists, ability-focused praise led to significantly higher likability ratings ($M = 4.24, SD = 0.698$) than effort-focused praise ($M = 3.38, SD = 1.20$), $t(96) = 3.681, p = .002, d = 1.06(95\%CI[0.47 - -1.65])$. Furthermore, no significant difference between ability ($M = 4.48$, SD $= 0.552$) and effort-focused praise on ratings of likability ($M = 4.37, SD = 0.694$), $t(96) = -.510, p = .956, d = 0.14(95\%CI[-0.40, 0.69])$, was observed for incremental theorists. These findings supported H1 and H2 (see Fig. 4).

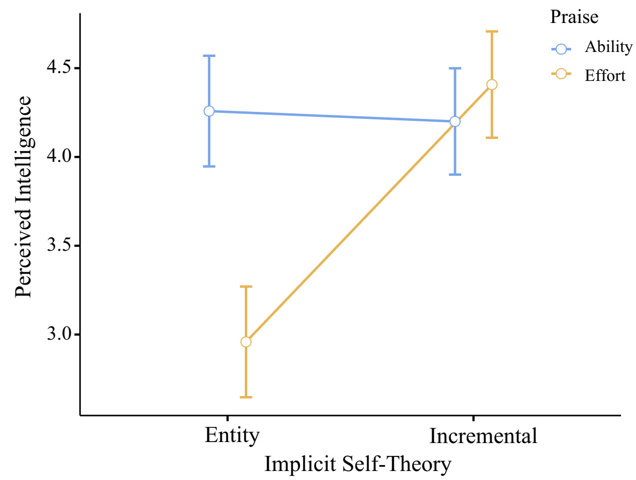


**Fig. 3** Perceived intelligence means and 95% confidence intervals for the interaction between implicit self-theories and praise

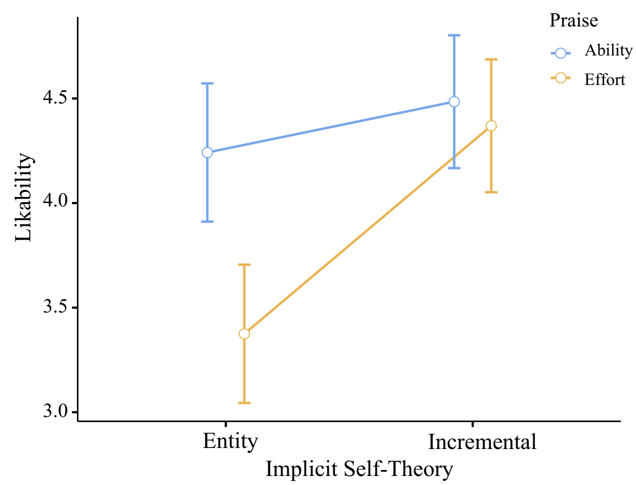


**Fig. 4** Likability means and 95% confidence intervals for the interaction between implicit self-theories and praise

# 4 Discussion

The findings presented herein provide evidence that implicit self-theories (entity vs. incremental), and robot-delivered praise (ability vs. effort) can interactively influence the way people evaluate social robots after a challenging task. More precisely, we demonstrate that entity theorists, who are prone to conceal their shortcomings and seek out favorable judgments from others, rate a robot lower in both perceived intelligence (H1) and likability (H2), when it praises them for effort (vs. ability).

Conversely, incremental theorists, who are more self-driven and learning-oriented, appear unaffected by praise

[9] As described in Sect. 2.6, lower (vs. higher) scores on the ITIS indicate more (vs. less) of an entity (vs. incremental) self-theory.

type, such that they evaluate a robot high in both perceived intelligence (H3) and likability (H4), regardless of the praise it delivers.

We subsequently discuss the theoretical contributions of these findings, as well as limitations and directions for future research below.

### 4.1 Theoretical Contributions

Building on our previous work (see [3]), which implicated implicit self-theories to be an important and unresearched variable in the field of HRI, we herein show that one's response to robot-delivered praise (ability, effort-focused) is influenced by one's implicit self-theory orientation. More specifically, in identifying the significant differential effects of robot praise on two core dimensions of robot acceptance, likability and perceived intelligence for entity theorists, in particular, we enrich the HRI literature with respect to work on robot-delivered feedback (e.g., [1,37,40,48]) and robot acceptance (e.g., [11,22,23,36,41,94]). By extension, this study adds to the literature underscoring the importance of examining under-explored psychological factors affecting social robot acceptance [4,5,9,38,90,102].

Our work also contributes to the social psychological research on implicit self-theories. As discussed previously, prior work has long established the link between praise and beliefs about intelligence, and has argued that the types of praise that children receive (e.g., ability vs. effort) plays an important role in the development of children's implicit self-theory (see [46], for review). Here, we extend this body of work by presenting what might be the first evidence of a strong and direct interactive match between implicit self-theory (entity vs. incremental) and praise (ability vs. effort), outside of child samples and educational or learning-related contexts.

More peripherally, our findings may be valuable to HRI interaction designers interested in developing social robotic products that are more humanly engaging. For example, our findings would suggest that a robot specially designed to praise for ability (e.g., "You're great at this" or "You're so smart"), perhaps from time to time sporadically–could provide considerable enjoyment, satisfaction, and engagement for entity theorists, and at the same time not diminish the user experience for incremental theorists. In this manner, future designers may draw on our findings and incorporate implicit self-beliefs into the design of robotic social feedback behaviors–to positively increase user satisfaction, or possibly even reduce entity theorists' apparent robot anxiety and aversion (see [3]).

### 4.2 Limitations and Future Directions

Though we found strong support for our hypotheses, our findings were nonetheless subject to certain limitations. First, generalizations from our findings may be limited by our decision to use the NAO V5 robot. However, it might be mentioned that some, such as Keizer et al. [57], have argued that the NAO does not differ meaningfully from current-day humanoid robots in terms of features, capabilities, and intended use. Nonetheless, a replication employing alternative humanoid robots (e.g., Pepper, Zeno, or even Baxter) is warranted.

Second, a control condition was not included in the study design. Although, this decision was made on the basis of time, space, and resource constraints (i.e., the inclusion of a control condition would have required 50% more participants), future studies should include a control condition to compare with the experimental group. Likewise, future research might consider including a human control condition, in which a human delivers praise.

Another potential limitation might be that every participant who was recruited into the study was required, in part, to have no experience with robotics. We note, however, that a recent review by Naneva et al. [74] suggests, that many people have yet to have contact with social robots (let alone experience with robotics, more broadly). Thus, as the authors seem to conclude, studies excluding these individuals may be more generalizable than initially thought.

Notwithstanding the above limitations, the present study indicates directions for potential future work. One intriguing area to be explored might be whether and how implicit self-theories (incremental vs. entity), and robot-delivered negative feedback, may interactively increase performance, and the extent to which people assign more (vs. less) favorable robot evaluations and use-intentions, as a consequence.

To illustrate: There is some evidence that a robot's negative or impolite feedback can engender behavior change (see [48, 69]) and increased task performance [84], although people tend to prefer a robot's positive feedback [40].

Given that incremental theorists, compared to entity theorists, exhibit positive effort beliefs in the face of adversity [52], and are more motivated by learning goals [30], while favoring goal progress cues [68], it could be that incremental (vs. entity) theorists respond somewhat positively to a robot that displays negative or critical feedback to encourage better performance.

In any case, future researchers could test this prediction by implementing a human-robot interaction in the context of a robot-assisted training task (e.g., [84]), and by measuring implicit self-theory and different measures of robot acceptance (e.g., [3]).

## 5 Conclusions

We herein demonstrate that individuals endorsing an entity self-theory rated a robot more favorably after it delivered ability-focused praise following a difficult task. In contrast, those endorsing an incremental theory did not differ in their evaluations of a robot, regardless of its praise type. These findings fall in line with our recent work indicating that implicit self-theory is an important psychological variable that affects how people view and evaluate social robots. These findings, when considered together may provide an important stimulus for further investigation into implicit self-theory and its consequences, in the domains of HRI and social robotics.

**Acknowledgements** This research was supported by the University of Canterbury, New Zealand. The authors would like to acknowledge A. David Nussbaum for providing the priming articles used in this experiment. The authors would also like to thank Jeremy Botting for his research assistance during this project.

**Data availibility Statement** The dataset generated for this study is available at https://osf.io/j69nv/.

## Declarations

**Conflicts of interest** The authors declare that they have no conflict of interest.

**Ethical approval** The authors declare that this article complies with the ethical standards of this journal. Informed consent was obtained from all participants involved in the study.

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