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Improving Psychological Wellbeing with Robots*

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***Abstract*— Robot users that receive psychological or psychotherapeutic support from robots (e.g. robots that motivate users to perform certain tasks) are usually aware of participating in a psychological intervention. The present paper aims to ascertain whether robot users should indeed remain aware, or rather unaware, of participating in such type of interventions. We present an experiment with two conditions. In one condition (direct) the robot made participants aware of being subjected to a psychological intervention, the three good things exercise from positive psychology, whereas in the other condition (indirect) participants were not made aware of the intervention. Our results show that the robot succeeded in improving participants' positive affect in the direct condition but their affect worsened in the indirect condition.**

I. INTRODUCTION

Robots are able to perform various types of activities, such as physical tasks and offering us company [1], [2]. Also, some studies have focused on robots that support users psychologically. Typical examples include applications for elderly people suffering from mental disorders, for children with autism, and for users that need to be motivated to lose weight (see Section II). In our study we offer an innovative approach by introducing an exercise from positive psychology to human-robot interaction. This approach is based on the assumption that psychological interventions should not only aim at healing people that already have a mental illness, but also at preventing psychological disorders and fostering general psychological wellbeing [3].

We conceive two ways of having robots perform such psychologically supportive tasks. One alternative is to make the user aware that he/she is undergoing a psychological intervention, aided by the robot, whereas the other alternative is to cover this intervention in such a way that the participant is not aware of it. We believe that this question is not trivial for the following reasons: if participants are told that they will interact with a robot which enhances their mood, we might expect that hope and autosuggestion could add up to the success of the intervention. However, some participants might feel stigmatized when knowing that a robot has been set up to aid them psychologically, which in this case would diminish the effect of the intervention. On the other hand, if participants are unaware of the intervention, they would not benefit from the effects of hope and autosuggestion. Nevertheless, studies show that the mere exposure to social robots can improve the mood of the participants [4]. Thus, we believe that approaching the question of whether robots should engage users in direct or indirect interventions could potentially contribute to the success of such interventions. In this paper we will refer to the situations where participants are aware or unaware of the intervention as "direct interventions" and "indirect interventions", respectively.

Fig. 1. Interaction between Giraff robot and user

We implemented the "three good things in life" exercise [3] on a Giraff robot to test whether the robot would improve people's affect more in a direct or in an indirect setting (see Figure 1).

II. THEORETICAL BACKGROUND

In the study described in this paper, we adapted an exercise from positive psychology to implement it on a robot. The following subsections offer an overview on previous work on robots for psychological support and on positive psychology.

A. Robots for Psychological Support

Within the scope of HRI, some robots have been employed with psychotherapeutic or motivational purposes. In most cases the interventions were targeted at specific types of users with specific illnesses or deficiencies, such as elderly people with dementia. Paro, the seal robot, has widely been employed in this context. Various studies report how elderly people hold Paro and interact with it in nursing homes. Among the benign effects of interacting with Paro are general improvement in feelings and reduction in depression [4].

Robots have also been used as a therapeutic aid for children with autism. Robins et al. [2] allowed autistic children to play with Robota, a humanoid robotic doll. This approach permitted an exploration of the interaction space of robot-human and human-human interdependence. A meaningful outcome was that the children, once accustomed to the robot,

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opened themselves up, included the investigator in their own world and were willing to share their experiences with him and their carers.

Also, studies have been carried out with robots that psychologically support the users by motivating them to perform wholesome activities. For instance, Kidd and Breazeal investigated the effects of a robot that had the role of a weight loss coach [5]. Its effectiveness was compared to a computer and a paper log. The results showed that even though only minimal differences were found in weight loss across the three conditions, the participants used the robot for a longer time and reported a closer alliance with it. Noticeably, all the related work with robots focuses on user groups with specific psychological needs.

B. Positive Psychology

In the second half of the 20th century, psychology largely focused on mental disease and healing, neglecting the potential to flourish that people have under more benign circumstances [6]. Aiming to broaden the focus of psychology, Seligman and Csikszentmihalyi have laid the foundations of the field known as positive psychology, referring to studies that address valued subjective experiences (e.g. wellbeing, hope and flow), positive individual traits (e.g. courage and forgiveness) and civic and institutional virtues (e.g. tolerance and moderation) [6], [7], [8]. Within the framework of positive psychology, exercises have been proposed and empirically tested that can foster psychological wellbeing and combat depression. For instance, Seligman et al. carried out an Internet study where participants could perform five different exercises for a period of one week. The authors compared the efficiency of the exercises in increasing levels of happiness and reducing depressive symptoms [3]. One of the most successful techniques was the so-called ”three good things” exercise, which consisted in writing down three things that went well on that day and their causes. Its positive effects progressively increased even after six months from the intervention, due to the fact that some participants spontaneously decided to carry on with the exercise after the one-week experiment [3]. This was one of our motivations to choose this exercise for the experiment presented in this paper.

Seligman et al. used happiness and depressive symptoms to measure the effect of the positive exercises [3]. Such longer-term psychological variables require a long-term research setting [9], going beyond the scope of the present study. We considered that positive affect could be used as a proxy of happiness in short-term studies [9]. Positive affect (PA) has been defined as the ”extent to which a person feels enthusiastic, active and alert” [10]. PA is closely related to social activity and satisfaction [11], whereas low PA is regarded as a distinguishing feature of depression [12]. Very importantly, evidence shows that PA fosters success in multiple life domains (e.g. social life, health and work) [13]. Positive psychology interventions that increase positive emotions have been realized (e.g. the positive exercise in this study), thus, we expected that they will increase PA [14].

To conclude, we envision three main advantages of positive psychology interventions in HRI. First, positive psychology offers exercises that have already been empirically tested by professionals in psychotherapy. Second, positive psychology interventions are not only aimed at patients suffering from a psychological disorder, but they are also administered as preventive means [15], strengthening the psychological, social and material resources of the recipient [8]. Third, the fact that positive exercises do not necessarily focus on specific target groups makes them greatly generalizable [6].

C. Research Question

In view of the potential of robots to assist people in psychological interventions, we were confronted with the question of whether such interventions would be more effective with participants being aware or unaware of them. This has never been tackled before in research with robots that act as coaches or motivators. We believe that approaching this question can be of great relevance in specific psychotherapeutic contexts with robots (see Section II-A). We foresee that the question will become even more crucial once social robots become more common in our households. Many of the interactions between users and robots will probably consist of playing and chatting. Thus, it might be a great opportunity to also embed psychotherapeutic exercises in these activities, perhaps in such a way that users are not aware of undergoing a psychotherapeutic intervention.

Based on this, we propose the following research question:

RQ1: Will people's positive affect increase more with a direct intervention or with an indirect intervention?

III. Method

The robot engaged the participants in the three good things exercise in two conditions. In one condition the robot made the participants aware of the positive exercise, whereas in the other it did not. This experiment was conducted in the lab with participants from a wide age-range and a robot that was teleoperated. In the following, we describe the sample, the robot platform, the procedure of the experiment and our mixed-methods approach to collect data.

A. Sample

42 people with an age ranging from 20 to 83 (m = 39.11, sd = 18.24) participated in the experiment. We aimed to have a sample with a wide age range because exercises from positive psychology could be beneficial for people from all age groups and the effects could differ depending on participants' age. 5 users were excluded due to technical problems with the robot or not understanding the robot because of language issues. Of the remaining participants, 16 were male and 21 female. Regarding their occupations, the majority were students at the University of Twente (11), staff members from the same university (15) or retired (3). 16 of the participants had not seen a robot in real life before; 13 had access to robots approximately once a year; 4 once a month; and 3 once a week or more often. 26 participants were Dutch, 9 from other western countries and 2 from Indonesia.

B. Robot Platform

The robot employed in the experiment was Giraff [16]. Non-anthropomorphic in design, it is approximately as tall as a person and has wheels to move around as well as a screen with camera that allows for teleconference (see Figure 1). The robot's screen presented a pair of simple eyes (two blue, big LED light-like circles on black background) which blinked regularly. The robot was teleoperated from another room without the participants knowing this. The teleoperator had a video feed of the interaction and controlled the robot movements and utterances.

For communication, the operator chose pre-recorded utterances from a list in accordance with a script that pre-defined the reactions in all possible situations. These robot utterances were pre-recorded for the sake of speed, so that the operator would only have to press a button to make the robot emit a given utterance. The utterance repertoire included multiple sentences that referred to similar questions so as to sound less repetitive, as well as utterances to allow the robot to react in a more human manner in unexpected situations. Examples of these utterances are "yes", "no", and "please, could you repeat?". All the robot utterances were in English language.

C. Procedure

The interactions with the robot took place in a lab. Each participant was welcomed and thanked for participation. After the introduction and a brief explanation of the procedure, a consent form was administered. Subsequently, the PANAS affect scale [10] was given to the participant to determine his/her affect baseline (see Section III-D.1 for more information). The main experimenter then left the participant alone and sat hidden nearby, while the teleoperator drove the robot, which had remained invisible until this moment, towards the participant who remained seated. Once the robot approached the participant, it stood in front of them at a distance of approximately 1.5 meters (see Figure 1), without moving during the interaction. After the approach, the interaction started. The robot's utterances were the same in both conditions except for the introduction that it gave to the participants. In the direct condition the robot introduced itself and explained to the users that they would perform an exercise that has its origins in positive psychology and that has been proven to increase positive feelings. The robot asked the participant whether the procedure was clear. If the participant did not understand correctly or hesitated, the robot repeated this first part of the script but in different words to ensure that the participant would understand the purpose of the interaction. In the indirect condition, the robot started introducing itself and then it talked about itself with a duration similar to that of the explanation of the positive exercise in the direct condition. The robot gave emotionally trivial information about the building where it lives. We carefully designed these robot utterances in accordance with the three good things exercise as described in the positive psychology literature [3], [14].

The following part of the procedure remained identical for both conditions. The robot proposed to have a chat, told something positive about itself as an example and invited the participant to start the exercise by stating: "please, tell me something that went well for you in the last few days". Once the participant had finished, the robot asked about the cause of why that went well: "why do you think that (reference to what went well) happened?" This process was repeated two more times, so that the participant reported three positive things. Finally, the robot thanked the participant for the participation and said goodbye.

After the interaction with the robot, the experimenter came back and asked the participant kindly to fill in more questionnaires (see Section III-D.1). Subsequently, a short semi-structured interview took place, where the participant was asked to give his/her impressions about the experiment, the robot and the interaction with it, improvements in affect (if any) and what he/she thought about the idea of having a robot that fosters positive thoughts at home. The experimenter explained that the participant would receive an email with a survey that would serve as the last input for the experiment. Finally, the participant was thanked, offered chocolate and accompanied to the exit of the laboratory.

D. Data Collection and Measures

Data were collected from questionnaires and an interview with each participant after the interaction with the robot. We also analyzed the participants' replies to the three-good-things exercise with respect to how positive their answers were and how engaged they were with the task (i.e., how long the utterances were that the users produced). This analysis was based on recordings from two cameras that recorded the interaction with the robot and the interview. All methods are described in more depth in the following.

1) Questionnaires: The Positive Affect and Negative Affect Scale (PANAS) [10] was employed to measure the participants' affect as a baseline. It consists of 20 items and is subdivided into two subscales, Positive Affect (PA) and Negative Affect (NA). We only measured PA because NA was not relevant in the context of our task. The items consist of adjectives describing the current affective state of the participant, such as "determined" and "interested". Each item is rated on a 5 point Likert scale that ranges from "very slightly or not at all" to "extremely". Thus, scores of the PA range from 10 to 50 points. We checked reliability for the PA scale administered before the interaction. Cronbach's alpha was .770 which we accepted as high enough.

Immediately after the interaction with the robot, the PA scale was administered again to measure changes in the participant's positive affect due to the treatment. To test our research question (whether the change in positive affect was different in the two conditions), we calculated a repeated-measures ANOVA on the PA scale with condition and time of measurement as factors. This was followed up with paired T-tests for the individual conditions as suggested by Field [17].

2) Interview: We performed a semi-structured interview after completion of the post-test questionnaire. It consisted of general questions about the experience with the robot,

about the robot and interacting with it, about changes in affect and whether these were attributable to the technique from positive psychology. Finally the participant was asked about how social robots could improve people's affect. The recordings of the interviews were transcribed and subjected to content analysis [18].

A manipulation check was performed by asking participants "What do you think the robot was trying to do?" and "What do you think was the purpose of the conversation with the robot?" Participants in the direct condition were expected to answer that the robot's goal was to improve one's affect, whereas participants in the indirect condition would believe that the robot just tried to have a conversation or entertain the user. We categorized the replies with respect to their content and conducted a One-Sample Chi-square test.

3) Content Analysis: We also measured task engagement and positiveness of the messages by analyzing the video data for the participants' replies to the three good things exercise. We believe that both aspects reinforce our answers to the research question because engagement appears in the literature as greatly related to positive affect [19]. In fact, another definition proposed for positive affect is "state of high energy and pleasurable engagement" [19].

To conduct these analyses, we first transcribed the participants' utterances. Altogether, we transcribed all 111 replies that we received to the question of what positive things had happened to the participants recently. We analyzed the length of each reply in the three good things exercise as a measure of the participants' engagement in the task. We counted the words in each utterance and conducted a repeated-measures ANOVA with condition as between-subject factor and the three rounds of the task that each participant completed as repeated measures.

We conjectured that the possible changes in the affect of the participants might also be related to the degree to which their answers were positive. Thus, we tried to account for this. For the analysis of positive tone of the participants' replies we had three people rate all 111 transcripts in random order. They were asked to "Please, rate each of the texts on a scale from 1 to 10 according to how positive each text is (1 means "not positive at all" and 10 means "extremely positive")". To assess interrater agreement, we calculated intraclass correlation (ICC) between the raters. The ICC between the three raters was .650 with a 95% confidence interval from .521 to .750 ($F(110,220)=2.861$, $p<.001$). We deem this sufficiently reliable. Hence, we calculated the means of all three ratings for each item for further analysis. Based on the mean rating of positiveness, we conducted a repeated-measures ANOVA with condition as between-subject factor and the three rounds of the task that each participant completed as repeated measures.

IV. Results

In the following, we present the results of our data analysis. We first describe our manipulation check before we address our research question. Results from the different methods (questionnaires, interviews, and video analysis) are included wherever relevant.

A. Manipulation check

We counted the cases where the participants replied as intended by the condition, i.e., cases where participants in the direct condition thought the robot's goal was to make the user happier, plus the cases where participants in the indirect condition believed the robot's purpose was to entertain the user. A One-Sample Chi-Square Test was performed, revealing a significantly higher number of cases where the manipulation check succeeded (χ^2 = .05 , $p < .001$). Thus, we assume that overall the manipulation has worked as intended.

B. Results on research question

We performed a repeated-measures ANOVA on the PA scale to ascertain whether the participants' positive affect would increase more in the direct condition or in the indirect condition. No significant main effects were found for neither factor (condition and time of measurement). However, a significant interaction effect between condition and time of measurement was found ($F(1, 35) = 8.145$, $p = .007$).

Paired T-tests showed that the participants' positive affect actually improved only after the direct treatment ($m\_direct_{post} = 31.15$, $sd\_direct_{post} = 4.58$) compared to the same measure taken before the interaction ($m\_direct_{pre} = 28.95$, $sd\_direct_{pre} = 4.78$); $T(20) = 1.971$, $p = .032$, one-tailed. In contrast, the affect seemed indeed to have decreased after the indirect treatment ($m\_indirect_{post} = 26.41$, $sd\_indirect_{post} = 6.51$) compared to before the interaction ($m\_indirect_{pre} = 29.00$, $sd\_indirect_{pre} = 4.89$); $T(17) = 2.053$, $p = .029$, one-tailed (see Figure 2).

This is in line with the results from the interview. The majority of participants in the direct condition reported increasing positive affect (13 improved, 6 not improved). However, this did not result in a significant difference (χ^2 = 2.58, p = .11). In the indirect condition barely half of the participants reported an increase in positive effect (8 improved, 9 not improved), $\chi^2 = 0.06$, $p = .81$.

In the interviews we further followed up on this finding and tried to determine to what causes the users attributed the change in affect if they experienced any. Participants of the direct condition that experienced an improvement in positive affect attributed this to doing something new, being forced to think positively, to the experience of talking to a robot and, often in the case of students and researchers, to finding the experiment a distraction or alleviation to their stress. Participants in the indirect condition attributed increasing positive affect more to the robot, e.g., because it was funny and cheerful. Reasons for participants in both groups to not experience increasing positive affect included the interaction being too short, regarding the robot as "just a machine", and already having had a very high positive affect before the experiment. So while the participants in the direct condition actually had a tendency to attribute changes in affect to the task, people in the indirect condition did not.

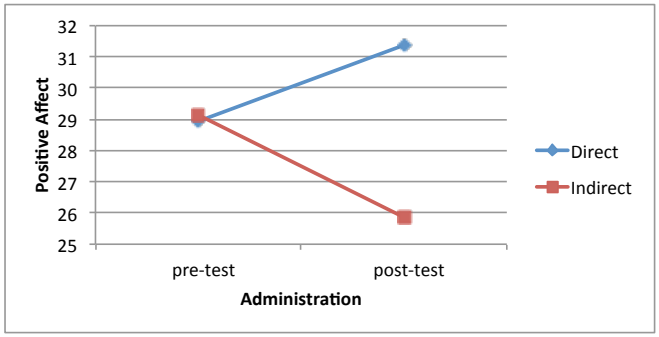

Fig. 2. Positive affect of participants depending on condition, before and after the interaction with the robot.

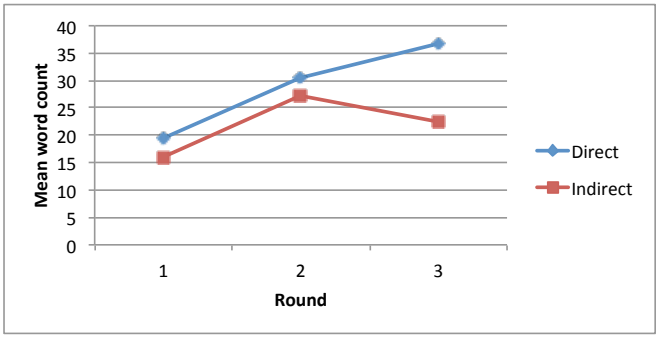

Fig. 3. Mean length of the answers of the participants to the robot, depending on condition and reporting the first, second and third good events.

This is backed up by our findings from the content analysis of the users' replies to the three good things exercise. The results of a repeated-measures ANOVA revealed a main effect for condition; $F(1,35) = 27.668$, $p < .001$. The positive valence of the participants' replies was higher in the direct condition ($m = 5.70$, $sd = .128$) than in the indirect condition ($m = 4.71$, $sd = .139$). Hence, the answers that the people gave in the direct condition were actually more positive which might be one factor leading to the higher increase in positive affect after the interaction (see Section V).

We also looked into participants' engagement with the task to back up this finding, i.e., we analyzed the number of words of each reply. While there was no main effect of condition on the overall number of words uttered; $F(1,35) = 2.791$, $p = .104$, there was a main effect for the number of words in the different stages of the experiment; $F(1,35) = 11.294$, $p < .001$. Thus, we took a closer look at the data that revealed an interaction effect for word count and condition between the three rounds; $F(1,35) = 4.133$, $p = .05$. The graph of the word counts in the two conditions shows that it keeps increasing in the direct condition (see Figure 3). The number of words also increased between the first and second round in the indirect condition but then, in the third round, it dropped below the level of the second round. So while in the first two rounds in the direct condition the length of the utterances was only slightly longer, it was significantly longer in the third trial. Hence, this finding may suggest that the participants stayed more engaged throughout the interaction in the direct condition.

V. Discussion

The results showed a great difference in the change in positive affect depending on condition (more than 5 points in PANAS). Positive affect increased significantly in the participants of the direct condition and was reduced in the indirect condition. Thus, we found evidence to answer the research question, that is, direct interventions appear to be more effective than indirect interventions when employing a robot for psychological support. The medical literature reports similar findings. Benedetti et al. compared the effects of medical interventions where participants were aware of the intervention to the effects of the same interventions while keeping participants unaware of treatment. They demonstrated through a series of experiments with different interventions that medical treatments were more effective when participants knew that they were carried out [20].

Since both experimental conditions remained constant except for the introductory speech of the robot before performing the positive exercise, we conclude that the differences in positive affect after the interaction with the robot were due to this framing of the exercise by the robot. Even if it is beyond the goal of this paper to find the causes that made the two conditions differ in their effectiveness in enhancing positive affect, we would like to conjecture and list a few potentially mediating factors. It would make sense to think that participants in the direct condition were biased to give replies to the three good things exercise which were more positive. In turn, research indicates that positive thinking promotes subjective wellbeing [21]. Our results showed indeed that the participants from the direct condition were higher both on positiveness of their answers and on positive affect. We could conjecture the same about task engagement. Participants were found to be more engaged throughout the task in the direct condition compared with the indirect condition where the engagement dropped at the end. They probably put more effort into the task which might have made it more successful. Another contributing factor to the higher success in the direct condition might have been the presence of hope. That is, the participants in the direct condition knew about the treatment, and the hope that it could increase their positive affect influenced the outcome. It is reasonable to assume that awareness of a treatment may elicit positive expectations or hopes. Researchers in psychology have underlined the importance that clients' hope has in their improvement [22].

Also demand characteristics might have influenced the results [23]. Participants in the direct condition might have believed that they were supposed to show an enhanced positive affect after the robot interaction. Thus, they might have given more positive results.

Something that might also have contributed to the drop of positive affect in the indirect condition is the repetitiveness of the task. In the direct condition the participants were likely more engaged because they had an idea of the purpose of the interaction and an estimate of its duration. Even though

the indirect robot asks to have a "short conversation" it does not indicate the actual duration, nor does it seem to have any particular purpose. It may indeed come across as repetitive by the time it approaches the final "good thing" in the exercise. This might thus explain the drop of engagement by the end of the task in the indirect condition.

VI. Conclusion

Should users be aware or unaware of the fact that they are undergoing a psychological intervention in the interaction with a robot? In this study we found evidence that robots administering treatments from positive psychology will be more effective when they are openly presented as such. We considered that exploring this question is relevant in contexts where robots aid users with specific limitations, but especially in the context of social robots at home, where they will have the potential to tailor their behaviors in ways that foster the psychological well-being of users.

We find two main types of limitations in this study. First, even if we found evidence that making participants aware of the psychotherapeutic role of the robot might indeed contribute to the success of the intervention, we remain greatly ignorant as to what ultimately causes this greater success. We took a merely pragmatic approach in this paper and, even though we ventured to list a few conjectures, we would like to leave this task for future work. This includes the exploration of long-term human-robot interactions to determine the long-term effects of the interventions on people's lives. The adaptation of interventions that involve a high degree of interactivity between therapist and patient will prove challenging to state-of-the-art robotics.

Second, we do not expect the results of this study to be absolutely generalizable to any context involving robots for psychological support. For example, we could suppose that some treatments outside the scope of positive psychology, especially those that specifically target highly morbid or stigmatizing disorders, could make some participants feel stigmatized when they learn that they are under such interventions. For such cases it might be possible that a covered (indirect) intervention might be more suitable. Nevertheless, we hope that our work inspires researchers and carers to choose more carefully between direct and indirect interventions.

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