

The Effects of Motivational Strategies and Goal Attainment on Children's Trust in a Virtual Social Robot: A Pilot Study

Natalia Calvo-Barajas
natalia.calvo@it.uu.se
Uppsala University
Uppsala, Sweden

Giulia Perugia
giulia.perugia@it.uu.se
Uppsala University
Uppsala, Sweden

Ginevra Castellano
ginevra.castellano@it.uu.se
Uppsala University
Uppsala, Sweden

ABSTRACT

Understanding the way different robot's strategies affect children's perceptions of social robots is crucial for a trustworthy child-robot relationship. This paper presents a preliminary study on whether motivational strategies based on Regulatory Focus Theory and goal attainment affect children's perception of a virtual social robot when solving a task. The ongoing pandemic (COVID-19) is altering the way we perform research. Hence, we designed a fully autonomous game with a virtual social robot. In an online user study, 25 children (8 to 17 years old) played a regulatory focus goal-oriented game with a virtual child-like version of the Furhat robot. We evaluated children's perceptions of the robot's social trust, competency trust, and likability. Also, we assessed the children's affective state (valence and arousal) before and after playing the game. Our preliminary results show that in the prevention condition, fulfilling the goal elicited less happiness in children. Surprisingly, we observed a trend increase in the social and competency trust elicited by the virtual robot when children were prevented from fulfilling the goal of the task. We discuss the results and the effects of online setups on conducting user studies with children.

CCS CONCEPTS

• **Human-centered computing** → **Empirical studies in HCI**; *User studies*; *Graphical user interfaces*.

KEYWORDS

Child-Robot Interaction; Trust; Virtual Robots; Regulatory Focus Theory

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1 INTRODUCTION

As social robots are becoming more present in digital and physical scenarios in settings such as education and healthcare, the understanding of children's relationships with robots and the effect of

robot's behaviours on children's task performance are gaining more attention. Constructs such as trust and likability are crucial for the investigation of child-robot relationship [23], [20]. The existing literature on people's trust in robots sets a distinction between two main components of trust: *affective-based trust*, which is related to the evaluation of a robot's moral characteristics (sincerity and integrity), and *competency-based trust*, which refers to a robot's performance (ability and reliability) [17].

In the context of Child-Robot Interaction (cHRI), trust can be defined and measured along two main dimensions: social and competency trust. The first encompasses interpersonal trust (e.g., honesty, and perceived warmth), while the second assesses perceived competence and reliability [24][19]. While there is evidence that robot-related factors (i.e., embodiment and behaviours) influence trust in cHRI [16], a meta-analysis by Stower et al. [19] found out that social robots with more human-like attributes do not always lead to a higher perception of competency trust and likability. Recent cHRI studies have implemented different robot's behaviours to investigate children's perception of trust in robots. Kennedy et al. [16] found that a social adaptive robot increased children's compliance with the robot's suggestions and promoted higher competency trust in the robot. Conversely, Tielman et al. [21] found that a non-affective robot was perceived as more trustworthy compared to a more affective one. These inconsistent findings of the impact of robot's behaviours on children's trust towards social robots appear to depend upon the nature of the scenario and the collaborative task [23].

Overall, it seems that children evaluate a robot's personality, expressiveness, embodiment, competence, and behaviours when judging trustworthiness [6][23][8]. However, it is still unclear how to design robot's behaviours so as to elicit higher social and competency trust. The Regulatory Focus Theory (RFT) proposed by Higgins [14] suggests that humans approach goals by regulating their emotions and behaviours on the basis of two motivational systems: promotion and prevention. *Promotion* is concerned with the presence of positive outcomes as a motivational strategy towards goal attainment, whereas *prevention* is concerned with the absence of negative outcomes as a motivational strategy towards goal fulfillment [14][15].

In the context of RFT, Regulatory Closure (RC) refers to fulfilled versus unfulfilled goals [3]. Studies in social psychology suggest that within a promotion focus, the successful attainment of a goal (i.e., closure) leads to positive mood states (e.g., cheerfulness), whereas the lack of such an attainment (i.e., no closure) evokes disappointment and anger. Within a prevention focus, instead, the fulfillment of goals leads to mood states such as relief. In contrast, when goals remain unfulfilled, prevention focus is associated with

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anxiety [3][1][12]. In CHRI, the effect of RFT and RC strategies on children's affective state has not been investigated.

The interaction between RFT and RC has proved to be beneficial for creativity performance and cognitive development [2][3]. We believe that the design of robot's behaviours based on these motivational strategies might have strong implications for children's social and cognitive skills. However, it is of vital importance to investigate the effect of these strategies on child-robot relationship formation to avoid reverse effects. In fact, scholars demonstrated that, in the prevention focus, individuals show decreased trust in a trust game compared to individuals in the promotion focus only when regulatory goals remain unfulfilled [15][10].

2 METHOD

For this study, we pose the following research questions (RQs):

RQ1: How do regulatory focus and regulatory closure strategies affect children's affective state?

Promotion focus is generally associated with reward-seeking, whereas prevention focus is usually associated with loss-aversion, hence prevention focus might decrease trust [10]. As most studies on RFT focused on addressing the impact of self-regulation on people's generalised trust in strangers, it is yet to be understood how these strategies influence children's trust in social robots. Therefore, we aim to investigate the following RQ:

RQ2: How do regulatory focus and regulatory closure strategies affect children's perceptions of a virtual robot's social trust, competency trust, and likability?

2.1 Design

To answer our research questions we designed a 2 (Regulatory focus: Promotion - Prevention) x 2 (Regulatory closure: Closure - No Closure) between-subjects experimental design (see Table 1). Participants were randomly assigned to one of the four conditions.

2.2 Game

We built an interactive-collaborative online game embedding different regulatory focus and closure strategies in the game dynamics. The game created for this study is an extended version of our previous work [9]. We designed a game where the child and the robot were locked together in a spaceship. The game was goal-oriented, therefore, the goal of the participant was to find a secret key to get out of the spaceship and go to planet Mars. We developed four versions of the game for the four conditions. Goal attainment was based on one of the two motivational conditions: promotion and prevention. In the promotion condition, the child was told that she would receive a gift (reward) once she found the key and was on planet Mars. In the prevention condition, the child was told she needed to find the key because there was a bomb in the spaceship and they needed to get out of the spaceship before it exploded (threat). To manipulate RC, we built two more versions of the game: in the closure condition participants found the key and went to Mars (goal fulfilled), whereas, in the no closure condition, the game was unexpectedly broken due to a connection issue (goal unfulfilled).

The game was implemented using the PlayCanvas Web Game Engine¹ for the graphical interface. It consisted of six different

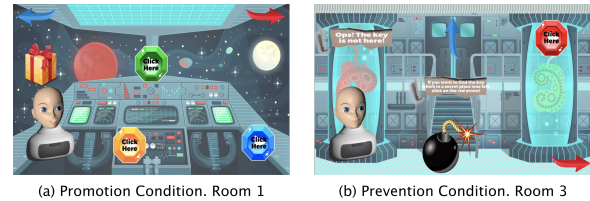


Figure 1: Example of the Game's Graphical Interface

scenes, one for starting, four represent different rooms in the spaceship, and one for the end of the game (i.e., planet Mars or technical problem). An example of the different scenes of the graphical interface is illustrated in Figure 1. Each room of the spaceship contained three coloured buttons children could click on to find either the key or a hint, buttons had messages such as "Ops! The key is not here" or "Go to the room on the right". Besides, each room contained two arrows which led to the same next room. The key was to be found in the fourth and last room in the closure condition, whereas in the no closure condition participants were restrained from goal fulfilment.

We included motivational features that were present in all the scenes of the game (i.e., gift and bomb). The gift received at the end of the Promotion-Closure interaction was a party with the aliens on planet Mars. In the Prevention-Closure interaction, once the robot and the child were on planet Mars, an explosion was played in the background, then the robot thanked the child for helping it to escape the explosion.

Within the game, children interacted with a virtual robot. As virtual social robot, we designed a child-like version of the Furhat robot in Blender² and integrated it into the graphical interface. Due to the limitations of the software, we only animated the mouth of the robot to simulate that the robot was talking. The robot's behaviours were fully autonomous and were designed to exhibit happiness in the promotion condition and fear in the prevention condition. For this version of the game, we manipulated the robot's prosody and conversational content to convey the different emotions. Based on children's choices, the robot's verbal behaviours provided suggestions (e.g., "I think we should click on the arrow on the right") or expressed emotions (e.g., "I am so scared of the explosion", "I am so excited to see what is inside the gift"). We used the Ivy Ivona³ synthetic child voice.

2.3 Participants

We conducted the online study at a digital science fair for children in Uppsala (Sweden) called Scifest. People who visited the Uppsala Social Robotics Lab's digital booth were invited through a link to play an online game with a virtual social robot. We collected data in four of the seven days of the festival. We did not collect personal data from the users' interaction but only asked them to fill out the questionnaires. A total of 134 attendees participated in this activity. Due to the digital nature of the festival, we could not directly interact with users. Therefore, we included four attention checks to filter out the data (i.e., age, played game before, duration

²<https://www.blender.org>

³Available at <https://harposoftware.com/en/>

¹<https://playcanvas.com>

Table 1: Description of the Conditions

Condition	Manipulation of Regulatory Closure	Manipulation of Regulatory Focus Strategies
Promotion-Closure	Goal fulfilled seeking for a reward	The robot conveyed emotions of happiness and cheerfulness through verbal messages such as "I am so excited to do this" or "We are almost there! We are going to do it."
Promotion-No Closure	Goal not fulfilled seeking for a reward	
Prevention-Closure	Goal fulfilled avoiding a risk	The robot conveyed emotions of fear and anxiety through verbal messages such as "I am so scared" or "We are almost there! Let's hurry up".
Prevention-No Closure	Goal not fulfilled avoiding a risk	

of the game, and full-questionnaires). We excluded 109 participants who failed any of the attention checks. For this study, responses from 25 children (15 Girls, 9 Boys, 1 No Answer) were included in our analysis. They ranged in age from 8 to 17 years old ($M = 13.2$, $SD = 3.3$). The number of valid responses per condition is: Promotion-Closure = 6, Promotion-No Closure = 8, Prevention-Closure = 5, and Prevention-No Closure = 6.

2.4 Procedure

The online game was designed to be fully autonomous. Participants got access to the activity through the Lab's booth. Our booth was launched on the digital platform provided by the organisers of the science festival and it was opened to the public for four days. Participants who visited our booth found a link that redirected them to the game. We used the LimeSurvey⁴ online tool to embed the game and the questionnaires. The activity had instructions in basic English to help children navigating through it. First, participants were informed that they were about to play an online game with a virtual social robot called "Nikky", but they did not receive information on the purpose of the game. Before meeting the virtual robot, participants were asked to fill a pre-test questionnaire. Then, they had access to the game, on average participants spent 6 minutes playing the game. The robot explained the objective of the game based on the condition each participant was allocated to. Besides, the instructions were also written in case the robot was not clear enough. Once participants finished the game, the robot asked them to fill a post-test questionnaire and told them that they would see each other again at the end of the activity. After filling the questionnaires, a video clip of the robot was played with the robot thanking participants for their participation and encouraging them to visit the other booths of the festival.

2.5 Measures

To assess children's affective experience and measure the valence and arousal associated with their reaction before and after the game, we used the self-assessment manikin (SAM) [7][13]. We implemented a post-session survey to evaluate children's perception of *Social Trust*, *Competency Trust*, and *Likability* in the virtual robot. Social trust was captured using the 4-items validated scale developed in [22]. Competency trust was measured using a modified version of the 5-items scale used in [20]. Regarding likability, we

used a modified version of the "Likability" component of the God-speed questionnaire [4]. We implemented a 14-items questionnaire on a 5-point Likert scale.

3 RESULTS

All analyses were conducted using R Studio version 4.0.5. We tested our questionnaire to measure internal consistency by using Cronbach's alpha. The three constructs presented high internal consistency: social trust Cronbach's $\alpha = 0.77$, competency trust Cronbach's $\alpha = 0.91$, and likability Cronbach's $\alpha = 0.91$. A Levene's Test for Equality of Variances indicated that our data met the assumption of homogeneity of variance ($p > 0.05$) needed for ANOVA tests.

3.1 Children's Affective State

To assess whether Regulatory Focus and RC affected children's affective state after playing the game. We employed a three-way mixed ANOVA with Regulatory Focus and Closure as between-subjects factor and Session (pre - post) as within-subject factor, and *Valence* and *Arousal* as dependent variables. The results of the ANOVA showed a statistically significant main difference of RC ($F(1, 19) = 5.778, p = .027$), Session ($F(1, 19) = 6.193, p = .022$), and an interaction between Regulatory Focus and Closure ($F(1, 19) = 4.406, p = .049$) on the dependent variables. Post-hoc analysis with Bonferroni correction revealed that children's valence was significantly higher, $p = .013$, in the pre-session ($M = 3.6, SD = 0.8$) than in the post-session ($M = 3.1, SD = 1.1$), $p = .013$, as well as in No Closure ($M = 3.7, SD = 1.0$) than in the Closure condition ($M = 2.9, SD = 0.9$), $p = .014$. Besides, the interaction effect was significant between Prevention and RC on children's score of Valence for Prevention, $p = .007$. After finishing the game, children who fulfilled the goal exhibited less happiness ($M = 2.5, SD = 0.9$) than those who could not fulfill it ($M = 4.0, SD = 1.2$). We did not find any significant effect of Regulatory Focus, Closure, and Session on Arousal (see Table 2).

3.2 Social and Competency Trust, and Likability

To assess whether Regulatory Focus and Closure affected children's perceptions of social, competency trust and likability in the virtual robot, we employed a two-way ANOVA with Regulatory Focus and Closure as between subject factors. We found no significant effect of Regulatory Focus on social trust ($F(1, 11) = 0.01, p =$

⁴<https://www.limesurvey.org>

Table 2: Means and SD's: Valence, Arousal, Social Trust, Competency Trust, and Likability

Dep. Variable	Mean (SD)			
	Prom.-Clos.	Prom.-No Clos.	Prev.-Clos.	Prev.-No Clos.
Valence				
Pre-session	3.50 (0.54)	3.57 (0.53)	2.75 (0.95)	3.83 (1.60)
Post-session	3.00 (1.09)	3.14 (0.69)	2.25 (0.95)	4.33 (0.81)
Arousal				
Pre-session	3.16 (0.98)	2.85 (0.90)	3.25 (0.50)	4.00 (0.89)
Post-session	3.33 (1.03)	2.85 (0.69)	3.00 (0.00)	4.00 (0.89)
Trust and Likability				
Social Trust	2.43 (1.08)	3.31 (1.28)	2.33 (1.15)	3.50 (0.86)
Competency Trust	2.30 (1.19)	3.35 (1.68)	2.26 (1.13)	3.00 (1.44)
Likability	2.62 (1.10)	3.31 (1.67)	2.25 (1.25)	3.33 (0.80)

.94), competency trust ($F(1, 11) = 0.07, p = .79$), and likability ($F(1, 11) = 0.071, p = .79$), neither of RC on social trust ($F(1, 11) = 3.03, p = .11$), competency trust ($F(1, 11) = 1.64, p = 0.22$), or likability ($F(1, 11) = 1.67, p = 0.21$, see Table 2). These preliminary results led us to believe that changing the strategy to complete a task in collaboration with a virtual social robot does not impact children perception of social trust, competency trust and likability in the robot.

4 DISCUSSION

Effects on Children's Affective State (RQ1) We found that *regulatory closure affects children's valence in a goal-oriented task in prevention-focused strategies*. This preliminary result suggests that children who were prevented from fulfilling their goal exhibited significantly more positive feelings after finishing the game. One possible interpretation of this result could be that the lack of fulfillment of a goal due to an external situation (e.g., unexpected technical issue) might have indirectly relieved children's anxiety caused by prevention-focused strategy [9]. Overall, we observed that children were less happy after playing the game with the virtual robot (see Table 2). Although our results were not significant, we believe that this tendency could be associated with children's expectations on the game and/or the virtual robot [5]. Further research is needed to draw more significant conclusions regarding the effect of robot behaviours based on RFT and RC on children's expectations.

Effects on Children's Trust and Likability (RQ2) We found that *regulatory focus and closure do not affect children's social trust, competency trust, and likability in a virtual social robot*. Overall, the mean ratings of the virtual robot were higher for Promotion-No Closure and Prevention-No Closure conditions in terms of social trust, competency trust, and likability, than for Promotion-Closure and Prevention-Closure (see Table 2). This finding is surprising as there is evidence that suggests that RC is detrimental for trust [10]. We believe that children could have had high expectations for the robot's capabilities, but these expectations were not fully met due to the absence of closure.

Overall, the goal of this pilot study was to assess whether RFT and RC have an impact on children's trust towards and likability of a virtual child-like version of the Furhat social robot. Our study was entirely online. We found that the motivational strategies did not affect children's judgements of trustworthiness and likability. However, our preliminary results revealed that children's affective state is influenced by motivational strategies. Due to the limitations of this study our results should be interpreted with caution. First, the large age range of the participants might have affected their perceptions of the robot as children and teenagers are in different social-cognitive development stages [11]. Due to the small sample size, we could not assess these differences in this study. In future work, we plan to focus on children between 7 and 9 years old as our activity is more suitable for them [9]. Second, the online nature of this study could have affected the children's perceptions of the virtual robot that might not be reflected in their interaction with a physical robot [18]. To investigate more these effects, we plan to conduct a user study with the physical robot when possible. This will also reduce the limitations of the animation of the facial emotions encountered in the virtual social robot. Also, we aim to capture children's behavioural data to investigate possible correlations with questionnaires.

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