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# SERIOUS GAMES TO TEACH EMOTION RECOGNITION TO CHILDREN WITH AUTISM SPECTRUM DISORDERS (ASD)

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## SUMMARY

**Background:** The serious game "JeStiMulE" (Educational Game for Multisensory Stimulation of Children with developmental disorders), developed by the Autism Resources Center of Nice, was created to teach social cognition including emotion recognition for children and adolescents with autism. The purpose of our study is to investigate the effectiveness of the serious game JESTIMULE in remediating recognition' deficits of emotional facial expressions (EFE) in autistic children.

**Material/ Methods:** Thirty-two Moroccan children and adolescents were recruited for this study. All participants received a diagnosis of autism spectrum disorder (ASD) based on the Diagnostic and Statistical Manual of Mental Diseases, Fourth Edition (DSM-IV-R) criteria for ASD, as well as the Rimland Checklist E2. IQ level has been assessed by using Raven's Progressive Matrices as an IQ testing scale. The participants received two one-hour JeStiMulE sessions per week over four weeks. Game data were collected for each participant. The Faces test was used to quantify the progression of the ability to recognize emotions in our subjects.

**Results:** The results of the descriptive analyses showed suitable adaptability, effectiveness and efficiency of JeStiMulE. In Faces test, a significant difference between scores of the Pre-intervention and Post-intervention ($Z= -3.58$, $p<0.001$), in favour of the Post-intervention ($M=23.22$, $SD=2.96$ versus $M=27.27$, $SD=2.77$). That indicate that participants were more accurate at recognizing emotions after JeStiMulE. In addition, a main effect of type of autism was found for the facial scale ($H = 6.673$, $ddl = 2$, $p = 0.036$). High-functioning autism were significantly better than Low-functioning autism at recognizing emotions from faces in both Pre-intervention and Post-intervention.

**Conclusions:** With such non-verbal tool, training could start early. Thus, early management, the more the progression in the recognition and imitation of facial expressions is important, the more we gain autonomy and social integration just in time to begin school.

**Key words:** emotions, JESTIMULE, autism, serious game, Morocco

# INTRODUCTION

Diagnostic and statistical manual of mental disorders (fourth ed. Text revision ed, DSM-IV-R) defined autism spectrum disorder ASD as a group of deficits touching social and behavioral contexts; these deficits are divided into persistent deficits in social communication and social interaction across multiple contexts as well as restricted repetitive patterns of behavior, interests, or activities (APA, 200).

Difficulties with social interaction, reciprocal communication and emotion recognition are characteristics of individuals diagnosed with an ASD, regardless of cognitive abilities and severity of symptoms (Whalen et al., 1994; Wing et al., 2011). Individuals with ASD have a general affective deficit to interpret another person's mental state based on facial expressions or tone of voice (Hobson et al., 1988; Howard et al., 2000; Baron-Cohen et al., 1999).

Many individuals with autism do not develop functional language skills (DeMyer et al., 1973; Eisenberg, 1956) and show deficiencies in non-verbal communication (Mundy, 1986).

Although the differences are not very flagrant, children with autism engage less often in face-to-face interaction with their parents and other children, following the pointing gesture, and return to the call of their names. All observations show that children with autism exhibit aberrant social responses in the second year of life. It is unclear whether children aged 3 and 6 months exhibit the same quality of dyadic interaction as ordinary ones (Wan, 2012). Most likely, there are variations from one child to other. Moreover, it is not clear that all autistic children present from the onset significant disorders of the interactive relationships (Clifford and Dissanayake, 2008).

For some children, the damage is visible and the abnormal behavior emerges from the onset. On the other hand, other autistic children experience a period of development during which social behaviors may seem normal. Some of these children react or approach a person but they are less integrated in a coherent set of social cues disallowing the maintenance of interaction. The behavior of autistic children lacks reciprocity and mutual commitment as seen in the youngest ordinary ones (Rogé, 2008).

What is a serious game?

A Serious Game is a video game that conveys a serious message, educational, social, charitable, advertising, journalistic... etc. It is a computer application combining a serious objective with fun elements. The Serious Game has a utilitarian purpose of allowing the user to improve his skills by training, to accustom himself to situations, to treat his phobias, or to understand an educational situation. A Serious Game (SG) is "a simulation with a videogame structure whose purpose is to promote the development of important skills and strategies in order to increase the cognitive and intellectual abilities of the users" (Botte et al., 2009).

The most synthetic definition of a Serious Game was proposed by the video game designers Michael and Chen (Michael and Chen, 2005): "Any game whose primary purpose is other than just entertainment." According to this definition,

a Serious Game potentially applies to a multiplicity of sectors: education, health, advertising, communication, politics, humanitarian, defense, religion, art ...etc.

In the context of this article, we are only interested in games used in education. According to this simple definition, a Serious Games can be a game on any type of support. The first examples of Serious Games known for the education sector, dating back to the 1960s-1970s, were mostly card, board, and role-playing games (Clark, 1987; Jansiewicz, 1998).

While the idea of using the game as a pedagogical medium has remained more or less popular over time, it experienced a sharp decline in the late 1990s, especially with the fall of the so-called "ludo-educational" games (Kellner, 2007). In the first half of the 2000s, a new trend has sought to revive this concept, under the name Serious Game, refocusing this time almost exclusively on video games (Djaouti, 2016).

Through this new wave of Serious Games, today we have an ever-growing number of video games that openly claim educational interest.

The benefits and limitations of the Serious Game for Education vary significantly depending on the game chosen and its context of usage, so there is no simple or absolute answer to this question. However, many case studies have been conducted by researchers in the field. In their review of the literature on the subject, Pivec and Pivec (Pivec and Pivec, 2008) work shows the following main advantages of serious games:

1. Motivating learners
2. Learning by trial and error
3. Taking into account differences in learning rhythms and styles;
4. Stimulating pedagogical interactions between learners.

In this research, conducted within the association AMVM (Moroccan Association for a better life) and in Albert Center (Kenitra, Morocco) has adopted the Rimland tool for the diagnosis of autism. We used the program "JESTIMULE" to improve the social skills of children and adolescents with Autism or Invasive Developmental Disorder.

The main objective of this work is to evaluate the effectiveness of this remediation tool in the Moroccan cultural context. To do this, we have followed the improvement of thirty-two autistic children (both verbal and non-verbal) at the level of emotional social interactions after the experimentation implemented by this program. We also made the use of "JESTIMULE " easier by giving details of its manipulation and result collection.

# MATERIAL AND METHODS

This section describes the methodology used. A variety of instruments were used to collect the data necessary to answer the research questions.The experimental protocol consists of Faces Test, The Rimland E2 questionnaire, and JESTIMULE serious game.

## Subjects

Thirty-two children and adolescents were recruited by the Albert Center (Kenitra, Morocco) during the period from March to June 2019. All participants received a diagnosis of ASD based on the Diagnostic and Statistical Manual of Mental Diseases, Fourth Edition (DSM-IV-R) criteria for ASC, as well as on Rimland's questionnaire.

The distribution of scores is not normal; we used nonparametric tests (Wilcoxon signed-rank test and Kruskal–Wallis test multiple comparisons)

The participants' characteristics are presented in Table 1. IQ was assessed using the Raven progressive matrices Scale of Intelligence (PM38). Only participants who were able to discriminate primary and secondary colors and had already used a computer were included in the training.All participants were presented with five emotion recognition tasks before and after training: two tasks include pictures of game avatars (faces and gestures) and the three other tasks involve pictures of real-life characters (faces, gestures and social scenes).

## Research Instruments

### A – The Raven's Progressive Matrices

To measure the fluid intelligence, we used the Raven's Progressive Matrices (Raven, 2000; Latifi et al., 2009; Mènon et al., 2019). This test comprises 60 items, divided into five sets of increasing complexity. All items have a similar format: A matrix of geometric designs with one cell of the matrix left blank is presented with six or eight alternatives for the matrix's completion. Minimal instruction is required for this putatively nonverbal test.

Tab. 1. Distribution of sex/age/ability to read/ability to speak/ type of autism/ RPM

| | | | |
|---|---|---|---|
| Sex | F | 8 | 25 % |
| | M | 24 | 75 % |
| Age | 6 to 8 | 14 | 43,75 % |
| | 9 to 11 | 8 | 25 % |
| | 12 to 14 | 10 | 31,25 % |
| Ability to Read | Yes | 18 | 56,25 % |
| | No | 14 | 43.75 % |
| Ability to Speak | Yes | 22 | 68,75 % |
| | No | 10 | 31,25 % |
| Type of autism | LFA | 8 | 25 % |
| | MFA | 6 | 18,75 % |
| | HFA | 18 | 56,25 % |
| RPM | 56th percentile (SD = 35.11) | | |

LFA: Low-Functioning Autism; MFA: Moderate-Functioning Autism;
HFA: High-Functioning Autism ; RPM: Raven's Progressive Matrices

Raven's Progressive Matrices, The standard version of the Raven's Progressive Matrices was administered to all subjects, with no time limit. Norms for North American children were taken from the test's manual (Raven, 2000).

**B – The Rimland E2 questionnaire**

The E2 scale (Rimland, 1964 ; Rimland, 1971) consists of 80 multiple-choice questions. The first 17 questions concern the child's age, sex, birth order, disability onset date , as well as the possibility of perinatal complications (oxygenation); other questions seek to pinpoint characteristics of early development from birth to age 5, anomalies in perception, reactions to sensory stimuli, auto stimulation, motor development, and intelligence.

Forty-one questions concern behavioral patterns associated with the syndrome: spontaneous motor and imitative ability, ritual acts, visual and auditory problems, withdrawal, social interaction, particular aptitudes, and the child's physical appearance.

Seventeen questions concern speech: its absence or presence, age of speech appearance and evaluation of first utterances, subsequent speech behavior, ability to communicate, echolalia, use of personal pronouns, yes and no, oral comprehension.

Four questions concern the child's parents: level of education, antecedent mental disorders. The last question (#80) invites the parents to read over their answers and select 10 questions best describing their child.

We asked parents to complete the questionnaire after explaining its composition and purpose. The parents were offered help in completing the form and the opportunity to make comments on their answers on the back of it. In all cases, the parents' answers were respected, even when contradicted by clinical information on the child. Answers for each questionnaire were noted separately and were submitted to the Rimland scoring key based on positive (autistic) and negative (no autistic) points.

The final score was obtained by adding the negative and positive points. The upper and lower limits of the scale are + 57 and - 46; + 20 (the cutoff point for autism proposed by Rimland) indicate that the child exhibits at least 20 more signs of autism than of non-autism.

**C – Faces Test**

It consists of photos of children's faces expressing various emotions (frightened, angry, neutral, sad and happy) (Baron-Cohen et al., 1997). The photos were printed in A4 color format on a gray background. The data were collected using two rating sheets: one for free evocation and one for indexed evocation.The presentation of the faces was balanced between both the children's different emotions and their sex in the photos (see Fig. 1).

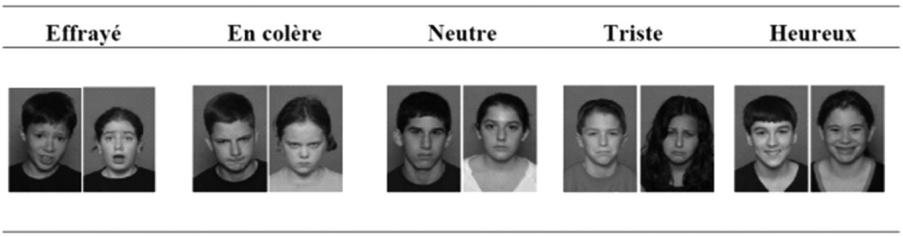


Fig. 1. Extract of Faces test used

## D-JeStiMulE

JeStiMulE is the prototype of an individual interactive and multi-sensory computer game played with a gamepad. It was specifically designed for children and adolescents with ASC (HFA and LFA). It aims at stimulating emotion recognition skills, including facial expressions, emotional gestures, and social situations (Serret et al., 2014).

For this purpose, nine expressions are presented in the game: six basic emotions (which are happiness, anger, disgust, fear, sadness, surprise), one complex emotion (that is pain) and two complementary expressions (which are neutral and 'funny face'). These emotions are displayed on both static and animated avatars.

Each basic emotion was associated to a specific color from Plutchick's emotional wheel (happiness = yellow, anger = red, disgust = purple, fear = green, sadness = light blue, surprise = dark blue). Pain was associated with black. Neutral was associated with the color white and 'funny face' was associated with a trash can.JeStiMulE comprised three phases (which are calibration, learning and training, see Fig. 2).

1) **JeStiMulE calibration phase:** a tactile calibration was conducted separately for each participant according to his/her tactile sensory profile measured by the DUNN parental questionnaire.

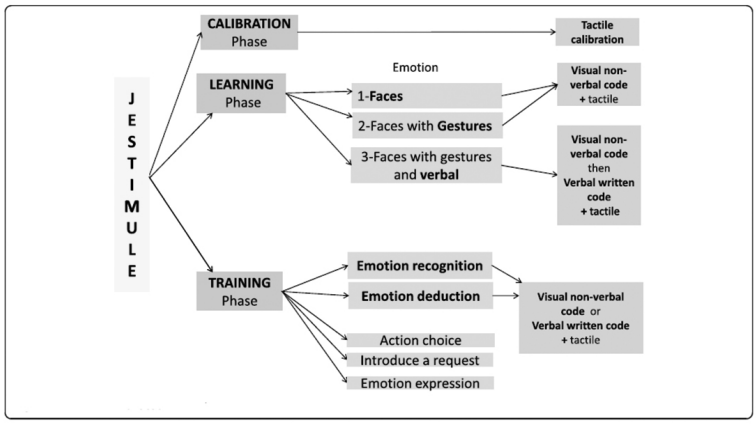


Fig. 2. Illustration of JeStiMulE's design

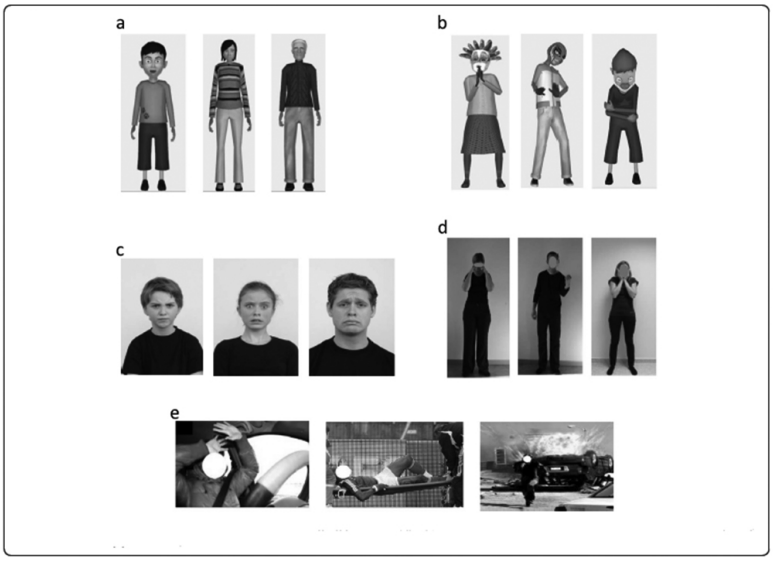


Fig. 3. Example of the stimuli used in the experimental tasks. (a) Avatar faces. (b) Avatar gestures. (c) Real-life character faces. (d) Real-life character gestures. (e) Real-life social scenes

2) **JeStiMulE learning phase (see Fig. 3):** this phase included three levels with gradually increasing complexity. On level 1, emotions were displayed on faces and associated with a visual non-verbal code and a specific tactile stimulation. On level 2, emotions were displayed on faces combined with gestures and associated with a visual non- verbal code and a specific tactile stimulation. On level 3, emotions were displayed on faces combined with gestures and associated with a visual non-verbal code, a verbal written (emotional words and idiomatic expressions) code and a specific tactile stimulation.
3) **JeStiMulE training phase**: The training phase included three modules in which the participants could apply the knowledge acquired during the learning phase of the game.

## Experimental tasks

In order to assess the acquisition of emotional skills and progression after playing JeStiMulE, all participants were presented with five emotion recognition tasks before and after training. The tasks comprised 2D visual stimuli (photographs) and were separated into two types: 1) emotions displayed by JeStiMulE's avatars (faces and gestures), and 2) emotions displayed by real-life characters (faces, gestures and social scenes). Seven emotions were presented in each task. Stimuli examples for all tasks are presented in Fig. 3.

# RESULTS

### The Raven's Progressive Matrices

The children's scores on the Raven's Progressive Matrices were at the 56th percentile (SD = 35.11), indicating an average level of performance.Their scores were between 30 percentile points, and in some cases more than 70 percentile points.

### JeStiMulE adaptability and efficiency

After a training phase on the use of the gamepad or the mouse and computer equipment, the participants were able to play end recognize displayed figure of Avatar on computer. Children can improve their ability to utter some words suitable to the context of expressing emotions, which proves JeStiMulE is suitable to the ASD profile.

To assess JeStiMulE' efficiency, in this study, emotion recognition skills were assessed before and after four-week JeStiMulE training.

We note that after the learning phase, 80% of the participants were able to make JeStiMulE visual non-verbal code-expression faces associations and 73% of them were able to make JeStiMulE visual non-verbal code-expression gestures associations.

Most of the participants (81%) completed the two key stages of JeStiMulE, namely visual non-verbal code expression associations and recognition of emotions displayed in social scenes. These participants played, on average, 6 sessions of one hour each.

Tab. 2. Results obtained from JeStiMulE's pre and post training avatars

| | | Pre-training | | Post-training | | |
|---|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD | P |
| Faces | Happy | 51,50 | 5,09 | 68,69 | 5,03 | < 0,001 |
| | Anger | 54,13 | 4,75 | 64,57 | 4,82 | < 0,001 |
| | Surprise | 31,94 | 4,68 | 45,14 | 4,15 | < 0,001 |
| | Disgust | 12,19 | 4,38 | 33,19 | 4,30 | < 0,001 |
| | Sadness | 54,31 | 5,31 | 65,22 | 4,90 | < 0,001 |
| | Pain | 17,66 | 4,32 | 46,02 | 4,65 | < 0,001 |
| | Fear | 41,85 | 4,90 | 53,25 | 4,67 | < 0,001 |
| Gesture | Happy | 50,75 | 4,41 | 72,38 | 3,79 | < 0,001 |
| | Anger | 53,88 | 4,99 | 63,65 | 4,85 | < 0,001 |
| | Surprise | 29,88 | 3,61 | 39,69 | 4,90 | < 0,001 |
| | Disgust | 11,50 | 5,09 | 33,46 | 4,35 | < 0,001 |
| | Sadness | 54,50 | 5,09 | 66,43 | 3,76 | < 0,001 |
| | Pain | 16,70 | 5,09 | 33,66 | 4,58 | < 0,001 |
| | Fear | 41,85 | 4,88 | 56,43 | 4,67 | < 0,001 |

Results of statistical analysis revealed a significant effect of the learning game between pre-intervention and post intervention stages (Z= -5.16, p<0.001). The results suggested that the participants were more accurate in comprehensive recognizing of emotions after Jestimule (M=35.54, SD=13.36 versus M=51.04, SD=11.54) (see Tab. 2 and Tab. 3).

Emotion processing and face processing deficits in ASD can be attributed to more general impairment in the processing of relational information (Davies et al., 1994). We can work on facial expressions and infer remediation on the treatment of relational information in general.

Several published studies have evaluated the efficacy of computer based interventions to enhance the social skills abilities of children with ASD (Silver and Oakes, 2001 ; LaCava et al., 2007; Tanaka et al., 2010; Markiewicz et al. 2019). These technology-based social skills interventions all leverage the affinity of students with an ASD for the predictable and animated environment of a computer game or video (Goldsmith and LeBlanc, 2004).

The results indicate that the participants' performance in this study was more superior on the facial (M = 52.80, SD = 4.02) than on Gestural (M = 48.05, SD = 2.87) emotion recognition task, with a significant difference (Z= -3; P = 0.001). Moreover, results revealed that emotions such as Happiness (M = 68.7, SD =

Tab. 3. Results obtained from JeStiMulE's pre and post training real-life characters

| | | Pre-training | | Post-training | | |
|---|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD | P |
| Faces | Happy | 58,38 | 9,93 | 66,02 | 9,02 | < 0,001 |
| | Anger | 42,87 | 9,93 | 53,46 | 8,91 | < 0,001 |
| | Surprise | 37,57 | 9,93 | 50,74 | 8,85 | < 0,001 |
| | Disgust | 26,68 | 8,30 | 45,98 | 8,30 | < 0,001 |
| | Sadness | 48,79 | 9,65 | 62,11 | 8,39 | < 0,001 |
| | Pain | 22,67 | 8,54 | 44,00 | 8,91 | < 0,001 |
| | Fear | 25,75 | 9,34 | 40,82 | 9,57 | < 0,001 |
| Gesture | Happy | 33,63 | 7,17 | 49,96 | 5,91 | < 0,001 |
| | Anger | 40,96 | 6,12 | 60,60 | 5,50 | < 0,001 |
| | Surprise | 28,21 | 5,94 | 37,83 | 5,99 | < 0,001 |
| | Disgust | 24,11 | 5,52 | 37,90 | 5,36 | < 0,001 |
| | Sadness | 28,38 | 6,14 | 41,68 | 6,14 | < 0,001 |
| | Pain | 31,28 | 6,14 | 46,18 | 6,14 | < 0,001 |
| | Fear | 20,98 | 6,14 | 32,88 | 6,14 | < 0,001 |
| Social scene | Happy | 48,92 | 7,17 | 62,21 | 7,40 | < 0,001 |
| | Anger | 49,15 | 5,12 | 65,71 | 5,79 | < 0,001 |
| | Surprise | 32,36 | 6,74 | 47,63 | 7,17 | < 0,001 |
| | Disgust | 29,01 | 6,28 | 55,05 | 6,18 | < 0,001 |
| | Sadness | 20,88 | 4,81 | 48,01 | 7,47 | < 0,001 |
| | Pain | 30,52 | 7,17 | 44,79 | 7,17 | < 0,001 |
| | Fear | 40,42 | 7,17 | 51,20 | 6,28 | < 0,001 |

Tab. 4. The results obtained from pre and post training of autistic patients in Faces' Test

| | Pre-intervention | | Post-intervention | | |
|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | P |
| Free evocation | 10,06 | 1,48 | 11.81 | 1.42 | < 0,001 |
| Evocation indexed | 13.16 | 1.48 | 15.46 | 1.48 | < 0,001 |
| Total | 23.22 | 2.96 | 27.27 | 2.77 | < 0,001 |

5.04), Anger (M = 64.57, SD = 4.82), Sadness (M = 65.22, SD = 4.9) and Fear (M = 53.25, SD = 4.67) were better recognized than emotions like Disgust (M = 33.19, SD = 4.30), Pain (M = 46.05, SD = 4.65) and Surprise (M= 45.14, SD = 4.15) (Friedman Test: K=91.7; $p < 0.001$). A significant improvement was found in most of the tasks despite the heterogeneity of the participants' group.Other studies assessed the efficacy of computer programs to teach emotion recognition to autistic children. For example, Hopkins and al. (2011) have used FaceSay, a computer-based social skills training program for children with Autism Spectrum Disorders (ASD).

This study indicates that providing children with low-functioning autism (LFA) and high functioning autism (HFA) opportunities to practice attending to eye gaze, discriminating facial expressions and recognizing faces and emotions in FaceSay's structured environment with interactive, realistic avatar assistants improved their social skills abilities. Serret and al. (2014) provides an advance in this research field, by showing that children and adolescents with heterogeneous ASC were able to understand, play and complete JeStiMulE as well as benefit from its intervention. JeStiMulE was developed specifically to provide a rule based computer game relying on 'autistic intelligence' to develop other, more social, skills. Thus, The underlying working hypothesis was that rule-based learning could be a relevant pathway to reach gradually more complex, social learning in ASC.

# CONCLUSIONS

1. Through the efforts of the associations concerned to improve the autonomy and personal security measures of autistic children, a national charter organizing their teaching becomes more and more urgent, provided that its realization takes into account all the regions of Morocco. It is now recognized that people with Autism Spectrum Disorder have a strong interest in computer science. We were able to see it ourselves thanks to this work, given the the great deal of enthusiasm shown by children while playing JeStiMulE.
2. As a matter of fact, The computer is more predictable; so it is less stressful. It provides essentially visual information that is easier to treat for people with autism, who are therefore in a better condition to learn. In addition, with necessary equipment, training could begin early as soon as the child has sufficient verbal understanding. The earlier the patients are taken care of, the more

important and probably sustainable is the benefit they may draw from the training program.

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