Intentional and Phenomenal attributions in the light of the influence of personality traits, and Attitudes towards robots on pro-social behaviour in human-robot interaction.

Spatola, Nicolas¹; Marchesi, Serena¹; Wykowska, Agnieszka¹

¹ Social Cognition in Human-Robot Interaction Laboratory, Italian Institute of Technology,
Genova, Italy

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Corresponding author:

Nicolas Spatola

Istituto Italiano di Tecnologia, Center for Human Technologies

Via Morego, 30 16163 Genova, Italy.

Tel: +39 010 2896163037

Abstract

In the decades to come, robots could become more present in the human environment increasing the likelihood to interact with them. When reasoning about them, individuals tend to endow robots with human-like characteristics such as intentions or emotions, they develop attitudes toward them and differ in their likelihood to cooperate with them-. However, how these different variables emerge, interact in the human mind and effect actual behaviour in HRI is still poorly understood. In three studies, using the intentional and phenomenal stance theoretical framework, the attitudes toward robots evaluation and the Big-Five personality traits framework we investigated the attribution of intentional and phenomenal experience to robots and the influence of imaginative representation robots on the interpretative attributions (Experiment 1). We also evaluated how the context of evaluation presenting robots with different level of human-likeness as potential social actors compared to mere technological prototypes and the prior attitudes toward them could bias intentional/phenomenal attributions (Experiment 2). Finally, we used a human-robot a prisoner's dilemma game and developed a structural integrative model using attributions, attitudes and personality traits to evaluate the likelihood of participants to make a prosocial decision in HRI (Experiment 3).

Experiment 1, 2 and 3 results showed that intentional stance is more readily adopted than phenomenal stance and that the imaginative type of the stances predicts the interpretative type. In experiment 2 level of attributions were predicted by attitudes toward robots. Also, attributions were influenced by robot human-likeness and the presentation of robots as social, compared to non-social, agents. Finally, experiment 3 structural integrative model showed a predominance of personality traits and attitudes to predict the likelihood to cooperate in an actual HRI.

Keywords

Intentional Stance; Phenomenal Stance; Attitudes towards Robots; Prosocial behaviour; Human-Robot Interaction

1. Introduction

Human-Robot Interaction (HRI) studies (for a review see Złotowski et al., 2015) have already demonstrated that people are capable of ascribing cognitive (e.g., *intentionality*, rationality) and social (e.g., warmth, trustworthiness) human properties to robots, a process called anthropomorphism (Epley, Waytz, & Cacioppo, 2007). According to Dennett (Dennett, 2009), individuals can adopt various stances when they observe and explain (or predict) behaviours of various systems. Whenever they try to predict physical phenomenon such as the trajectory of a kicked ball, they adopt a *physical stance*¹, referring to causal-mechanical relationships. However, more complex phenomenon such as human behaviour are difficult (if not impossible) to be efficiently described using only physical factors. Therefore, the *intentional stance* is adopted, which relies on mentalizing. In particular, attribution of mental states such as beliefs, desires or intentions (Dennett, 1988) is used in order to explain the behaviour of an observed system. More recently, some authors proposed an additional stance: the *phenomenal stance* that describes the ascription of *phenomenal* experiences to others and covers a more social perception of agents (Jack & Robbins, 2012).

Research has already shown that humans could adopt, beyond the *physical stance*, also the *intentional stance* toward robots (Chaminade et al., 2012; Marchesi et al., 2019; Perez-Osorio & Wykowska, 2020). However, the adoption of the *phenomenal stance* towards robots is still under question. Furthermore, neither of the concepts has been discussed in the context of the anthropomorphic framework involving an imaginative and interpretative process. Indeed, Fisher identified two different ways to engage in anthropomorphic thinking: 1) interpretative, the attribution of anthropomorphic characteristics based on observation, and 2) imaginative, as the representation of fictional entities detached from concrete perception, (Fisher, 1991). If we consider that adoption of an *intentional* or *phenomenal* stance in HRI is a sub-category of anthropomorphism, then they both could be conceptualised in terms of interpretative and imaginative forms which has never been done.

¹ While we understand the philosophical dichotomy proposed by Dennett between the design and physical stance, so far there is no evidence for a cognitive or neural process difference between the two processes. Therefore we will use the terminology “physical stance” as an umbrella term for design and physical stance

Attributions of human-like traits to robots are also intrinsically related to prior attitudes toward these agents (Spatola, 2019a, 2019b, Perez-Osorio, Marchesi, Ghiglino, Ince & Wykowska, 2019). But other prime building blocks of individual psychology such as personality traits (Goldberg, 1992) have proven to influence both attributions and attitudes towards robots (Kaplan, Sanders, & Hancock, 2019, Ghiglino, De Tommaso, Willemse, Marchesi & Wykowska, 2020). While a few research have investigated each variable in isolation there is actually no integrative view of how personality traits, attitudes toward robots, intentional and phenomenal attributions relate to each other. In addition, while informative, most of the studies do not investigate these effects in an actual HRI setup with behavioural output.

In three experiments, we investigated for the first time the *intentional* and *phenomenal stance* in their imaginative and interpretative form as a function of the level of human-likeness of robots (Experiment 1). We aimed to disentangle how adopting various stances is modulated by dispositional factors (individual traits) and by robot design (Experiment 2). In addition, we attempted to provide a first integrative model of the influence of personality traits, attitudes and stance adoption on actual behaviour toward robots (Experiment 3).

1.1. Intentional and Phenomenal Stance

1.1.1. Intentional Stance (Experiment 1, 2 and 3)

Adopting the *intentional stance* is how humans developed the strategy of interpreting the behaviours of fellow creatures by considering them as a rational agent who produces an action because of a decisional process influenced by beliefs and desires. In psychology, this process has been prototypically theorized as mindreading (Carruthers, 2013), mentalizing (Frith & Frith, 2006), or the theory of mind (Carlson, Koenig, & Harms, 2013). All these theories assume the human capacity to ascribe *intentionality* and to explain the behaviour of others based on those ascriptions.

1.1.2. Phenomenal Stance (Experiment 1, 2 and 3)

Not only we do understand others as a locus of *intentionality* when ascribing to them beliefs, desires or intentions to make sense of their behaviour (i.e., *intentional stance*), but we also perceive them as a locus of *phenomenal* experience ascribing to them emotions, moods or pain (i.e. *phenomenal stance*)

(Jack & Robbins, 2012). The *phenomenal stance* makes it possible to understand others' *phenomenal* experience, to detect emotion in others, and to react accordingly. This is why some authors (Jack & Robbins, 2012) posit that moral concern for others emerges when we consider others as a subject of *phenomenal* experience, especially experience that we may share and simulate. Adoption of *phenomenal stance* would, therefore, promote affiliation, social interaction and cooperation.

As much as we know, there is no study investigating the adoption of *phenomenal stance* with robots. Whether one can consider a robot as a locus of *phenomenal* experience is still unknown. Therefore, an aim to the present research will be to evaluate whether individuals may consider robots to be endowed with experiences and whether these attributions differ from the adoption of *intentional stance* at the imaginative and interpretative level.

1.1.3. Human-likeness in robot design (Experiment 2)

In examining factors contributing to the adoption of various stances, one needs to consider not only the internal factors of the observer (individual differences in motivation) but also the characteristics of the observed agent (robot in this case). The attribution of *intentionality* or *phenomenal* experiences is very likely to be dependent on human-likeness of the robot. If we consider the adoption of *intentional* and *phenomenal stance*, we may assume that it should be easier to adopt such stance in function of the human-likeness level of robots because of the easier activation of usual human-human interaction social schemas. In line with this assumption is that people tend to attribute more anthropomorphic traits to human-like robots and, interestingly, would be likely to view themselves and the robot as having similar traits (Woods, Dautenhahn, Kaouri, Te Boekhorst, & Koay, 2005).

1.1.4. Motivation, attitudes and personality as catalyzers of intentional/phenomenal attribution (Experiment 2 and 3)

In their anthropomorphism framework, Epley, Waytz and Cacioppo posit that attribution of human-like characteristics such as intentional or phenomenal experience has strong motivational triggers, particularly effectance (Epley et al., 2007). Effectance motivation is the need to make sense of the actions of other agents as a mean to reduce uncertainty about their behaviour and the situation. Therefore, high levels of effectance motivation theoretically elicit anthropomorphic representations

(when alternative non-anthropomorphic representation are not easily accessible) and, as a consequence, potentially *intentional* and *phenomenal* attributions. In support of this hypothesis is the fact that the adoption of mentalistic stances is motivated by a social effectance of the observer to interact, predict, and collaborate with the target (Waytz, Gray, Epley, & Wegner, 2010). This motivation could be extrinsic to the observer (e.g. the context) or intrinsic (e.g. attitudes, personality traits). In the present series of experiment, we will investigate both side of the coin considering how the context of the presentation of robots may influence intentional/phenomenal attributions but also how intrinsic variables such as attitudes and personality traits may bias participants' judgments and behaviours.

Indeed attitudes toward an agent have been shown as fundamental in how one consider this agent (Ajzen, 2005) even a robotic one (MacDorman, Vasudevan, & Ho, 2009). Attitudes are sets of emotions, beliefs, and behaviours of an individual with respect to a target that can be human or not. As attitude are mental predispositions to act in a specific way toward a target they are indispensable in the explanation of social behaviour (Ajzen, 2005) and a necessary notion in the explanation of cognitive, affective and conative reactions especially in a social situation (Maio & Haddock, 2009). For instance, positive attitudes will lead to a greater likelihood of considering a human or an agent with human characteristics, while negative attitudes will strengthen negative reaction such as discomfort, defection or rejection (Bohner & Dickel, 2011; Maio & Haddock, 2009). For instance, negative attitudes toward robots have proved to be a reliable predictor of the avoidance of HRI situation (Nomura, Kanda, Suzuki, & Kato, 2008).

Personality traits are also central in how individuals relate to their environment and other agents, ~~both~~ either humans (Donnellan, Oswald, Baird, & Lucas, 2006; Matthews, Deary, & Whiteman, 2009) ~~and~~ or robots (Kaplan et al., 2019; Nomura et al., 2008; Woods et al., 2005). In HRI personality may influence peoples' attitudes toward robots (Müller & Richert, 2018), how they engage in anthropomorphism and ultimately attribute human characteristics to robots (Woods et al., 2005). However, while the findings related to the link between personality traits and attitudes towards robots or anthropomorphism are inconsistent, some evidence point toward the role of neuroticism (i.e., the disposition to negative emotions and a lack of emotional stability) in attitudes extroversion (i.e., the

disposition to interact with the outside world) in anthropomorphism. The higher the neuroticism traits, the more negative the attitudes toward the robots (Müller & Richert, 2018). The more extroverted, the more likely the anthropomorphic attributions (De Graaf & Ben Allouch, 2014; Kaplan et al., 2019). The lower autistic traits, the higher the likelihood of interpreting a humanoid robot behaviour with reference to mental state (Ghiglino, de Tommaso, Willemse, Marchesi & Wykowska, 2020). Still, while informative, these study lack of a more global approach and mainly focus on a direct path from personality to attitudes and anthropomorphic attributions without considering an integrative model or the effect on actual behaviours towards robots. We develop further the personality traits and the measure of personality traits in experiment 3.

1.1.5. Pro-social behaviours toward robots (Experiment 3)

Behaviours toward robots can be considered as the physical output of all the variables that we mentioned: personality traits, attitudes toward robots, intentional and phenomenal attributions. In the present series of experiments, we were specifically interested in prosocial behaviours toward robots. Prosocial behaviours are social behaviours that benefit to others or are accomplished in the purpose of collaboration with others. One standard measure of prosociality is the prisoner's dilemma (Balliet, Parks, & Joireman, 2009; Braver & Barnett, 1976; Hulbert, Corrêa Da Silva, & Adegboyega, 2001; Simpson, 2004). In the prisoner's dilemma, people are faced with a decision between their self-interest and the interest of the group. The two players make a simultaneous decision (to cooperate or defect). If both player decide to cooperate, they each earn a moderate amount. If only one chooses to cooperate, the defecting players receive the highest reward while the cooperative player gets the worst reward. Finally, if both players defect, both receive a minimal reward. Therefore, cooperation is considered as the safest option but defection makes it possible to receive the maximal reward.

In the prisoner's dilemma, people tend to act prosocially when they care about the outcome of others. Nonetheless, their likelihood to cooperate with the other depends on their personality traits (Hirsh & Peterson, 2009), prior attitudes or evaluation of the other. First, applying an individual differences approach to a prisoner's dilemma, Hirsh and colleagues showed that low neuroticism and high extraversion predicted a greater likelihood of cooperation (Hirsh & Peterson, 2009).

~~the other hand~~, Lönqvist and colleagues found that low Neuroticism –in line with Hirsh and colleagues (Hirsh & Peterson, 2009)– and high Imagination/Openness to Experience (Lönqvist, Verkasalo, & Walkowitz, 2011). Concomitantly, both studies argue that personality traits are relevant predictors of prosocial behaviour. Second, attitudes toward others are, obviously, a determinant of the kind of interaction one will engage. Attitudes moderate the perception of distance from the others (Cialdini, Brown, Lewis, Luce, & Neuberg, 1997) and lead to a lower/higher likelihood to engage in cooperation and synchronization with the others (Cappella, 1997). Research already showed that attitudes have a direct effect on the cooperation decision in prisoner's dilemma (Sally, 2000) as well as the social evaluation of others (Jahng, Kralik, Hwang, & Jeong, 2017; Kahn & Murnighan, 1993). The more positive the attitudes towards others and the more positive the attributions, the higher the likelihood for cooperation.

Building on these human-human interaction research, some authors have introduced the prisoners' dilemma in HRI (Hsieh, Chaudhury, & Cross, 2020; Krach et al., 2008; Sandoval, Brandstetter, Obaid, & Bartneck, 2016) as a measure of cooperation with robots. However, until now, there was no study investigating the effect of personality traits, attitudes towards robots and intentional/phenomenal (anthropomorphic) attributions –embedded in a structural model– on the likelihood to cooperate with robots in a prisoner's dilemma setting. In addition, the determinants of this cooperation remain poorly understood and the present research aimed to provide an integrative view of this phenomenon.

1.1.6. The present experiments

The first experiment aimed to test a measure of the imaginative and interpretative intentional and phenomenal attribution toward a NAO robot. Also, we tested the predictive power of imaginative attributions over interpretative attributions.

Building on the first experiment, the second experiment aimed to test the predictive power of the imaginative intentional and phenomenal attribution on interpretative attributions as the function of the level of anthropomorphic design of robots (6 levels). Also, we tested the differences of interpretative

intentional and phenomenal attributions between the different robot designs and how information about the robots could bias robots' evaluation. We also took into account the role of attitudes toward robots.

Finally, the third experiments aimed to replicate and structure the results in a model embedding the personality traits of participants, their attitude toward robots, their imaginative and interpretative intentional and phenomenal attributions and a behavioural output in a prisoner's dilemma-like game with a NAO robot.

2. Experiment 1

The first experiment aimed to explore the adoption of *intentional* and *phenomenal stance* at the interpretative and imaginative level by evaluating participants' individual prior (imaginative) and actual representation (interpretative) of a robot.

2.1. Hypotheses

We hypothesized that participants' imaginative *intentional stance* should predict the interpretative *intentional* attribution. The same should be true for the interpretative and imaginative *phenomenal stance*. Moreover, since the *phenomenal stance* has been linked only to the social network of the brain, while *intentional stance* as linked to both physical and social processes (Jack & Robbins, 2012), participants should adopt *intentional stance* to a higher extent than the *phenomenal stance*. This is because of the nature of the robot which sits in between categories (it is likely to evoke the physical/design stance due to being an artifact, and might evoke the *intentional stance* due to resembling a human) (Spatola & Urbanska, 2019). Finally, the last hypothesis posits that *intentional* and *phenomenal stance* should appear as two separate but correlated dimensions.

2.2. Method

Participants were 79 students from Clermont-Auvergne university ($M_{age} = 21.16$, $SD = 8.69$, 20 males, 57 females, and 2 others) recruited by mailing list. All participants gave written consent to participate freely in the study.

To evaluate the adoption of an *intentional* or *phenomenal stance* reality towards robots we designed a questionnaire based on the concept of the *intentional* and *phenomenal stance*. For each dimension, we used three questions. For the *intentional stance*, the following items were listed: "A robot can make

rational choices”, “A robot may have beliefs about the functioning of its environment”, “A robot can produce behaviours according to its desires”. The *phenomenal* stance, was addressed with the following items: “A robot can have sensations”, “A robot can feel emotions”, “A robot can feel empathy”. Participants evaluated to what extent they agreed with each sentence from 1 “not at all” to 7 “totally”.

The experiment was conducted as an online survey. To measure the imaginative *intentional* and *phenomenal* stance, we first presented these items without any stimuli asking participants whether each sentence was appropriate to describe what a robot meant to them. In the second part, to measure the interpretative *intentional* and *phenomenal* stance, we presented, for 1.36 minutes, a video with a NAO robot interacting with a human, an object and another NAO. The video was extracted from an Aldebaran (now Softbank) Nao presentation video (from <https://www.youtube.com/watch?v=rSKRgasUEko>). To control for external priming effects, the video was cut to not display any logo or sound. After this presentation, participants had to evaluate the robot with the use of the items presented in the first part. Psychometric reliability of questionnaires is described in the following paragraphs.

2.3. Results

2.3.1. Control analyses

To evaluate the reliability of our measure we conducted a factor analysis (Maximum likelihood extraction and Promax $\kappa = 4$ rotation) on the two theoretical dimensions that are *Intentional stance* (3 items) and *Phenomenal stance* (3 items). The first-factor analysis was processed on the “imaginative attribution” (i.e., before videos). The pattern matrix showed a reliable structure, the same was true for the “interpretative attribution” (i.e., after the videos). (Table 1).

Table 1. Factor analysis on imaginative and interpretative attributions. Factor 1 encompasses the *phenomenal* items while factor 2 subsumes the *intentional* items (study 1).

	Factor (imaginative)		Factor (intepretative)	
	1	2	1	2
<i>Phenomenal</i> 2	1,007	-0,029	1,019	-0,082
<i>Phenomenal</i> 3	0,862	0,055	0,961	0,022
<i>Phenomenal</i> 1	0,628	-0,003	0,516	0,345
<i>Intentional</i> 3	-0,014	0,968	-0,104	0,920
<i>Intentional</i> 2	0,079	0,651	0,336	0,516
<i>Intentional</i> 1	-0,027	0,494	0,091	0,508

2.3.2. *Intentional vs. Phenomenal stance*

Conducting a repeated ANOVA, we found an interaction between stance (*Intentional* vs. *Phenomenal*) and type (imaginative vs. interpretative), $F(1, 78) = 6.85, p = .011, \eta^2_p = .08$. We found that participants naturally (imaginative type) adopt more the *Intentional* than the *Phenomenal* stance when thinking about robots, $F(1, 78) = 74.89, p < .001, \eta^2_p = .49, CI_{95\%} [1.18, 1.89]^2$. The same was true on the interpretative type, $F(1, 78) = 54.39, p < .001, \eta^2_p = .41, CI_{95\%} [.75, 1.31]$. Interestingly while participant declared higher *Intentional* stance in the imaginative compared to interpretative level, $F(1, 78) = 15.30, p < .001, \eta^2_p = .16, CI_{95\%} [.40, 1.22]$, this effect was not significant on *Phenomenal* attribution, $F(1, 78) = 2.58, p = .112, \eta^2_p = .03, CI_{95\%} [-.07, .69]$.

Furthermore, the difference between *Intentional* and *Phenomenal* stance was higher for the imaginative than interpretative type, $F(1, 78) = 6.83, p = .011, \eta^2_p = .08, CI_{95\%} [.12, .88]$ (figure 1).

Figure 1. Study 1. *Phenomenal* and *Intentional* stance for the Imaginative and Interpretative type. Error bars represent one standard error. *: $p < .05$, **: $p < .01$, ***: $p < .001$.

In line with our hypothesis, we found that the higher the imaginative attribution, the higher the interpretative attribution for both *Intentional* stance, $t(77) = 2.53, p = .014, r_{pearson} = .28, CI_{95\%} [.06, .47]$, and *Phenomenal* stance : $t(77) = 4.48, p < .001, r_{pearson} = .45, CI_{95\%} [.26, .61]$. In line with these results,

² With Bonferroni correction.

regression analysis showed that the difference between *Intentional* and *Phenomenal stance* at the imaginative level predicted the same difference at the interpretative level, $t(77) = 2.64$, $p = .010$, $r_{\text{pearson}} = .29$, $CI_{95\%} [.06, .40]$.

2.4. Discussion

The first study aimed to evaluate whether the adoption of *intentional* and *phenomenal stance* of the imaginative type could predict the same process for the interpretative type and confirm the structural and conceptual reliability of the two concepts in evaluation. In addition, a secondary purpose was to compare the level of *intentional* and *phenomenal* attribution for the imaginative and interpretative types.

The present results confirm the two *intentional/phenomenal* dimensions in the evaluation and the correlation between the two for both imaginative and interpretative types. We also found higher *intentional* than *phenomenal* attributions for both imaginative and interpretative type and more generally, higher imaginative than interpretative attributions.

These results also confirmed that purely social concepts are less accessible when dealing with robots than physical/social concepts. The validation purpose of the first study is fulfilled. The second study will aim to develop a more complex model of stances adoption based on these first results.

3. Experiment 2

Experiment 1 demonstrated the association between imaginative and interpretative *intentional* and *phenomenal* stances to a robot. While these first results are informative, they do not allow for evaluating the evolution of these attributions and the imaginative/interpretative *intentional/phenomenal* relationship with respect to two important factors: the internal factor of individual dispositions vs. the external factor of robot human-likeness. Indeed, one aim of the present study was to disentangle how adoption of various stances is modulated by dispositions and by robot appearance design.

The human-like shape of robots is an important moderator of anthropomorphic evaluation (Yoo, Kwon, & Lee, 2016). This factor is for instance considered as a determinant of the degree to which human socio-cognitive mechanisms are activated (Ferrari, Paladino, & Jetten, 2016; Oztop, Chaminade, & Franklin, 2004; Złotowski et al., 2015). In Experiment 2, we manipulated the level of human-likeness

of robots to evaluate to what extent robot appearance modulates the attribution of *intentional* and *phenomenal* traits to robots.

In addition, we were interested modulatory effects of the way the robot is depicted/presented to participants. For half of the participants we presented the robot as a technological object, while for the other half, as future social agents that they could encounter in the next decades.

Finally, we evaluated the attitudes of participants toward robots as a moderator of intentional/phenomenal attributions and of the effect of the experimental manipulation.

3.1. Hypotheses

In Experiment 2, we aimed first to replicate the results from experiment 1. We hypothesized that participants imaginative attribution should predict the interpretative attribution and that participants should adopt *intentional* stance to a higher degree than *phenomenal stance*. The *intentional* and *phenomenal stance* should appear as two separate, but correlated dimensions. Second, by manipulating the human-likeness level of robots we hypothesized that both *intentional* and *phenomenal stances* should increase as a function of the level of human-likeness of robots, as humanoid shape is, closer to our stereotypical representation of social (and in consequence capable of *intentional* and *phenomenal* experiences) agent. Because the two dimensions are strongly correlated, we hypothesized that the slope of *intentional* and *phenomenal* attribution as a function of human-likeness of robots should be correlated as well. As an explorative analysis, we aimed to evaluate which robot shape is the most representative of the imaginative *intentional* and *phenomenal* robot in term of the human-likeness level. This analysis provided an insight into mental representation of robots. On the attitudes toward robots, we hypothesized that presenting robots as future social agents should elicit more *intentional* and *phenomenal* attribution due to the social motivation related to the higher perceived likelihood of encountering and interaction with the presented robots (Epley et al., 2007). Finally, as attitudes are a central predictor of evaluation and behaviour, we hypothesized that the more positive the attitude, the higher the *intentional* and *phenomenal* attribution.

3.2. Method

Participants were 220 students from Clermont-Auvergne university ($M_{\text{age}} = 21.16$, $SD = 8.69$, 68 males, 149 females, and 3 others) recruited by mailing list. All participants gave written consent to participate freely in the study.

We used the same procedure as in the previous study except for a priming manipulation in the second step, and except for showing static robot pictures rather than videos. First, to evaluate the imaginative *intentional* and *phenomenal* attribution participants filled out the questionnaires without any observation of robot stimuli. Second, we used different instructions to prime participants in a social vs. non-social condition. In the social condition, participants saw the instruction: “In this study you will evaluate different robots on 6 criteria. These robots represent types of agents that you may interact with in the coming decades. It is therefore important that you consider this information in your answers.”. In the non-social condition, the instruction was “In this study you will evaluate different robots on 6 criteria. These robots represent different types of agents.”. In the third part of the experiment, participants had to evaluate 6 robots with different levels of human-likeness, 1 for each Human-likeness level, randomly selected among 3 robots for each of the 6 levels of human likeness. This procedure has the advantage to create 729 stimuli pattern ensuring enough variance for generalization of results. The 18 robots were selected by sextile selection on the human-likeness score of the ABOT database resulting in the use of the 18 robots presented in figure x. The ABOT (Anthropomorphic roBOT) Database, a collection of real-world anthropomorphic robots (Phillips, Zhao, Ullman, & Malle, 2018). This database proposes a quantification of the human-likeness score for more than 250 robots. Participants evaluated both *intentional* ($\alpha = .78$) and *phenomenal* ($\alpha = .93$) domains for 6 robots displayed in a random order to avoid any order effects.

Figure 2. Experimental stimuli for each level of human-likeness. Participants saw one randomly chosen picture for each level.

At the end of the experiment, participants completed Nomura, Kanda and Suzuki's (Nomura et al., 2008) scale measuring negative attitudes toward robots, hereafter referred to as NARS scale. The NARS scale constitutes of three constructs: *social/future implications* (e.g., "I feel that if I depend on robots too much, something bad might happen") ($\alpha = .74$); *emotional attitudes toward robots* (e.g., "I would feel uneasy if robots had emotions") ($\alpha = .70$); and *actual interactions* (e.g., I would feel very nervous just standing in front of a robot) ($\alpha = .95$). For the reasons of clarity in analysis, we kept the actual interactions in its original positive form and did not reverse the scores. For each dimension, participants rated whether they agreed or disagreed (from 1 to 7).

3.3. Results

3.3.1. Replication

Again, we controlled for the reliability of the questionnaires using a factorial analysis (Maximum likelihood extraction, Promax rotation). The same factor structure was found (see table S1 in supplementary materials).

In line with experiment 1 results, results showed that participants attributed more *Intentional* than *Phenomenal* traits for both imaginative, $F(1, 218) = 107.07, p < .001, \eta^2_p = .33, CI_{95\%} [.76, 1.11]$, and

interpretative, $F(1, 218) = 113.23, p < .001, \eta^2_p = .34, CI_{95\%} [.64, .93]$, stance type. Again, while participant declared higher *Intentional* stance in the imaginative compared to interpretative type, $F(1, 218) = 7.50, p = .007, \eta^2_p = .03, CI_{95\%} [.06, .37]$, this effect was not significant for *Phenomenal* attribution, $F(1, 218) = .79, p = .376, \eta^2_p = .01, CI_{95\%} [-.08, .20]$. However, in contrast to Experiment 1, the difference between *Intentional* and *Phenomenal* stance attribution was not significantly different between the imaginative and interpretative level, $F(1, 218) = 3.63, p = .058, \eta^2_p = .02, CI_{95\%} [-.01, .31]$ (figure 3).

Figure 3. Study 2. *Phenomenal* and *Intentional* stance for the Imaginative and Interpretative type. Error bars represent one standard error. ***: $p < .001$.

We found that the higher the imaginative attribution, the higher the interpretative attribution for both *Intentional* stance, $t(218) = 18.89, p < .001, r_{pearson} = .78, CI_{95\%} [.63, .78]$, and *Phenomenal* stance : $t(218) = 14.13, p < .001, r_{pearson} = .69, CI_{95\%} [.57, .75]$.

3.3.2. Priming

First, we conducted a multivariate analysis to evaluate the effect of priming manipulation (non-social vs. social robots) on interpretative attributions³. Results summarized in table 2 show that

³ We controlled that there was no effect of condition on imaginative attribution, $F(1, 218) = .66, p = .416, \eta^2_p < .01, CI_{95\%} [-.21, .50]$.

participants in the social condition adopted the *Intentional* and *Phenomenal stance* more than participants in the non-social condition arguing for a role of social motivation.

Table 2. *Intentional* and *Phenomenal* attribution as a function of experimental condition (non-social vs. social robots) on interpretative attributions.

Dependent Variable	$F(1, 218)$	p value	η^2_p	$CI_{95\%}$	
<i>Intentional</i>	4.22	0.041	0.02	-0.77	-0.02
<i>Phenomenal</i>	6.86	0.009	0.03	-0.88	-0.12
Difference (Int – Phe)	0.58	0.447	0.00	-0.18	0.40

Second, using mediation analyses⁴, we further investigated how the experimental condition (non-social vs. social robots) could impact the relation between imaginative and interpretative stance types. While the relation between imaginative and interpretative *Intentional stance* type was not moderated by the experimental condition, $t(218) = -1.66$, $p = .100$, $r_{pearson} = -.16$, $CI_{95\%} [-.34, .03]$, priming significantly influenced the *Phenomenal stance*, $t(218) = -2.65$, $p = .009$, $r_{pearson} = -.21$, $CI_{95\%} [-.36, -.05]$. The predictive power of imaginative *Phenomenal* attribution on interpretative *Phenomenal* attribution was higher in the non-social, $t(218) = 14.73$, $p < .001$, $B = .81$, $CI_{95\%} [.70, .93]$, than social condition, $t(218) = 11.73$, $p < .001$, $B = .61$, $CI_{95\%} [.50, .71]$. We also found that the difference between *Intentional* and *Phenomenal stance* at the imaginative level predicted the difference at the interpretative level, $t(218) = 9.70$, $p < .001$, $r_{pearson} = .55$, $CI_{95\%} [.36, .54]$, without any experimental condition effect, $t(218) = 9.70$, $p < .001$, $r_{pearson} = .55$, $CI_{95\%} [.36, .54]$.

Regarding Human-likeness of robots, we found a linear increasing attribution on both *Intentional*, $F(1, 218) = 92.73$, $p < .001$, $\eta^2_p = .30$, and *Phenomenal*, $F(1, 218) = 91.97$, $p < .001$, $\eta^2_p = .30$ domains as a function of human-likeness. Considering the difference between *Intentional* and *Phenomenal* attribution at each level of Human-likeness, we found higher *Intentional* compared to *Phenomenal* attribution for all levels (all $p_s < .001$) (figure 4).

⁴ Analysis conducted with PROCESS (Vinet & Zhedanov, 2011) plugin in SPSS (model 1).

Figure 4. *Phenomenal and Intentional stance of the interpretative type as a function of human-likeness of the robot stimuli. Error bars represent one standard error.*

Contrasts (with Bonferroni correction) on *Intentional* attribution as a function of human-likeness showed a sign of an uncanny valley shape (Mori, 1970) with a decrease in *intentional* attribution between the fourth and the fifth level of human-likeness, $F(1, 218) = 12.97, p < .001, \eta^2_p = .06, CI_{95\%} [- .43, .13]$, followed by an increase between the fifth and the sixth level, $F(1, 218) = 33.97, p < .001, \eta^2_p = .14, CI_{95\%} [.29, .59]$ ⁵.

On *Phenomenal* attribution, we did not observe a significant difference between the fourth and the fifth level of Human-likeness, $F(1, 218) = .36, p = .550, \eta^2_p < .01, CI_{95\%} [- .17, .09]$. However, we found an increase between the fifth and the sixth level, $F(1, 218) = 18.49, p < .001, \eta^2_p = .08, CI_{95\%} [.16, .43]$. The experimental condition influenced this increase, $F(1, 218) = 4.31, p = .039, \eta^2_p = .02$. Indeed, the difference between the fifth and the sixth level was significant in the social condition, $F(1, 218) = 20.51, p < .001, \eta^2_p = .09, CI_{95\%} [.25, .63]$, but not in the non-social condition, $F(1, 218) = 2.45, p = .119, \eta^2_p = .01, CI_{95\%} [- .04, .35]$ (figure x).

As an explorative analysis, we conducted multivariate regression analyses to evaluate which level of human-likeness was the most representative of the imaginative mental representation of robots (i.e., how people intrinsically represent “what is a robot?”). We used the standardized regression

⁵ We controlled for the gender of the robots, no results were significant (all $ps > .01$).

coefficients so that the variances of all predictors were equal. We included all robots' level evaluation scores as predictive factors of imaginative *intentional* and *phenomenal* attribution to control for collinearity and extract the more predictive variable(s). Analyses extracted only one significant variable (all other became non-significant with $p_s > .05$) and showed that the level 4 was the most correlated level for both the imaginative *intentional*, $t(213) = 3.28, p = .001, b = .42, CI_{95\%} [.15, .60]$, and *phenomenal* attributions, $t(213) = 4.93, p < .001, b = .54, CI_{95\%} [.28, .66]$.

3.3.3. Attitudes toward robots and stances

Finally, we conducted regression analyses to evaluate the relation between attitudes toward robots and *intentional* and *phenomenal* stances. First, for the imaginative type, we found a negative relationship between negative emotional attitudes toward robots (e.g., "I would feel uneasy if robots really had emotions) and the *intentional*, $t(191) = -3.39, p = .001, B = -.25, CI_{95\%} [-.39, -.10]$, and *phenomenal*, $t(191) = -3.65, p < .001, B = -.29, CI_{95\%} [-.45, -.13]$, stance. The same was true for the interpretative type for both *intentional*, $t(191) = -2.47, p = .001, B = -.18, CI_{95\%} [-.32, -.03]$, and *phenomenal*, $t(191) = -3.67, p < .001, B = -.27, CI_{95\%} [-.42, -.13]$, type. In other words, the more the negative attitudes toward robots, the less likely the adoption of *intentional* or *phenomenal stance* of both imaginative and interpretative types. Second, our results showed that the more the negative emotional attitudes toward robots, the more increasing was the difference between *intentional* and *phenomenal stance* as a function human-likeness of robots, $t(191) = 2.43, p = .016, B = .33, CI_{95\%} [.06, .59]$. We found the opposite pattern regarding the positive attitudes toward robots, $t(191) = -3.67, p < .001, B = -.27, CI_{95\%} [.01, .43]$. Therefore, the more negative the attitude toward robots, the more participants extended the dichotomy between *Intentional/Phenomenal stance* as the robots looked more human-like.

3.4. Discussion

The first aim of Experiment 2 was to replicate results from Experiment 1. Indeed, in Experiment 2 we found a strong correlation between imaginative and interpretative attributions in both *intentional* and *phenomenal* stances, in line with results of Experiment 1. Interestingly, however, we observed that the attribution of *intentional* and *phenomenal* traits to robots was biased by attitudes of participants toward robots, the level of human-likeness of robots and also the context of evaluation (social vs. non-social

priming). Comparing the imaginative and interpretative levels made it possible to evaluate which robots' human-likeness level was prototypical of the imaginative common representation of robots. For both *intentional* and *phenomenal* domains, the present results argue for the 4th level which corresponds to what Duffy labelled the "iconic robot". The iconic design seeks to employ a minimum set of features similar to those found in comics that still succeed in being expressive. These robots are the more common in Western pop-culture which could have frame participants representations (Sundar, Waddell, & Jung, 2016).

4. Experiment 3

The purpose of the third experiment was to embed the previous results in a structural model taking into account their personality traits and evaluating how this model could predict an actual behaviour toward a robot. Personality measures have demonstrated to be reliable predictors of attitudes and behaviours (Ajzen, 2005). In psychology, the Big Five is a descriptive model of personality in five central traits used as a reference point for the description and theoretical study of personality (Goldberg, 1992). 1) Extraversion is marked by intense interaction with the outside world. 2) Agreeableness is reflected in the desire for cooperation and social harmony. 3) Conscientiousness describes how the individual controls, regulates and directs his or her impulses. 4) Neuroticism refers to a disposition to negative emotions and a lack of emotional stability. 5) Imagination (Open-mindedness) describes open-mindedness and curiosity.

Paradoxically to the fundamental dimensions that are personality traits for the individual (Goldberg, 1992), little has been done to link personality traits to attitudes towards robots, human-like characteristics to robots attributions (Kaplan et al., 2019), and behaviour toward artificial agents. The third experiment aimed to fill this gap by measuring participants –Big Five– personality traits and using them as predictors of attitudes towards robots and intentional/phenomenal attribution but also actual prosocial behaviour toward robot in a single-shot prisoner's dilemma paradigm (Batson & Moran, 1999; Charness, Rigotti, & Rustichini, 2016).

4.1. Hypotheses

First, we hypothesized that personality traits should influence attitudes toward robots and intentional/phenomenal attributions. Especially, extroversion should predict more positive attitudes and, related to that, more intentional/phenomenal attributions (Kaplan et al., 2019) while higher neuroticism level should predict more negative attitudes and lower intentional/phenomenal attributions (Müller & Richert, 2018). Second, personality traits should influence the prisoner's dilemma decision (defection vs cooperation). In line with previous studies, we expect that lower level of neuroticism (Hirsh & Peterson, 2009; Lönnqvist et al., 2011), higher extraversion (Hirsh & Peterson, 2009) and imagination/openness to experience (Lönnqvist et al., 2011) should increase the likelihood to cooperate. Third, building on the experiment 2 results the effect of personality traits on intentional/phenomenal attributions should be—at least in part—mediated by the attitudes towards robots. More positive attitudes being related to more attributions, especially at the imaginative level. Fourth, therefore, positive attitudes toward robots should be significant predictors of the likelihood to cooperate with the robot in the prisoner's dilemma task (Sally, 2000). Fifth, in line with experiment 1 and 2, the imaginative intentional/phenomenal attributions should predict their interpretative counterparts. Sixth, a higher level of intentional/phenomenal attributions should increase the likelihood of cooperation decision (Nijssen, Müller, van Baaren, & Paulus, 2019).

4.2. Method

Participants were 162 students from Clermont-Auvergne university ($M_{\text{age}} = 20.04$, $SD = 4.54$, 47 males, 108 females, and 7 others) that participated in this study in exchange for credit courses. All participants gave written consent to participate in the study.

First, participants had to complete the mini International Personality Item Pool (mini-IPIP) (Donnellan et al., 2006) that measure that evaluated 5 *personality traits*: *extraversion* ($\alpha = .82$), *agreeableness* ($\alpha = .70$), *conscientiousness* ($\alpha = .72$), *neuroticism* ($\alpha = .70$), *imagination* ($\alpha = .78$), considered as central in defining personality of individuals (see Big-Five model; Goldberg, 1992). Each personality traits is assessed by 4 items (e.g., “Sympathize with others' feelings.”, “Have a vivid imagination.”). Participants evaluated to what extent each description described them from 1 “not at all”

to 7 “totally”. Second, as in experiment 1 and 2, to evaluate the imaginative *intentional* ($\alpha = .70$) and *phenomenal* ($\alpha = .88$) attributions participants filled out the questionnaires without any observation of robot stimuli. Third, participants completed the NARS scale with the three constructs: *social/future implications* ($\alpha = .56$); *emotional attitudes toward robots* ($\alpha = .58$); and *actual interactions* ($\alpha = .89$)⁶. Fourth, participants were informed by the experimenter that they will take part in a game with a NAO robot. Before starting the game, the NAO robot introduced itself to the participants with the following talk: “Hello! My name is NAO! We will play together. That is great!” (translation from french). Participants read the instruction of the *prisoner’s dilemma* (see Nash, 1951) (see in supplementary materials). We choose to not explicit the purpose of the game as “winning the maximum of points” to avoid bias toward the deflection choice. The *decision* (deflection vs. cooperation) of the participant and the *time to take the decision* (response time) were used as variables of interest. Fifth, after the game, participants completed a second time the intentional and phenomenal attribution questionnaire as the interpretative *intentional* ($\alpha = .70$) and *phenomenal* ($\alpha = .89$) attribution measure. This time the questionnaire explicitly mentioned NAO has the robot to evaluate.

4.3. Results

The data of five participants were discarded from analyses because they did not complete the entire experiment.

4.3.1. Replication

Again, we controlled for the reliability of the questionnaires using a factorial analysis (Maximum likelihood extraction, Promax rotation). The pattern matrix was similar to experiment 1 and 2 (see table S2 in supplementary materials).

4.3.2. *Personality traits to attitudes toward robots and intentional/phenomenal imaginative/interpretative attributions.*

To test the effect of personality traits on attitudes toward robots we introduced the five personality traits (extraversion, agreeableness, conscientiousness, neuroticism, imagination) in a multiple linear

⁶ As the two first constructs did not reach a reliable Cronbach alpha (Cronbach, 1951) we computed a general NARS score aggregating all the items and reaching a .81 alpha.

regression analysis as predictors of participants' NARS scores to evaluate each variable holding all other predictors constant. Results showed only an effect of imagination, $b = -.20$, $t(155) = -2.47$, $p = .015$, $CI_{95\%} [-.36, -.04]$. The higher the imagination, the lower the negative attitudes toward robots. All the other $ps > .10$.

The same multiple linear regression analysis on imaginative/interpretative intentional/phenomenal attributions showed that the higher the imagination, the higher the imaginative, $b = .18$, $t(155) = 2.25$, $p = .026$, $CI_{95\%} [.02, .36]$, and interpretative, $b = .18$, $t(155) = 2.32$, $p = .022$, $CI_{95\%} [.03, .39]$, intentional attributions. Also, the more the agreeableness the higher the interpretative intentional attributions, $b = .20$, $t(155) = 2.42$, $p = .017$, $CI_{95\%} [.06, .55]$. Finally, on phenomenal interpretative attributions, results showed that the higher the neuroticism, the higher the phenomenal attributions, $b = .19$, $t(155) = 2.34$, $p = .021$, $CI_{95\%} [.04, .47]$.

4.3.3. Attitudes toward robots to intentional/phenomenal imaginative/interpretative attributions.

Introducing participants' NARS scores in a multiple linear regression analysis as predictors of their imaginative/interpretative intentional/phenomenal attributions, the results showed that the more negative the attitudes, the lower the attributions (see table 3).

Table 3. Regression analyses including NARS score as a predictive factor of imaginative/interpretative intentional/phenomenal attributions.

Negative attitudes towards robots	
Imaginative	Intentional $b = -.35$, $t(155) = -4.59$, $p < .001$, $CI_{95\%} [-.53, -.21]$
	Phenomenal $b = -.33$, $t(155) = -4.27$, $p < .001$, $CI_{95\%} [-.65, -.24]$
Interpretative	Intentional $b = -.39$, $t(155) = -5.30$, $p < .001$, $CI_{95\%} [-.61, -.28]$
	Phenomenal $b = -.44$, $t(155) = -4.18$, $p < .001$, $CI_{95\%} [-.64, -.23]$

A mediation analysis including NARS scores as mediators of the effect of imagination on attributions showed a significant results for imaginative intentional attributions, $b = .07$, $SE = .03$, $CI_{95\%} [.01, .14]$ and interpretative intentional attributions, $b = .09$, $SE = .04$, $CI_{95\%} [.02, .17]$,

but also imaginative phenomenal attributions, $b = .10$, $SE = .04$, $CI_{95\%} [.02, .20]$, and interpretative phenomenal attributions, $b = .09$, $SE = .04$, $CI_{95\%} [.02, .19]$.

4.3.4. *Personality traits, attitudes toward robots and intentional/phenomenal imaginative/interpretative attributions as predictors of and prisoner's dilemma decision.*

One hundred twenty-five participants (80.13%) decided to cooperate with the NAO. To test the predictive power of *personality traits, Attitudes toward robots, imaginative intentional/phenomenal attributions and interpretative intentional/phenomenal attributions*, we conducted a logistic regression analysis including set of variables as predictors to evaluate each variable of the same set holding all other predictors constant, and the prisoner's dilemma decision of participants as dependent variable (defect/cooperate). The first analyses included personality traits (extraversion, agreeableness, conscientiousness, neuroticism, imagination) as predictive variables. Results showed that while agreeableness and imagination were positive significant predictors of cooperation, extraversion was associated with defection. The second analysis including the *NARS* as predictors showed that the higher the negative attitudes the higher the likelihood to defect. Finally, while we did not find any significant results including the *phenomenal (imaginative and interpretative) attributions* as predictors, we found that a higher level of *intentional (imaginative and interpretative) attributions* increased the likelihood to cooperate with the robot (all results are presented in Table 4). In addition, we found that, again, the effect of imagination on the decision was mediated, at least in part, by the attitudes toward robots (*NARS*), $b = .18$, $SE = .10$, $CI_{95\%} [.04, .43]$.

Table 4. Binary logistic regression analyses including the personality traits (extraversion, agreeableness, conscientiousness, neuroticism, imagination), attitudes (*NARS*), attributions (imaginative intentional/phenomenal and interpretative intentional/phenomenal attributions) as predictive factors of the prisoner's dilemma choice (defect vs cooperate). Significant results ($ps < .05$) are presented in bold.

Predictors		Statistics
Personality traits	Extraversion	$\text{Exp(B)} = .59$, $W(155) = 10.58$, $p = .001$, $\text{Exp(B)} CI_{95\%} [.42, .81]$
	Agreeableness	$\text{Exp(B)} = 1.77$, $W(155) = 5.90$, $p = .015$, $\text{Exp(B)} CI_{95\%} [1.12, 2.80]$
	Conscientiousness	$\text{Exp(B)} = 1.24$, $W(155) = 1.14$, $p = .286$, $\text{Exp(B)} CI_{95\%} [.84, 1.81]$

	Neuroticism	Exp(B) = .74, W(155) = 3.17, $p = .075$, Exp(B) CI95% [.53, 1.04]
	Imagination	Exp(B) = 1.91, W(155) = 12.41, $p < .001$, Exp(B) CI95% [1.34, 2.73]
Attitudes	NARS	Exp(B) = .42, W(155) = 20.26, $p < .001$, CI95% [.29, .62]
Imaginative attributions	Intentional	Exp(B) = 1.52, W(155) = 6.2, $p = .013$, CI95% [1.10, 2.10]
	Phenomenal	Exp(B) = 1.13, W(155) = .76, $p = .385$, CI95% [.86, 1.49]
Interpretative attributions	Intentional	Exp(B) = 1.72, W(155) = 9.19, $p = .002$, CI95% [1.22, 2.44]
	Phenomenal	Exp(B) = 1.05, W(155) = .10, $p = .761$, CI95% [.78, 1.43]

On the response to take decision in prisoners' dilemma, the multiple linear regression analysis including the personality traits as predictors only showed a direct effect of the *neuroticism*, $b = -.18$, $t(155) = -2.17$, $p = .031$, CI95% [-5.55, -.26]. The higher the level of neuroticism, the lower the time to take the decision. This effect was modulated by the defection vs cooperation decision of participants, $b = -.20$, $t(155) = -2.48$, $p = .014$, CI95% [-9.87, -1.12]. The effect was only true for participants that choose to cooperate, $b = -.20$, $t(124) = -2.16$, $p = .033$, CI95% [-6.37, -.28], while there was no effect on the defection choice, $b = -.17$, $t(30) = -.78$, $p = .440$, CI95% [-9.24, 4.15]. Also, a linear regression analysis showed that the higher *NARS* the lower the time to take the *decision* (defect vs cooperate), $b = -.17$, $t(155) = -2.20$, $p = .030$, CI95% [-5.42, -.29]. Again this effect was moderated by the decision of participants, $b = -.36$, $t(155) = -4.86$, $p < .001$, CI95% [-14.64, -6.17]. While there was no effect on the cooperation decision, $b = -.16$, $t(124) = -1.81$, $p = .072$, CI95% [-6.28, .27], on the defection decision, the higher the *NARS* (the more the negative attitudes), the lower the time to choose to defect, $b = -.51$, $t(30) = -3.20$, $p = .003$, CI95% [-12.10, -2.66].

4.3.5. Complete predictive model.

To model the predictors of the prisoners' dilemma decision, we used a path analysis (an application of structural equation modelling without latent variables). One of the advantages of path analysis is the inclusion of relationships among variables that serve as predictors in one single model. This model allows for investigating the weight of each variable in the decision process. The model was estimated in AMOS with maximum likelihood estimation method as the objective was to test a specific model⁷ (Tabri & Elliott, 2012). Table 5 presents the model fit metrics. Figure 5 presents the significant paths. Results showed that extraversion, agreeableness, imagination and neuroticism were significant predictors of the

⁷ Reproducing the covariance matrix of the manifest variables by means the model parameters

cooperation decision. The last was partially mediated by the attitudes towards robots. Attitudes towards robots were also predictive of imaginative intentional attributions and imaginative phenomenal attributions, the last being also influenced by neuroticism. Finally, while imaginative intentional and phenomenal attributions predicted their interpretative counterparts, there was no significant effect on the decision in the prisoners' dilemma when taking into account personality traits and attitudes effects (the tables presenting the regression weights and the model fit estimates are accessible in supplementary materials; osf.io/my5t6/).

Table 5. Model Fit metrics with their respective threshold (Hair, Ringle, & Sarstedt, 2013)

Indices	Model	Threshold
χ^2/df	1.392	< 3
Model <i>p</i>	.108	> .05
CFI	.986	≥ .95
GFI	.968	≥ .95
AGFI	.900	≥ .90
SRMR	.053	≤ .08
RMSEA	.050	≤ .05
PCLOSE	.458	> .05

Figure 5. Path model of prisoners' dilemma cooperation decision as a function of the personality traits, attitudes towards robots and imaginative/interpretative attributions. Black curved arrows present

the significant covariance, blue arrows present the positive paths, red arrows present the negative paths. The line thickness is proportional to the estimate (regression weights). *: $p < .05$; ***: $p < .001$.

4.4. Discussion

The aim of the third experiment was, first, to investigate the predictive power of personality traits, attitudes towards robots and intentional/phenomenal attributions on prosocial behaviour in HRI. The second aim was to introduce these variables in a structural model for the first time to provide an integrative view on the important variables (at the level of the individual) in HRI.

Experiment 3 results showed specifically a role of imagination (Lönqvist et al., 2011) in the prediction of attitudes towards robots. The higher the imagination/openness to experience, the more positive the attitudes, but also the higher the intentional imaginative and interpretative attributions. Interestingly, these last effects were in part mediated by the attitudes showing a core model of personality traits $\rightarrow$ attitudes towards robots $\rightarrow$ intentional attribution to robots. We also found that higher level of agreeableness was associated to a higher level of interpretative intentional attributions which can be related to a tendency to evaluate others one interact with more positively (Graziano & Eisenberg, 1997). Also, we found that the higher the neuroticism level, the higher the attribution of phenomenal experience to the NAO. This finding is interesting as it echoes Epley and colleagues framework (Epley et al., 2007) that posits a higher tendency to anthropomorphize when facing a non-human in a context associated with high uncertainty or energizing anxiety. A meta-analysis showed that strong neuroticism predicts the development of anxiety (Jeronimus, Kotov, Riese, & Ormel, 2016). Therefore, the higher likelihood to experience uncertainty and anxiety in the present HRI could have resulted in more anthropomorphic attributions (Epley et al., 2007; Waytz et al., 2010). However, if this explanation could solely explain the present effects, we should have found the same results on intentional attributions. Further studies will have to disentangle this point. In line with our hypotheses, results showed that personality traits significantly predicted the outcome of the prisoner's dilemma game especially extraversion, agreeableness, neuroticism and imagination traits, the latter being partially mediated by the attitudes towards robots. These direct paths show how determinant it is to consider the personality traits of individuals to better understand how people engage in HRI. In line with experiment

2, attitudes predicted attributions especially imaginative attributions completely mediating the effect on interpretative attributions. Also, as in human-human interaction studies task (Sally, 2000), attitudes toward robots were reliable predictors of the decision in prisoner's dilemma. Finally, we found that imaginative and interpretative intentionality attributions –taken in isolation– were reliable predictors of behaviour in line with the postulate that the higher the perception of robots as intentional agents, the higher the consideration of these agents (Nijssen et al., 2019). However, this effect faded in the structural model while the role of personality traits and attitudes remain arguing for a predominance of these dimensions over the direct evaluation of robots.

5. General discussion

The general aim of the study was to investigate the relation and influence between imaginative and interpretative intentional/phenomenal attributions to robots and to consider these attributions in a structural model including prime components of individual psychology that are the personality traits and attitudes. Also, we aimed to investigate the behavioural outputs (in a prisoner's dilemma game) of these variable considering the integrative structural model.

5.1. Intentional/Phenomenal imaginative/interpretative attributions

A common result of the three experiments is that individuals dichotomize, at least explicitly, the attribution of *intentionality* and *phenomenal* experience. One explanation could be that the *phenomenal* experience would be related to an inner state of the observed agent while *intentional* attribution would be related to the capacity of an agent to influence its environment, which can, as an incidence, influences observers environment (Jack & Robbins, 2012). Further, the attribution of *phenomenal* traits was always lower than *intentional* traits attribution independent of robots' level of human-likeness. To explain this result we may consider three non-exclusive hypotheses. First, *phenomenal* attributions could be more linked to biological beings as it supposes a sensory system while *intentional* attributions could be more cognitive and likely to be embedded in an artificial system. Second, *intentional* attribution to robots could be more common than *phenomenal* experience attribution. *Intentionality* attribution could be necessary for making sense of others actions; consequently, these attributions would be more accessible and more automatic, while attributing *phenomenal* experience to others only make sense in more

complex interaction with the agents (Leyens, Demoulin, Vaes, Gaunt, & Paladino, 2007). In other words, to predict robots' behaviours would be more relevant for observers than reasoning about their sensorimotor experience. Third, this difference could explain why more complex attribution such as emotions or empathy (Demoulin et al., 2004; Viki et al., 2006), would be less associated with robotic agents. To experience emotions is considered as more "uniquely human" than having intentions (Haslam, 2006). Even with other humans, individuals tend to demonstrate lower concern for others' inner states as a function of subjective perception of distance (Kteily, Hodson, & Bruneau, 2016). Therefore, robots would be considered distant by essence, outgroup members, those that belong to the group of "non-humans" (Spatola & Urbanska, 2019). Thus, *phenomenal* attribution might be reduced compared to *intentional* attributions that are less sensitive to this distance-related bias.

Interestingly, experiment 2, in line with Guthrie (Guthrie, 1997) showed that the more the robot agent shared human-like features, the higher the *intentional/phenomenal* attribution (Guthrie, 1997). Guthrie proposed a model in which the attribution of such anthropomorphic traits as *intentional* or *phenomenal* experience would be a "host of mechanisms" that evolved to interpret any ambiguous human-like or human-related stimulus in the environment. Uncertainty would energize anthropomorphic attribution to fulfill the need for understanding the behaviours of non-human agents (for a review see Epley et al., 2007). Therefore the more a robot looks like a human, the easier it is –to some extent– to attribute it human-like characteristics (Woods et al., 2005). Interestingly, our results support the idea that it is not only the observation of complex behaviours but also the likelihood that an agent may produce such complex behaviours (Wullenkord & Eyssel, 2019), based on its human-like features (Guthrie, 1997), that triggers social cognition, and consequently *intentional* and *phenomenal* stance. In support to this assumption, we also found that, when primed by a social account of future robots, participants tend to attribute more *intentional* and *phenomenal* traits to the robots; this priming also increases the distance between imaginative and interpretative type of *intentional* attributions, arguing for motivational social processing in robot evaluation, in line with the theory of Epley and colleagues (Epley et al., 2007). In other words, individuals that consider robots as more likely to be integrated into their environment are more willing to attribute to them *intentional* and *phenomenal* traits. The reason could be that potential future interaction could increase the need for predictability which might be a

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driving factor for *intentionality* attribution, in order to make sense of our environments (Epley et al., 2007; Waytz et al., 2010).

Finally, the third experiment showed that taken in isolation the attribution of intentionality at both the imaginative and interpretative level to robots (but not phenomenal experience) may predict the likelihood to cooperate with a robot. Therefore it is the perceived capacity of the robot to make decisions (rather than feeling an emotion) that seems to be determinant in cooperative HRI.

5.2. Attitudes toward robots, personality traits and prosocial behaviour

However, while the role of attributions, especially intentional one, was interesting to understand how people adopt cooperative –prosocial– behaviour toward robots, this link became less significant embedded in a more integrative model taking into accounts fundamental dimensions of individuals such as personality traits. First, experiment 2 and 3 showed that prior attitudes toward robots were indeed predictive of the *intentional* and *phenomenal* attributions, negative attitudes toward robots leading to lower scores in the attributions. Attitudes toward an agent might be considered a mindset in which the individual will process information about that same agent (Ajzen, 2005). Experiment 3 also showed that imagination/openness to experience, agreeableness and neuroticism were related to participants' attributions. Therefore, people that are creative, curious, and imaginative or selfless and helpful would consider robots with more *intentional* and *phenomenal* attributions innately but it would also be true for anxious persons (related to the anthropomorphism as a copying mechanism facing uncertain situations or stimuli). One of the more interesting results in our series of experiments is the fading of the intentional attributions effect on prisoners' dilemma when embedded in the structural model at the expense of attitudes and personality traits. This result argues that, compared to attitudes and personality traits, the importance of the direct evaluations of robots to predict should be put into perspective. Therefore the evaluation of the psychological constructs that are attitudes and personality traits should be favoured. The reason is that attitudes and personality are more fundamental building blocks and determinants of peoples' actions as they are less contextual than a target-specific evaluation.

6. Conclusion

The present studies demonstrate that 1) *intentional* stance is more readily adopted towards robots than *phenomenal* stance; 2) Imaginative type of the stance predicts the interpretative type meaning that participants probably have a mental set towards robots, and this could drive the way they would interpret the behaviour/appearance of the robot in the interpretative stance. This is also supported by the fact that attitudes toward robots determine the stances. 3) Personality traits are determinant for the type of attributions one will produce. 4) Apart from individual differences and biases, also robot appearance plays a role in attribution of intentionality and attribution of phenomenal experiences: the more human-like the robot, the higher the degree of attributions, except for a small “dip” that echoes the uncanny valley theory; 5) The adoption of *intentional* and *phenomenal* stances might also depend on contextual factors (social vs. non-social context of evaluation) and are therefore more than a process driven only by individual predispositions, but is rather influenced also by the characteristics of the observed agent and the context of evaluation. 6) To better understand the type of behaviour that one will adopt in HRI the evaluation of psychological constructs such as personality traits and attitudes toward robots is of prime importance for who want to investigate these interactions in an integrative framework.

7. References

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