The Effects of Observing Robotic Ostracism on Children's Prosociality and Basic Needs

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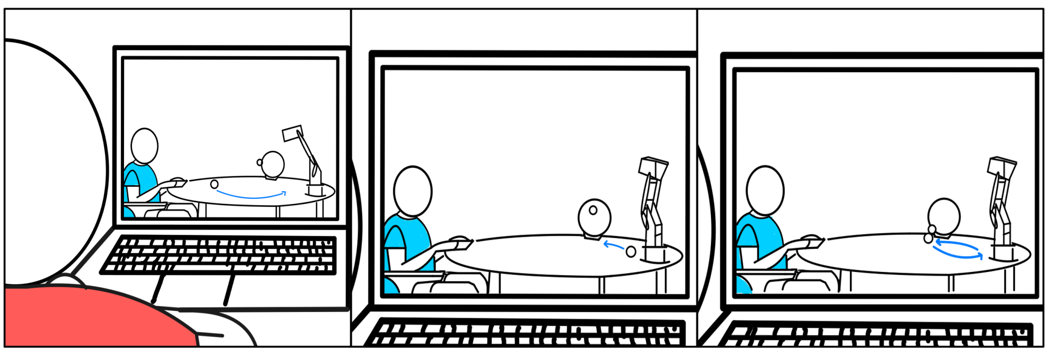

Figure 1: Methodological approach to manipulate robotic ostracism with a young population of children between five and ten years old, using the Robotic Cyberball Paradigm in a third-person perspective.

ABSTRACT

Research on robotic ostracism is still scarce and has only explored its effects on adult populations. Although the results revealed important carryover effects of robotic exclusion, there is no evidence yet that those results occur in child-robot interactions. This paper provides the first exploration of robotic ostracism with children. We conducted a study using the Robotic Cyberball Paradigm in a third-person perspective with a sample of 52 children aged between five to ten years old. The experimental study had two conditions: *Exclusion* and *Inclusion*. In the *Exclusion* condition, children observed a peer being excluded by two robots; while in the *Inclusion* condition, the observed peer interacted equally with the robots. Notably, even 5-year-old children could discern when robots excluded another child. Children who observed exclusion reported lower levels of belonging and control, and exhibited higher prosocial behaviour than those witnessing inclusion. However, no differences were found in children's meaningful existence, self-esteem, and physical proximity across conditions. Our user study provides important methodological considerations for applying the Robotic Cyberball Paradigm with children. The results extend previous literature on both robotic ostracism with adults and interpersonal ostracism with children. We finish discussing the broader implications of children observing ostracism in human-robot interactions.

CCS CONCEPTS

• **Human-centered computing → Empirical studies in HCI**.

KEYWORDS

Child-Robot Interaction, Cyberball Paradigm, Ostracism, Social Exclusion, Robotic Nonverbal Behavior

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1 INTRODUCTION

Social robots take on various roles within modern society, such as language teaching [45], care and assistance [1], mental health [20], games [40], and companionship [65]. These devices have been shown to create rich social environments that can significantly influence human behaviour, for example, related to conflict resolution [46], enhanced sense of security [25], reduce social awkwardness [39], and balancing group participation [31]. The effects can even go beyond the interaction with the robots and also affect human behaviour in follow-up human-human interactions, such as the experience of robotic ostracism leading to carryover effects on humans' prosocial attitudes [13].

Ostracism refers to the experience of being socially excluded by others [60]. It can lead to negative effects, including anxiety [5], depression [9], and decreased sense of self-worth [32], even in children [54]. These effects are attributed to a threat to psychological needs related to wellbeing. On the other hand, experiencing ostracism can also have positive carryover effects, i.e., positively influencing subsequent unrelated social interactions. Examples include increased prosocial behaviour and generosity [21, 60], conformity [61], obedience [41], and compliance [24]. In these cases, people try to compensate for the negative impact of ostracism and seek opportunities to strengthen interpersonal bonds and increase their acceptance by others [54, 58]. Still, research on ostracism has been largely limited to non-HRI contexts [17]. Moreover, even less attention has been paid to subpopulations such as children. As social robots are increasingly used with and by children, particularly in educational and healthcare contexts [7, 10], extending this body of work becomes extremely important.

We contribute to the study of ostracism by examining whether Human-Robot-Robot Interaction can cause children to experience ostracism. Additionally, we assess whether such an experience influences a subsequent Human-Human Interaction (i.e., carryover effect). We pioneered the Robotic Ostracism Paradigm with children, by leveraging the methodological approach proposed by Erel et al. [13, 14], and combining it with a third-person evaluation, commonly used in social psychology to investigate the effects of social exclusion with younger populations. We conducted a between-subjects study where we asked 52 children to observe one of two possible video stimuli of a ball-tossing game between two non-humanoid robots and a child (see Fig.1). We manipulated the tossing ratio in each video to create an *Exclusion* condition, where the child received only 10% of tosses, and an *Inclusion* condition, where the child received 33% of tosses.

Results show that children as young as five years old could tell when robots were excluding and upsetting another child, which validated that our manipulation was perceived as intended. Regarding the measurement of children's basic needs, our results are in line with our expectations. When they saw exclusion towards another child, they reported a reduced sense of belonging and control compared to an inclusion situation. The reported levels of self-esteem and meaningful existence were similar across conditions. Also aligned with our hypothesis on prosocial attitudes, children who witnessed robotic exclusion offered more balloons to another child compared to the *Inclusion* condition. However, contrary to the hypothesis on physical proximity, no difference was found in how close children sat to the researcher during the questionnaire following an exclusion/inclusion observation. Lastly, and most surprisingly, children reported high levels of willingness to play with the robots at the end of the experiment, even those observing and perceiving robotic exclusion.

This paper provides three key contributions. First, it offers new empirical evidence on how Robot-Robot-Human Interaction influences children's perceptions of ostracism. As it constitutes the first investigation using the Robotic Cyberball Paradigm with children, we addressed sensitive methodological aspects of applying this paradigm with younger populations for the first time. Second, it presents novel results on how robotic ostracism influences children's feelings and behaviours. In particular, our experimental results show carryover effects in subsequent interpersonal interactions, and we discuss how they extend previous literature. Finally, we contribute with a thorough discussion on the implications of robotic ostracism for future applications of Child-Robot Interactions.

2 RELATED WORK

The social nature of human beings to live and organise themselves in groups leads to a need for belonging and a drive to create affiliative relations [6]. As a result, humans are susceptible to perceiving and coping with social exclusion [15, 50]. Considering our goal of exploring how social exclusion by robots affects children, we will first review related works on children's responses to exclusion and then the current literature on social exclusion by robots.

2.1 Children's Responses to Exclusion

Social exclusion, where someone is deliberately ignored, is a distressing experience that can have lasting effects on children [54]. It impacts children's fundamental needs, including self-esteem, a sense of belonging, control, and a feeling of meaningful existence [54]. Additionally, it influences their prosocial behaviours [21, 60], and if prolonged over time, it can lead to long-term issues such as depression and anxiety disorders [5, 9]. However, facing sporadic episodes of exclusion can also offer benefits for children's social development [54]. These experiences teach children strategies to cope with exclusion, which they can apply throughout their lives [15]. Several strategies are employed to mitigate the negative effects of exclusion [54]: detachment (putting the negative event into perspective); positive appraisal (reframing the situation in a positive light); mindfulness (focusing on the present moment without judgement); distraction (shifting attention to another situation); or just by selective memory (recalling only the positive aspects of a particular situation).

One of the most used instruments to study the impact of social exclusion is the Cyberball Paradigm [17], in which participants play a virtual ball-tossing game with two other alleged humans. Most experiments hold exclusion and inclusion conditions, which differ in the number of ball tosses to participants. Several studies report a negative effect on mood and basic needs after exclusion compared to inclusion in adolescents (12-17 yo) [37, 42, 62] and older children

(9-11 yo) [42, 62]. Hopkins et al. have also found a carryover effect on lexical imitation with children (7-12 yo) imitating a partner's language choices more frequently during a picture-matching game after being ostracised in the cyberball game [18].

Regarding the use of the cyberball paradigm up to the age of six years old, the results are less congruent. For instance, Baker and Woodward looked at the executive function capacities, which are behind children's moral selves and their moral behaviours such as aggression and prosociality [4]. Their results do not support differences between inclusion and exclusion on the perceptions of self-concepts (i.e. prosocial, physically harmful, relationally harmful). Instead, these perceptions were mostly explained by children's executive function capacities, which are underdeveloped in younger ages. Watson-Jones et al. have used a modified version of the cyberball game, displaying coloured shirts on the other three virtual players (instead of two) to investigate ostracism by in-group or out-group members [57]. They measured behavioural imitation in a subsequent task (i.e. carryover effect) after the game and found that participants (5-6 yo) who were excluded by in-group members performed higher-fidelity imitation than those who were included by in-group members. Interestingly, when comparing exclusion and inclusion by their out-group, no significant differences were found. Additionally, in-group ostracism led to increased anxiety levels compared to out-group ostracism. The last noteworthy example of applying the cyberball paradigm until six years old (with a puppeteering adaptation of the game) supports children's general inability to identify excluders [63].

Younger children's perception of social exclusion has also been studied through a third-person perspective. For example, children were primed with a video of abstract shapes moving around in a way that conveys either ostracism or inclusion. Children that watched the video priming with exclusion sat closer to the experimenter for the following questionnaire (4-6 yo) [26], displayed higher behavioural imitation (5-6 yo) [33], drew themselves closer to a friend in drawings (4-5 yo) [48], and even toddlers of 30 months-old demonstrated higher facial imitation [11] compared to those that watched the inclusion video. Lastly, in a cross-cultural study, Stengelin et al. used the same video priming followed by a ball tossing game between each child, the experimenter, and a third puppet element. The puppet could be of the in-group or out-group according to coloured caps [51]. No main effect of the priming condition was found on the inclusion of the new puppet. However, results revealed that children from more independent countries (Germany and New Zealand) were less likely to include the out-group member than children from the more interdependent country (Cyprus).

Overall, there is a lack of consistent methods in studying social exclusion across experiments and age groups [43]. The cyberball paradigm has proven to be effective for older children (6-11 yo) and adolescents (12-17 yo) [64]. However, younger children (3-6 yo) were mostly primed with videos of social exclusion instead of being excluded in the first person, which also revealed positive effects on several affiliative behaviours by children.

2.2 Social Exclusion in HRI

Erel et al. were the first to explore whether the Cyberball Paradigm would apply within human-robot multiparty interactions [14]. In their experiment, participants in the exclusion condition (i.e., the robots stopped throwing the ball to the human participant) reported more negative levels of mood and basic needs than those in the inclusion condition, which is congruent with the original findings from the social sciences. Later, Erel and collaborators investigated the carryover effects of robot ostracism on human-human interactions [13]. The results showed that participants in the exclusion condition (compared to the inclusion condition) sat closer to the experimenter during the follow-up interview, more frequently beside the researcher, and complied more with the request to answer an additional questionnaire on the day after the cyberball game.

Considering other experimental setups, Mongile et al. studied the effects of being excluded by a robot in a teenagers-robots conversational turn-taking game [29]. Two human players and one robot were asked to take turns, where the active player answered a personal question about experiences and preferences, and then decided who would be the next one to play. Results suggested the included player tried to compensate for the exclusion and reestablish balance by re-engaging with the player excluded by the robot. In a similar experiment, participants were recruited in pairs that knew each other and were asked to perform a bomb-defusing task with a robotic teammate [49]. In the exclusion condition, the robot favoured one participant and ignored the other. In the control condition, the robot similarly addressed both participants before and during the main task. The results revealed no significant differences in the mood nor perceived closeness between control, favoured and discriminated participants. However, the results support previous findings of the effects on perceived threat, and the control groups performed better than the experimental groups in completion time.

Current literature on social exclusion by robots has briefly explored its effects on adults and adolescents [29]. To our best knowledge, the effects of robot ostracism on children remain unexplored. Thus, in this work, we aim to fill this gap and provide empirical evidence of the effects of social exclusion by robots on children.

3 USER STUDY

The study aims to assess the effect of observing child-robot-robot exclusion on children's perception of their basic needs, affiliation, and prosocial attitudes. To manipulate exclusion, we used the Cyberball Paradigm, which was previously used in human-robot interactions with adult populations [13, 14]. We also followed most experimental studies on social exclusion with children that used observation of exclusion in the third-person, rather than being the target of exclusion. As a result, our participants were assigned to one of two between-subjects conditions, in which they would observe either an exclusion or an inclusion situation between another child and two robots during a cyberball game.

In this study, we have the following three hypotheses:

- H1 Children who observe exclusion between another child and two robots will report lower levels of belonging, control, and meaningful existence (but not for self-esteem) compared to children who observe inclusion.
- H2 Children who observe exclusion between another child and two robots will look for more physical proximity with others compared to children who observe inclusion.

H3 Children who observe exclusion between another child and two robots will have more prosocial behaviours towards another child compared to children who observe inclusion.

The rationale behind our hypotheses lies mostly in the previous findings by Erel and collaborators that explored the cyberball paradigm between robots and adult humans [13]. Moreover, our expectations also go in line with previous literature applying the standard cyberball paradigm with children and adolescents, as reviewed in our related work section.

3.1 Participants

We collected our sample at two schools in Portugal, one private and another public. Among 52 children, 28 were female and 24 male, and their ages ranged between five and ten years old ($M = 7.60, SD = 1.36$). All children were sighted, one of them had hearing aids, and three of them were autistic. Children participated upon the signature of the consent form by their legal guardian, and were randomly assigned to each condition (26 per condition). At the start of the experiment and after a brief explanation, all children provided verbal consent that they were interested in participating. They were informed they could stop at any time.

3.2 Robotic Setup

We used the same robotic setup of Erel at al. [14], which allows a human to seemingly play a ball-tossing game with two non-humanoid robots, Kip and Gimi. Players are distributed around a round table, 120 degrees from each other (see Fig.2). Under the table, a hidden robotic arm moves a 42mm-sized ball atop the table to simulate ball tosses according to the players' choices. The human player presses on a two-button touchscreen interface to choose which robot should receive the ball, while the robots have scripted tossing choices. To the right of the human player, Kip extends its structure in the direction where it *wishes* to toss the ball. To the left, Gimi moves its smaller ball to one side to indicate this same *intent*. All robotic movements are coordinated through the E-prime platform [44] and executed by the Butter software [27]. This robotic setup was used to create the two video stimuli (i.e., *Inclusion* and *Exclusion*) described below.

3.3 Video Stimuli

To mitigate the potentially negative effects of feeling exclusion in the first person, we opted for a third-person experience, which has proven effective in previous works with younger populations [11, 26, 33, 48]. For children to relate more with the target of ostracism, we elected that they should observe another child be included or excluded. For ease of logistics and consistency, we pre-recorded two video stimuli of a seven-year-old girl playing the ball-tossing game with the robots in each of the two conditions.

For both conditions, the video shows a young girl sitting at the table with the robots in a wide shot from the side (see Fig.2). She plays the game, maintaining a neutral expression throughout. The ball always starts in front of the girl. In the *Inclusion* condition, she receives the ball seven times, corresponding to 33% of the total ball tosses. In contrast, in the *Exclusion* condition, she receives the ball only two times out of the 21 tosses. The number of tosses was adjusted to our young population considering their limited attention span and following the guidelines to apply the Cyberball Paradigm to children [64]. Both videos were shot in 1080p resolution and encompassed two minutes of footage each.

Figure 2: Screenshot of the video stimuli of a child playing the Cyberball game with two robots.

3.4 Procedure

The study took place at the children's school in a quiet room. Two researchers were present; one handled the robotic setup, and another the questionnaire portion. Informed consent was previously obtained from the children's parents, and verbal assent was given by each child at the start of their participation. Figure 3 illustrates the study procedure.

The researchers welcomed the participating children as they entered the room, introducing themselves and giving a brief explanation of the activity at hand - an activity with robots, where the child would learn and practice the ball-tossing game; watch a video of another child playing the exact same game they just tried; answer a few questions; and finally have the opportunity to play themselves a full game.

The researchers directed the child to sit and initiated a practice round with the physical robots in a training phase for eight ball tosses, explaining the game's premise to the child and emphasising each player's *choice* as to where they tossed the ball.

Following, the child moved to a different table and watched one of the two video stimuli on a laptop. While introducing this task, the researcher would refer to the child in the video by name. The two researchers left the room, allowing the child to watch the video without disruptions.

Afterwards, the researchers returned, and one asked the child to sit by the other in order to fill out a questionnaire. The child would then take the pillow they were sitting on and carry it to the second researcher, choosing where to sit down in relation to them (i.e., distance and orientation). The researcher would then verbally take them through the questionnaire. To aid in the Likert scale questions, the researcher would provide the child with a ring stacking toy so they could visually indicate their level of agreement with the statement.

Once the questionnaire was completed, the researcher would hand the child nine identical orange balloons and two envelopes. They would then ask the child to split the balloons between two envelopes: one for them to keep and another for the researchers to donate to the girl in the video.

Finally, a researcher would invite the child to play the ball-tossing game with the robots,letting them know they were now in a "*less*

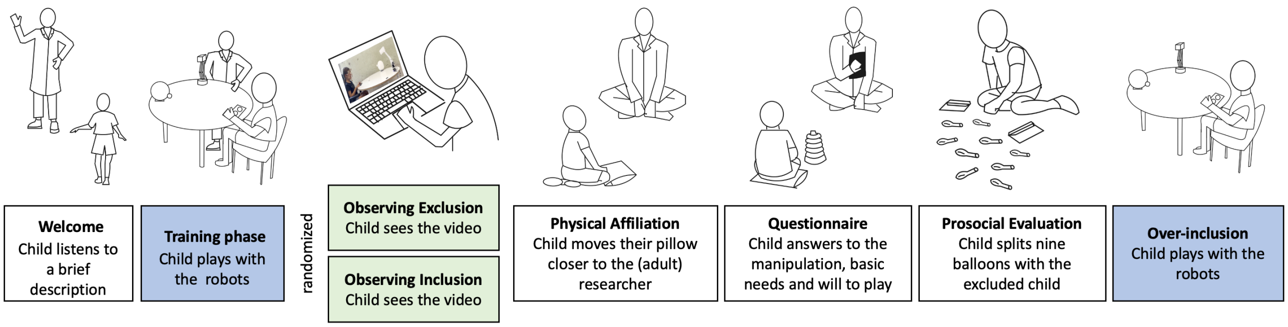

Figure 3: Experimental procedure of our user study comprising of the following stages: welcoming, training phase, video stimulus (portraying either an inclusion or exclusion situation), physical proximity, questionnaire, prosocial evaluation, and final game with the robots.

shy mood". If the child chose to do so, they played the game in an *over-inclusion* mode - where the robots tossed the ball to them 9 out of 12 passes (75% of tosses) , to counteract possible negative effects of the previously witnessed exclusion.

During the study, we captured video and audio recordings. After the questionnaire, children left the pillow they were sitting on untouched so that at the end of their participation, researchers could record their relative sitting position as an affiliation metric.

The user study methods and procedures were approved by the Ethical Committee of Instituto Superior Técnico in Portugal.

3.5 Measures

The questionnaire started with two manipulation check questions about how upset the child on the video was and the perceived inclusion level of the activity. Specifically, we asked, "Was the girl on the video upset with the robots?" and "Do you think the robots included the girl during the game?". The possible answers for the first question were: "no"; "more or less"; and "yes". For the second question, the answers could be: "no, because the two robots only passed the ball to each other", "yes, because they passed the ball evenly between them", and "yes, because the robots passed the ball many more times to the girl".

To measure basic needs, we used the Primary Needs Questionnaire with the 8-item child-friendly version [64], with the four dimensions of belonging, self-esteem, control and meaningful existence. We used a 5-point Likert scale for this subjective questionnaire. We assess the reliability of 2-item dimensions using Spearman's correlation, as recommended in [12]. We found good reliability for the dimensions of belonging ($r = .337, N = 48, p = .019$) and control ($r = .403, N = 47, p = .005$), but not for self-esteem ($r = .240, N = 48, p = .101$) nor for meaningful existence ($r = .113, N = 45, p = .459$), which is discussed on Sec.5.

The physical proximity was assessed with two measures: the distance (in cm) between the child and the researcher during the final questionnaire, and the orientation of the child towards the researcher, i.e., sat in front, diagonally or side by side. The prosociality was measured with the number of balloons given to the other child, as they were asked to split nine balloons between themselves and the girl on the video. Additionally, we measured children's willingness to play the final game with robots after watching the video and answering the questionnaire, we asked children how much they wanted to play (in a 5-point Likert scale).

3.6 Data Analysis

The statistical data analysis used the non-parametric Mann–Whitney U tests for comparisons of numeric measures between the two conditions due to its robustness to normality violations. We also used a Chi-Square Test for Association to analyse our categorical measure of the sitting orientation. For the data analysis, we removed four autistic participants who required substantial help understanding the questionnaire or the activity, and we performed the analysis on a sample of 48 children (24 per condition).

4 RESULTS

This paper aims to understand whether observing a child-robot-robot interaction can cause children to experience ostracism. Moreover, we aim to understand if such an experience has carryover effects on subsequent human-human interactions. Thus, in the following sections, we analyse the effect of robotic ostracism on children's basic needs, affiliation, and prosocial attitudes.

4.1 Manipulation check

Starting with our manipulation check questions, children perceived the robots as significantly more inclusive in the *Inclusion* condition ($M = 1.250, SD = .608$) compared to the *Exclusion* condition ($M = .083, SD = .408; U = 43, Z = -5.553, p < .001$). When children were asked how upset the child on the video was, the difference between conditions was also significant ($U = 164.5, Z = -2.916, p = .004$). Even though our child actor was instructed to keep a neutral expression in both videos, participants perceived her as more upset in the *Exclusion* condition ($M = .708, SD = .464$) compared to the *Inclusion* condition ($M = .292, SD = .550$). Overall, our manipulation had the intended effect on children's perception.

4.2 Basic Needs

The questionnaire of basic needs revealed significant differences in the dimensions of belonging ($U = 168.0, Z = -2.529, p = .011$) and control ($U = 194.0, Z = 1.960, p = .050$; see Fig. 4). Children reported higher levels of belonging ($M_{Bel} = 3.146, SD = 1.147$) and sense of control ($M_{Con} = 2.583, SD = 1.213$) in the *Inclusion* condition, compared to the *Exclusion* condition ($M_{Bel} = 2.521, SD = .926$; $M_{Con} = 1.792, SD = 1.375$). No significant difference was found for self-esteem ($U = 286.0, Z = -.435, p = .664$) nor for meaningful existence ($U = 280, Z = -0.168, p = .866$), with similar reported levels for the *Exclusion* condition ($M_{S.Est} = 3.420, SD = .717$; $M_{M.Ex} = 2.360, SD = 1.095$) and *Inclusion* condition ($M_{S.Est} = 3.520, SD = .586$; $M_{M.Ex} = 2.400, SD = 1.208$).

These results indicate that children in the *Inclusion* condition felt more sense of belonging and control, which **support H1** in all dimensions except meaningful existence. We did not expect a significant difference in self-esteem as prior studies on robotic ostracism with adults did not observe such an outcome. The absence of significant differences in meaningful existence was the only basic need diverging from the hypothesised effects. Nevertheless, both self-esteem and meaningful existence presented lower levels of scale reliability (as previously detailed), suggesting difficulties in applying these two dimensions of the subjective questionnaire to children.

4.3 Affiliation

Regarding the affiliation measures, we found no significant difference between the two conditions on children's physical proximity with the researcher during the questionnaire ($U = 286.5, Z = -.031, p = .975$). The distance between children and the researcher during the questionnaire was similar in the *Exclusion* condition ($M = 70.800cm, SD = 29.280$) and the *Inclusion* condition ($M = 68.000cm, SD = 28.720$). The association between the orientation of their sitting position (i.e., next to, diagonally, or in front of) and the condition was also not statistically significant ($\chi(2) = 1.867, p = .393$). Specifically, in the *Inclusion* condition, fourteen children preferred "in front", eight chose to sit "diagonally", and three of them were "in front of" the researcher. In the *Exclusion* condition, the respective amounts were eighteen, four and three. These results do **not support H2**.

4.4 Prosociality

For the prosociality measure, we found a significant difference in the number of balloons given to another child between our two conditions ($U = 185.5, Z = -1.982, p = .048$, see Fig. 5). Specifically, on average, children gave one more balloon to another child in the *Exclusion* condition ($M = 4.739, SD = 1.242$) compared to the *Inclusion* condition ($M = 3.792, SD = 1.787$). This result **supports H3** as children adopt more prosocial attitudes after observing robotic ostracism.

4.5 Additional exploratory analyses

We performed two exploratory analyses beyond our hypotheses. First, we analysed the difference between conditions in the reported level of their willingness to play the last game (i.e., after observing robotic ostracism). The difference was not statistically significant

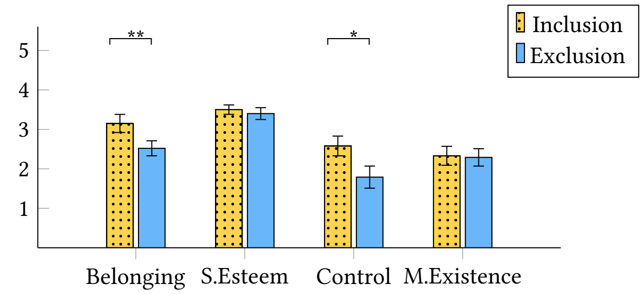

Figure 4: Differences between conditions on the four dimensions of the basic needs questionnaire. Error bars represent the standard error. *p<.05 **p<.01

($U = 276, Z = .000, p = 1.000$). The high levels of willingness to play the final game in both the *Exclusion* ($M = 3.833, SD = .381$) and the *Inclusion* conditions ($M = 3.800, SD = .500$) point to a possible ceiling effect on this measure.

Second, we did a correlation analysis between all our dependent variables. We found two significant correlations: a moderate positive correlation between the need for meaningful existence and prosociality ($r = .372, N = 47, p = .010$) and a weak negative correlation between self-esteem and the physical proximity ($r = -.286, N = 48, p = .049$). In other words, the higher the need for a meaningful existence reported by children, the more balloons they gave to another child. For the physical proximity correlation, the closer children sat to the researcher, the lower the levels of self-esteem they reported. These correlations involved two dependent measures with weak reliability and should, therefore, be interpreted with caution. Nevertheless, they generally suggest intrapersonal factors (e.g. children's basic needs) might also play an important role on their affiliation intentions.

5 DISCUSSION

In this section, we discuss children's perceptions of robotic ostracism and its effects. Moreover, we provide broader implications for the future of child-robot interaction research and describe the limitations of our work.

5.1 Children's perceptions of robotic ostracism

Our results generally support that children are able to identify situations of exclusion by robots towards another child. We extend previous literature on three aspects.

First, the perception of robotic exclusion has only been investigated with adult populations [13, 14, 19, 30]. Our results suggest children can also identify robots as actors of exclusion. This is particularly important as robotic devices become widely used in classroom activities or similar contexts with children.

Second, previous results have shown the effectiveness of the Cyberball Paradigm to perceive inclusion/exclusion with children mostly between seven and twelve years old when they allegedly play with other children [18, 37, 42, 62]. Nevertheless, for children up to six years old, some findings suggest they may not always perceive ostracism [63]. Our experimental setup demonstrated the Cyberball Paradigm remains effective when the game has robotic

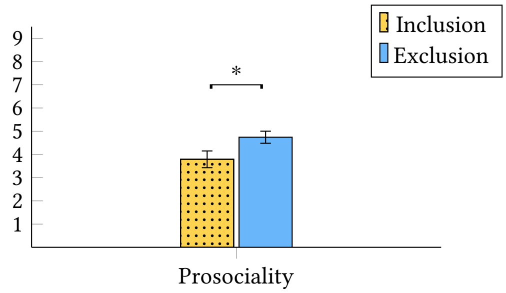

Figure 5: Difference between conditions on the number of balloons given to another child. Error bars represent the standard error. *p<.05

players, and remarkably, with a sample that included children with five and six years old.

Third, investigations of social exclusion with younger children have mainly used the third-person evaluation. Our experimental methods showed the effectiveness of combining the Cyberball Paradigm with a third-person evaluation. Showing children a video of another child playing the game with two robots revealed consistent results with previous literature presenting children with video stimuli of abstract shapes as actors that portray social exclusion [11, 26, 33, 48, 51].

5.2 The effects of robotic ostracism

The results of our user study supported two out of three hypotheses, specifically regarding basic needs and prosociality. After observing the exclusion video, children reported lower levels of belonging and control, and they were more prosocial towards another child, compared to the children who observed the *Inclusion* video. These findings are aligned with previous literature supporting that prosociality is one of the possible carryover effects after an exclusion situation. Once people's need to belong is negatively affected, they subconsciously seek opportunities to strengthen bonds or be accepted by others [59]. Our results extend both previous results on children's prosociality after interpersonal ostracism [55, 56], and previous results on adults' prosociality after robotic ostracism [13].

An additional result was that all children reported a high willingness to play with the robots after the video and the questionnaire, regardless of the experimental condition. Especially after identifying exclusion by the robots and reporting lower levels of their basic needs, children still wanted to play with the exact same robots. While playing with robots can have many benefits (e.g., social inclusion [3, 16, 31], activity engagement [23], interpersonal cohesion [53], creativity [2]), these findings imply that robots can be a vehicle to keep children engaged with negative experiences. Researchers, designers, and practitioners should be mindful in designing child-robot interactive experiences, look beyond engagement measures, and carefully analyse carryover effects on children.

Our unexpected findings on the willingness to play the final game with the robots can be attributed to three primary factors. Firstly, the well-established novelty effect of robots, especially in educational settings, likely played a role in our results [22, 47]. Children were told the whole experimental steps beforehand; we believe their enthusiasm for participating in the experiment would be centred on the last game with robots. This procedural step, aiming at reducing children's discomfort with the experimental setup, together with the fact that some children were seeing robots for the first time might have overlapped with the negative effects of the *Exclusion* video. Secondly, exclusion naturally occurs in the dynamics of school life, allowing children to navigate power dynamics and develop conflict resolution skills with their peers [54]. Children employ various coping strategies, one of which is detachment, in which they compare their experiences with those of others, contextualising the episode and mitigating the adverse effects of exclusion [54]. Our findings align with this notion, suggesting that our participants, in a third-person party role, may also cope with others' exclusion through detachment, thus reducing its negative impact and maintaining their willingness to play with the robots. This is supported by their comments made about the video, such as one child's observation, "The robots were playing with each other, ignoring Mary. However, at some point, the two robots tossed the ball to her, and everything became alright (C22)." Another child empathised with Mary, remarking that "Mary was upset because the robots were playing between themselves. Like me, I wouldn't say I liked it when they did not pass me the ball. But eventually, they tossed the ball to me and Mary. (C10)" Thirdly, adults often unconsciously focus on positive aspects to overcome the negative effects of exclusion, selectively recalling experiences [15]. Our findings align with this concept, suggesting that children placed more emphasis on their positive training session interactions [63], influencing their willingness to engage with the robots again, rather than being significantly affected by the exclusion they observed in the video.

Nevertheless, we did not find support for our hypothesis on interpersonal distance, contrary to previous results on adult-robot interactions [13] and to interpersonal child-adult interactions [26]. First, our measure of physical proximity might not have been successful for children. We used a similar proximity measure as in [13], where adults have freely placed a chair as close as they wanted to the researcher. In contrast, other studies with children opted for placing several pillows close to the interviewer and measured the distance to the pillow children chose to sit on [26]. Second, we measured the interpersonal distance between children and an adult (i.e., a researcher), which may have introduced a ceiling effect as it was perceived as an authority figure. Future research should measure affiliation between children. A final remark worth mentioning is the significant correlation between physical proximity and self-esteem, which suggest these measures might be strongly related to other intrapersonal aspects of each child.

5.3 Broader Implications

The first broader implication of our results is related to the Robotic Cyberball Paradigm. Based on our results, we recommend conducting more studies using this paradigm with younger populations, emphasising the third-person perspective. This can involve direct observation or video-based methods, similar to our approach. Notably, children could effectively perceive exclusion when observing it without needing to experience it personally. This observation aligns with prior research [63], suggesting that witnessing exclusion is more efficient than experiencing it firsthand, as it is less emotionally demanding.

Second, despite the inherent negative effects on children's fundamental needs, social exclusion can also be used as a constructive tool [62], namely to control contra-normative behaviour [52], develop coping and regulation mechanisms during childhood and adolescence [54]. As robots are being introduced in children's educational settings, and considering they are perceived as social actors, robots can also be used by teachers and educators to demonstrate social norms and behaviours that trigger inherent psychological mechanisms to cope and regulate certain negative situations or fostering positive actions (e.g., prosocial attitudes).

Third, the positive effects on children's prosocial attitudes, as a carryover effect of social exclusion, should also consider possible negative aspects of prosociality, namely social susceptibility. Children's willingness to strengthen bonds with others or be accepted by others may be used for manipulative or harmful purposes.

Lastly, and drawing on the previous two implications, our results raise attention to the presence of social robots in environments with children (e.g., schools). Considering that the mere observation of human-robot interactions (i.e., in the third-person perspective) results in carryover effects on children's interpersonal interactions, the deployment of those robotic devices should be carefully monitored. Indeed, little attention has been given to carryover effects after child-robot interactions. Our user study looked specifically at their reported basic needs, the physical proximity they establish, and their prosocial attitudes towards another child. Further investigation should pay attention to other intrapersonal and interpersonal measures. Moreover, further research is needed to understand which robotic behaviours can trigger carryover effects. While our findings specifically addressed *intentional* robotic exclusion, such behaviours can also happen inadvertently (i.e., robotic behaviour that was not intentionally programmed to be perceived as exclusion). Overall, it is critical to extend this scope of literature on robotic behaviours that influence subsequent and unrelated interactions among humans.

6 LIMITATIONS AND FUTURE WORK

In this section, we acknowledge the limitations of our work and suggest directions for future research. **Cultural Influence:** we studied children from two schools in one country. While our findings may have broader applications, it is essential to consider the impact of cultural backgrounds on basic needs [38, 51]. Future studies should explore different countries and settings for a more comprehensive understanding. **Age range:** our participants ranged in age from five to ten years old, accounting for wide differences in children's social skills [28] and neural development [8]. **Using subjective questionnaires with children:** it was challenging for children to comprehend and respond to the questionnaires, even with child-friendly versions [64]. To mitigate this issue, we pretested the questionnaire with 20 children of the same age group. We maintained consistency by employing a single interviewer and a strict interview protocol. Even with this mitigation approach, the self-esteem and meaningful existence answers did not present good reliability scores, suggesting children might not have interpreted these items as intended. **Child affiliation:** future research should investigate how witnessing ostracism experiences between robots and children influences children's interactions with their peers rather than their physical affiliation with unknown adults. **Robot mutual exclusion:** further studies should explore the effects of children witnessing ostracism solely among robots without active human involvement. This will help us understand how such experiences affect children's basic needs and their subsequent prosocial behaviours. **Long-term effects:** our study involved the measurement of carryover effects immediately after the observation of a child-robot interaction. Future studies should also assess if the impacts found sustain for longer periods of time.

7 CONCLUSION

In our study, we used a Cyberball Paradigm, to assess how children's perception of their own basic needs, affiliation, and their prosocial attitudes towards others might be affected when they observe a child being excluded by robots. The research questions addressed in our experimental study fill a research gap on the impact of robotic exclusion on young populations. Furthermore, we focused on the carryover effects of a child-robot interaction in subsequent interpersonal interactions.

In our user study, we examined how children reacted to ostracism by robots just by witnessing it, in a third-person perspective. Therefore, we used a between-subjects experimental design where children saw another child playing a ball game with two different robots. In the *Exclusion* condition, the child was left out by the robots during the majority of ball tosses, and in the *Inclusion* condition, the child received the ball from the robots just as much as they did to each other.

Results showed that even children as young as five years old could recognise when robots were excluding someone, and they acknowledged that the excluded child was upset during the interaction. We validated two of our three hypotheses. Specifically, in the *Exclusion* condition, children reported lower levels of belonging and control, and displayed more prosocial behaviours towards another child compared to the *Inclusion* condition. Surprisingly, we did not see any difference in how physically close the children got to an adult, nor in their meaningful existence across conditions.

Our user study constitutes the first investigation applying the Robotic Cyberball Paradigm with children, therefore it holds important methodological considerations for the target population. In addition to the experimental findings, we discussed children's perceptions of ostracism and the effects of robotic ostracism. We relate the results with prior work on both robotic ostracism with adults and other ostracism approaches with children. Moreover, we reflect on the broader implications of our results for researchers and practitioners deploying robots in environments with children.

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