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The effect of individual differences and repetitive interactions on explicit and implicit attitudes towards robots

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Abstract

The exploitation of Social Assistive Robotics (SAR) will bring to the emergence of a new category of users, namely experts in clinical rehabilitation, who do not have a background in robotics. The aim of the present study was twofold. First, we were interested in addressing individual differences in the attitudes towards robots this new category of users. The second aim of the study was to investigate whether repetitive interactions with the robot during the SAR intervention would affect attitudes towards robots. To this end, we evaluated both explicit and implicit attitudes towards robots in a group of therapists rehabilitating children with neurodevelopmental disorders. The evaluation took place before they started a SAR intervention (T0), ongoing (T1), and at the end of it (T2). Explicit attitudes were evaluated using self-reported questionnaires, whereas implicit attitudes were operationalized as the perception of the robot as a social partner and implicit associations regarding the concept of “robot”. Results showed that older ages and previous experience with robots were associated with more negative attitudes toward robots and less willingness to perceive the robot as a social agent. Explicit measures did not vary across time, whereas implicit measures were modulated by increased exposure to robots. Specifically, the more the clinicians were exposed to the robot the more the robot was considered a social partner similarly to the human player. Moreover, across time, users’ memory association between the concept of a robot and mechanical attributes became weaker. In conclusion, our results suggest that individual differences towards robots in a group of SAR users play a crucial role in both explicit and implicit attitudes. Moreover, they also suggest that increased exposure to robots modulates implicit but not explicit attitudes.

Keywords: Human-Robot Interaction; Repetitive interactions; Individual differences

Introduction

In the near future, the application of robots in clinical training will be one of the most relevant challenges for the Socially Assistive Robotics (SAR). One of the main consequences will be the emergence of a new category of users. This new category will comprise clinicians and experts in different fields of rehabilitation (from motor training to socio-cognitive therapies) who do not have a background in robotics. A crucial aspect that has been scarcely examined is individual differences in robot perception in those users, who play a critical role in choosing and implementing any SAR protocol. Indeed, most SAR studies focused on (i) the reliability of the platform and/or (ii) on the success of the training. However, the success of any clinical protocol relies not only on the quality of the training itself but also on the therapeutic alliance and the commitment of the therapist [1]. In this context, it is crucial to investigate attitudes towards robots among this category of users. Importantly, in examining attitudes towards robots, one should address not only the group of users as a whole but also individual differences. Indeed, individual differences have been found to affect the perception and acceptance of robots human-robot teams [2–5]. Recently, Hinz et al. [6] showed that when playing a game with the Cozmo robot (Anki robotics), the more people felt discomfort towards the robot, the less they were susceptible to the social facilitation effect induced by its presence [6]. A similar pattern has been reported for personality traits, with higher levels of neuroticism predicting the preference of more machine-like robots [2]. The second critical aspect that has been neglected in literature is understanding of the strength of these attitudes. Indeed, a priori negative attitude towards robots might be the consequence of a lack of familiarity with them, which are often considered as a “mysterious” system. A recent study [7] showed that negative attitudes towards robots were reduced in a group of education students after they took part in robot programming classes. Specifically, students said

that the programming course allowed them to better understand how robots work. Thus, it is possible that increasing familiarity with robots may reduce negative attitudes towards them among SAR users.

Aim

The present study had two aims. Firstly, we were interested in evaluating individual differences in explicit and implicit attitudes towards robots in a group of clinicians who had the opportunity to conduct a robot-assisted intervention for the first time in their professional practice. To this end, we tested explicit and implicit attitudes towards robots in a group of specialists who were involved in a robot-assisted intervention protocol to train joint attention mechanisms in children with autism spectrum disorders. The protocol involved the Cozmo robot [see 28 for details about the training]. Explicit attitudes were evaluated using self-report questionnaires as the *Frankenstein Syndrome Questionnaire* (FSQ; [29]); the *Negative Attitude Towards Robots Scale* (NARS; [2]); and the *Robotic Social Attributes Scale* (RoSAS; [30]).

Implicit attitudes were evaluated with the use of the Implicit Association Test (IAT) and the perception of the robot as a social partner. The perception of the robot as a social partner was our first implicit measure. To this end, we developed a modified version of the Cyberball paradigm [31, 32]. The Cyberball paradigm is used in social psychology to simulate social exclusion and ostracism. It consists of a ball-tossing game in which participants believe they are playing with two or more players and they have to throw the ball to the "others", which are controlled by the programmer. Although the paradigm was designed to induce social exclusion, it can also be used as an implicit measure of group membership. Indeed, by focusing on whether and how often participants throw the ball to the other players it is possible to evaluate their attitudes to include or exclude (and to what extent) a player that belongs to a specific social category. In our study, we

developed a version of the task in which the users were playing with another human being and the Cozmo robot. Both players were programmed to include in the game both the other player and the user, equally. We hypothesized that the willingness to perceive the Cozmo robot as a social partner would have been predicted by individual differences. Thus, participants with a more negative attitude towards robots should be less willing to interact with the Cozmo robot instead of the human player.

The IAT is a well-known test used in social psychology to evaluate implicit attitudes towards a social category [33; see 34 for a review]. It allows detecting the strength of associations between concepts (e.g., flower and insects) and attributes (positive and negative) in memory. The typical result is that responses are faster for those pairings that are strongly associated within the memory (flower/positive) than those that are not (insect/positive). In our study, we were interested in addressing whether the concept of a robot could be implicitly associated with Intentional or Design stances [15, 16, 17]. To this end, we developed a version of the IAT to measure associations between the human and robot concepts with mentalistic and mechanical verbs (e.g. “to desire” or “to process”) [e.g., 17]. Based on previous studies showing that humans tend to explain robot behavior mostly with reference to the Design Stance [17], we hypothesized to find an IAT bias indicating that the concept of a robot is strongly associated in memory with mechanistic attributes instead of mentalistic ones. Moreover, we expected that individual differences in attitudes and expertise with robots should correlate with the magnitude of the IAT bias. Specifically, the more negative toward robots the clinicians are, the less they should adopt Intentional Stance towards, meaning that a larger IAT bias is expected.

The second aim of the study was to investigate whether repetitive interactions with the robot during the SAR intervention affected explicit and implicit attitudes towards robots. To this end,

we repeated the evaluation of clinician's attitudes at three different moments in time. The a priori evaluation was made before the starting of the training (Time 0: T0), after that, all the clinicians took part in the familiarization session during which the intervention protocol, the Cozmo robot, and the user interface were presented [see 28 for a detailed description of the SAR protocol to train joint attention in ASD children]. The second (Time 1: T1) and the third (Time 2: T2) evaluation occurred when in the middle and at the end of the SAR training, respectively.

Accordingly, to the *contact hypothesis* [20, 21], we hypothesized that repeated interactions with the robot should have affected explicit and implicit attitudes. Specifically, in line with Bartneck et al.'s results [11], we expected that increased exposure to robots should result in less negative attitudes toward them, measured with explicit measures.

Regarding the perception of the robot as a social agent, we hypothesized a reduction of the intergroup bias across time, meaning that the Cozmo robot would be perceived as a potential agent similar to the human player, thus at the end of the SAR intervention, no difference in the choice between including human vs. robot in the in-group category should occur.

Finally, for the IAT bias, we hypothesized that if the increase of familiarity with the robot reduces the intergroup bias, then we expected the IAT effect to be reduced as a function of time. Such a result would indicate that following repetitive interactions the concept of a robot is less associated with mechanistic attributes in memory, suggesting that familiarity may increase the likelihood of adopting Intentional Stance towards robots.

Materials and Methods

Sample

Nineteen clinicians (mean age: 35.74 ± 7.51 , 1 Male) working in the Provincia Religiosa San Benedetto di Don Orione took part in this study. Participants were all expert clinicians working

with neurodevelopmental disorders, and our sample included four professional profiles: logopedist, psychomotricist, educator, and psychologist. All participants had a normal or-corrected-to-normal vision and were naïve to the purpose of the study. The study was conducted under the ethical standards laid down in the 2013 Declaration of Helsinki and approved by the local ethical committee (Comitato Etico Regione Liguria). All participants gave written informed consent before the experiment.

Procedure

Explicit attitudes towards robots were assessed before the starting of the SAR protocol (T0), during the training (T1), and the end of it, i.e. after 10-12 months (T2). To this end, participants filled out the following questionnaires:

- RobEx questionnaire [35], a self-report questionnaire that investigates familiarity, experience, and expectations towards robots and robotics. The RobEx was administered only at time T0;
- FSQ, self-report scales that investigates the anxiety perceived towards robots in contexts of interaction [29];
- NARS, self-report scales that investigates negative attitudes towards robots [2];
- ROSAS, self-report questionnaire that investigates the attribution of anthropomorphic characteristics to robots [30].

Sel-report questionnaires presentation, response timing, and data collection were controlled by Opensesame software. [36].

The willingness to perceive the robot as a social agent was addressed by a computer game inspired by the Cyberball paradigm [31], which allows evaluation or simulation of social exclusion. Stimuli were pictures of human partners and a picture of Cozmo robot. The act of throwing the ball was

simulated by presenting a 1sec video of a schematic ball moving. In our version of the task, none of the players was excluded and participants were instructed to pass the ball to whoever they wanted. Each trial started the presentation of pictures of the human player and Cozmo on the left and right side of the screen, while the name of the participant was presented at the bottom. The ball was always presented next to the player who received it in the previous trial. Upon receiving the ball, participants were instructed to wait until the go-signal (i.e. their name turned from black into red) before passing the ball. Following the go-signal participant had 500 ms to pass the ball by pressing the “Z” or “M” key on a standard Italian keyboard. Time-out was highlighted with a 500ms feedback display. The task was programmed to comprise 240 trials plus trials to replace time outs. A short rest was given after 120 trials. The task was administered at three different stages of the SAR intervention: before the starting of the training (T0), ongoing (about 4-6 months later, T1), and at the end of it, i.e. after 10-12 months (T2). Stimuli presentation, response timing, and data collection were controlled by the E-Prime version 3 software (Psychology Software Tools, Inc.).

Implicit attitudes towards robots were assessed using the Implicit Association Test (IAT) [33, 34], which allows evaluating implicit attitudes. Pictorial stimuli were 20 pictures of silhouettes depicting humans (females and males) and humanoid robots [see 38]. As linguistic stimuli, we used 20 verbs taken from the InStance questionnaire items [17] referring to mechanical processes or mental states (e.g. “to process” or “to desire”, respectively). Specifically, participants performed a short version of the IAT comprising 5 blocks (Fig. 1). In Block 1, participants had to categorize human vs. humanoids silhouettes. In Block 2, they were required to categorize Mentalistic vs. Mechanistic words (e.g. to desire vs. to process). In Block 3, both silhouettes and words were presented. Participants were asked to categorize both. The association between the silhouettes and

the word was congruent, meaning that the same response key was used to categorize congruent stimuli (e.g. left key: Human silhouettes and Mentalistic words; right key: Humanoid silhouettes and Mechanistic words). Block 4, was the same as Block 1 but the association between the target and the response key was reversed (see Fig.1). Finally, in Block 5 both silhouettes and words were presented as in Block 3 but the association between the silhouettes and the words was incongruent (i.e. left key: Humanoid silhouettes and Mentalistic words; right key: Human silhouettes and Mechanistic words). Each trial started with the presentation of the stimulus (a silhouette or a word) in the center of the screen with the respective response-category presented in the left and right upper corners. Responses were executed with the “Q” and “P” keys on a standard Italian keyboard. The time allowed to respond was infinite, however, participants were instructed to respond as fast and accurately as possible. Incorrect responses were followed by 500ms feedback. The ITI was 400 ms. Block 1, 2, and 4 comprised 40 trials each. 80 trials were presented in Blocks 3 and 5. Block order was fixed but the presentation of stimuli was randomized within each block. The IAT was administered at three different stages of the SAR intervention: before the starting of the training (T0), training ongoing (about 4-6 months later, T1), and at the end of it, i.e. after 10-12 months (T2). Stimuli presentation, response timing, and data collection were controlled by the E-Prime version 3 software (Psychology Software Tools, Inc.).

Figure 1. IAT blocks procedures.

Results

Individual differences in attitudes towards robots

Our first aim was to address if previous experience with artificial agents or individual differences in terms of age or level of education correlates with explicit attitudes towards robots in a sample of clinicians, who are not professionally trained in robot programming. To this end, we estimated Pearson's correlations between the scores of the above-mentioned self-report measures. Results showed that age positively correlated with the "Discomfort" sub-scale of the ROSAS [$r_{17} = .50$, $p = .030$], the "Perceived anxiety towards robots" subscale of the FSQ [$r_{17} = .50$, $p = .030$], and the attitude towards robots during social interaction assessed with the NARS [$r_{17} = .49$, $p = .034$] (Fig.2, upper panel). We also found a positive correlation between the participant's experience with robotics, assessed with the RobEx questionnaire, and the attitude towards the social influences of robots assessed with the NARS [$r_{17} = .49$, $p = .032$] (Fig. 2, upper panel). Furthermore, we found a negative correlation between the participant's experience with robotics and their perception of the robot's warmth assessed with the ROSAS [$r_{17} = -.48$, $p = .039$] (Fig. 2, lower panel).

The effect of repetitive interactions on explicit measures of attitudes towards robots.

Our second aim was to evaluate if, after repetitive interactions with a robot, clinicians' attitudes changed. To this end, we compared average scores for each subscale of FSQ, NARS, and RoSAS questionnaires as a function of time. Given that only 7 participants took part in all the three testing sessions of self-report questionnaires, we decided to consider data collected before and after the clinical training (T0 and T2, respectively) from 12 participants, thus analysis was run on a sub-sample (N=12). Wilcoxon tests on average scores showed that no differences occurred across the two sessions in explicit measures (all $ps > .12$, Fig.3).

Figure 2. Correlation between expertise with robots and explicit measures of attitudes towards robots.

Perception of the robot as a social partner

Regarding the perception of the robot as a social partner, we firstly estimated the frequency of robot and human choices. At T0, when a sample of $N=19$ was considered, participants chose to toss the ball toward the robot 50.07% of the time. Then we focused on evaluating whether individual differences in explicit and implicit attitudes towards the robot correlated with the willingness to interact with it. To this end, we estimated Pearson's correlations between the scores of the above-mentioned self-report measures, age, education, and the percentages of robot choices at T0. Firstly, we found a negative correlation between age and frequencies of robot choice [$r_{17}=-.58$, $p = .009$]. Results showed that the probability of choosing the robot negatively correlated with all the NARS subscales [Situation of Interaction: $r_{17}= -.77$, $p < .001$; Social Influence: $r_{17}= -.53$, $p = .021$; Emotions in Interaction: $r_{17}= -.67$, $p = .002$], see Fig.3. We also found a negative correlation between the probability to interact with the robot and the general anxiety [$r_{17}=-.79$, $p < .001$], the level of apprehension [$r_{17}=-.58$, $p = .010$], and negative expectations towards humanoid robots [$r_{17}=-.58$, $p = .010$], assessed with the FSQ questionnaire, Fig.4. Finally, we found a positive correlation between participants' perception of the robot as Warmth and Competent assessed with the ROSAS and the probability to toss the ball to it. [$r_{17}= .49$, $p = .035$, $r_{17}= .82$, $p < .001$, respectively], Fig.5.

Figure 3. Correlation between Negative attitudes towards robots and frequencies of robot choices at T0.

To evaluate if the repetitive interactions with the robot affected the willingness to perceive it as a social agent, we analyzed both frequencies of choices and reaction times (RTs) from the modified Cyberball paradigm across time (T0, T1, and T2). From the initial sample, only 11 participants completed the task at all the testing sessions. Analyses were conducted by using the lme4 package in R v.3.0.6. (R Core Team, 2014). Parameters estimated (β) and their associated t-tests (t, p-value) were calculated using the Satterthwaite approximation method for degrees of freedom; they were reported with the corresponding bootstrapped 95% confidence intervals.

Frequencies of robot choices were analyzed with a logistic mixed model with Session Time as a fixed factor and participants as a random effect. The analysis revealed that the probability to choose the Robot was significantly reduced both at T1 [$\beta = -0.41$, $z_{12.22} = -3.19$, $p = 0.001$, $CI = (-.65; -.16)$] and T2 [$\beta = -.36$, $z_{12.22} = -2.29$, $p = .004$, $CI = (-.60; -.12)$], relative to T0, see Table 1. Specifically, the reduction in the probability of choosing the robot was equal to 0.67% and 0.70% at T1 and T2, respectively.

Table 1. The average percentage of robot choices in the modified cyberball paradigm as a function of the session of testing and agent (N= 11).

Session Time	%Robot Choices
T0	58.5%
T1	48.6%
T2	51.8%

Mean RTs were submitted to a general linear model with Choice (Human vs. Robot), Session time (T0 vs. T1 vs. T2), and their interaction as fixed effects. The analysis revealed no main effects or significant interactions (all $ps > .11$).

Figure 4. Correlation between FSQ subscales and frequencies of robot choices at T0.

Figure 5. Correlation between RoSAS subscales and frequencies of robot choices at T0.

Implicit association Task (IAT)

To evaluate implicit attitude towards robots we estimated the IAT effect following Greenwald et al's procedure [34]. Firstly, we were interested only in those blocks in which the target and the attribute were congruent or not (i.e. Blocks 3 and 5, see Fig.1). Trials with RTs longer than 10 s or shorter than 300 ms were considered as outliers and removed ($< .01\%$). Then following [34], for each participant RTs of incorrect trials were replaced with the mean RT for each block plus a 600 ms penalty.

Our first aim was to evaluate if individual differences in explicit attitudes towards robots correlated with implicit measures. Thus, we estimated Pearson's correlations between the scores of the above-mentioned self-report measures and the IAT bias estimated as the difference in RTs

between incongruent and congruent blocks at T0. Results showed no significant correlations (all p s > .13).

Our second aim was to evaluate if repetitive interactions with the robot modulated clinicians' implicit attitudes. Thus we compared the performance at the IAT task across three sessions. Only 12 participants took part in all the sessions, thus the analysis of IAT was run on a sub-sample ($N=12$). Mean RTs were submitted to a repeated-measures analysis of variance (ANOVA) with Session Time (T0, T1, and T2) and Congruency (C vs. NC) as within-subjects factors. Results showed a main effect of Congruency [$F_{11} = 111.41$, $p < .001$, $\eta_p^2 = .91$] showing that participants responded faster to congruent than incongruent blocks (727 vs. 1056 ms, respectively). The two-way Session Time * Congruency interaction was significant as well [$F_{11} = 7.29$, $p = .004$, $\eta_p^2 = .40$]. Bonferroni-corrected comparisons showed that RTs were faster for congruent than incongruent blocks at all sessions (T0: 735 vs. 1143 ms, $t_{11} = 8.28$, $p < .001$, $d = 2.39$; T1: 704 vs. 1046 ms, $t_{11} = 9.01$, $p < .001$, $d = 2.60$; T2: 740 vs. 980 ms, $t_{11} = 7.37$, $p < .001$, $d = 2.13$). However, the IAT bias, i.e. the difference in mean RTs between incongruent and congruent blocks, was significantly reduced at T2 (239 ms) compared to both T0 (408 ms, $t_{11} = 3.36$, $p = .012$, $d = .97$) and T1 (342 ms, $t_{11} = 2.98$, $p = .026$, $d = .86$), see Fig.6.

Figure 6. Mean RTs (ms) for the IAT task plotted as a function of Session Time and Congruency. Error bars are standard errors of the means.

Discussion

The aim of the present study was twofold. First, we were interested in addressing individual differences in the attitudes towards robots in a category of users crucial for socially assistive robotics, namely experts in clinical rehabilitation. To this end, we evaluated both explicit and implicit attitudes towards robots in a group of therapists rehabilitating children with neurodevelopmental disorders. This evaluation took place before they started a SAR intervention. Explicit attitudes were evaluated using self-reported questionnaires, whereas implicit attitudes were operationalized as the perception of the robot as a social partner and implicit associations regarding the concept of “robot”. Results showed that individual differences play a role in the attitude displayed towards robots. In particular, age seems to play a critical role. Indeed, older clinicians displayed more negative attitudes, as suggested by the positive correlation between age and subscales of the three questionnaires. A second factor that may play a role in individual

differences is the level of familiarity with robots. Results indicated that experience with robotics affected participants' tendency to attribute "Warmth" to the Cozmo robot and their concerns related to the negative social influence of robots. Specifically, the more they were experienced with robots, the less they perceived the Cozmo robot as "Warm" and the more they were negative toward social interaction with robots. Based on these results, we can speculate that younger clinicians with a lower level of experience with robots would be more positive toward the application of robots during a rehabilitation training compared to older clinical with a higher degree of experience with robotics.

Individual differences and self-reported attitudes partially correlated with implicit measures. Individual differences correlated with the perception of the robot as a social partner. Indeed, results showed that similarly to explicit measures, age negatively correlated with the frequencies of robot choices. Moreover, results showed that the less negative clinicians were towards robots, the more they chose to interact with Cozmo instead of the human player. Such a result is also confirmed by the positive correlation between positive attitudes attribution, such as warmth and competence, and the frequencies of choices to pass the ball and play with the robot.

No correlation was found between individual differences, self-reported scores and the magnitude of the IAT bias

Taken together, these findings suggest that individual differences are crucial in the willingness of clinicians to interact with robots and they could also affect their propensity to embed SAR protocols in rehabilitation.

The second aim of the study was to investigate whether repetitive interactions with the robot during the SAR intervention would affect attitudes towards robots. According to the contact hypothesis [20, 21], we hypothesized that repeated interactions with robots should have affected both explicit

and implicit measures. Results showed that explicit measures did not vary across time (and experience with Cozmo), as indicated by the lack of significant main effect of testing sessions (T0, T1, T2). Such a result is not in line with previous evidence [11, 12] showing that increased exposure to robots resulted in increased positive attitudes towards them. However, Wullenkord et al. [26] highlight that the effect of exposure occurred when there were no preexisting negative attitudes. However, in their study, the interactions with the robot produced even more negative attitudes in people with previous negative emotions toward robots. In our sample, the attitudes towards robots were not homogeneous as highlighted by individual differences. Thus, age and previous experience with robots might have affected the modulatory effect of repetitive interactions on explicit measures, resulting in a null effect. Future studies should explore this possibility on a larger sample, in order to better understand whether repetitive interactions with robots during a SAR intervention can reduce self-reported attitudes among clinicians.

Interestingly, implicit measures were modulated by increased exposure to robots.

The perception of the robot as a social partner was operationalized as the preference to throw a ball toward the Cozmo robot or a human player. According to the literature [13, 20, 21], we hypothesized that if repetitive interactions modulate the perception of the Cozmo robot as a social agent, then we expected that the Cozmo robot would have been perceived as an interaction partner, similar to another human. Results showed that across time, the difference in the probability of choosing the Cozmo robot as the recipient of the ball reduced. Such a result should be interpreted in light of the binary nature of the task. Indeed, the reduction in the frequencies to throw the ball to the robot correspond to a reduction in the difference between the two players, meaning that the more the clinicians were exposed to the robot the more they treated the two players equally (see Table 1), suggesting that the robot was considered a social partner similarly to the human player.

Our last implicit measure was the IAT bias. Results showed that the IAT bias was reduced at the end of the SAR intervention in comparison to the pre-training evaluation. In line with Marchesi et al., [17], we found an IAT bias towards robots at T0, suggesting that before the SAR intervention, clinicians associated the concept of a robot with mechanical instead of mentalistic attributes. As familiarity with the robot increased, the IAT bias reduced. This reduction indicates that across time, the association in memory between the concept of a robot and mechanical attributes became weaker, suggesting that repetitive interactions may have increased the likelihood of adopting Intentional Stance towards the robots. Moreover, given that IAT bias has been traditionally used as an implicit index of intergroup bias, our results extend previous studies showing that inter-group bias towards robots can be reduced through repetitive HRI [13, 25]. However, these results need to be taken with caution, as the reduced difference in reaction times between incongruent and congruent trials might simply manifest a learning effect across the sessions.

Taken together, our results suggest that individual differences towards robots in a group of SAR users play a crucial role in both explicit and implicit attitudes. Moreover, they also suggest that increased exposure to robots modulates implicit but not explicit attitudes. Such dissociation is in line with a series of studies by Kompatsiari and colleagues showing that implicit measures, such as reaction times and eye-fixations, are more sensitive to detect the effect of social cognition manipulation in robots' behavior instead of self-report measures [38, 39]. Similar results have been shown by Ghiglino et al. [40]. Explicit measures are dependent on introspective abilities and interpretation of the questions and can be prone to various biases, such as cognitive consistency [41], i.e. the tendency of people to prefer thoughts, beliefs, knowledge, opinions, attitudes, and intents that are congruent with how they see themselves. Moreover, explicit measures are not sufficiently informative about specific cognitive mechanisms involved in social categorization,

such as the strength of associations in memory between concepts and attributes, which are automatic and thus not necessarily accessible to conscious awareness.

Conclusions

Understanding individuals' dispositions and biases towards robots is fundamental to ease the adoption of such technologies in social and assistive environments. Our results suggest that clinicians providing therapy for individuals with neurodevelopmental disorders were negatively biased towards robots before being exposed to our protocol. However, the prolonged exposure to the robot progressively decreased implicit biases that could undermine the robot's use in everyday life scenarios. Therefore, we believe that clinicians' attitudes should be accounted for when evaluating the success of a SAR intervention as they might undermine the level of users' commitment. Moreover, we believe that activities to promote the use of innovative technologies, such as robots, in the healthcare environment could spontaneously improve the relationship between users and technology.

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