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# A pilot usability study of a humanoid avatar to assist therapists of ASD children

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**Abstract.** In this paper, we report on a pilot study consisting of an evaluation of the usability satisfaction and effectiveness of a preliminary telerobotic system to assist therapists of children with ASD. Unlike existing pre-programmed robotic systems, our solution beamed therapists in a humanoid robot (Pepper) to reproduce in real-time the therapist’s gestures, speech and visual feedback aiming to embody the therapist in a humanoid robot avatar and be able to perform activities during an ESDM intervention. Evaluations of our system, used by eleven therapists in internal tests during mock session without children, are reported and suggest that future use in real therapy sessions with ASD children can begin.

**Keywords:** ASD therapists beaming · teleoperation · humanoid avatar.

## 1 Introduction

Children diagnosed with autism spectrum disorder (ASD) have well-known difficulties in social communication. While the merit of behavioural methods for early social communication training in ASD is well documented, e.g., [23], that of robot-mediated social communication training is only emerging [24, 19]. Studies suggest that robots provide socialisation benefits for people with autism by increasing social engagement and attention, see examples in [22, 28]. These findings suggest that social robots could be therapeutic aids in ASD. For several years now, various studies have been conducted on the possibilities of interaction between humanoid robots and humans, especially with children with ASD, e.g., [9, 22, 28]. However, there are few studies evaluating or highlighting the effects over time of the beneficial contributions of robotic interventions [32, 4]. These perspectives imply new interdisciplinary studies for the design, development and implementation of new robotic observation and interaction systems.

According to a very recent study [38], approximately 1/100 people have an ASD and the recommendations of the French National Authority for Health highlight the value of early and personalised behavioural intervention models in ASD. One of these models is the Early Start Denver Model (ESDM) [16, 31] which is a programme

developed specifically to work with children with autism between the ages of 12 and 48 months (although the programme can be used up to a maximum age of 60 months, that is 5 y.o.). This method is employed for at least 20 hours per week per child in some western countries such as the United States [3]. In France, the care time using this model is most often less than 5 hours/week due to a lack of trained professionals in sufficient numbers, according to the Hospital of Montpellier, which limits the progress of children. Furthermore, one of the foundations of ESDM is the positive engagement between a child and a therapist built through the pleasure of play. Each intervention therefore consists of offering the child different activities that s/he can choose from, then playing with her/him and using every interaction opportunities: e.g., singing songs, approving what s/he is doing by vocal interaction, grabbing and asking for toys to interact with her/him as well, and so on. Through this intervention, therapists have to adapt to each child through play and their wishes. However, it can be difficult for a therapist to accurately and faith-fully collect and analyse all the socially adapted or expected behaviours of the child while being fully engaged in the interaction required by the behavioural intervention. An assistant in these tasks could reduce the therapist’s workload and improve interventions. Therefore, it seems appropriate to use teleoperation technology in this case to assist the therapist in games and collecting data at the same time.

To both see how the robot can assist the therapist during an intervention with the Denver method,

1. we designed a complete humanoid (Pepper) teleoperation system to be operated (beamed) by therapists as own avatar;
2. we conducted a pilot study aiming to train therapists in the use of their social robot avatar Pepper as a tool for therapeutic mediation and assistance in routine care; and
3. assessed our results with respect to complement those found in [24] where virtual reality (VR) teleoperated robots are a relevant tool to deliver intervention with ASD children.

Our hypothesis is that an interactive teleoperated robot is indeed an effective tool for therapists, and is ready to use for future interaction with an ASD child during an ESDM intervention.

## 2 A teleoperated robotic avatar

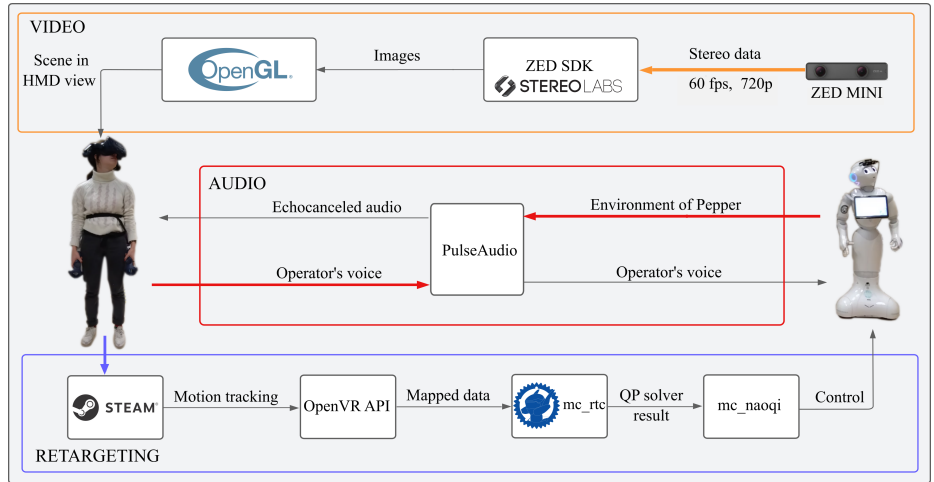
Teleoperation designates a robotic system that is remotely controlled by a user [20]. We choose to use the humanoid Pepper [29] – a robot designed for assistive purpose, e.g., [39], as a therapist avatar to interact with children with ASD. Indeed, this robot is specifically targeted to interact with and assist people in social environments. The robot is 1.20 m high, weighs 28 kg, has 20 DoF and was already used to interact with children, e.g., [24, 35, 14].

To devise our telepresence system, we accounted for different criteria determined by therapists. We have based our technical specifications from two sources: (i) the study in [21] that includes collaboration between doctors, parents and ASD adults;

and (ii) our multiple meetings and discussions with therapists of the Autism Resource Centre (CRA)<sup>5</sup> of the Montpellier hospital, that started two years ago.

The main robot functionality requirements we retained are: the appearance shall be “friendly”; the voice should be soft; the robot must be able to get down to the appropriate children’s level; to interact with them with human-like gesture and be able to carry an object when given (e.g., carry a small toy to propose the child to play with it). The main requirements for the whole telerobotic system are: a minimal training phase (time) for therapists before the intervention; installation with minimalistic equipment for easy set-up on hospital premises.

The whole body control is made with our framework `mc_rtc`<sup>6</sup> and `mc_ naoqi`<sup>7</sup> thanks to previous work carried out in [8].



**Fig. 1.** The simplified system architecture to teleoperate Pepper through VR. The system is divided into three parts: (1) The video stream; (2) The audio stream; (3) The retargeting module.

To enable remote control of the robot, VR tools are integrated into the development of the remote operation system. As shown in Fig. 1, the whole architecture is structured between two main entities: the Pepper and the VR materials connected to the software `SteamVR`. An `HTC VIVE Pro` Head-Mounted Display (HMD) enables the teleoperator to display to the therapist the stereo video environment perceived by a `ZED Mini` camera mounted on the head of Pepper. Then, to transmit the sound environment between the therapist and the child, the internal microphone and loudspeaker of Pepper are connected to the HMD.

<sup>5</sup> <https://www.autisme-ressources-lr.fr/index.php>

<sup>6</sup> [https://github.com/jrl-umi3218/mc\\_rtc](https://github.com/jrl-umi3218/mc_rtc)

<sup>7</sup> [https://github.com/jrl-umi3218/mc\\_ naoqi](https://github.com/jrl-umi3218/mc_ naoqi)

## 2.1 Retargeting

One of the main challenges is to have an intuitive anthropomorphic mapping between the therapist and the robot workspaces. This is particularly challenging due to the short size of this robot and the limited number of DoFs. Different methods have been proposed to solve this issue, e.g., [24, 13, 1]. To control the robot remotely in real-time, a first method trial is tested based on [13]. The idea is to base the whole retargeting on the orientation and angular velocity of each link and not to take into account the positions. This way, size and morphology factors are not an obstacle. However, the limited number of DoFs, 6 in each arm with the wrist and elbow yaw being redundant, leads to an over-constrained arm control. This method is therefore not suitable.

In the end we developed our method that we also implemented successfully in another context and another humanoid [11]. The user is equipped with an HTC VIVE VR headset, two controllers in the hands and one VIVE tracker on the lower back as shown in the Fig. 1. Each of these elements allows to track in real-time the position and the orientation of the following articulations: head, wrists, and lower back. End-effector hands tracking allows for easy and complete arm movements. Tracking hand posture in the workspace is sufficient to achieve “human-like” arm movements for the robot Pepper, due to the limited DoFs in each arm. Hand, lower back and head postures are tracked in the **SteamVR** reference world  $w$  with the transformation matrix at the origin  $O$ :  $T_{Ow}^{Hw}$ ,  $T_{Ow}^{Bw}$  and  $T_{Ow}^{HEw}$  respectively.

As a difference with [11], a scaling ratio  $\alpha$  is determined at the start of the controller’s launch, to match the size of the therapist’s arms to that of the controlled robot with a sensation of matching size. The position of the user’s shoulder  $S$  relative to the tracker in the lower back is assessed *a priori* using a tape measure. The ratio  $\alpha$  corresponds to the ratio between the length of the user’s arm  $l_{\text{human}}$  (measure between the position of the shoulder and the beginning of the finger) and that of the robot  $l_{\text{robot}}$ , that is,

$$\alpha = \frac{l_{\text{robot}}}{l_{\text{human}}}, \quad \alpha \in [0,1] \cap \mathbb{R} \quad (1)$$

The lower back tracker is used as the reference frame to sustain posture coherence between the robot and the operator if the latter moves during the teleoperation. The position of the hand for example, relative to the shoulder in the **SteamVR** world reference is:

$$T_{Sw}^{Hw} = T_{Ow}^{Hw} (T_{Bw}^{Sw} T_{Ow}^{Bw})^{-1} \quad (2)$$

Thus with the robot’s wrists as end-effectors, the hands are directed into the robot’s frame  $r$  through the position and orientation of the controllers. The ratio  $\alpha$  is applied to the relative position of the hand in the world frame of reference to obtain its posture relative to the shoulder in the robot frame of reference.

$$T_{Sr}^{Hr} = \begin{pmatrix} R_{Sw}^{Hw} & \alpha \cdot p_{Sw}^{Hw} \\ 0 & 0 & 0 & 1 \end{pmatrix} \quad (3)$$

As the reference frames are not oriented in the same way between the robot and **SteamVR** (designed as a world reference frame), a mapping is defined manually for each tracked body. Moreover, an offset is applied to correspond to the correct initial posture.

Then, the position of the hand in the robot frame is determined by multiplying the matrix in eq. (3) by the transformation matrix of the shoulder in the robot frame, assuming that the robot and human shoulder are in the same posture. The same method is applied for the head, with only the orientation needed (head yaw and head pitch).

## 2.2 Perceptual feedback

**Visual Feedback** To display the view to the user, we render the scene (in practice, the child room environment) in the VR headset. To do this, a **ZED Mini** camera is mounted on the robot at the eye level. The camera is attached using a system that allows its height and orientation to be adjusted. Adjusting its orientation, notably slightly forward, allows the therapist to better see the robot hands in the reduced field-of-view of the camera and due to the anatomical proportion of the robot. Adjusting the height allows the therapist to be better embodied [2]. To render the view in the HMD, data from the robot camera are extracted by means of the **ZED SDK** with a 720 p resolution and at 60 fps; then they are rendered through a texture in a scene with **OpenVR** and **OpenGL**.

To help users become more aware of their ability to move in space, red bands appear around the visual field of the display point-of-view, as the mobile base approaches an obstacle. An obstacle is detected at a 50 cm distance. The sonars in Pepper’s mobile base can be used to assess possible impacts to the front and rear, and the infra-red sensors for the right and left sides.

**Sound feedback** Real-time audio feedback is established between the robot and the teleoperator via the PulseAudio server and the FFmpeg library as shown in Fig. 1. On the robot side, the loudspeaker and microphone are very close together, inducing an echo that will be heard on the user side. The **echo-cancel** module is then used to cancel this effect. The voice of the robot is then the one of the therapist who knows how to modulate her/his voice according to the child in front of her/him.

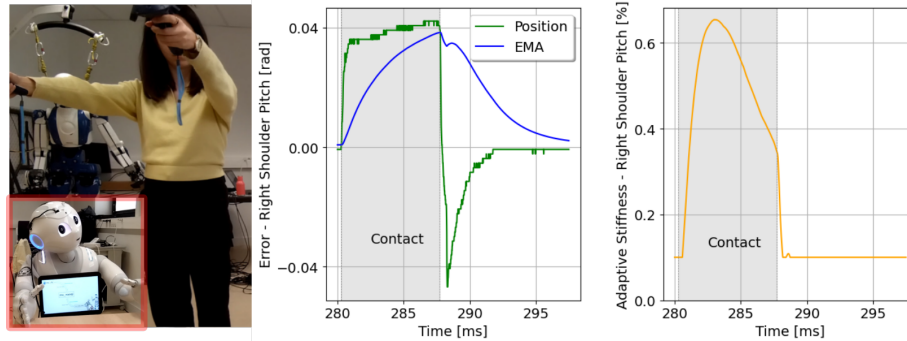
## 2.3 Adaptive joint stiffness

During teleoperation the hip actuator (between the torso and legs) is supporting the weight of all the upper body which is half of Pepper weight. The joint is in a quasi-static posture during 15 mn of intervention and has a tendency to overheat. In NAOqi the stiffness is in %, 0 meaning the joint is free and 100 meaning the joint can use full torque power. When the stiffness of all joints is at 100% all the time, as our design control with **mc\_ naoqi** was before, the leg joint overheats in less than 15mn. Aldebaran Robotics proposes a *smart stiffness*<sup>8</sup> solution to adjust the torque power over time, proportional to the error. However, since the error is not considered as an absolute value, as soon as the error is negative, stiffness falls to 0. This means that during teleoperation, one may be locked in a position, by moving one’s arm backwards for example. We decided to propose our own adaptive stiffness with a corrector as follow:

$$S = K_p \cdot |q_d - q_r| + K_i \cdot \text{EMA}_{\Delta t}(|q_d - q_r|) \quad (4)$$

<sup>8</sup> <http://doc.aldebaran.com/2-4/naoqi/motion/reflexes-smart-stiffness.html>

where  $q_d$  (rad) is the joint target value provided by the QP controller;  $q_r$  is the real encoders value (rad);  $K_p$  is a positive proportional gain;  $K_i$  is the negative integral gain; and  $\text{EMA}_{\Delta t}$  stands for exponential moving average along  $\Delta t$  s. We use the EMA filter instead of an integral value to reduce the stiffness if the average absolute error, over a time window, is too large. In this case, if the therapist pushes over one arm during teleoperation, the stiffness will grow proportionally and then decrease after a few seconds so it can avoid damaging the motors.



**Fig. 2.** Adaptive stiffness values (in light orange) on the right shoulder over time when the arm is pushed manually and the torque error increases (dark green). The EMA of the absolute error is in (dark blue).

This is particularly useful because Pepper does not have a force sensor so it is not easy to implement haptic feedback [7, 6]. So during teleoperation one could contact a table, for example on the side, without being aware of it and unintentionally push over the table which can damage the motors. With our method, the stiffness will decrease avoiding damaging the motors, see Fig. 2. The final value is then filtered with: (i) the robot’s native method of reducing stiffness when it reaches a threshold according to four defined levels; (ii) a value always between 10 and 100%, except when the temperature reaches level 4, in which case the stiffness is reduced to 0; (iii) a first-order low-pass filter with sampling period  $dt=0.012$  s and a cutoff period of  $100dt$ .

### 3 Use case and pilot study

#### 3.1 Early Start Denver Model: a use case

The ESDM is a behavioural therapy technique with a major advantage: its therapeutic methods are entirely play-based. This helps to improve the social and communicative skills of children with ASD. A list of skills is drawn up to assess the child’s abilities, and learning objectives are written in collaboration with the parents. Each goal is divided into several progressive learning steps, from the basic skill, the one observed in the initial assessment, to complete mastery of the goal as defined in [34]. Several studies

have shown the effectiveness of ESDM for autism, e.g., [33]. The study in [17] show a significant improvement in autism symptoms in children aged between 18 to 30 months. These improvements included language, IQ and social skills after two years of therapy.

For the purpose of this study we determined with two speech therapists, three tasks over 15 mn. This duration is chosen to represent the end of 1-hour sessions, during which children often lose attention. They would therefore need to re-engage them in the session. The three tasks chosen were determined in such a way that Pepper would be able to carry them, and which are part of the tasks proposed in the Rogers and Dawson manual on learning to communicate [34]. These three tasks are:

- Task 1: *responding to greetings* - Social Competencies, Level 1, item 8;
- Task 2: *imitate 5 movements involving visible parts of the body in song/play routines* - Imitation, Level 1, item 2;
- Task 3: *giving the requested object* - Receptive Communication, Level 1, item 13.

### 3.2 Preliminary testing scenario with therapists

**Population** To evaluate the acceptance of the guided robot in teleoperation as a therapy tool in the department of the CRA, we recruited 11 therapists (2 registered nurses, 2 child psychiatrists, 6 psychologists, 1 speech therapist), all are staff of the Montpellier Hospital and none of them is from the co-author list. We don't have the benefit of feedback from the psychomotor therapist, who lost interest in the issue after noticing that the robot has very little grip in the hands and lacks dexterity. We considered the following as inclusion criteria: work in the CRA team with children with autism syndrome, no history of epilepsy for visual feedback in VR. The group is constituted with 81.81% of women (9) and 18.18% of men (2), with 4 people under the age of 30, 2 between 31 and 40 and 5 over 41. This repartition is representative of the gender proportion in this department. Few of the participants in the study are familiar with new technologies: only one had already used a virtual reality headset (but not with ASD children); none had ever used a humanoid robot such as Milo [27], Kaspar [36] or Pepper [14], and only 4 out of the 11 participants said they were used to using digital tools during their work (such as eye tracking, tablets and external cameras), one 'always', two 'rather' and one 'sometimes'. The other participants are not used to working with digital tools (4 'at all' and 3 'rather not').

**Study protocol** During the preliminary study, each participant tries the system within the same conditions, in order to complete tasks needed during interventions.

**1) Training:** First, a period of 5 mn for each participant is dedicated to the training of the system, recognizing the button commands, understanding the goal and the movement possibilities. This first part of training is made in simulation with the robot displayed in an RVIZ scene.

**2) Teleoperation trial:** Then, a session of 10 mn of VR teleoperation is started with different goals to meet: (i) To see if they are able to move in space and be aware of their environment, they are asked to cross the hall from the teleoperation room to the intervention room (around 2 m away); (ii) greeting another person in the intervention room, as asked for the (Task 1); (iii), asking each user to reproduce



different song routines they know, one at least, with gestures (Task 2), (iv) and finally we ask them to choose a game among many disposed in front of them, and try to ask for it and catch it (Task 3).

**3) Teleoperation free time:** At the end of the session we proposed to each participant if s/he wanted to test something else, and let them try to see if they succeeded in doing other tasks.

**4) Feedback:** After removing the VR material, each participant answered four questionnaires: (i) one overall questionnaire to know the profile of each of them (age, gender, career...); (ii) one *Usability* Metric for User Experience (UMUX) questionnaire which follows the definition of the ISO 9241–11 of usability [15], adapted to our design setup and evaluate with a 7-point Likert scale [25]; (iii) one *pragmatic* quality scale from AttrakDiff2 [18] which describes the usability of the system and determined if the user is able to meet her/his goal using it. It is used to complete and to compare with the previous one and is evaluated also with a 7-point Likert scale; (iv) an *acceptability* score to assess the views of therapists from CRA towards social robots as a tool for autistic children, this survey is inspired by the study of [30] with 5-point Likert scale. The questions are: Q1- In your opinion, is it acceptable for social robots to be used as assistants for care staff during interventions with ASD children? Q2- In your opinion, is it acceptable for social robots to be used to monitor the progress and help diagnose an ASD child? Q3- In your opinion, is it acceptable for information to be recorded and stored by a robot when it interacts with an ASD child? (assuming parental consent) Q4- In your opinion, would it be acceptable for some ASD children to perceive social robots as friends following their therapy? Q5- Do you think the risk that some children might become attached to social robots is acceptable? Q6- Do you think it's acceptable to use social robots that closely resemble humans? The original version of the questions is established in French.

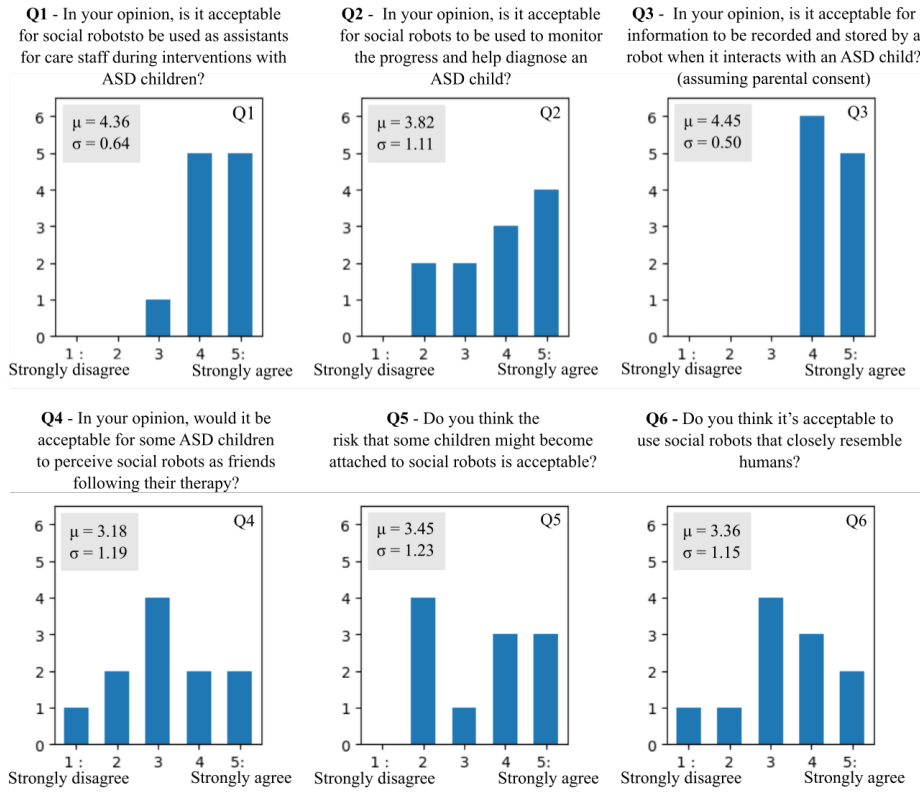
## 4 Results

Each of the 11 participants succeeded in completing all the tasks during teleoperation: saying “hello” and “goodbye” using speech and gestures (Task 1); mime and sing a nursery rhyme (Task 2); managing to move the robot to another room along a hall in the hospital ward to go to the intervention room; and grabbing an object to play with (a rainstick and a ball) after asking for it (Task 3). These tasks took between 4 and 10 mn to complete, depending on the skill and willingness of each operator to complete the tasks quickly. Some of the therapists asked to try other activities: 3 decided to point their hand at another object they wanted to try and manipulate (maracas, for example); 1 therapist wanted to shake the hand of another therapist with whom the robot was interacting; and 5 therapists tried to return the ball by throwing it. However, due to the delay in opening the hand, the throws were unsuccessful. Some limitations of the system were raised. Almost all participants needed guidance to be able to move around the corridor and the slightly heavy rain stick tended to slip out of Pepper’s hands.

The user experience (UX) is evaluated using two questionnaires: one usability score and one pragmatic quality score. The first questionnaire, adapted from methode UMUX, is evaluated following the method of System Usability Scale (SUS) score and

the one presented in [15]. Each question is scored with a value between 0 and 6. The questions Q1, Q2, Q3 and Q5 are scored following the rule  $[score - 1]$  and the Q4 and Q6 with  $[7 - score]$ . To calculate the total score as a percentage, we divide the sum by 36 and multiply the result by 100. This score is calculated for each participant and we obtain a final average score of  $\mu = 66.67\%$  and  $\sigma = 10.83\%$ . The pragmatic quality score is above 4 on average for each question, which is the minimum value to be acceptable.

The acceptability of the robot as a therapeutic aid for carrying out an ESDM session is obtained from the final questionnaire. The aim of this questionnaire is to understand the wishes and concerns of the therapists with regard to this new technology and the possibilities of working in the department. The first three questions concern the acceptability of using the tool. The second part is about the general use of humanoid robots. Responses to the questions 1 and 3, see 3, have on average high scores (value out of 5 from 1-“Strongly disagree” to 5-“Strongly agree”) and small standard deviation (std) as shown in Table 1. Whereas questions 2, 4, 5 and 6 have lower average score with wider std.



**Fig. 3.** Acceptability score data, mean and standard deviation (in grey boxes) for each question. The answer are evaluated with semantic differential questions and the answers : 1- Strongly disagree 2- Disagree 3- Neutral 4- Agree 5- Strongly agree.

**Table 1.** The UX results for usability and pragmatic quality of the system.

UMUX questions (Scale score 1 to 7)	n	mean	std
1. Do you think this teleoperation system is a good intermediary for interacting with children with ASD?	11	4.72	1.35
2. Do you think this remote operation system is a good tool to assist you during interventions?	11	4.64	1.21
3. The system allows users to perform a 15 mn ESDM session.	11	5.10	1.51
4. Using Pepper in teleoperation is a frustrating experience.	11	2.91	1.97
5. This remote operation system is easy to use.	11	5.18	0.75
6. I have to spend too much time correcting things with this teleoperation system.	11	2.72	0.90
AttrakDiff2 - (Scale score 1 to 7) - The teleoperation system is rather :	n	mean	std
1. 1-Technical 7- Intuitive	11	4.64	1.63
2. 1-Complicated 7- Simple	11	5.18	0.98
3. 1-Not practical 7- Practical	11	4.64	1.03
4. 1-Cumbersome 7- Straightforward	11	4.00	1.00
5. 1-Unpredictable 7- Predictable	11	5.36	1.36
6. 1-Confusing 7- Clearly structured	11	5.73	1.01
7. 1-Unruly 7- Manageable	11	5.45	0.93

## 5 Discussion

The results of the questionnaires and the feedback from the therapists and our observations show that *the system is usable* to perform a 15 mn ESDM session for three predefined tasks. The results of the UMUX-like survey of 66.67% highlights the correct usability of the system according to the SUS and UMUX score metrics: between “ok” and “good” on the scale, but also reveal paths of possible improvements. The score of the pragmatic quality questions validates this same hypothesis with scores slightly above the average (i.e., above 4). The main limitations put forward the therapists are: the lack of dexterity in the hands that prohibits fine manipulation of toys. Currently, a single actuator enables the hands to be opened and closed completely, making it impossible to point with the fingers (useful for expressive communication [5]). This lack of dexterity due to the design of the robot [29] means also that it is unable to grip objects that are too large or relatively heavy. And the absence of wrist flexion/extension actuator makes the gripping tasks more complicated. This clearly puts high-constraints on next-generation robotics design for ASD applications, notwithstanding the consequent impact on prices. During teleoperation, some therapists also discovered that due to the limited workspace of Pepper [1] some postures are more complicated up to not possible to reproduce with Pepper than others. For example: clapping both hands, spinning both arms around one another or maintaining both hands in contact while moving. Two participants judged

that a more important amount of time, i.e., higher than 5 mn, is necessary to be trained with the system before manipulation, to be completely efficient during interventions.

Regarding *visual feedback in VR*, many therapists mentioned before teleoperation that they might have sickness and nausea, but only one participant mentioned a disorientation after removing the HMD. The reduced field of view means that therapists do not always have full confidence that the robot is perfectly replicating the gestures produced and do not feel completely aware of their environment (i.e., lack of embodiment [2]). However, when interacting and learning with ASD children, they want to make sure that the movements made are understandable to the child. We might consider having two point-of-views displayed on two different screens such as the setup of the Team Northeastern during the global competition ANA Avatar XPrize [26]: (i) in a first screen: a ZED 2 camera with a wide field-of-view and positioned high up to display a global view of the room, 2) in a second screen: the ZED Mini camera on Pepper displays the robot’s point of view, and the operator wears 3D glasses. A VIVE tracker is then placed on the head to track the movement of the user instead of the HMD. The latest feedback on VR is to sit down during teleoperation so as to be more or less at the same height as the robot, and so be less disturbed in seeing the environment from below.

As raised by one participant of this study, the *acceptance* is subjective to each individual and requires a multidisciplinary approach. These results are only indicative in the context of the Montpellier CRA and our protocol.

According to the results, most of the therapists agreed that a social robot can be used as a tool to interact with ASD children as an assistant and for recording and collecting data. Although the average is high for diagnostic aid and assessment of the child’s progress, the standard deviation is higher. Practitioners emphasise that the robot must remain in the field of assistance as it is also highlighted in [12]. However, as this department is a diagnostic unit, the feeling of being able to be replaced was often evoked and may have had an impact on the answers to this question. The responses from the 11 therapists show heterogeneous opinions on the acceptability of the *robot’s appearance* in the case of it being a humanoid robot. The study in [30] reveals the same non-conclusive results regarding the acceptability of human-like robots. The lack of examples of this type of interaction may be a hindrance, and as one of the therapists pointed out, the look and ease with humanoid robots may be different for autistic children. A study carried out in [37] shows a positive appreciation by children of the Pepper robot. On the other hand, any other shape would have made it difficult to beam and teleoperate!

Another concern raised is that the child may interact with the robot and make progress in social communication with it. Yet, there is no guarantee that any progress can be reproduced when interacting with humans over time.

## 6 Conclusion and future work

This pilot study allowed us to assess that our system can effectively be used by and assist therapists during a short ESDM intervention with ASD children. It also shows that they are willing to try out new tools and agree to help design new ones

to better assist them during therapy sessions. Obtained feedback revealed rooms of improvements for the teleoperation system with a view to setting up a future protocol at Montpellier University Hospital. The improvements will focus on visual feedback by adding SLAM [10] or two point-of-views on two screens [26] to increase therapists awareness of their environment, and on the implementation of haptic feedback to avoid collisions and complement sensory feedback for better interaction with the children. Another protocol beginning in fall 2023 will evaluate the quality of the robot as a tool during ESDM intervention with children aged between 18 to 30 months. This new study aims to evaluate the relevance of the solution during real interventions both for therapists and children. That is, whether this technology will enhance the learning effects of social communications according to the tasks defined above, and whether this will enable therapists to concentrate more on the session while the robot itself records the children’s progress and proceed with predefined markings.

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