Research Article

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The role of prior exposure in the likelihood of adopting the Intentional Stance toward a humanoid robot

Abstract: One of the key questions in human–robot interaction research is whether humans perceive robots as intentional agents, or rather only as mindless machines. Research has shown that, in some contexts, people do perceive robots as intentional agents. However, the role of prior exposure to robots as a factor potentially playing a role in the attribution of intentionality is still poorly understood. To this end, we asked two samples of high school students, which differed with respect to the type of education they were pursuing (scientific/technical *vs.* artistic) to complete the InStance Test, measuring individual tendency to attribute intentionality toward robots. Results showed that, overall, participants were more prone to attribute intentionality to robots after being exposed to a theoretical lecture about robots' functionality and use. Moreover, participants' scientific/technical education resulted in a higher likelihood of attribution of intentionality to robots, relative to those with artistic education. Therefore, we suggest that the type of education, as well as individually acquired knowledge, modulates the likelihood of attributing intentionality toward robots.

Keywords: prior exposure, attribution of intentionality, intentional stance, humanoid robot

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1 Introduction

Throughout human history, we have made ourselves increasingly dependent on machines. It has become particularly evident since the Industrial Revolution, when the massive increase in the use of machines transformed the industrial system and, by extension, the economic system, and the society as a whole. At present, machines are not only used in industrial settings, but their presence is becoming more pervasive in social spaces of human life [1,2]. For example, machines, sometimes in the shape of humanoid robots, can serve as assistants in workplaces, educators, or social companions in elderly care (for a review see ref. [3]). Therefore, individuals are increasingly exposed to the presence of these types of agents, and more and more often share various kinds of social contexts with them (*e.g.*, schools, hospitals, and workplaces) [1,3]. Repeated exposure to robots should naturally lead people to gain knowledge about how such artifacts work. Thus, it is crucial to examine how exposure to robots and acquisition of knowledge regarding their functioning affect individuals' tendency to treat robots as intentional (and/or perhaps social) agents.

1.1 Intentional stance toward robots?

Given the robots' mechanical nature, people should treat them as artificial systems that have been programmed to display specific kinds of behaviors. Following Daniel Dennett's framework [4,5], people should adopt the *Design Stance* toward robots and, thus, interpret and explain their behavior with reference to the way that the robots were programmed to behave [4,5]. However, in some contexts, people are also inclined to attribute mental states to robots, in order to explain their behaviors. It would mean that, under certain circumstances, people might adopt the *Intentional Stance* toward robots [4,5]. The adoption of the Intentional Stance leads to treating robots as intentional agents whose behaviors

result from mental (intentional) states such as beliefs or desires ([6,7]; for a review see ref. [8]).

For instance, recent evidence [6] showed that, when presented with a series of various behaviors displayed by a human or by a humanoid robot, participants ascribed intentional states to the humanoid robot to a similar degree as when they observed the human displaying the same behaviors. In a similar vein, Marchesi and colleagues [7] asked participants to rate whether the behaviors displayed by the humanoid robot iCub [9] were motivated by a mechanical cause (such as malfunctioning or calibration, thus referring to the Design Stance) or by a mentalistic cause (such as desire or curiosity, thus referring to the Intentional Stance). Results showed that, overall, people adopted the Intentional Stance toward the humanoid robot to some degree [7]. Interestingly, individual differences among participants seem to play a role in the likelihood of adopting the Intentional Stance, as some of them were more prone to choose the mechanistic explanations overall, whereas some others tended to choose the mentalistic explanations [10]. Thus, the authors argued that the likelihood of adopting the Intentional Stance might depend on several factors, such as individual differences in attitudes toward robots [11–13].

1.2 Individual differences in the tendency to adopt the Intentional Stance toward robots

Epley and colleagues conceptualized the role of individual differences in attitudes toward robots and presented a three-factors theory explaining whether, and under which conditions, people are likely to anthropomorphize them [14]. According to the authors, three psychological determinants are crucial for people's tendency of anthropomorphizing robots: (i) the elicited agent knowledge, namely the amount of knowledge about the other agent that people have access to; (ii) the motivation to understand and explain the behavior of the other agent (*i.e.*, *effectance motivation*); and (iii) the desire for social contact and affiliation. In line with this, the authors suggest that interpersonal differences in these determinants strongly predict people's likelihood of anthropomorphizing the other agent (*i.e.*, a social robot), and it would explain why anthropomorphism is so variable [14]. In a similar vein, also Fischer and colleagues underlined the role of individual differences in human–robot interaction (HRI), arguing that there is a considerable amount of interpersonal variation with respect to whether artificial agents are treated as social actors [15]. Recent pieces of evidence further confirmed the role of

individual differences in attitudes toward robots [16–18]. For example, individual differences in ascribing human-like features to a non-human-like agent predict the degree of moral care and concern related to an agent, the amount of responsibility and trust, and the extent to which the agent can serve as a source of social influence on the self [13,18]. Moreover, differences in the perception of the trustworthiness of a robot resulted to be predictive of humans' behavior toward robots in a human–robot team [19,20].

In sum, knowing that people's attitudes toward robots (and, potentially, their tendency to adopt the Intentional Stance) can vary depending on context and individual differences, calls for addressing the question of what factors are at play in this phenomenon. In the present study, we chose to focus on the role of prior exposure to robots, which may be a likely candidate factor affecting the adoption of the Intentional Stance toward them.

Specifically, one hypothesis may be that the more people are exposed to robots, and thus, they gain knowledge about the way robots are programmed and controlled, the less likely they would adopt the Intentional Stance toward robots. In other words, acquiring notions about robots' functionality and use would allow people to explain their behavior based on the assumption that it is the outcome of a designed system [21]. This hypothesis would be in line with Epley and colleagues' theory of anthropomorphism [14], according to which repetitive interactions can decrease individuals' likelihood to attribute mental states (*i.e.*, adopting the Intentional Stance) toward a robot, since the acquired knowledge about it would weaken the motivation to understand its behavior. Notably, a recent study seems to support this view [22]. The authors used a gaze-cueing paradigm to investigate participants' likelihood of attribution of intentionality as a function of the duration of the exposure to the robot's repetitive gaze behavior. Results showed that a short exposure had a positive change in participants' attribution of intentionality. On the contrary, long exposure did not increase the initial likelihood of attributing intentionality toward robots [22].

2 Aims

The present study aimed at understanding whether exposure to robots, in terms of acquired theoretical knowledge, modulates participants' likelihood of adopting the Intentional Stance toward robots and whether it depends on participants' type of education (scientific/technical *vs.* artistic). We decided to examine the factor of education

type, as we reasoned that a more technical/scientific profile of education might be more likely to familiarize students with technology in general and perhaps even robotics. On the other hand, students undergoing artistic education might be less exposed to technology, programming classes, and acquisition of knowledge about how technological artifacts, such as robots, work.

We designed an experiment in which we compared the likelihood of attribution of intentionality toward robots before and after a theoretical lecture about robots' functionality and use. We examined two samples of high school students: one attending a scientific/technical high school (thus specializing in technical subjects), and the other attending an art high school (thus specializing in art). We asked the two groups of high school students to attend a 45-min presentation in which they were given a theoretical lecture about robots' functionalities and

potential applications. At the end of the presentation, participants watched two videos in which we showed how the humanoid robot iCub [9] could be controlled using the Wizard-of-Oz (WoOZ) technique [23,24] in a laboratory setting. This meant that the students observed an experimenter remotely operating the robot to control a few behaviors, such as its speech and movements. Specifically, we presented a video of a short sequence of a lab experiment (see ref. [25] for more information related to the experimental procedure). In the video, a scene was depicted in which a person watched movies together with iCub, controlled by an experimenter who was located in a different room. Two videos were presented to participants: in the first video, the scene was shown from the participant's perspective, whereas in the second video, the scene was shown from the experimenter's perspective (Figure 1). This was done to demonstrate that what may appear as an
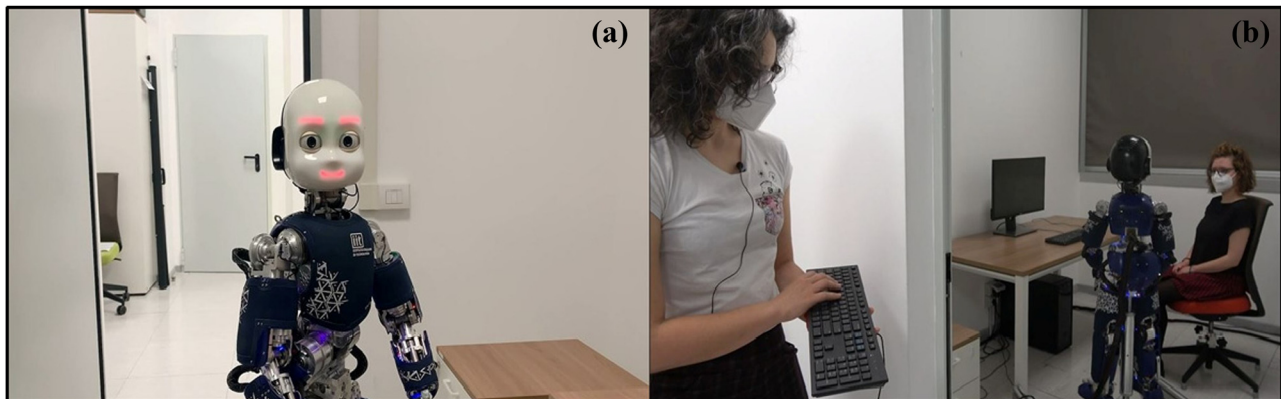

Figure 1: Representation of the WoOZ experiment described in Marchesi and colleagues' work [25]. On the left side (Panel a), the experiment was shown from the participant's perspective, *i.e.*, with the experimenter hidden from the participants' view while controlling the robot. In contrast, on the right side (Panel b), the experiment was shown from the experimenter's perspective, to unveil that the robot was not autonomously interacting with participants, but the experimenter remotely controlled it.
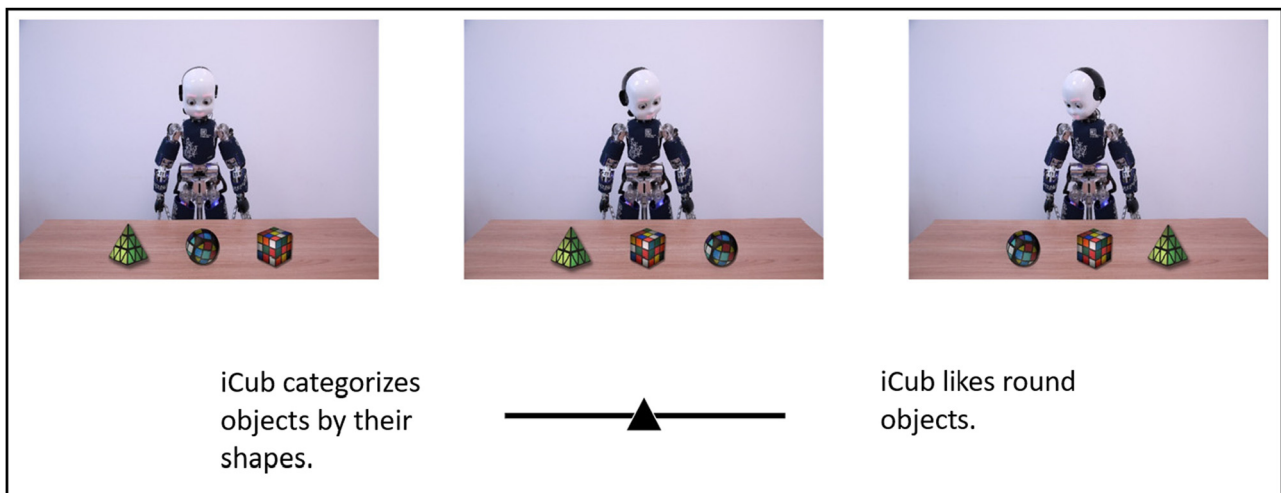

Figure 2: Screenshot of the example scenario of the IST. Mechanistic explanation on the left and mentalistic on the right.

intentional behavior of the robot from the participants' perspective is in fact a behavior fully pre-programmed and controlled by an experimenter. This should highlight to participants that a robot is just a machine without a will of its own.

As a measure of the tendency to adopt the Intentional Stance toward robots, we employed the InStance Test (IST) [7]. The test consists of 34 fictional scenarios depicting the humanoid robot iCub while performing various daily activities. Each scenario comprises three pictures showing a sequence of events, with a scale (ranging from 0 to 100) providing a mechanistic description of the scenario on one extreme and an mentalistic description on the other. By moving the cursor on a slider's scale toward one of the extremes, in each scenario participants have to rate whether they think that iCub's behavior has a mechanical or a mentalistic explanation (see Figure 2 for an example scenario).

To test whether the tendency to attribute intentionality toward robots was modulated by participants' acquired knowledge about robots' functionalities and use, we asked participants to fill out the IST test in two separate sessions, namely half of the test before ("Pre" Session), and the other half after the theoretical lecture and the two videos showing the WoOZ experiment [25] ("Post" Session).

Furthermore, to examine the role of education type, we tested one sample comprising students who attend the scientific/technical high school (*i.e.*, "Scientific–Technical" sample), while the other sample comprised students attending an art high school (*i.e.*, "Artistic" sample).

3 Materials and methods

3.1 Participants

Two samples of Italian high school students were recruited during two different science dissemination sessions at schools. The first sample included students with a scientific–technical background ("Scientific–Technical" sample; $N = 41$ students from scientific high school, $N = 17$ from scientific–technical high school, and $N = 20$ from technical high school, for a total $N = 80$; $N = 2$ students did not explicitly state which school they were enrolled, and thus, they were considered as NAs). The second sample included students with an artistic background ("Artistic" sample: $N = 56$ students from an art high school). All students that took part in the study were adults (age range =

18–19). All participants gave informed consent and declared themselves to be of legal age by ticking the appropriate box in the online form before completing the IST. All participants were naïve to the purpose of the study.

The study was approved by the local Ethical Committee (Comitato Etico Regione Liguria), and it was conducted following the Code of Ethics of the World Medical Association (2013 Declaration of Helsinki).

3.2 Apparatus and stimuli

Students were invited to attend a theoretical lecture about robots' functionality and use, held by the authors. Before and after the authors' presentation, participants were asked to complete the IST [7], which was programmed using the online platform SoSci (https://www.soscisurvey.de/) [26]. At the end of the lecture, participants watched two videos. First, they watched a typical HRI in a laboratory context from participants' point of view; subsequently, they watched the same experimental context from the experimenter's point of view, controlling the robot through a WoOZ manipulation [23,24].

3.3 Procedure

Participants were asked to complete the first half of the IST before the lecture ("IST-Pre"), whereas the other half of the IST was sent and completed at the end of the presentation, specifically after participants watched the WoOZ videos ("IST-Post"). Notably, the IST-Pre was made accessible the day before the lecture session, whereas access to the IST-Post was available only at the end of the lecture. This was done to ensure that participants filled out the second part of the IST only after attending the lecture and watching the videos.

Given the specific requirements of our study, namely the need to provide the two parts of the IST at different time points and the need to match the anonymized answers of the same participant, we designed a custom solution using the tools provided by SoSci Survey. In detail, we created another survey (called "IST-init") in the form of a Web Form asking only participants' email addresses. By submitting this form, a custom script incrementally generated a unique identifier for each new request and sent an email to the specified address with two links, one to access IST-Pre and another to access IST-Post. These generated links have encoded the

identifier of the participant, so they were unique for each participant.

It is important to point out that participants' email addresses were used only to send the links; thus, participants' sensitive data (such as email addresses) were not accessible by the experimenters in any phase of the study.

4 Results

All analyses were conducted using R Studio v.4.0.2 [27] and JASP v.0.14.1 (2020).

4.1 Overall analysis

Regarding the Scientific–Technical sample, we excluded from further analyses the two NA participants who did not declare which school they were enrolled in. Thus, the final sample resulted in $N = 78$. First, we were interested in investigating whether both factors, namely participants' education type and acquired knowledge, affected the likelihood of adopting the Intentional Stance toward robots. Thus, we performed a Repeated Measures ANOVA, with the IST mean scores in the two sessions (*i.e.*, Pre *vs.* Post) as the repeated measures factor, and the education

type (scientific/technical *vs.* artistic) as the between-subject factor ("Artistic" sample, $N = 56$; Mean IST score$_{Pre}$ = 34.47, SD$_{Pre}$ = 20.89; Mean IST score$_{Post}$ = 41.67, SD$_{Post}$ = 24.99. "Scientific–Technical" sample, $N = 78$; Mean IST score$_{Pre}$ = 34.97, SD$_{Pre}$ = 19.77; Mean IST score$_{Post}$ = 41.79, SD$_{Post}$ = 24.11). Only the main effect of IST emerged as significant [$F_{(1, 132)}$ = 10.04, $p = 0.02$, $\eta^2 = 0.02$] (Figure 3).

4.2 Analyses of the artistic *vs.* technical groups

To further explore the impact of technical background on the adoption of the Intentional Stance toward a humanoid robot in adult high school students, we decided to select only students with a technical background. In other words, we excluded students who attended a purely scientific high school without a technical component. We compared their mean scores to the students with an artistic background education with a Repeated Measures ANOVA ("Artistic" sample, $N = 56$; Mean IST score$_{Pre}$ = 34.47, SD$_{Pre}$ = 20.89; Mean IST score$_{Post}$ = 41.67, SD$_{Post}$ = 24.99. "Technical" sample, $N = 37$; Mean IST score$_{Pre}$ = 39.77, SD$_{Pre}$ = 17.8; Mean IST score$_{Post}$ = 53.86, SD$_{Post}$ = 19.32).

Results showed both the within-subject main effect of IST scores in the two sessions (Pre *vs.* Post) [$F(1, 91)$ =
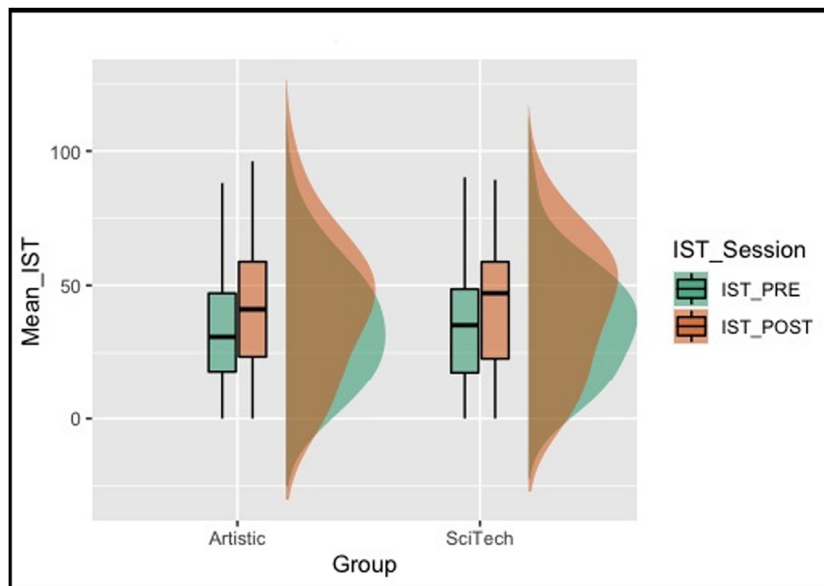

Figure 3: Mean IST scores, plotted as a function of Session (IST Pre *vs.* Post), separately for Education Type (Artistic *vs.* Scientific–Technical students). Bars indicate the 95% confidence interval.

13.84, $p < 0.001$, $\eta^2 = 0.05$] and the between-subject main effect of the education type (technical *vs.* artistic) [$F_{(1, 91)}$ = 6.2, $p < 0.0001$, $\eta^2 = 0.04$] (Figure 4). No interaction emerged as significant [$F_{(1, 91)} = 1.4$, $p = 0.23$, $\eta^2 = 0.006$].

4.3 Analysis of social and non-social factors of IST

In a recent work, Spatola and colleagues [28] explored the factorial composition of a shorter version of the IST, identifying two factors. Factor 1 identifies scenarios where the robot is involved in social interaction with a human ("Social" factor), whereas Factor 2 identifies scenarios where the robot is alone, and thus, the social component is absent ("Non-Social" factor). That being said, we were interested in assessing whether there was a difference, in terms of likelihood of attributing intentionality to robots (*i.e.*, IST scores), between the scenarios in which iCub was depicted while interacting with a human ("Social" scenarios) compared to the ones in which the robot was depicted alone ("Non-Social" scenarios), and whether it might depend on participants' education type (*i.e.*, Scientific–Technical *vs.* Artistic). Therefore, we decided to subselect only the IST items identified by Spatola and colleagues [28]. Then, we explored the two factors with a Repeated Measures ANOVA, where the IST scores for the Social *vs.* Non-Social items (Pre and Post) were considered as within-subject factors, and the education type (Scientific/Technical *vs.*

Artistic group) was considered as a between-subject factor. Given that the assumption of sphericity was not met, results are reported with the Huynh-Feldt correction for sphericity. Results showed a significant main effect of IST Pre *vs.* Post scores [$F_{(2.313, 91)} = 39.48$, $p < 0.0001$, $\eta^2 = 0.2$]. The main effect of education type was not significant [$F_{(1, 91)} = 3.68$, $p = 0.06$, $\eta^2 = 0.01$], as well as no significant interaction between education type and IST Factors (Social and Non-Social) emerged [$F_{(1, 91)} = 2.24$, $p = 0.10$, $\eta^2 = 0.01$] (Figure 5).

5 Discussion

The present study aimed at understanding whether exposure to information about robots' functionality and use affects participants' tendency to attribute intentionality to robots, namely to adopt the Intentional Stance [4,5], and whether this depends on the type of education. The tendency to adopt the Intentional Stance was operationalized as responses in the IST [7].

We asked adult high school students (split into two samples: students attending an art high school, and students attending a scientific–technical school) to take part in a theoretical lecture about robots, in which they were given an overview of robots' functionalities and use in a laboratory setting. In addition, they were presented with videos in which a robot was depicted as a purely mechanical device controlled by a human (*i.e.*, WoOZ videos: see Data Availability statement at the end of the
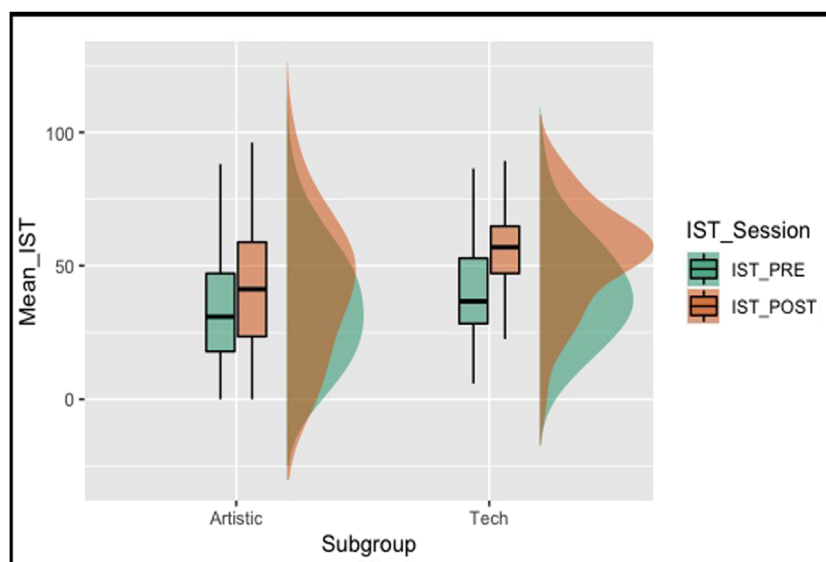

Figure 4: Mean IST scores, plotted as a function of Session (Pre *vs.* Post), separately for each education type (artistic *vs.* technical students). Bars indicate the 95% confidence interval.
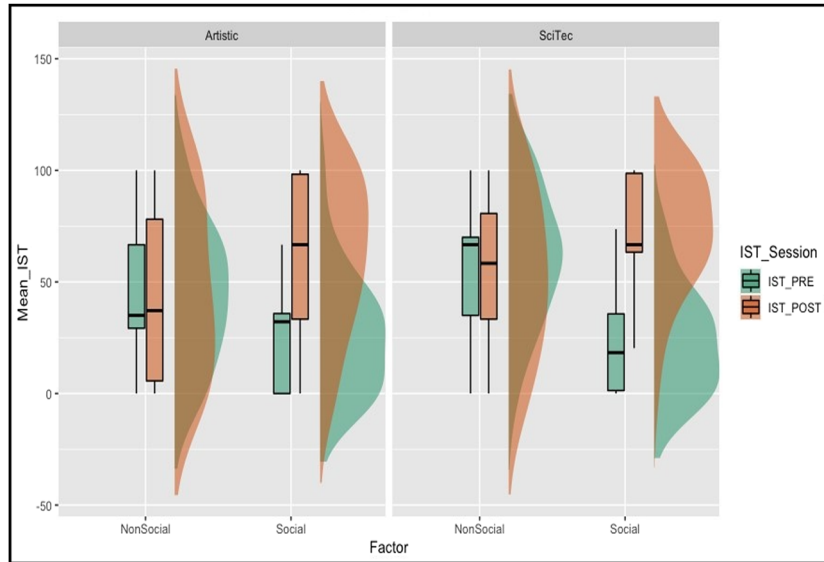
Figure 5: Mean IST scores for Social and Non-Social items, plotted as a function of Session (Pre *vs.* Post), separately for each education type (artistic *vs.* scientific–technical students). Bars indicate the 95% confidence interval.

manuscript). All the students completed the IST in two separate sessions, namely before and after the lecture (*i.e.*, Pre and Post sessions). Results showed that, overall, participants tended to attribute more intentionality to robots (*i.e.*, higher IST scores) in the Post session compared to Pre, regardless of participants' education type (scientific–technical *vs.* artistic).

However, when subselecting from the "Scientific–Technical" sample of only students with a purely technical background, results showed that students enrolled in technical schools tended to attribute more intentionality to robots (*i.e.*, higher IST scores) in the Post session compared to the Pre. Notably, the same did not occur with students enrolled in an art school, as no significant differences in the IST scores emerged between the two sessions. Furthermore, the two-way interaction (Session × Education Type) was not significant, indicating that participants' acquired knowledge about robots after the theoretical lesson did not modulate the likelihood of adopting the Intentional Stance depending on their type of education.

These results are in contrast to the initial hypothesis, according to which more information about the robot's functionality and a higher degree of technical education should decrease the tendency to adopt the Intentional Stance toward robots, as technical education should inform participants that robots are just artifacts and machines without will or mind of its own.

One possible explanation may refer to a psychological phenomenon called the *mere exposure effect* [29].

This phenomenon shows that the mere exposure to a novel stimulus, if reiterated over time, increases individuals' likeability, and positive attitudes, toward it [30–32]. Indeed, repeated exposure to a stimulus leads people to gain knowledge about it, which would allow for more fluent processing. In turn, this perceptual and cognitive fluency seems to positively affect the liking of the stimulus [33]. Interestingly, it can also occur when individuals are exposed to other humans' faces [34,35] or in situations of interactions with other humans (see ref. [32] for a more complete overview). In the context of HRI, the same phenomenon seems to take place also when interacting with robots, as demonstrated by people reporting more positive attitudes toward robots after being repeatedly exposed to them [36,37]. For instance, it emerged that performing an interactive game with a robot significantly improved participants' perception of the robot on dimensions like anthropomorphism or likeability [38]. Along the same line, other evidence showed that people already familiar with robots are more likely to display positive attitudes toward ascribing intentions to robots [39].

Therefore, it may be that the more people are exposed to robots, and thus gain knowledge about them, the more they would be prone to interact with them and to consider them as part of their own in-group [32,34,40]. It would translate into a higher likelihood of perceiving robots as intentional agents (like other humans), *i.e.*, a greater tendency to adopt the Intentional Stance, toward them [25].

An alternative explanation might be that, by watching the WoOZ video of the teleoperated robot, participants acquired the knowledge that robots are actually often controlled by humans. Thus, our reasoning was that, perhaps, the presence of a human might boost participants' tendency to attribute intentionality toward robots, as participants might have assumed that the depicted human was actually controlling the robot. In other words, it might have led participants to attribute intentionality to the depicted human, whom they might have imagined controlling the robot from "behind the scenes."

With this in mind, we assessed whether seeing iCub depicted during social interaction with a human (*i.e.*, IST "Social" scenarios) might evoke a higher attribution of intentionality compared to those scenarios in which iCub was depicted alone, *i.e.*, where the social component was absent (*i.e.*, IST "Non-Social" scenarios).

Our results confirmed an overall increase in IST scores (*i.e.*, higher intentionality attribution) in Post compared to Pre. However, this effect emerged regardless of the type of scenario (social *vs.* non-social), suggesting that the presence of a human in the IST scenarios did not make any difference in participants' likelihood of attributing intentionality toward robots.

In sum, our results did not confirm the initial hypothesis, according to which the more people are exposed to information about robots, the less they are prone to attribute intentionality to them. However, the observed effect, which was in the opposite direction than expected, could be in line with the *mere exposure effect* [29] phenomenon. However, this interesting result should be further confirmed in future research.

6 Conclusions

Taken together, these findings suggest that exposure to knowledge about robots' functionality and use modulates the likelihood of adopting the Intentional Stance toward robots. However, the directionality of this effect needs to be addressed in future studies, which may help to clarify whether, and under what conditions, the tendency to perceive robots as intentional agents could be enhanced.

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