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Can AI-assisted therapy (PARO robot) be a treatment option for children hospitalised in an acute mental health ward? A pilot study.

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Summary

Aim. The aim of the study was to assess changes that occur in the behavioural and emotional sphere in psychiatrically hospitalised children with serious self-aggressive tendencies after therapy using interaction with the PARO therapeutic robot.

Method. The study is of a pilot and observational nature. It was carried out over the course of three weeks. It included patients admitted to a psychiatric hospital due to threats to life and health, who were divided, by randomisation, into an experimental group (working with the PARO robot) and a control group (working with a plush toy). The methods used were related to both external observation and children's self-description.

Results. The results suggest that interaction with the PARO robot can increase positive and decrease negative emotions. This is also related to the increase in the number of interactions between children.

Conclusions. The study results encourage further activities in the area of introducing artificial intelligence as a therapeutic potential that can be used by children with mental disorders hospitalised due to threats to life and health.

Keywords: PARO robot, mental disorders, children

Introduction

The past decade has witnessed an intense growth of artificial intelligence technologies accompanied by a search to find possible applications for them in different areas of human life. Child and adolescent therapy seems to be a good match for such innovative solutions as young people appear to be more willing to embrace AI-equipped technology, such as, for example, online photo editing platforms or chat GPT, providing grounds for their potential benefit in the field of psychiatric care [1]. Apart from online applications, AI is also used in various types of therapeutic robots [2]. There is a growing body of evidence on their positive effects in supporting children and adolescents in areas such as education [3] or social skills improvement [4]. Scientists are currently researching AI potential in the field of therapeutic support for children diagnosed with cancer, developmental disorders, mobility issues [4], and intellectual disability [5]. However, the emphasis is placed on the use of robots in the therapy of autistic children – helping them improve their attention scope, emotion recognition and expression, verbal and nonverbal communication, mimicking and initiating reactions [6]. There is no available research on the use of AI in the therapy of children with other psychiatric disorders.

The PARO robot is based on artificial intelligence and was created in Japan by professor Takanori Shibata for therapeutic applications [7]. The robot looks and behaves like a baby seal. It adapts to the level of communication skills of the user with which it interacts. The robot has been equipped with a series of sensors – a light sensor for simple vision, touch sensors under the fur and near the whiskers, microphones to recognise speech and localise sound, temperature sensors to control body temperature, and orientation sensors enabling the robot's recognition of the position in which it is held. PARO can also move and comes with two learning functions – it can learn its own name and can adapt its behaviour through interaction with the user [8]. Interaction with the PARO robot can lead to an improvement in various areas of functioning, including an increase in nonverbal communication, e.g. eye contact and touch, which is an important element in the therapy of persons with emotion and communication disorders.

Studies of therapeutic interactions with the PARO robot in clinical populations, predominantly among dementia patients, showed positive therapeutic effects in the area of emotional functioning as well as in verbal and nonverbal communication [9–11]. Research involving children reported a stress reducing effect of PARO interactions, particularly among children with verbal skill deficits [5]. A controlled study among healthy children showed that the robot may increase positive emotionality [12]. Furthermore, contact with PARO has a beneficial effect on the ability of autistic children to initiate interactions with their carer [13].

Material

This observational and pilot study is the first such study in Poland on the effect of PARO on the behaviour and emotions of the clinical population of children hospitalised

for behaviours dangerous to life and health. As the number of study participants is low, this research is presented in the form of a series of case studies. The goal of the study was to evaluate the changes in behaviour and emotionality of children hospitalised in a psychiatric unit after therapeutic interventions using the PARO robot.

This study attempts to answer the following research questions:

– Do interactions with the PARO seal robot increase positive emotions in children hospitalised for behaviours dangerous to life and health?
– Do interactions with the PARO seal robot decrease negative emotions in children hospitalised for behaviours dangerous to life and health?
– Do interactions with the PARO seal robot increase the number of interactions between the children and 1) the robot, 2) the therapist, 3) other children?

The study was conducted in January 2023 in an inpatient child psychiatric unit. Two comparable groups of children aged 12–13 years were assessed. The PARO robot was used in the experimental group while the control group interacted with a regular seal toy. The therapy sessions were video and audio recorded. The authors collected informed consent in writing from the children's parents separately for participation in the study and for the video and audio observation of the child during the experiment. Verbal consent was obtained from the study participants. Both the children and the parents were informed that they can withdraw from the experiment at any time without a cause. The study received the consent of the Bioethical Commission of the Collegium Medicum of the Nicolaus Copernicus University in Torun No. KB 475/2022.

The study participants consisted of children admitted to the psychiatric hospital in relation to behaviours dangerous to life and health – active suicidal ideation and/or self-harming behaviours. The study excluded patients diagnosed with intellectual disability, chronic neurological disorders and comorbid somatic disorders. The patients varied in psychiatric diagnosis, some had comorbid disorders (e.g. depression and autism spectrum disorders, namely Asperger's Syndrome). The participants also varied in terms of the presence of self-harming behaviours, life story and the presence of traumatic behaviours. The clinical characterisation of the participants has been presented in Table 1.

In the beginning, 12 children were randomly and equally assigned to the experimental and the control group. In the course of the study some participants withdrew their consent resulting in a final count of five children in the experimental group and two in the control group.

Table 1. **Clinical data of study participants aged 12–13 years (N = 7)**

Clinical data	Experimental group N = 5 2 boys, 3 girls	Control group N = 2 2 girls
Total number of suicide attempts in life span	3	1
Suicide of family member	2	0

table continued on the next page

Self-harming	3	2
PTSD	2	0
Attachment disorder	2	0
Sexual abuse	1	0
Depressive disorder	1	1
Autism spectrum disorder	2	1
Eating disorder	2	0

Method

Patients from both groups participated in six sessions of 45 minutes each. The sessions in both the experimental and the control group were conducted by the same therapist and took place twice a week at the same time throughout a period of three weeks. The seal (PARO and plush toy) was treated as a co-therapist and was held by the person who was speaking at any given moment. Moreover, a whiteboard was used on which both the therapist and the participants wrote the currently discussed topics. Each participant received a printed photograph of the whiteboard notes post-session. Pleasant activities were the main theme of all of the sessions.

The topic of the first session consisted of naming pleasant activities of a seal. Children were then asked to consider if they like similar activities (e.g. swimming, eating fish). The second session discussed the participants' favourite activities categorised by the type of sense affected – sight, hearing, smell, taste, and touch. The next session pertained to obstacles in carrying out favorite activities related to the stay in an acute psychiatric ward. During the fourth session, participants discussed which of the pleasant activities can be done in the psychiatric unit and were asked to practice these activities between sessions. The topic of the fifth session consisted of naming what helped and what hindered the performance of the pleasant activities with some children presenting how they performed their chosen activities (e.g. by showing the cards to their favourite game or the art projects they did in the unit). The final session served as a conclusion to the study during which the participants summed up what gave them positive emotions and what was difficult for them during the therapy sessions.

Two types of evaluation methods were used – self-assessment by the participants and assessment of external observers.

The participants filled in the Polish version of the Children's Depression Inventory CDI-2 for ages 7–18 years by Maria Kovacs [14]. The full 28 item version of the questionnaire was used. The results were then presented in tens. The CDI-2 provides information on various types of depressive symptoms with a general score and subscales of negative mood, emotional difficulties, low self-esteem, lack of efficacy, difficulties in functioning, and interpersonal problems. The children filled in the CDI-2 questionnaire twice, pre – and post-study.

A specially formulated Emotion Self-Assessment Scale, which consisted of the rating of three negative emotions (sadness, fear, irritation) and three positive emotions (joy, calmness, pleasure), was also used. The scale included statements relating to the assessed emotions (I am sad, I am irritated, I am happy, I am calm, I feel nice) which the children rated on a five-point scale presented in grey-scale stars where the darkest star represented the highest intensity of the rated emotion. Thereby each emotion could be rated from 1 to 5 points. The Emotion Self-Assessment Scale was filled in each time before and after the seal-assisted therapy session.

The external evaluation of patient behaviour was based on a list of 17 emotions (surprise, curiosity, relaxation, boldness, trustfulness, joy, enthusiasm, amusement, contentment, fear, anger, sadness, anxiety, embarrassment, boredom) prepared separately for study purposes. The evaluation was performer by two experts – a psychiatrist and a psychologist who observed the sessions in real-time in a separate room on a monitor. Each observed emotion was named and its intensity rated on a scale of 0–5. After each session the number of observed emotions and their intensity was calculated to a total score (e.g. an emotion that was observed three times with an intensity of 4 points received a final score of 12 points). The external observers also assessed the number of interactions between the participants and: the seal, the therapist, other participants. This evaluation was done after each session.

Results

The mean results for the pre – and post-session emotional self-assessment for both the experimental and the control group have been presented in the tables below. The results were analysed globally (Table 2). A "-" symbol in the column representing a given emotion signifies that a patient rated an emotion higher pre-session compared to the post-session rating. For example, if a patient from the experimental group rated sadness with 3 points pre-session and 2 points post-session, the value in the experimental group's column marked "sadness, – " increases by 1 point.

The self-assessment results were also compared solely between the first and the last session (Table 3). The results for most emotions showed no differences in ratings. However, taking into account emotion dynamics, desired changes were the most frequent (i.e. an increase in positive emotionality and a decrease in negative emotionality) in both groups. The emotion of irritation represented the sole exception, particularly in the experimental group.

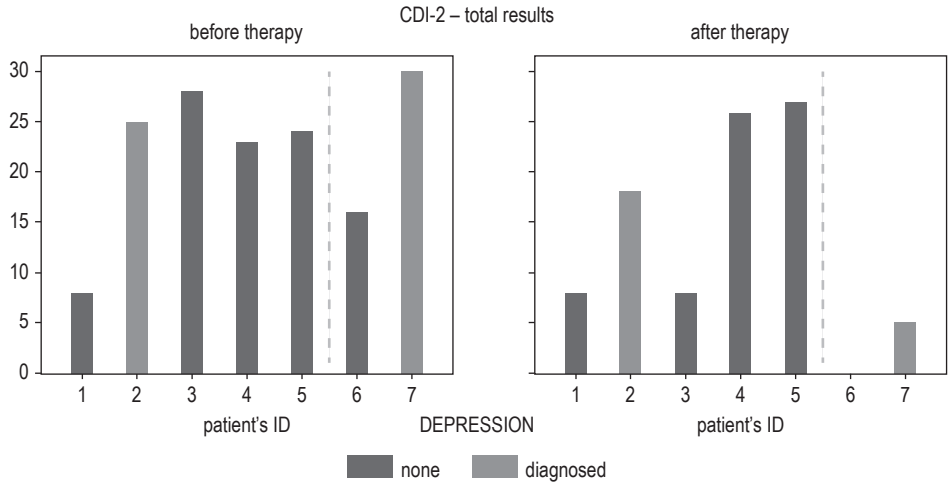
Table 2. **Total number of observed post-session emotion rating increases (+), decreases(*) and lack of emotion presence (=)**

	Sadness			Anxiety			Irritation			Joy			Calmness			Pleasure		
	+	=	-	+	=	-	+	=	-	+	=	-	+	=	-	+	=	-
Experimental group	4	17	6	2	21	4	6	12	9	11	11	5	6	19	2	8	16	3
Control group	0	7	1	0	5	3	2	4	2	4	3	1	6	2	0	3	5	0

Table 3. **Number of emotions that increased (+), remained unchanged (=) or decreased (-) between the first and the last session**

	Sadness			Anxiety			Irritation			Joy			Calmness			Pleasure		
	+	=	-	+	=	-	+	=	-	+	=	-	+	=	-	+	=	-
Experimental group	1	2	2	1	2	2	2	2	1	2	3	0	2	1	2	2	2	1
Control group	1	0	1	0	2	0	0	1	1	1	0	1	1	1	0	0	1	1

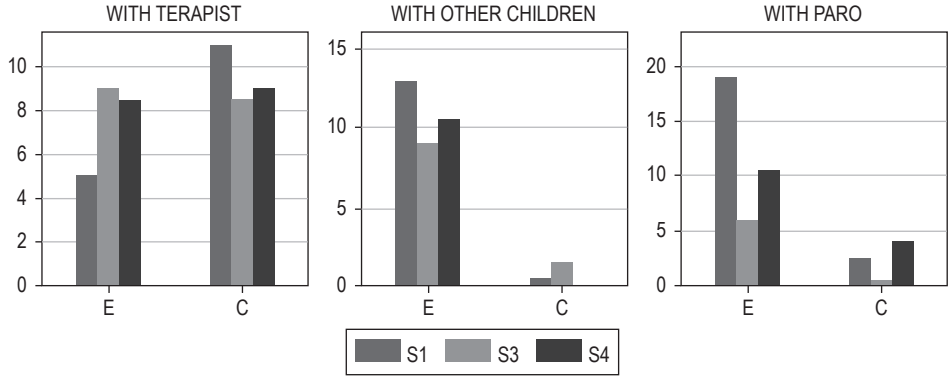
The patients differed in the assessment of their depressive symptoms as stated in the CDI-2 questionnaire, both in terms of the pre-study evaluation (first CDI-2 result) and the post-study evaluation (second CDI-2 result). For example, some participants rated their depressive symptom intensity as very high, others as low. There were no diagnosis-dependent differences in depressive symptom ratings, i.e. no differences between patients diagnosed with autism spectrum disorders, PTSD, attachment disorder, or eating disorder. There were also no differences in the CDI-2 results related to the presence/absence of suicide attempts, family history of suicide, or sexual abuse. However, a decrease in the global score as well as in the ratings of the individual subscales of the CDI-2 (with the exception of low self-esteem) was observed among participants diagnosed with depressive disorder (Graph 1).



Graph 1. **Reduction of the general CDI-2 score among participants diagnosed with depressive disorder**

External observations of the patients by the experts show high intragroup variance which allowed for only a qualitative analysis of each patient individually. Furthermore, the variance of data pertaining to the number of interactions (with the therapist, other participants, and the seal) made it difficult to make general assumptions in the control group which consisted of two participants and where only one participant was present

during two of the sessions. In the experimental group, some patients increased and some decreased the general tendency related to the number of interactions. Taking into account the experimental group sessions with a valid number of participants, the number of interactions with the PARO robot and with other participants was highest during the first session (Graph 2).



Graph 2. **Number of interactions with other children, the seal and the therapist during sessions 1, 3 and 4 in the experimental group (E) and the control group (C)**

In the experimental group, statistically relevant Spearman's *r* correlations ($p < 0.05$) were noted between the observed number of interactions with the PARO robot and other children ($r = 0.64$), and the emotions of curiosity ($r = 0.48$), enthusiasm ($r = 0.65$), joy ($r = 0.53$), amusement ($r = 0.59$), and surprise ($r = 0.53$) recorded by external observers.

Discussion of results

This is the first study of the impact of using PARO robot based on artificial intelligence in the therapy of children hospitalised for life-threatening reasons in an acute psychiatric ward. As mentioned above, scarce research has been published worldwide on the use of PARO in the therapy of children with mental disorders. Nevertheless, the findings that are available show that this method has promising potential, especially in the scope of improving emotional state. This study confirms these findings despite the fact that the results can be considered at the level of statistical tendency and should be viewed in a qualitative manner. The discussion focuses mainly on the clinical context.

The most important results pertain to the observed relationship between the positive emotions recorded by external observers and the number of interactions with the robot and other children in the experimental group. These findings suggest that contact with the seal robot can contribute to an improvement not only at the emotional level but also at the behavioural level in terms of social interaction. Maintaining this effect seems therapeutically desirable taking into account the characteristic of children hospitalised due to a threat to life or health. Information obtained from clinical interviews

suggested a prevalence of negative emotions, difficulties in everyday functioning and a withdrawal from peer relations.

It is worth noting that the number of interactions with the PARO robot and between the participants of the experimental group was highest during the first session which can be explained by a sense of enthusiasm towards the novel possibility to interact with a seal robot. This assumption is confirmed by an analysis of the statements uttered by the children which included many spontaneous questions about how the robot was made and how it works and expressions showing the will to hold and touch it. During successive sessions, the seal robot no longer appeared so attractive. Furthermore, the topic of the sessions was to identify and practice pleasant activities. The provided whiteboard on which children wrote down their ideas was also an element of the interaction. This may have contributed to the seal's reduced importance which seemed to be confirmed in the children's own statements. This points to a need to re-evaluate the method of conducting the sessions in successive studies so as to shift the focus entirely to an attractive and new form of interaction with the robot.

As two of the participants were diagnosed with depressive disorder, the level of depressive symptoms relevantly decreased irrespective of the type of seal used – one child was in the experimental group, the other in the control group.

In the entire study group and irrespective of the type of seal used (plush toy vs PARO robot) the observed changes pertained mostly to an increase of positive emotions. "Irritation" was the sole exception which was mainly observed in the experimental group. This type of effect was not recorded in the population of healthy children [7]. The finding could be analysed in many ways. The child observations show that the PARO robot incited positive emotions which were, at times, simultaneously accompanied by negative affect. The experimental group included two children with a history of abuse. One of them withdrew from the study after the third session. According to statements made by this boy, it appeared that he no longer liked the seal despite visibly showing his interest in it. This patient played a dominant role in the group during the first three sessions, shaping the mood with his behaviour which included, for example, changing the name of the seal from Fredzia (name assigned pre-study in honour of Fryderyk Chopin) to Pablo (after Pablo Escobar) as he believed that seals may have a tendency towards using drugs. Apart from clearly observed warm feelings toward the robot, the seal also became a persecutory object – patients voiced assumptions that the seal may have killing lasers in its eyes, that it can come to them at night with its friends. A female participant with a history of long-term sexual abuse stated that the seal is too heavy and for this reason it is difficult for her to touch it.

However, it should be noted that the group was being observed via camera of which the children were aware which may have contributed to the expression of negative emotions. The patients' statements show that the expressed irritation may have been related to the fact that the participants viewed the PARO robot as a toy meant for children younger than 12–13 years. It appears that the seal incited more positive emotions when it was perceived as an animal that has soft fur and reacts to the children's behaviour with sounds and by moving its flippers and tail.

The results should be analysed with caution due to the study's limitations, namely the short study period, low number of participants in the control group, and differences in psychiatric diagnosis. Other factors possibly affecting the participants' mental state include: parallel group therapy, applied pharmacotherapy, contacts with relatives, and respiratory tract infections which occurred during the study period.

The contrast between the study's assumptions (three-week closed study of two randomised groups of six participants each) and the study's actual course reflects the dynamic character of an acute inpatient psychiatric ward for children.

Conclusions

The results of the pilot study, despite being impossible to interpret in terms of statistical power, suggest that interaction with the PARO robot may contribute both to an increase in positive emotionality as well as and a decrease in negative emotions in children psychiatrically hospitalized due to serious self-aggressive tendencies. This, in turn, can be reflected in an increased number of interactions between group members. These findings prove further actions are warranted in the scope of the introduction of the therapeutic potential of artificial intelligence in the treatment of children presenting with a threat to life or health.

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