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Article

Educational play-based activities with CoderBot in a pediatric short-term recovery ward: a case study intervention.

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Abstract: Being hospitalized is a threatening and stressful experience for many children. From a psychological point of view, children may experience increased feelings of anxiety and fear that can negatively interfere with behavioral, cognitive, and emotional outcomes. To limit these impacts on children's well-being and mental health, interventions that could contribute to protecting the emotional domain of hospitalized children are welcomed. The present research reported a single-setting case study intervention to evaluate the impact of educational play-based activity with a CoderBot robot in a pediatric short-term recovery ward (N=61). The methodology included multiple sources of data (i.e., children, parents, nurses), observations on the field, and a sequential (quantitative-qualitative) mixed-method approach to data analysis. Results supported the idea that robot-based activities were associated with increased participant well-being (particularly positive emotions). The conclusions of this pilot study discuss the strengths, limitations, and further developments of using robots with hospitalized children.

Keywords: Robot-Based Activities; Hospitalized Children; Psychological Health; Well-Being; CoderBot; Positive Emotion; Single-Setting

1. Introduction

This paper focuses on the use of robots as tools to improve the well-being of children hospitalized in pediatric wards. During their stay in the hospital, children often undergo medical procedures, which often create pain and distress [1]. Such a situation results in a longer recovery time and more extended hospital stay, often producing prolonged suffering [2].

For decades, there has been a vast and consolidated literature on children's hospitalization (especially prolonged hospitalization) and on the various psychological effects that it exerts on the child, on the relationship between family and hospital staff, on "school in the hospital," clown therapy and other playful interventions to support children's psycho-physical well-being [3-11].

Although the use of robotic technologies appears to be increasingly widespread in health care and hospital settings for various purposes, ranging from surgery to rehabilitation to patient and staff well-being [12,13], the specific literature on the use of robotics in pediatric wards for playful-educational purposes is still relatively scarce.

Among the experiences carried out in this field, it is worth mentioning that Messias et al. [14,15] describe a robotic platform dedicated to edutainment in pediatric-oncology wards developed in Portugal within the MOnarCH project. However, the research so far produced within this interesting and innovative project seems to focus primarily on the technical characteristics that robots must have to be used in these highly constrained contexts, both physically and socially. Taking for granted the assumption that recreational-educational robots play a positive role in the psycho-physical well-being of young patients, the authors' discussion is mainly focused on programming problems and technical aspects (i.e., robot movement capacity, level of autonomy, and interactivity) of robotic-engineering type. The specific psychological aspects (cognitive, emotional, relational, social, etc..) concerning the hospitalized child remain in the background. In this sense, the project does not seem to have produced rigorous empirical evidence concerning this specific field of application of robotics to support its effectiveness on young patients.

Some interesting experiences conducted in the Italian Veneto region pay more attention to the psycho-social and emotional effects of the playful interaction between child and robot. Starting from the analysis of the critical factors that characterize the condition of the hospitalized child and that can negatively influence the therapeutic efficacy, and the relationship with the doctors, Baroni and Nalin [16] conduct an interesting analysis on the possible uses of robotics as "companion therapy," comparing it with pet therapy. Due to obvious hygienic and sanitary difficulties, it is not easy to introduce animals to a hospital ward. Hence the idea of introducing anthropomorphic robots, which - having a humanoid appearance and behaving like living beings - could be able like animals in pet therapy to help reduce the level of anxiety and stress of hospitalized children, as well as to improve their response to treatment, their sense of self-efficacy and their degree of motivation to care. In this regard, the research conducted by Nalin and collaborators [17,18] on children's expectations and representations of humanoid robots appears significant, from which it emerges that children attribute to them psychological characteristics such as the ability to feel emotions, that of implementing pro-social behaviors, as well as having friends and a family.

In 2016 at the Hospital of Padua, two other promising robotics experiences in pediatrics were carried out under the supervision of the Department of Women's and Children's Health of the University of Padua. The first called the Baby Goldrake project and carried out with the collaboration of the "Enrico Fermi" scientific high school in Veneto city, used in the pediatric surgery ward and the classrooms of the school in the hospital of the humanoid robot Nao, appropriately programmed to carry out play activities with hospitalized children. The second project was carried out with the Department of Information Engineering and Fisher Italy collaboration [19]. They used the same robot with the function of "non-pharmacological therapy" to manage the anxiety of children undergoing invasive procedures performed at the Department of Palliative Care and Pediatric Analgesic Therapy of the Hospital of Padua. The "non-pharmacological therapies," which include a wide range of interventions (cognitive, behavioral, physical, interactive...) [20-22] aim to reduce anxiety and fear and, consequently, the number of sedatives to be administered to children before painful and invasive examinations, such as biopsies and endoscopies [e.g., 23, 24]. The robot Nao first welcomed the young patients into the room, took them by the hand, and accompanied them to the bed; then, according to their requests, he entertained them by playing, singing, dancing, and telling them stories.

This innovative experience is comparable to those conducted by the group of Beran and colleagues with pediatric patients undergo a variety of painful medical procedures [e.g., 25-27] and children with cancer [28]. The data collected in these studies seem encouraging, although for now, they are for a limited number of subjects and thus not amenable to statistical generalization. It should be noted that the use of robotics as a non-pharmacological therapy appears to be most effective among males in the 7–10-year age group. The projects mentioned above represent a clear sign of the growing interest in using robots to improve the well-being of hospitalized children.

The present contribution settles within this line of research; its objectives and methods are described in the following sections.

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2. Materials and Methods

2.1. Objectives of the Study

The field study presented here has an exploratory character and represents a pilot project to develop further future research. It has the twofold objective of:

1. to evaluate whether the activity performed with a mobile robot (designed for play and educational purposes) positively influences the emotions of hospitalized children;
2. to compare the experience of such a robotic play with the "traditional" play and entertainment activities generally carried out in the "game room" of pediatric wards.

The survey plan has a mixed qualitative-quantitative matrix, which includes, on the one hand, the administration of closed response questionnaires for the participants in the activities with the robot and, on the other hand, the request made to some operators who are dedicated to the entertainment of young patients to answer open questions in written form. This approach makes it possible, on the one hand, to verify whether and in what direction the play activities with the robot influence the children's emotions, as well as their general satisfaction with them; and, on the other, to understand the opinions and suggestions of the operators concerning the robotic activities carried out, comparing them with those normally conducted in the playroom of the pediatric wards.

The study was conducted before the outbreak of the Covid-19 pandemic, and all planned activities based on the data reported here were and still are suspended.

2.2. Sample

The sample was composed of 61 children admitted to a hospital ward in the Milan area. The sample was gender-balanced (54.1% male) and had approximately 9 years (mean age = 105 months, standard deviation = 36.4, range = 48-168 months). In terms of age, the difference between boys (m=100.3; sd= 32.5) and girls (m=110.6; sd=40.55) was not statistically significant. The most occurring reasons of hospitalization were: respiratory diseases (n=9, 14.7%), unclassified pain (n=8; 13.1%), orthopedic reasons (n=8, 13.1%) and pediatric appendicitis (n=8, 13.1%). It is a convenience sample for which hospitalization in the host facility and the age of the children (4-14 years) were used as inclusion criteria (i.e., ward patients include an age range from infants to teens at the threshold of majority). Admission times at this facility are very short, averaging 2-3 days.

Participants' eligibility was verified through a medical history questionnaire completed by the children's parents/guardians.

Participation in the trial occurred as a result of the voluntary adherence of the children and family (or caregivers). Before participating in the study, the investigator informed each child about the research characteristics, both verbally and through an information sheet that they signed; the same information, oral and written, was provided to the parents/caregivers. In addition, the signature for informed consent was requested from the parents/caregivers of the children.

2.3. Procedure

Approval from the human research ethics committee (Commissione Etica per la Ricerca in Psicologia CERPS, Department of Psychology, Catholic University of the Sacred Heart, Milan) has been requested. On behalf of all authors, the corresponding author states that there is no conflict of interest.

The study was conducted in a pediatric unit of a medium-size public hospital located nearby the city of Milan, a large industrialized area of Northern Italy. The unit (15 hospital beds) was accessible to young patients aged from 0 up to 17 years. The pediatric unit also provided emergency service 24 hours a day. In addition to patient rooms, the pediatric unit was composed of several other spaces, including a playroom. In general, patients' average length of stay in the unit was three or four days. The doctors' room was made available in the afternoon to have a dedicated space for the activity with the robot since no other extra space was available. Given the size and the internal structure of the room, this has implied the need to carry out only individual activities and not group ones.

The robot used is a specimen of "CoderBot" (www.coderbot.org), an "open source" robot equipped with a camera and ultrasonic sensors, teleoperable through a simple web interface and programmable through graphical and textual languages of various kinds. It has the form of a small vehicle with a wooden structure with two independent front-drive wheels and a third rear support point consisting of a free sphere; therefore, it does not have a humanoid or anthropomorphic appearance, nor that of a small animal, unlike the robots used in some of the studies mentioned above. The proposed activity consisted in guiding the robot through an obstacle course. It was carried out individually (i.e., one child at a time, in the presence of a researcher as "facilitator", eventually a parent and, when possible, an operator of the Children in Hospital Association – in Italian: Associazione Bambini in Ospedale, ABIO – as observers) in the reserved space in the doctors' room. Obstacles consisted of fruits placed on the floor. The difficulty of the path increased in relation to age: for preschoolers, there were three obstacles, which had to be simply avoided by the robot; for children between 6 and 8 years of age, there were five obstacles on the path, which had to be followed according to the direction indicated by special arrows; finally, for older children (9-14 years of age) a path was proposed that developed in increasing degrees of difficulty, with 11 obstacles, more distant in the first part and closer together in the second. (See Figure 1)

Figure 1. Example of complex obstacle course for 9-11 years old children.

The robot was controlled through a PC interface. Participants could observe both the robot's behavior placed on the floor and the image acquired by the frontal camera of the robot, reproduced in real-time on the PC screen.

In case of an impasse, the conductor supported the participants by formulating questions designed to stimulate reflection, thus avoiding suggesting solutions that had to be found by the child anyway. Any other adults present (parents, ABIO operators) could not intervene in this regard.

The total duration of the activity was about 20 minutes. After an initial phase of familiarization with the game's rules and the robot's commands, the children had to lead the robot along the obstacle mentioned above course, created on a poster placed on the room floor.

3. Results

3.1. Research methods and data analytic strategy

The case study involves the investigation of generally small samples, ethnographically based, participant-observation conducted on-site in order to identify specific properties of a single case or phenomenon through the collection of data from multiple qualitative and quantitative sources [29-32]. Therefore, the methodology used is mixed-method: The qualitative paradigm provides the general framework within which the quantitative information collected locally (biographical data, observation grids, inventories, and questionnaires) can be inserted. An excessive focus on quantitative or measurement aspects leads to little consideration of the case's more "interactive" factors with its surroundings [33]. According to the tradition of program evaluation case studies [34,35], the research method adopted in the current study was based on exploring: a) what occurred during the intervention, b) what type of impact it generates on children emotional states and c) how the intervention was delivered and evaluated by all the actors involved (children, parents, and nurses). A combination of quantitative and qualitative information was collected to grasp the complexity of the phenomenon under study. Two sets of items were administered to monitor from a quantitative perspective the efficacy of the intervention: one dedicated to the detection of the change in the emotional state of the children (B1) and one dedicated to the evaluation (satisfaction) of the activity carried out (B2).

The first battery of questions (B1) includes five polarities (happy-sad, strong-weak, interested-bored, calm-agitated, and quiet-scared) which aim to monitor the emotional state of the child before (t0) and after (t1) the activity carried out. The response mode follows the methods of collecting information typical of the semantic differential [36]. It requires the respondent to indicate on a Likert-type response scale the closeness/distance to each of the two semantic poles (i.e., "happy vs. sad" or "useful vs. useless," etc.). The overall reliability of the scale was good ($\alpha = .823$). This instrument was administered just before starting the activity with the robot (pre-test) and immediately after it (post-test) to measure any differences between the two surveys regarding the child's emotional state.

On the other hand, the second battery of questions (B2) comprises six polarities (easy/difficult, useful/unuseful, beautiful/ugly, fun/annoying, pleasant/unpleasant, new/old) that aim to collect reactions related to the activity just performed. In this case, data are collected only at the end of the intervention in the department. The reliability of B2 was found to be .91.

Children above six years of age were administered the traditional Likert-type response mode (ordinal scale with numerical values) since performance appears to be already reliable for that age group [36]. On the other hand, under six years of age, a visual-analog type of response mode was used (Figure 2). Subsequently, the two scores were standardized through standard data normalization practices [see 38].

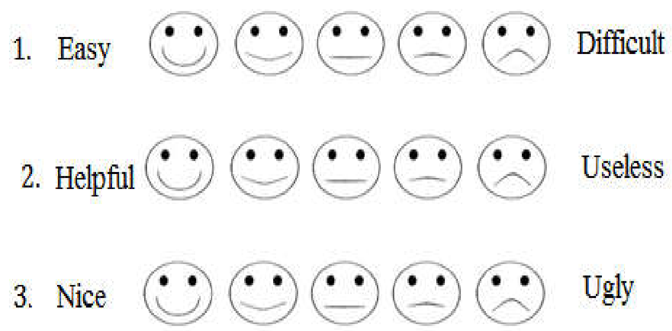

Figure 2. Examples of face-type modified Likert scale (used with children under six years).

Several semi-structured interviews were conducted with children, parents, and nurses to validate and integrate the quantitative data. In general, the interview was focused on exploring strengths, points of weakness, past experience with robots, observed reactions and opinions about the ludic experience with the robot. Overall, 4 nurses and 18 parents of hospitalized children that participated in the activities with CoderBot were interviewed.

According to standard data analysis practices in the social sciences [39], variables of interest were assessed for skewness and kurtosis values to evaluate their distribution and identify potential violations of assumptions of normality. The data were also explored to identify uni- and multivariate outliers; the criterion used is Mahalanobis distance [40] with a p-value < .001. Accordingly, four cases (two admitted for appendectomy and two for tonsillectomy, all younger than 6 years) were identified and eliminated from the analyses. To test whether the changes in emotional state (B1) scores have an adequate level of statistical significance, thus supporting the hypothesis of the effectiveness of the intervention on emotional states, the course study (Δt0-t1) was conducted by comparing averages for repeated measures [41]. Such analyses allow assessing the size of scores changes and determining their level of statistical significance [42], and assessing the power of effects (effect size, Cohen, 1992 [43]). Data were analyzed following two trajectories to evaluate the impact of age on emotional profile and reactions to the intervention. For the transformative information of emotional states (B1), a generalized within-subjects linear model for repeated measures, covaried for the age variable, could be applied. For data on participants' evaluation of the intervention (B2), on the other hand, a zero-order correlational study was chosen. To compensate for the risk of type I errors, a Bonferroni correction was adopted at the level of statistical significance (p), which is .025 [44]. Regarding the power of the effects [45], the effect is considered 'large' for values greater than .50, 'medium' for values greater than .30, 'small' for values greater than .10, and 'negligible' for effects less than .10.

Regarding the qualitative data analysis, interviews were primarily transcribed and integrated with quantitative measures. The material collected from children, their parents, and caregivers on the ward were then analyzed using thematic analysis conducted by two independent judges.

3.2. Quantitative measures of emotional states and evaluation of the activity

The main descriptive statistics of all considered measures were summarized in table 1. With regards to baseline measures, fearless (m=4,02; sd=1,29) and interested (m=3,78; sd=1,42) ranked at first places as most cited emotions.

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Table 1. Descriptive statistics of emotional states. Data referred to baseline (t0) and post-activity (t1) measures (N=61)

	Baseline (t0)		**Post-activity (t1)**		**Δt0-t1**
	Mean*	**SD**	**Mean***	**SD**	
Happy - Sad	3,52	1,30	4,07	1,48	0,54
Strong - Weak	3,15	1,29	3,71	1,25	0,57
Interested - Bored	3,78	1,42	4,37	1,07	0,59
Calm - Stressed	3,77	1,39	3,94	1,44	0,17
Fearless -Scared	4,02	1,29	4,43	1,13	0,41

*Note: Mean scores range = 1-5

Interestingly, the first set (B1) of emotional scores changed after those children participated in the robot-based activity. At t1, three of five emotions reported statistically significant differences. Multivariate analysis of covariance revealed that regardless of the gender and the age of children, the models were statistically significant in correspondence to being "happier' ($F(1,58)=5.45$, $p = .038$, $\eta 2= .072$) and 'stronger' ($F(1,58)=6.47$, $p = .014$, $\eta 2= .111$). The effect size, in this case, is .11 (low). With regards to being "interested", the pre-post model was not statistically significant. In contrast, a statistically significant effect of gender was found [i.e., generally speaking, boys (m=4.64), rather than girls (m=4.04), tended to score more "interested" after the activity with CoderBot]. The other emotional dimensions did not report statistically significant differences. The result of the activity evaluation is described in table 2.

Table 2. Evaluation of the activity: descriptive statistics (N=61)

	Post-activity evaluation	
Items	**Mean***	**SD**
Easy/difficult	4,07	1,48
Helpful/useless	3,71	1,25
Good/Bad	4,37	1,07
Funny/Boring	3,94	1,44
Pleasant/Unpleasant	4,43	1,13

Note: Mean scores range = 1-5*

Analysis of the data shows that, overall, the activity was evaluated by the children as positive. From this point of view, it is therefore important to go into the details of the analysis by identifying which age group is optimal and provides the greatest effectiveness of the activities. In this case, the data show how it is possible to detect a threshold effect corresponding to about 120 months of age. In fact, the analyses show how beyond 10 years of age, the differential scores detected before and after the activities lose statistical significance. Multivariate analysis of the cohort between 48 and 120 months (corresponding to the 4-10 year age group) shows that there is a difference between the averages between t0 and t1 [$t(28)= 25.01$, $p < .001$; $\eta 2= .390$] with an effect size of .40 (medium-high).

3.3. Qualitative evaluation: participants' voices.

A thematic analysis of the content of the texts produced by the operators was carried out using a bottom-up approach. The main and most recurrent contents that emerged are summarized below. Compared to traditional activities, it emerges that robotics has the characteristics of novelty, actuality, and technological appeal among its strengths. This makes the use of robots particularly attractive, especially for children in the intermediate range (6-10 years). Greater difficulties are found with younger children, particularly due to the use of the mouse, which is still quite complex for them. In particular, the difference between touch screen vs. PC controlled by mouse emerged: children are, in fact, more used to using touch screen devices (parents' smartphones, video games, etc.); implementing this "touch mode" would make the interaction with the robot more user friendly. For example, we remember the case of a 4-year-old girl who, after having tried unsuccessfully to play by pressing on the PC screen, began with frustration and annoyance to twirl the mouse in the air in an attempt to make the robot work. Only the intervention of the conductors brought the situation under control. Another factor considered crucial by the operators concerns the lack of opportunity to use social skills associated with the experience. Socialization and sharing experiences with other peers are considered fundamental elements for hospitalized children's well-being. The individual character of the experience imposed by the constraints of the context did not allow in any way to affect this aspect, neither in a collaborative nor in a competitive sense. Among the ideas proposed for future robotics experiences in pediatrics is the organization of team games, designed to stimulate both the first and the second socializing aspect. The spaces dedicated to the activity were judged quite adequate for the proposed activity. However, it emerges that it would be desirable to have ad hoc spaces (instead of a "repurposed" doctors' room), especially about the possibility of organizing robotic games in groups, as considered desirable by the interviewees.

From the interviews with parents, it emerged that the robotics activity was appreciated and considered appropriate and enjoyable in the hospital context.

"And yes, he liked it, before he was bored and he even said it and sad, then he is hungry it's three days that he hasn't eaten so he is hungry, and he was entertained, so it's interesting, he liked it" (Mom, 42 years old).

Among the main strengths identified by parents in the recreational use of robots emerges the dimension of fun and usefulness of performing an activity like this in the hospital. Parents' evaluation of the activity is generally positive. Some believe that it could be a valid experience to be included in pediatric wards, as it is appropriate and nice that there is the possibility to carry out an activity of this type that manages to captivate and stimulate curiosity in children and young people who, many times in the hospital, do not want to do anything and are not interested in any game.

Compared to traditional activities, robotics can stimulate children's curiosity and keep them focused and attentive for as long as it takes to do it. Some declare that their children often had no interest in going to the playroom or stayed there for a very limited time; they were surprised by the concentration and commitment that the children invested when playing with the robot.

"I tried to take him to the playroom this morning, but he wanted to do everything and play with everything; he brought out the dinosaurs and played for a second but wanted to change [game] right away; in fact I didn't think it lasted all the activity here [referring to the one with the Coder-Bot] and [I thought] halfway through he would tell you to stop, instead he was very interested" (Mom, 32 years old).

The robot appears to have a particular appeal to children and young people who see new technologies as an attraction that encourages them to get involved and try new experiences.

A limitation brought to light by a parent concerns the duration of the activity, which was perhaps considered too short and sporadic. Given that, for his son, the game with the robot was pleasant and fun, he would have preferred it to last a little longer.

"Then the limitation is that it lasts relatively short for my son; it was fun. If it had lasted longer, maybe it would have been more interesting, more enjoyable for him; however, I realize that being a studio, maybe here it's a bit of a small department, but if there were twenty children who had to do it I realize that the time...and then definitely it's interesting because if you are doing studies towards this activity, it will definitely lead you to have results I hope for you satisfactory" (Mom, 43 years old).

In light of this, it emerges from the interviews that all of the parents noticed a positive change in their child's emotional state during the activity with the robot. Many declared to be surprised by their children's enthusiasm during the activity compared to the time before when they were bored and disinterested. The novelty is experienced as positive, and they declare to have seen their children happy and serene during the activity.

"He was very interested; novelty is always welcome; it's hard for him to care about anything" (Mom, 32 years old).

3.4. Other observations from the field and practical issues

Field observations show that when the researcher goes into the room to invite the child to be part of the research, many appear visibly bored and disinterested.

This discontent increases in direct proportion to the age of the patients, who are often found in the room playing with their cell phones or tablets. In this phase, the stimulus provided by the parents, who immediately saw in this unexpected activity a positive stimulus and a way to occupy their time, proved to be very useful and incisive. If the nurses were also present, they spent positive words encouraging the patient to participate.

Generally, participants were silent and focused on what they were doing. The questions and requests for help were reduced to the necessary; only in some cases, arrived at the end of the course and were curious about what had been done, they asked for more details.

It also happened that some of the older children questioned the researcher about the course of studies undertaken to understand in what context the research was inserted.

The participants were calm and at ease with using the computer and were surprised that it was necessary to use the PC to control the robot. They enjoyed watching the robot move but were so engaged in this and in watching the path that they always kept the same arrow clicked; the difficulty lay in coordinating the robot's maneuvers and shifting their gaze from the path to the PC. Only the youngest children - 4/5 years old - were visibly lost and unable to use the tool; during the activity with the youngest children, the conductor intervened several times to help the young participants position the cursor in the position they had indicated.

As the interviews revealed, some parents of children in this age group reported at the end of the activity that it was the first time their children had used the computer:

"The computer is definitely a plus point, being able to operate it. Maybe a little too difficult for a 4-year-old because he had never used it before." (Mom, 31)

Contrary to the widespread thought among participants before beginning the robotics experience, no difficulties emerged in performing the activity caused by impediments due to medical/health aids (IVs, bandages, stitches, etc...).

4. Discussion and Conclusions

A problem associated with case study methodology concerns the conclusions' robustness. They are based only on a single point of observation, limiting the possibility of transferring the results in terms of ecological validity.

The use of only the elements of internal triangulation (with-in case method) [46,31] requires caution in the interpretation of results in relation to other contexts. While it is important to select case characteristics in terms of typicality, it is equally important to reflect on situational uniqueness, especially from the perspective of the complex interactions of the case with background conditions [47].

In this regard, the second class of limitations of the present work is linked to the constraints posed by the characteristics of the context in relation to the brevity of hospitalizations, the heterogeneity of pathologies, and the impossibility of playing "social" games. A first methodological fallout of these constraints concerns the very close temporal distance between pre-test and post-test, which raises the question of whether follow-up research on the effectiveness of the intervention is appropriate.

The potential relevance of the different pathologies presents in the sample examined can be even more substantial. It is true that, in a context where only short admissions were made, the young patients tended to present a clinical picture of low gravity; similarly, children who were so ill that they could not get out of bed were automatically excluded from the activity. However, the researchers could systematically monitor neither the severity of illness nor the level of invasiveness of treatment. The wide age range of patients should also be mentioned. In this regard, Baroni and Nail [16] suggest to differentiate the activity and the type of robot in relation to the type of pathology and treatment.

In essence, the exploratory nature of field research and the consequent constraints posed by the specific context have prevented a systematic evaluation of the effects of playing with the robot, distinguishing them from those arising from other potentially influential factors, such as the sex of the subjects, any previous familiarity with robots, the presence or absence of the parent during the experience, etc. A final limitation is the lack of an adequate control group that can be compared to the experimental group.

In conclusion, future developments of the project should ideally include the following aspects. First of all, a systematic study of the effects that the play-educational activity with the robot obtains on young patients, in relation to the type of pathology from which they suffer; the recruitment of a larger sample, with more homogeneous age cohorts (preferably concentrated on the elementary school age group) and statistically comparable; the monitoring of the origin and socio-cultural level of the families, also to assess the possible influence of intercultural differences; all through the comparison with a suitably selected control group.

This is, as we can see, a very ambitious goal that presents important methodological challenges in ecological contexts. In addition, as far as the game with the robot is concerned, it is necessary to prepare activities that are more attractive to older subjects and easier to manage for younger ones, to be carried out in groups and with a temporal articulation in several phases (i.e., not only "one shot", but through paths structured in several meetings). Lund and Nielsen [48] point out that younger children are generally more sensitive to the "game interaction", i.e., to the aspects of interaction with the robot, while as they grow older, the objectives and the "technical" aspects of the game become important. Moreover, an evaluation of the "emotional effects" on the medium-term (follow up) and of the potential "cognitive" learning (through comparison with other educational robotics research, i.e., on the resolution of "errors") should be made using a mixed-method approach (qualitative-quantitative). Finally, an in-depth interdisciplinary reflection (epistemological, psychological, and technical robotics) and empirical experimentation in the field will have to be conducted to compare the modalities and the effects of the use of CoderBot with the use of humanoid robots: an enterprise that will probably engage researchers for a long time to come.

Our research group was about to start some activities set up to deepen some of the aspects emerging from this pilot study when the Covid-19 epidemic occurred, making it impossible to carry out any activities in hospital settings. At the time of writing, it is impossible to foresee if and when these activities may be resumed.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available upon request to the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

References

References must be numbered in order of appearance in the text (including citations in tables and legends) and listed individually at the end of the manuscript. We recommend preparing the references with a bibliography software package, such as EndNote, ReferenceManager or Zotero to avoid typing mistakes and duplicated references. Include the digital object identifier (DOI) for all references where available.

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