Article

Distance Special Education Delivery by Social Robots

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Abstract: The outbreak of the Severe Acute Respiratory Syndrome coronavirus (SARS-CoV2) has resulted in a significant disruption of almost all aspects of everyday life. Several governments around the world have adopted emergency actions to reduce spreading of the virus, which included suspension of non-essential activities and the implementation of social distancing practices. In our case, governmental measures have resulted in the suspension of our experimental protocol for testing the effectiveness of robot-based treatment of children diagnosed with Autism Spectrum Disorder (ASD) compared to conventional human (therapist)-based treatment. These circumstances led to an investigation of the potential of tele-consulting. This paper describes alternatives to implement synchronous and asynchronous therapeutic sessions for children already participating in the protocol, in order to reduce the negative effects of the strict cessation of the in-person sessions. The usefulness of our approach was assessed by recording the children's and the parent's satisfaction via questionnaires. In addition, we compare satisfaction between the synchronous and asynchronous sessions. The results show that the approach has been very satisfactory and useful for both children and parents, and that this was especially the case for the robot-based material.

Keywords: social robots; autism spectrum disorder; robot-assisted therapy; remote therapy; telehealth

1. Introduction

Robot-assisted therapy has been the central theme in numerous research studies in the past years. The main reasons behind the amount of attention this application of social robots has attracted, is a) the robots' ability to perform tasks repeatedly with consistency, and b) their attractiveness to children which improves children engagement and response [1–4]. This has been the case for both typical and special education [5–7]. In line with this trend in social robotics, the authors are currently involved in the national project titled, "Social Robots as Tools in Special Education (SRTSE)" project [8]. The objective of the project is to investigate the effectiveness of robot-assisted ASD therapy compared to traditional therapy with a human therapist, as well as some types of learning difficulties. Ultimately, the goal is to demonstrate that the use of a social robot in conjunction with a human therapist yields better educational results, and subsequently integrate robots in Greek Special Education. The implementation of the interventions on the social robot NAO was carried out at the Papageorgiou General Hospital in Thessaloniki, Greece in collaboration with the Human-Machines Interaction Laboratory (HUMAIN-Lab) from the International Hellenic University in Kavala, Greece. For the first phase of the intervention program, 11 children have been selected for participation in the protocol

(aged 7 to 11 years old) and have been divided into two groups: a) a robot-assisted intervention group (six boys) and b) a human-assisted control group (four boys and one girl).

Meanwhile, in mid-March this year, the World Health Organization (WHO) has declared COVID-19 a pandemic due to the increased rate of spreading and the uncontrolled increase of cases internationally. Governments around the world, including the Greek government, have been implementing emergency actions to prevent the spread of the virus in order to protect the health of the citizens. After the temporary closure of all educational institutions in the Greek territory (schools, universities etc.), all the non-life-threatening procedures on hospital premises were also suspended in order to prevent further transmission of the virus. As a result, the suspension of the in-person interventions for children with ASD at the Papageorgiou General Hospital were also suspended until further notice. This included the interventions carried out in the context of the aforementioned SRTSE project. Clearly, the children that were participating in the ongoing study needed additional support in order to process the new conditions of their daily lives and adapt to the necessary changes. The additional challenges that are presenting in this setting, are related to the particular characteristics of children with ASD at the level of communication, interaction and information processing, their difficulties in flexibility-adaptation and their tendency for stereotypical-repetitive behaviors, activities and interests [9].

To address these challenges, it was deemed necessary to support their intervention program by other means. This gave rise to the development of a comprehensive tele-consulting strategy for assisting children with ASD remotely, when in-person meetings are impossible, such as in a quarantine situation, or impractical, due to geographical limitations. In compliance with the infection prevention guidelines for the new SARS-CoV2 virus, and in order for the negative effects of the abrupt cessation of the in-person sessions to be reduced, it was decided by the research team that remote interventions would be implemented in two ways; First, in the form of asynchronous sessions involving digital support material that would be produced and distributed over the internet, and second, with synchronous sessions with the NAO robot via teleconference software. It was expected that, with the distribution of the additional information to the caregivers, in conjunction with the presence of the social robot NAO both in the material and the live sessions, the children and caregivers will be properly supported, thus allowing cohesion to be maintained for the intervention during the stay-at-home period. The support provided remotely cannot be considered an alternative form of intervention in the current protocol i.e., as an alternative therapeutic approach to replace the in-person sessions. However, it is worth noting that the use of technology for distance psychoeducation, counseling and supervision has been used and studied in research involving children with ASD and is suggested with some specifications as a primary or a complementary model [10–12].

The therapeutic scenarios that have been included in the ongoing intervention protocol, and have originally been presented in [13], cannot be used in their intended form, as they are based on the physical interaction between robot-child-therapist/instructor with specific therapeutic goals in a personalized intervention plan. However, the addition of the newly developed material to a) inform children about the changes in their everyday life and b) the preservation of their relationship and contact with the NAO robot appears to be the safest option to ensure that the intervention results achieved so far are preserved, despite the suspension of individual in-person interventions. This addition does not violate the original intervention protocol as it is aligned with the prescribed exercises in order to maintain the effect of the treatment outside of the therapeutic context.

This paper discusses our approach for presenting the social robot to children with ASD in a remote education and support scenario, and presents the statistical analysis of its perceived effectiveness according to a questionnaire-based study. The paper is structured as follows: Section 2 presents the additional material as well as the format of the synchronous sessions, and discusses the usefulness of each exercise. Section 3 describes the results from the questionnaires investigating the satisfaction of parents and children using the digital material and the synchronous sessions. Finally, Section 4 contains some conclusions regarding our approach and proposes directions for future work.

2. Materials and Methods

The current psychoeducational protocol as well as the original intervention protocol of the main study has been developed by the clinical scientific team at the Papageorgiou General Hospital in Thessaloniki, Greece [13]. The 11 children that have already been enrolled in the main study were eligible to participate in the current protocol.

2.1. Digital Material for the Asynchronous Sessions

The digital material for the asynchronous sessions that was distributed during the suspension of the in-person therapy is common for both groups in terms of content, but it differs in terms of delivery method. For the control group, the information is given in the form of a visually appealing interactive presentation, while for the robot-assisted group, the presence of the robot is central. This ensures consistency based on randomization of the sample. The concept map, the structure and the adaptation of the final material emerged from a focus group of three psychologists with experience in the field of autism. Table 1 summarizes the format of the additional material for both groups.

Table 1. List of materials for the two groups.

Control Group	Robot-Assisted Group
visualized material in the form of a presentation	visualized material with the NAO robot
digitized material with children's activities	digitized material with activities involving the NAO robot
information leaflets for parents	information leaflets for parents

The content of the asynchronous support material that has been developed is based on three main concepts:

1. **Information on current events:** Emphasis was placed on clarifying the basic information that children need to know about COVID-19 precautions and hygiene measures. At the same time, the areas that parents should pay attention to during the children's engagement with the material are highlighted by accompanying information leaflets.
2. **Strengthening resilience:** Modern research defines resilience as a dynamic process of positive adjustment of the individual despite the existence of adverse conditions and risks or despite the experience of traumatic events. Therefore, due to the present conditions, the focus on strengthening the protective factors associated with resilience is important [14,15]. The aim of the proposed activities is to accept and empower children, to promote a positive attitude towards the changing circumstances of their daily lives, to strengthen the emotional support they receive through the provision of information that will be given to the family environment, to promote techniques and activities that reduce the sense of isolation, and finally, to maintain coherence in the therapeutic process [16].
3. **Creative engagement:** Although children with ASD may feel more comfortable with social withdrawal, as in the case in a quarantine situation [17], it is also possible that they become distressed by even small changes in their routine, which usually involves multiple activities aimed at developing their skills. One such routine activity was their in-person sessions for the protocol twice a week. Maintaining a routine as much as possible reduces the negative effects and maintains balance in the family (see [18]). In the present conditions, it is even more important to enhance the experiences that promote feelings of enjoyment and satisfaction and adopt activities that calm children and strengthen their sense of control, thus strengthening their independence.

The support material that was developed to cover the projected lockdown period is divided into two Supporting Information Packages (SIP). Each SIP is different in terms of content, but both packages consist of five sections that follow the structure illustrated in Figure 1:
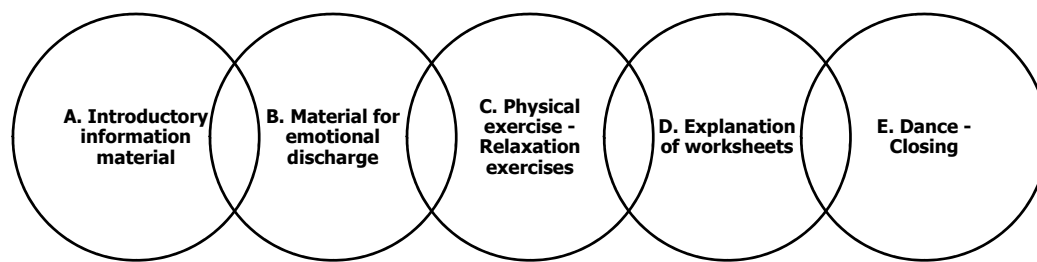
Figure 1. Structure of each supporting information package.

Each of the five sections of a SIP shown in Figure 1, deals with a different educational objective. The specific content of each section can be summarized as follows:

1. **Introductory information material**: The introductory section of the first SIP is dedicated to explaining the current situation, what is the SARS-CoV2 virus and the need to stay at home, and the various steps that need to be taken in order to stay safe. On the other hand, the introductory section of the second SIP encourages the child to describe its life so far, its activities with its family, and advocates the maintenance of a healthy lifestyle through healthy eating and exercise.

2. **Material for emotional regulation**: The second section of the SIP contains material for dealing with boredom and tediousness as well as other negative emotions. The material offers ideas for indoors activities but also offers advice for dealing with negative emotions.

3. **Physical exercise-Relaxation exercises**: Physical exercise and especially coordination and endurance exercises are very effective in children with ASD [19]. Movements similar to those that manifest as stereotyped behavior by children with ASD, appear to be helpful in providing the necessary feedback to the body. This can reduce repetitive behaviors, such as hitting the arm or "flailing" with the upper extremities [20,21]. Research shows that there is a reciprocal relationship between physical exercise and social functionality for people with ASD, reporting better emotional regulation, among other benefits [22,23]. The SIP also contains step-by-step instructions for conducting breathing exercises aiming at relaxation, which can also be used when the child becomes emotionally overwhelmed.

4. **Explanation of worksheets**: This section of the SIP includes information and instructions for both children, parents/caregivers on how to use the accompanying worksheets. Included in this section are the optional questionnaires where, at the end of the process, parents can provide feedback regarding the support material and record their children's response to it, even though a telephone interview was preferred, as will be explained later. Additionally, the section includes information targeted specifically to parents with advice on how to communicate effectively with the child, explanations for the material provided in the RIS and advice on how to appropriately respond to any difficult behaviors that may occur.

5. **Dance-Closing**: In this section the importance of the washing of the hands is explained and the process is demonstrated using graphics and video. The end of the section is marked by a visually appealing dance.

As mentioned earlier, the material used for each group differs in delivery type, with an interactive presentation for the control group and a video recording of the NAO robot for the robot-assisted group. As an example, Figure 2 shows a screenshot of the video where the NAO robot is explaining an exercise in the robot-based material, and a presentation slide explaining the importance of cleanliness (in Greek).

(**a**) (**b**)
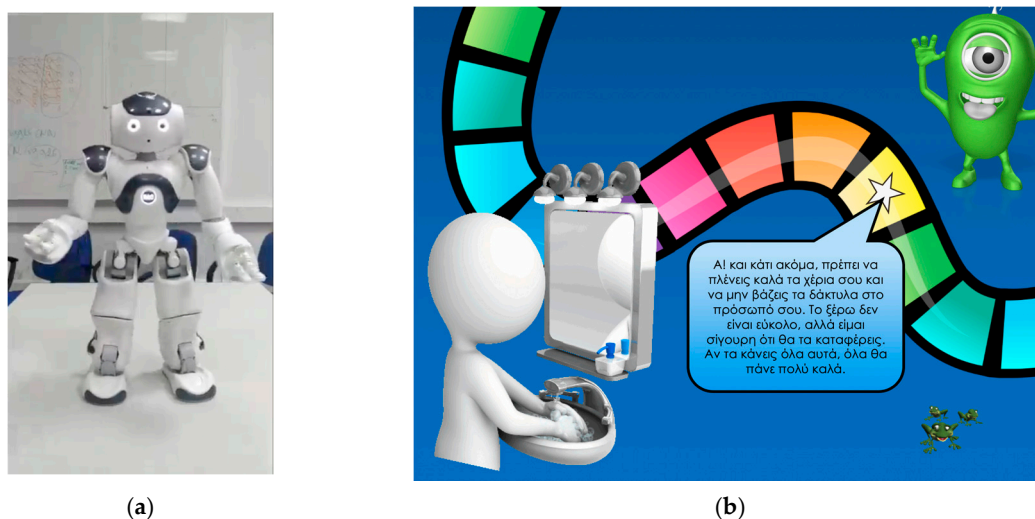
Figure 2. Screenshot of the robot-based video and a slide from the interactive presentation: (**a**) Screenshot of video; (**b**) Example presentation slide.

Since it was not possible for the child to interact with the therapist or the NAO robot in real time, the children were encouraged to follow the instructions given by the text included in the presentations with visual stimuli (for the control group) and by verbal guidance from the NAO robot (for the robot-assisted intervention group). In addition to the presentations and videos there were worksheets which consisted of self-help material and ideas or exercises for the children to work at home. The worksheets included adaptations of the information and activities proposed by the campaigns of official bodies against COVID-19 (see for example [17,18,24,25]), as well as original or customized material from the website Psygrams [26]. Moreover, until the in-person sessions are resumed, each child was encouraged to create a personal album or box with crafts, collages, drawings or related art activities, which they will be able to present to the therapist and/or the NAO robot at the end of the next in-person session. The aim was to maintain cohesion while the children stayed at home, to preserve the therapeutic gains of the preceding interventions as much as possible, and to engage the child in pleasant nondirectional activities that will enhance its motivation for action, according to his preferences and skills, without expectations or requirements regarding the quality of the result.

2.2. Educational Scenario for the Synchronous Sessions

Following the asynchronous digital material, a specially designed scenario for the live session was developed, specifically for the robot-assisted group. The live session is to be supervised and guided by the therapist. The therapist makes the conference call, controls the robot and initiates the various activities. The objective of the synchronous sessions was the investigation of the children's response to the social robot during a video conference call for a given therapeutic scenario. Moreover, results from the live sessions were used to compare the asynchronous and the synchronous methods. The advantages of the synchronous approach stem from the application of central aspects of the original intervention protocol, i.e., the enhancement of the children's engagement, to provide the motivation to actively participate in the various activities, to allow interaction using direct verbal or nonverbal communication, as well as implement imitation and joint attention-oriented activities.

The scenario that was designed specifically for the live Zoom sessions [27] was an adaptation of the original protocol developed for the robot assisted approach. No new concepts and methods were used, because it was decided that these would be detrimental to the purposes of the intervention. Instead, the difficulty level of the educational scenario was adjusted such that it would be to all participating children, and serve as a reminder of their already acquired skills.

The activities selected from the original protocol were the imitation exercise, a relaxation scenario and the end-of-the-session dance. These were selected based on their usefulness in terms of educational goals in conjunction with their implementation feasibility in a teleconferencing context, and were adjusted accordingly. In addition, information regarding the pandemic and the relevant safety measures was integrated, in the same manner as in the SIPs. More specifically, the educational scenario implemented involved the following activities:

1. **Greeting**: The robot greets the child using gestures and gives instructions on how to conduct the video call. Instructions include the way the child should stand in front of the camera and how the child should speak so that effective visual and auditory interaction can be achieved.

2. **Communication skills**: For the second part of the scenario, the robot initiates an imitation exercise designed to determine if the child remembers the imitation skills obtained during the in-person sessions. At the same time, the scenario is attempting to teach the child how to conduct itself in light of the special circumstances of the pandemic. For this reason, embedded in the actions to be imitated are explanations why these actions are needed. For example, the child is shown how to say hello from a distance using gestures, or explanations why wearing a mask is needed.

3. **Dance**: The robot asks the child whether it wants it to perform a dance and requests that the child replicates the movements as an exercise. The dance is chosen from the list of dances that are actually part of the original intervention scenario, so that the child is already familiar with the movements and music.

4. **Relaxation**: The relaxation scenario involves breathing exercises guided by the robot, conducted in the same manner as the in-person meetings. At the end of the relaxation activity, the robot says goodbye and the session is concluded by the therapist.

For the asynchronous sessions, before distribution of the material, parents of the children participating in the study were informed about this initiative and were asked whether they agreed to take part. Consenting parents were sent a link pointing to an online repository where they could download the digital material from, together with detailed instructions on its use. The initiative had a duration of six weeks, with each RIS being sent at the start of the first and the third week and the synchronous sessions starting in week 5. For the synchronous sessions, consenting parents were given instructions on how to setup the Zoom call and convenient meeting times were arranged. All the Zoom meetings took place two weeks after the completion of the asynchronous sessions.

2.3. Implementation on the Robot

The scenarios provided by the clinical scientific team were implemented on the NAO social robot, the robot that the children of the robot-assisted group were accustomed. From a technical standpoint, the scenarios involved speech and specific movements that illustrated specific emotions, actions and dances.

In developing the scenarios, the parameters of the robot's behavior have been the same as those used in the scenarios of the therapeutic protocol. Such parameters include speaking voice, speech speed, gestures etc. Children in the robot-assisted group were already familiar with the robot's physical characteristics, and so, for consistency, the robot was programmed to behave in the same manner. Therefore, while the robot was speaking, the hand motions and the posture were identical to those used for the original in-person intervention scenarios. Additionally, movements illustrating the actions highlighted in the material such as washing of the hands and demonstrations of physical exercises were implemented. Especially during the physical exercises, appropriate music was selected to accompany the exercises and provide additional incentive for their completion.

During the recording of the videos, care was taken to ensure that the position of the camera was at the same level as the eyes of the robot, thus giving the impression that the robot is looking at the child when the video was viewed. The reason for this was to simulate eye contact between the child and

the robot, since the face tracking process implemented for the in-person sessions, was not possible to be used in this case.

On the other hand, the implementation of the scenarios for the synchronous remote sessions was made possible by the fact that initial testing revealed that the robot motion and speech recognition algorithms worked adequately well when the robot was detecting a person on a monitor, as long as the sound and video quality were of a given standard. In our case, Zoom was selected because of its superior performance in these areas compared to other commonly used teleconferencing software. It must be noted though, that the sound and video quality depend on the quality of the internet connection of the participants. Another advantage of this platform was its ease of use, since the parents would only need to click on the link of a Zoom meeting initiated by the therapist, and sent to them prior to the session. In addition, it is a secure platform that preserves anonymity, where the participants do not need to login, enter their name or other personal information.

For the interactive aspect of the scenario to be successful, constant visual contact with the child had to be ensured. To achieve this, the robot was programmed to say, "Now I don't see you" when face detection failed, and to say, ''Now I see you" when visual contact was re-established. The design aimed at reinforcing communication with the child, maintaining their focus and increasing their engagement.

2.4. Evaluation Method

For the evaluation of this study, the parents were invited to supply their feedback via a telephone follow-up that lasted approximately ten minutes, as due to the imposed quarantine face-to-face interviews were not applicable and the exact date of the lockdown withdrawal remained unknown. As part of the intake process, all the responders gave oral consent to participate in the survey. The parents were invited to answer a questionnaire targeting their perceived satisfaction as well as children's satisfaction and engagement. A set of six closed-ended questions rated on a 10-point Likert scale was presented. Parents were asked to respond using ratings from 0 (maximum negative effect or minimum accordance) to 10 (maximum positive effect or maximum accordance) with 5 anchored as a midpoint.

Table 2 lists the questions posed to parents during the telephone follow-up.

Table 2. List of phone survey questions.

Questions
1. How would you rate you child's satisfaction in relation to the Supporting Information Package you received?
2. How would you rate your satisfaction in relation to the Supporting Information Package you received?
3. How would you rate your child's engagement in relation to the Supporting Information Package you received? Could you give me an example?
4. How would you rate the usefulness of the supplemental activities you received?
5. How would you rate your child's feeling of connectedness to the intervention procedure after the Supporting Information Package you received a. Did he/she mention the robot's or therapist's name? b. Did he/she mention anything related to the intervention?
6. Please rate your satisfaction in receiving the upcoming Supporting Information Packages.

As the Zoom version gave the opportunity to observe the interaction between the child and the robot an extra variable named "response" was included in the analysis, based on child's response to the robot's guidance. The variable was anchored from 0 to 6 according to the number of times the child responded to the tasks, posed by NAO (gestures: hand signal "salute", hand signal "no" and hand signal "dislike"); (dance 1, dance 2); (breathing exercise). Score ranged from 0 to 6 with a higher score indicating a better interaction between NAO and the child. The variables "Usage of Supplemental Activities" and "Willingness to receive Supporting Information Packages" were excluded from the second analysis as nonapplicable.

All statistical analyses were performed using SPSS 26.0 (IBM Corp) [28], with $p < 0.05$ as the level of statistical significance. Means (M) and standard deviation (SD) were used to describe the continuous variables. A paired *t*-test was used to compare children's' and parents' satisfaction, children's engagement and connectedness.

The parents' feedback from the telephone survey was collected in two stages: first, after the distribution and completion of the first SIP, and second, after the completion of the synchronous sessions.

3. Results

This section presents the statistical analysis of the answers collected during the telephone survey for the two types of sessions.

3.1. Asynchronous Sessions

In total, nine children, eight boys ($M_{age} = 8.90$, $SD = 1.37$) and one girl aged nine years old, entered the study. Parents of one child (from the control group) did not meet the criterion of being comfortable with the technology needed, and the two parents of the last child (NAO group) were and two parents were not accessible.

A paired *t*-test was used to compare children's overall satisfaction ($M = 8.88$, $SD = 1.61$) to the parents' satisfaction ($M = 9.11$, $SD = 0.92$). Although parent satisfaction was higher than the children's, the results were not statistically significant ($p > 0.05$) (Figure 3).
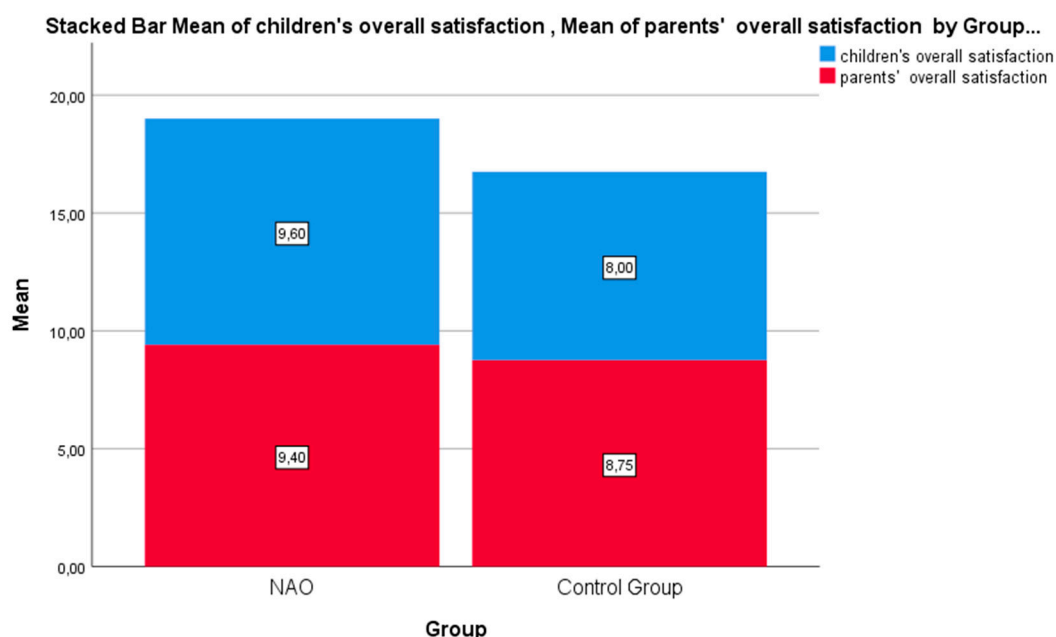

Figure 3. Children's and parents' satisfaction by group.

Results of the independent sample *t*-tests did not result in statistical significance when comparing for differences between the control group and the robot-assisted group in the variables "Children's engagement", "Usage of supplemental activities" and "Willingness to receive Supporting Information Packages" ($p > 0.005$). In contrast, the variable, "Feeling connected after treatment interruption" was found to result in a statistical significance ($t = 239$, $df = 7$, $p = 0.048$). Specifically, children on the NAO-assisted group presented a higher mean ($M = 9.80$, $SD = 0.44$) than children in the control group ($M = 8.0$, $SD = 1.63$). Means and Standard Deviations for all variables and for both groups are presented in Table 3.

Table 3. Means and standard deviations.

Variables	Group	*n*	*M*	*S.D.*	*Std. Error Mean*	*t*
Children's overall satisfaction	NAO	5	9.60	0.54	0.24	1.61
	Control Group	4	8.00	2.16	1.08	$p > 0.001$
Parents' overall satisfaction	NAO	5	9.40	0.54	0.24	1.05
	Control Group	4	8.75	1.25	0.62	$p > 0.001$
Children's Engagement	NAO	5	9.40	0.89	0.40	2.27
	Control Group	4	6.25	2.98	1.49	$p > 0.001$
Usage of Supplemental Activities	NAO	5	7.60	1.14	0.50	1.19
	Control Group	4	5.50	3.78	1.89	$p > 0.001$
Feeling connected after treatment interruption	NAO	5	9.80	0.44	0.20	2.39
	Control Group	4	8.00	1.63	0.816	$p = 0.048$
Willingness to receive Supporting Information Packages	NAO	5	10.00	0.00	0.00	1.78
	Control Group	4	9.25	0.95	0.47	$p > 0.001$

The same variables are also presented graphically in Figure 4.
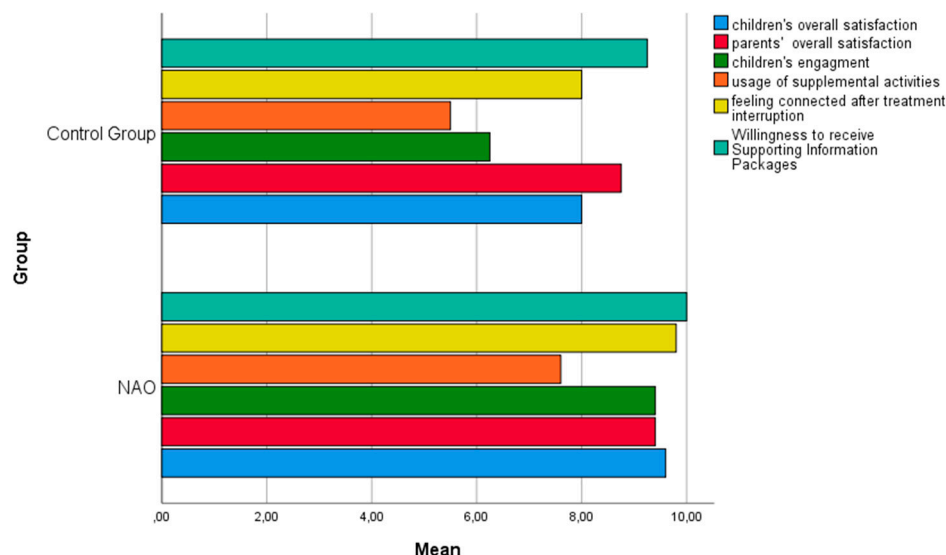

Figure 4. Graphic representation of the group mean variables.

3.2. Synchronous Sessions

Six children from the robot-assisted group, all males, participated in the second study (M_{age} = 8.83, *SD* = 1.47), but only five completed the Zoom session. One child was excluded because the camera was not working in the family's computer and the problem could not be solved, (due to the imposed measures, no technical support was available). As a result, this particular session was postponed to be carried out at a later date. The participant (of the NAO group) who did not participate in the synchronous session was of the same sex, age and carried the same diagnosis with similar clinical characteristics with the participant that although missed the asynchronous session, completed the synchronous one. Therefore, their answers were included in the statistical analysis, as appropriate.

A paired t-test was performed to compare the video (asynchronous) sessions to the Zoom sessions in terms of children's overall satisfaction, parents' overall satisfaction, children's engagement and connectedness. To confirm the appropriateness of the statistical tests used, prior to run the analyses, all assumptions were checked. Specifically the assumptions of normality were explored with the Shapiro–Wilk test that produced a non-significant result based on an alpha value of 0.05, W = 0.94, $p = 0.683$. The result of Levene's test was not significant based on an alpha value of 0.05, F (1, 6) = 0.00, $p = 1.000$, proving that the assumption of homogeneity of variance was met.

No statistically significant differences were found among the four pairs. While children's and parent's satisfaction was found to be higher for the video sessions, connectedness was higher with the Zoom session. The reports on the children's engagement were equally high in both cases. Table 4 compares the questionnaire results between the asynchronous and synchronous sessions.

Table 4. Comparison between video and Zoom session.

Variables	Session	*n*	M (SD)	Mea Dif. (SD)	S. E. Mean Dif.	*t*	*p* Value
Pair 1: Children's overall	Video	5	9.50 (0.57)	1.75 (2.36)	1.81	1.48	0.235
satisfaction	Zoom	5	7.75 (0.18)	-	4	-	-
Pair 2: Parents' overall	NAO	5	9.40 (0.54)	0.80 (1.92)	0.86	1.05	0.405
satisfaction	Zoom	5	8.60 (1.67)	-	-	-	-
Pair 3: Children's	NAO	5	9.25 (0.95)	-	-	-	-
Engagement	Zoom	5	9.25 (0.95)	-	-	-	-
Pair 4: Feeling connected	NAO	5	9.75 (0.50)	−0.25 (0.50)	0.25	2.39	0.391
after treatment interruption	Zoom	5	10.00 (0.00)	-	0	-	-

Children responded to NAO providing a mean of 4.40 (*SD* = 3.40). Taking into account the presence of some technical problems (such as microphone humming and hissing noise on the child's computer, robot's error before step 4, and the child's screen occasionally freezing) encountered during the sessions, the mean response was higher in sessions with a smooth progress (*n* = 2, *M* = 5.50, *SD* = 0.70 vs *n* = 3, *M* = 3.66, *SD* (1.15), but with no statistical significance (*p* > 0.001).

Finally, when parents were asked to choose between video sessions and Zoom sessions, the majority (83.3%) selected the Zoom sessions as their preferred method of tele-consulting. When the same question was repeated in a manner as to include consideration of the in-vivo sessions, all parents reported that they prefer the latter.

Parents were provided with the opportunity to comment on their experience answering an open ended question. Their answers were summarized as follows:

Comment 1: "I hope we had a better connection" (2 parents).

Comment 2: "Child loved it and parents were happy that the child tried Zoom for the first time" (2 parents).

Comment 3: "Very impressive" (3 parents).

Comment 4: "The most impressive part of the intervention was when NAO could restore child's attention by telling him, 'Now I don't see you' and, 'Now I see you'" (5 parents).

4. Discussion

This paper presented a methodology for delivering digital material to children participating in a protocol for ASD interventions during the COVID-19 pandemic, in order to mitigate the effects of the suspension of in-person sessions, in the form of presentations and videos for asynchronous delivery and video conference calls for synchronous sessions. The material was designed in accordance with the protocol applied during the in-person sessions taking place before the restrictions enacted by the government, for both groups of children (i.e., the group with the robot-assisted interventions and the control group). Specially designed questionnaires directed at parents were used to measure satisfaction regarding the material and its usefulness.

The results obtained after statistical analysis of the answers in the telephone survey, show that the children were feeling connected after treatment interruption, which means that the main objective of the initiative was achieved. In other words, the approach that was followed can be considered helpful in preserving the familiarity of children with the therapeutic protocol, while the stay-at-home measures are in place. According to the analysis, this is especially true for the children in the NAO-assisted group, which indicates the usefulness in using the social robot even in this context, where the ability of the social robot to interact with the child is not exploited. Also, the parents appear to be slightly

more satisfied than the children with the support material, even though the results are not statistical significant. This suggests that the initiative was a good way of providing support to the parents as well, in these circumstances. Moreover, children were found to be more connected during the Zoom sessions, and parents reported that they prefer this method for tele-consulting.

Results are limited by the small sample size and should be interpreted with caution, even though small sample sizes are common in the robot assisted therapy research [29–31]. Another potential limitation arises from the use of closed-ended questions. A qualitative research approach could possibly provide an enhanced analysis by offering additional data for consideration. Telephone interviews may also indicate certain amount of bias due to social desirability aiming at pleasing the researcher; however, for the convenience of the parents and in order to minimize misunderstanding and miscommunication, we agreed to collect their responses via a telephone follow-up. By using this method, we also had the chance to encourage respondents to contribute with their comments to the adaptation and improvement of future SIP materials and tele-consulting scenarios. Future studies are needed on this topic to confirm the usefulness of the proposed approach, as results are not considered conclusive. More samples will be needed in the future to confirm the present results with more statistically stringent significant level.

The study has shown that there are benefits in providing personalized support material to children with ASD during the pandemic where there are no in-person sessions, both in the form of asynchronous as well as in the form of synchronous delivery of the material. While it has been shown that even digital material with no interaction properties can potentially mitigate the negative effects of abrupt cessation of an intervention, the addition of a certain amount of interaction in the live sessions with the robot-assisted group resulted in higher connectedness, and has shown to be the parents' preferred method of psychoeducation material delivery compared to the asynchronous approach, which involved videos and presentations. These results offer motivation to further pursue this approach. Finally, the effects of the digital material will be further assessed when the protocol is resumed, where the therapist will be better positioned to determine the extent to which the intervention gains have been preserved.

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