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Identifying linguistic cues towards developing robots with empathy in autism interventions

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Abstract

The last decade autism research has been enhanced by the use of social robots and several studies suggest that children with Autism Spectrum Disorders could benefit from robot-assisted interventions. In order to design and implement therapeutic interventions with robots without interrupting the intervention's flow, one should take into account possible technical issues that could arise. The main objective of this study was to gather information from experts in the field of autism and develop linguistic cues to which the robot would respond automatically. A qualitative approach was used to explore specialists' preferences. Online surveys were completed by 33 professionals from different backgrounds to select the vocabulary more often used in psychosocial interventions with autism spectrum disorders children, in specific situations. Six linguistic cues were identified and specific phrases were used so as to accordingly program the robot to show empathy and respond, when a crisis emerges. The session's flow in robot-enhanced interventions could benefit by controlling robot's behaviour with linguistic cues phrased by the therapist. The implications of these findings are discussed in relation to pilot implementation. This work consists of a qualitative study aiming at strengthening the application of a larger research intervention protocol to explore the interaction of children with autism spectrum disorder with a social robot.

Key words: social robots, autism spectrum disorders, human-robot interaction, psychological intervention, robotic empathy, robot-assisted therapy

АУТИСТ БАЛАЛАРМЕН АРАЛАСУДА АЯУШЫЛЫҚ СЕЗІМІН БІЛДІРЕТІН РОБОТТАРДЫ ДАМЫТУ ҮШІН ЛИНГВИСТИКАЛЫҚ СИГНАЛДАРДЫ АНЫҚТАУ

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ТҰЖЫРЫМДАМА

Соңғы онжылдықта аутизмді зерттеу әлеуметтік роботтарды қолдану арқылы жақсарды, ал кейбір зерттеулер роботтық араласудың аутизм спектрі бұзылған балаларға пайдалы болатындығын көрсетті. Роботтарды қолдана отырып, терапевтік шараларды әзірлеу және жүзеге асыру үшін араласудың барысын тоқтатпай, туындауы мүмкін техникалық проблемаларды ескеру қажет.

Бұл зерттеудің негізгі мақсаты аутизм саласындағы мамандардан ақпарат жинау және робот автоматты түрде жауап беретін тілдік сигналдарды дамыту болды. Мамандардың қалауын зерделеу үшін сапалы тәсіл қолданылды. 33 түрлі маман белгілі бір жағдайларда аутизм спектрі бұзылған балалармен психоәлеуметтік араласуда жиі қолданылатын сөздік қорын таңдау үшін онлайн-сауалнаманы жүргізді. Алты лингвистикалық сигналдар анықталды және дағдарыс туындаған кезде жанашырлық пен реакцияны көрсету үшін роботты бағдарламалау үшін нақты тіркестер қолданылды. Роботтық араласулардағы сессияның барысы терапевт ұсынған лингвистикалық сигналдардың көмегімен роботтың мінез-құлқын бақылау арқылы пайдалы болуы мүмкін. Бұл жұмыс аутизм спектрі бұзылған балалардың әлеуметтік роботпен өзара әрекеттесуін зерттеу үшін зерттеу араласудың кеңейтілген хаттамасын қолдануды күшейтуге бағытталған сапалы зерттеуден тұрады.

Негізгі сөздер: әлеуметтік роботтар, аутизм спектрінің бұзылуы, адам-роботтың өзара әрекеті, психологиялық араласу, роботтық эмпатия, роботталған терапия

ОПРЕДЕЛЕНИЕ ЛИНГВИСТИЧЕСКИХ СИГНАЛОВ ДЛЯ РАЗРАБОТКИ РОБОТОВ С ПРОЯВЛЕНИЕМ СОЧУВСТВИЯ В ИНТЕРВЕНЦИИ С ДЕТЬМИ АУТИСТАМИ

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РЕЗЮМЕ

В последнее десятилетие исследования аутизма улучшились за счет использования социальных роботов, и некоторые исследования показывают, что для детей с расстройствами аутистического спектра роботизированные интервенции могут пойти на пользу. Для разработки и внедрения терапевтических интервенций с помощью роботов, не прерывая ход интервенции, следует учитывать возможные технические проблемы, которые могут возникнуть. Основная цель настоящего исследования состояла в том, чтобы собрать информацию от экспертов в области аутизма и разработать лингвистические сигналы, на которые робот будет реагировать автоматически. Качественный подход был использован для изучения предпочтений специалистов. 33 специалиста разной квалификации прошли онлайн-опросы, для того, чтобы выбрать словарный запас, который чаще всего используется в психосоциальных интервенциях с детьми с расстройствами аутистического спектра в определенных ситуациях. Идентифицировано шесть лингвистических сигналов и использованы конкретные фразы, чтобы соответствующим образом запрограммировать робота на проявление сочувствия и реагирования в случае возникновения кризисной ситуации. Ход сеанса в роботизированных интервенциях может пойти на пользу путем контролирования поведения робота с помощью лингвистических сигналов, предложенных терапевтом. Данная работа состоит из качественного исследования, направленного на усиление применения более широкого протокола исследовательской интервенции для изучения взаимодействия детей с расстройствами аутистического спектра с социальным роботом.

Ключевые слова: социальные роботы, расстройства аутистического спектра, взаимодействие человека и робота, психологическая интервенция, роботизированное сочувствие, роботизированная терапия

Introduction

There is a growing recognition of the potential value of robot-assisted therapy in children with Autism Spectrum Disorders (ASD) [1-5]. Despite the promising results from prior studies [6-8], we are far away from conducting a psychological intervention in which a robot will have the main role of a therapist [9]. In order to achieve this level of autonomy the robot's emotional intelligence should reach a level where the child's emotions, either expressed verbally or non-verbally, would be properly identified and addressed with an appropriate response.

During psychosocial interventions, the recognition and understanding of the child's emotions is crucial for establishing the therapeutic relationship [10]. Human therapists also use specific clinical skills and promote empathy to enhance the quality of interaction; they use their tone of voice, their facial expression, their body language and choose carefully their words to reflect, to paraphrase and to empower the child. These skills would also be effective for controlling human-robot interaction. Dialogue is the main joint process of communication in human-robot interaction. Thus, in order to improve the quality of such an interaction, it is essential for social robots to be capable of guiding a dialogue towards specific directions, so as to serve specific therapeutic intervention purposes. The latter is considered of great importance due to the current robots' perception (e.g. speech processing) limits. A meta-analytic review concluded that empathy accounts for between 7–10% of the variance in therapy outcome studies [11]). It is therefore very important to support robots' communication skills with empathetic cues.

A dominant approach towards the implementation of therapeutic interventions incorporates supervised autonomous robotic systems [12]. Until now the usual technological architecture in therapeutic scenarios includes the "pressing buttons procedure" or using the laptop to move forward from one scenario to another [13]. Most of the times in studies involving social robots, a professional is required to appraise the completion of the task and at the same time to manually guide the robot in order to include it in the process and keep the session flowing [9]. However, the challenges that derive when working with ASD children, due to the variety of their symptoms, make the previously described method difficult to implement without interrupting the session's flow. Challenging behaviours such as ignoring requests, physical aggression towards self or others, temper tantrums and extreme emotions are major barriers to robot's autonomy.

One of the biggest challenges in designing a robot-assisted intervention is to program the robot in order to be able to respond accordingly when the child is showing signs of distress. This needs to be done without manually controlling the robot from the laptop or by pressing embedded buttons, since this will demand a shift of the therapist's attention to the robot instead of the child.

The current study is part of an ongoing larger project that aims at involving the robot as a co-therapist in a psychosocial intervention targeting the autism core symptom of impaired social communication, challenging behaviours in children with ASD. In order to address the above mentioned challenges and develop a robust protocol design, a multidisciplinary focus group was put together to identify the intervention's requirements. After several focus group sessions, one of the main challenges was to identify how the robot will behave when a "crisis" appears relevant either to the child or to the robot itself (robot's malfunction).

To overcome the potential hurdles and minimize the children's discomfort, it was decided to conduct a qualitative study that would explore the vocabulary used by therapists, educators, and medical doctors when a problem arises during the interaction with the child. The results of the study would subsequently guide the IT team to program the robot in a way to be able to regulate a conversation, guide the therapeutic activities and thus, enrich the robot's communication with the child. Trigger words were selected based on the frequency the professionals are using them so as to guide the robot's behaviour when something unexpected is happening. We aim at programming the robot to react accordingly to linguistic cues phrased by the therapist facilitating the intervention's flow. Based on the results of the aforementioned qualitative study, the robot's vocabulary was adjusted so as to include phrases that express empathy, suitable for a variety of situations from minor to great difficulty.

Material and methods

The main objective of this study was to systematically transform information from experts in the field of autism into linguistic cues to which the robot would respond automatically by modifying its behaviour (movement or verbal communication). A qualitative approach was chosen to quantify the occurrence of words and phrases expressing empathy that are being used during therapeutic interventions with ASD children.

Research questions

The following research questions were formed to address the purpose of this study:

• What are the characteristic phrases that reveal empathy and strengthen the therapeutic relationship in a crisis?

• What are the most frequent words used by specialists under specific circumstances in autism interventions?

Participants

Purposive sampling was used [14]. The sample consisted of 33 people in total; 31 female and 2 male specialists (15 psychologists, 6 special educators, 6 speech therapists, 4 occupational therapists and 2 pediatricians). The sample consisted of employees in public hospitals (n=8), in private practice settings (22) or both (3) with at least four years of working experience each in the field of developmental disorders. Thirty percent of the participants (n=10) were aged between 26-29y, 45,5% (n=15) between 30-45y and 24,2% (n=8) between 46-59y. All the participants gave their informed consent prior to their inclusion in the study.

Data collection and analysis

An online survey with open-ended questions was the selected method in order to allow the access to a broader participant pool. The questions were developed by the researchers in line with the themes proposed by the focus group. A set of open-ended questions was used to identify the main research questions. Participants remained anonymous and used the online survey tool at a time and place of their preference.

Survey topics focused on the difficult situations potentially experienced during an intervention with an ASD-child and on how therapists empower children when needed.

The survey was conducted during a three months time-range, between June and August 2019 in Thessaloniki, Greece. Qualitative analysis was conducted using content analysis techniques [15-17]. Participants were given a numerical code for analysis purposes. Prior to responding to the open-ended questions, participants had to read the protocol rationale, provide their consent and some demographic data such as their age, years of experience and professional status. The completion of the survey required approximately 30 minutes.

The answers of the respondents were scrutinized one by one in a qualitative way. The analyst examined each patient's response and selected specific data according to the aim of the present study. Upon targeting data, the researcher focused on further analyzing the answers looking for potential correlations among the respondents. Furthermore, the aim was to discern specific topics associated with the current study's objectives.

Results

Table 1 presents categorised themes regarding situation-specific conditions usually experience during a therapeutic or educational session when working with ASD children. Furthermore, data analysis offered an interpretation of the communication strategies employed by professionals during their interaction with autistic children. Table 2 includes the communication and interaction strategies in specific contexts.

Table 1 Themes

Theme 1: Enhancing task repetition and/or the attempts to perform specific tasks
Theme 2: Responding to repetitive body movements/stereotypes
Theme 3: Responding to eye contact avoidance
Theme 4: Dealing with lack of cooperation or withdrawal
Theme 5: Addressing tiredness or mental fatigue
Theme 6: Handling aggressive outbursts
Theme 7: Handling meltdowns
Theme 8: Handling temper tantrums

The codes for the condensed meaning units were detected during the data analysis process while a combined coding template was agreed upon. The latent content was also assessed and included. Some participants' quotes were coded into multiple themes as appropriate. Seventeen categories of communication and interaction strategies were coded in total, and are summarized in Table 3 along with their frequency of occurrence between each professional.

According to the findings the most frequently reported communication technique regarding Theme 1 was "Positive Reinforcement" (N=58) followed by "Specific cues" (N=30). For Theme 2 and Theme 6 the most frequent proposed technique was "Setting Boundaries" (N=8) and (N=17), respectively. For Theme 3 the majority of specialists proposed "Specific cues" (N=11) and for Theme 4 "Encouraging active participation" (N=8). For Theme 5 they preferred "Time out" (N=13) and for Theme 7 "Acceptance" (N=20). Finally for Theme 8 the respondents selected "Reflecting feelings" (N=6) as their main technique.

The majority of the participants favoured techniques as "reflecting feelings", "acceptance" and "setting boundaries". "Suggesting time out" was also noted multiple times. Less frequently referred categories were "distancing techniques", "encouraging active participation", "emotion exploring", "physical contact", "relaxation techniques", "I" messages, "safety awareness", "comforting", "adjusting surroundings background", and "offering visual cues".

Following that, frequent used single word cues were identified from the examples that the experts gave representing each category and were tested at the IT lab for adaptability by the robot. This process resulted in six linguistic cues presented in Table 4 that were used to control the robot's behaviour, when the normal flow has to be changed. The trigger words-recognition implemented algorithm was based on Interval Numbers (INs) [18]. An IN is an established mathematical object that may represent either a fuzzy interval or a distribution of numbers. A classification scheme was adopted to recognize the trigger words. This method was especially designed to be a computationally inexpensive tool used in conjunction with the robots' build-in speech recognition engine.

Discussion

The purpose of this study was to explore patterns that shape empathetic rapport in clinical and educational settings that may subsequently aim to the development of robot-based therapeutic protocols for children with autism.

Firstly researchers have selected single words to be applied as trigger words based on the frequency they have been used by the professionals. Following that, phrases have been chosen to match the techniques revealed from the experts' reports. Lastly, the IT experts programmed the robot accordingly and tested it in the lab.

As verbal communication in humans does not come isolated from non-verbal signs and head nods and gestures are useful to provide positive feedback [19], researchers used the capabilities of the robot to produce some non-verbal behaviour to strengthen this rapport.

The first theme required that specialists report on how they encourage the child to perform specific tasks. From their responses it became apparent that they are mostly using simple

Table 2 Communication and Interaction Strategies in Specific Contexts

Category	Sample quote	Frequency of codes
Theme 1: Enhancing task repetition and/or the attempts to perform specific tasks		
Positive reinforcement	Participant 26: "Of course I often point any successful attempts using phrases like 'well done' or 'congratulations'."	58
Specific cues	Participant 20: "Simple words are always working well. I prefer to use one or two words to provide clear instructions."	30
Reflecting feelings	Participant 3: "I am always aware that responses reflecting emotions can be misunderstood by autistic children. Yet I guess for me reflection works every time, even when the child fails to complete a task."	3
Encouraging active participation	Participant 18: "I encourage their engagement by offering choices they tend to enjoy."	3
Theme 2: Responding to repetitive body movements /stereotypies		
Setting boundaries	Participant 24: "I would ask him/her to stop or calm."	8
Acceptance	Participant 6: "Acceptance is the most powerful tool I have…"	6
Distancing techniques	Participant 31: "I would change the activity to distract him/her."	5
Emotion exploring	Participant 8: "When a child makes stereotypical movements because he is anxious or stressed and recognises some feelings, I prefer to ask."	4
Safety awareness	Participant 4: "Whenever I feel he may get hurt, I remind him of our safety rules."	3
Suggesting time out	Participant 16: "I often use time out."	3
Offering visual cues	Participant 24: "I am using a visual structure of the session."	2
Reflecting feelings	Participant 14: "I would reflect using emotions…"	2
Physical contact	Participant 21: "…I try to gently stop the movement using my hands."	1
Theme 3: Responding to eye contact avoidance		
Specific cues	Participant 33:"look at me or eyes on me please…"	11
Encouraging active participation	Participant 20:"I often try to engage the child and motivate him/her to join more actively."	6
Commitment	Participant 10: "I respond in order to create a sense of belonging and value for the child."	6
Distancing techniques	Participant 25: "Bubbles or other toys, something fascinating to catch his eye."	4
Acceptance	Participant 5: "A lack of eye contact requires slower habituation. Well, when they don't look at me, I am just accepting their difficulties. "	3
"I" messages	Participant 9: "I would share with him/her my feelings, e.g. when you don't look at me I feel confused, because I am not sure if you are ok with what we are doing."	1
Theme 4: Dealing with lack of cooperation or withdrawal		
Encouraging active participation	Participant 27: "By changing the task in a way that motivates them…"	8
Commitment	Participant 8: "I always try to be in tune with their feelings and help them feel understood."	6
Specific cues	Participant 23: "…by repeating the instructions."	5
Reflecting feelings	Participant 26: "You are very tired today… or something like that…"	4
Emotion exploring	Participant 7: "I believe that the underlying emotion is more powerful and it takes only a moment to check on it."	3
Acceptance	Participant 3: "It happens very often, I am just following the child's lead."	3
Positive reinforcement	Participant 21: "You are doing it very well...."	3
Suggesting time out	Participant 19: "Sometimes I just suggest a time out."	1
Theme 5: Addressing tiredness or mental fatigue		
Suggesting time out	Participant 20 "We need some time to relax… let's take a break…""	13
Reflecting feelings	Participant 7: "I reflect his/her emotional reactions."	11
Acceptance	Participant 10: "Some days are bad and that's ok, for example when a child is sleepy or tired, we need to be flexible and understanding."	6
Distancing techniques	Participant 18: "…I would play music or sing a song he/ she likes."	3
Emotional exploring	Participant 1: "I explore their state of emotion. It allows me to stay connected. "	3
Physical contact	Participant 31: "…with a gentle touch."	2
Relaxation techniques	Participant 22: "I would ask him/her to count up to 5 and breathe."	1
Theme 6: Handling aggressive outbursts		
Setting boundaries	Participant 28: "I set boundaries using simple words and calm voice."	17

"I" messages	Participant 22: "I often express my negative feelings or insecurity…"	7
Reflecting feelings	Participant 11: "First of all I reflect the feeling of anger or disappointment…"	5
Safety awareness	Participant 3: "I repeat the phrase, this is not safe…"	4
Relaxation techniques	Participant 15: "Sometimes I suggest a count up to 10."	2
Suggesting time out	Participant 29: "I immediately stop any activity."	1
Physical contact	Participant 18: "I might try to stop the behaviour using my hands."	2
Adjusting surrounding background	Participant 5: "I would provide pillows or remove items to ensure safety."	2
Theme 7: Handling meltdowns		
Commitment	Participant 25: "With a silent, calm posture… I make sure the child knows I'm there and I understand that this may feel out of control."	14
Acceptance	Participant 7: "It usually don't try to stop an escalation very quickly, I give them space and time to process."	6
Relaxation techniques	Participant 9: "Breathing techniques usually work well."	5
Suggesting time out	Participant 17: "If they are overwhelmed, a break is the best option."	5
Comforting	Participant 30: "With soothing voice I would say that everything is ok."	5
Distancing techniques	Participant 16: "Usually I switch to another activity, more soothing or playful."	4
Reflecting feelings	Participant 21: "You are tired, I see…"	4
Adjusting surrounding background	Participant 2: "The first step is to manage the triggers, so I try to remove items or toys that are upsetting them."	4
Physical contact	Participant 13: "With a gentle touch or hug, if I'm sure it won't cause further distress."	2
Encouraging active participation	Participant 12: "I try to remind them of the coping skills we practice."	2
Safety awareness	Participant 10: "Safety is of course a priority…"	1
Theme 8: Handling temper tantrums		
Reflecting feelings	Participant 32: "You are upset…"	6
Commitment	Participant 13: "I try to tune in to the child's feelings and stay connected."	5
Suggesting time out	Participant 33: "I just wait for a few minutes, a break is always effective."	4
Setting boundaries	Participant 24: "Consistent boundaries help children feel safe, so I try to set boundaries."	4
Acceptance	Participant 1: "I will wait, until you feel better."	3
Distancing techniques	Participant 4: "A sensory distraction -music, songs, instruments- is usually comforting."	3
Physical contact	Participant 26: "…also with gentle squeezing or holding hands."	3
Emotion exploring	Participant 6: "Are you upset or do you feel sad?"	2
Relaxation techniques	Participant 25: "Let's take some deep breaths together… "	1
Comforting	Participant 23: "Everything is fine, don't worry…"	1
Positive reinforcement	Participant 32: "You are strong, you can do it."	1
Offering visual cues	Participant 27: "I usually use images [to handle tantrums]"	1

Note. Participants 1-15 (Psychologists); Participants 16-21 (Special Educators); Participants 22-27 (Speech Therapists); Participants 28-31 (Occupational Therapists); Participants 32-33 (Pediatricians).

words, familiar to the children. Two words have been selected as triggering linguistic cues. To mimic the human facial expression that usually accompanies words of encouragement, the robot will have his eyes changing colour.

Theme 1

Well done: the robot applauds and empowers the child saying "you did it, wow" having his eyes changing colour (when the child has completed a task successfully).

Again: the robot utters an interjection ("Hmmm") showing uncertainty and says "I am not sure, let's try one more time".

The next theme is referring to one of the most common symptoms in autism: stereotypes. Participants proposed setting boundaries acceptance and distancing techniques to overcome the situation. The trigger word that has been selected could be used to situations relevant to Theme 3 as well.

Theme 2/Theme 3

Break: robot stops whatever it's doing and says "we need some time to relax". This phrase could be used when the child looks tired, or performs stereotypical movements without stopping or does not participate in the scheduled tasks, or lacks eye contact for a significant amount of time or does not respond to the therapist's cues.

Sometimes the therapist will need to change the flow of the session adjusting to the child's mood and preferences. In that case the robot should adjust as well.

Theme 3/Theme 4

Change: robot stops whatever it is doing and says: "let's do something different". This phrase would apply as a transition signal to the next task.

When safety is an issue, there is a need to resolve the crisis as quickly as possible and ensure that the child won't get hurt.

Table 3 Categories of Communication and Interaction Strategies

Category	Frequency of codes					
	Total	Ps	SE	ST	OT	Pe
Positive reinforcement	62	20	10	15	13	4
Specific cues	46	12	14	5	10	5
Reflecting feelings	35	25	5	4	0	1
Commitment	31	17	4	8	1	1
Setting boundaries	29	9	4	9	4	3
Acceptance	27	14	4	7	2	0
Suggesting time out	27	12	6	5	3	1
Distancing techniques	19	7	2	5	2	3
Encouraging active participation	19	5	2	7	2	3
Emotion exploring	12	8	3	0	1	0
Physical contact	10	2	4	3	1	0
Relaxation techniques	9	2	2	5	0	0
"I" messages	8	5	0	2	1	0
Safety awareness	8	5	0	3	0	0
Comforting	6	3	0	2	1	0
Adjusting surrounding background	6	5	0	1	0	0
Offering visual cues	3	1	0	2	0	0

Abbreviations: Ps, Psychologists; SE, Special Educators; ST, Speech Therapists; OC, Occupational Therapists; Pe, Pediatricians.

Theme 5/Theme 6

Attention: robot says: "this is not safe, I am going" and moves to the relaxation space. This phrase will be used by the therapist when the child moves aggressively towards the robot and the therapist perceives a possible danger or when the child abuses toys or other therapeutic elements.

Meltdowns are very different from temper tantrums. They refer to an uncontrollable emotional overload possible due to overstimulation [20]. Temper tantrums are learned behaviours that a child uses to fulfill his/her desires. Both situations demand the full attention from the therapist, therefore in situations like this the robot needs to withdraw so the therapist could focus on the child and use strategies to minimize the stress of the child. Upon listening to the word "stop" by the therapist the robot withdraws but still communicates to the child that the situation in upsetting.

Theme 7/Theme 8

Stop: Robot pauses and says "I am upset; I need some time to relax". This phrase is used when the child meltdowns, has a tantrum, is aggressive or dysphoric.

Based on the same rationale if by any chance the robot's battery runs out or other technical problems arise, (that the robot recognizes itself) the robot informs the child: "I like your company a lot, but I have to rest". If the therapist realizes the existence of other technical problems that the robot itself cannot recognize, he/she says "Over" and the robot enters the sleep mode.

Robot's don't have all the capabilities a therapist has, therefore is extremely difficult to autonomously handle the session's flow. A therapist should always, at least at the current state, be responsible for the intervention, but it is possible to include the robot even when something unexpected arises.

Table 4 Linguistic Cues

Word	Frequency
Well done	26
Again	15
Time out/ Break	20
Change	13
Attention	12
Stop	20

Limitations

There is gender bias since only two males participated in the study. This difference though is similar in the representation of males in humanistic professions. Contingent Worker Supplement (CWS) estimates that 75% to 80% of students studying psychology or participate in health care training programs are women [21].

Given the heterogeneity of the autism spectrum disorders the strategies each specialist chose may vary. Professionals gave their answers based on their own experiences and not based on a specific case study.

Implications

The results of this study aim to facilitate the procedures involved to maintain the sessions flow when a crisis arises and to make robots more empathetic during robot-assisted therapy.

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