Promotion of creative activity in children with severe autism through visuals in an interactive multisensory environment.

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ABSTRACT

Autism is a developmental disorder which presents disability in communication and socialisation and a lack of imagination. To promote creativity, exploration and enjoyment in low functioning autistic children that have no verbal communication, we propose MEDIATE, an interactive environment that generates real time visual, aural and vibrotactile stimuli. This paper focuses on the design of interaction with visuals within MEDIATE. The design is guided by the objectives of giving children a sense of agency and enhance non repetitive actions. Other guidelines of this design include natural interaction, use of non invasive technology and non representational visuals. This visual interaction (together with sound and vibrotacile) allows the children to enjoy MEDIATE and be creative within this environment.

Keywords

Real time generated stimuli, environments, CHI, interaction-driven design, particles, autism.

INTRODUCTION

MEDIATE is an interactive environment that generates real time stimuli in visual, aural and vibrotactile modes for children between 6 and 12 years of age [4]; low functioning persons in the autistic spectrum (PAS), with no verbal communication. It is indeed tempting to apply such an environment as a therapeutic tool for PAS children. However, it was agreed that MEDIATE would not aim such ambitious goals in this first phase. On the one hand, current knowledge on autism, especially in low functioning children, is not detailed enough to attempt therapy with this environment. On the other hand, the uniqueness of MEDIATE, calls for special caution in these speculations. Because many families of PAS children are constantly searching for "the solution" to autism we do not wish to raise unjustified hopes when we have only begun to investigate this interactive multimodal system. Hence, our ethical responsibility asks us to be extremely cautious. Therefore, MEDIATE's main goal is for the children to have the chance to play, explore and be creative in a predictable, controllable and safe space.

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In this paper we firstly underline the major ideas we found about creativity promotion in autistic children. Design of visual interaction models is presented in section 3 and 4. The final interaction model implemented inside MEDIATE space is presented in section 5 and its results described in section 6.

HOW TO PROMOTE INTERACTION IN PAS

Autism

The factors that determine autism have a biological cause [3]. Three main characteristics –disability in communication and socialisation and a lack of imagination– are externally manifested in deficiencies of affective expression, an apparent lack of empathy, an obsessive concentration on particular elements and, often, repetitive movements [5]. This makes the child unable to discriminate between and, more importantly, predict, any of the events that occur in daily life. Technically it is said that they have no sense of agency [3]; i.e. they are unconscious of being able to exert control over their surrounding environment and obtaining a coherent response, even in the cases when they themselves are causing the events.

Control to achieve a sense of Agency

To make PAS gain a sense of agency, interaction is based on very clear action-reaction dialogues with the system –what is technically called a contingent interaction–. In other words, the interaction proposed must not have any uncontrolled latencies nor unexpected outcomes because, as stated before, autistic children have difficulties to understand and experience sense of control with respect to their surrounding environment. Associating the interaction responses very clearly with the actions that caused them is essential to make the children apt for expressing themselves within MEDIATE.

Enhance Non-Repetitive Actions

Children with autism often fall into repetitive attitudes like rocking movements or flapping an arm or a hand. They tend to do so when they feel overwhelmed by their surroundings or when they are obsessed by something. Both attitudes are considered undesirable by psychologists, because they isolate the child from the world. In MEDIATE, we want to promote exploration in children, i.e. non-repetitive or novel activity. This is our definition of being creative in MEDIATE's context. To achieve this, repetitive patterns are detected from sensor input, by a module we call the Signature Analyser, Fig. 1(c), hence allowing the environment to react to these undesired behaviours.

Adapt to each child

To adapt the stimuli to each child's potential and engage them in dialogue, a Decision Maker module was designed in the "brain" of MEDIATE. The Decision Maker, Fig. 1(d), is constantly informed of the repetitive activity found by the Signature Analyser. If the child is behaving in a repetitive manner the environment begins to dim down all responses making everything drop back to a less demanding or softer interaction. The environment can raise its complexity to make interaction richer if the child behaves in a novel (i.e. non-repetitive) manner. This increase in complexity starts within each modality and eventually evolves into a cross-modality mode where the different stimuli (image, sound and vibrotactile) affect each other.

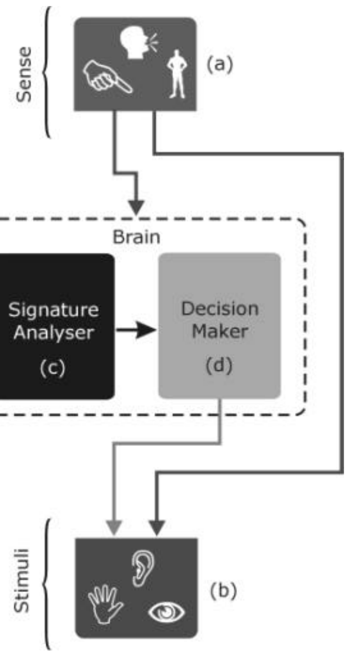


Figure 1: Block diagram of the modules of the system: (a) sensed inputs from user (sound, touch & gesticulation), (b) stimuli (output of the system to user: sound, vibration & visuals), (c) Signature Analyzer, (d) Decision Maker.

Environment approach

As said before one of the basic issues behind the design of MEDIATE was to provide the user with clear dialogues that give the children a sense of control. Interactive environments were found very suitable to reach this objective [11][1][9][10].

On the other hand an environment approach was chosen to promote a natural full body interaction, Fig 2. By simply moving through the defined space, the environment could already start responding, offering several options that could lead the child into playing with it. But also many other basic body behaviours like gesticulating, touching, leaning, pressing, screaming, clapping, etc., could be picked up and used to start the interaction dialogue.

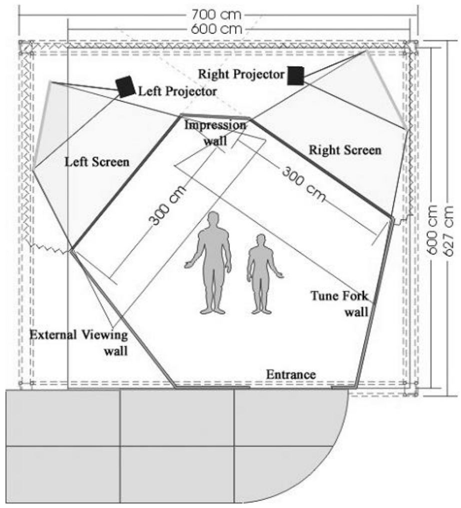


Figure 2: Plan view of the physical shape of MEDIATE: an irregular hexagonal space provides a good set up for free-roaming full-body interaction.

In order to make this possible, the environment is composed of, on one hand, a set of sensors that capture de user's actions and, on the other, a set of software that generates the response stimuli based on what we call interaction models. These interaction models do not only set the rules of a game, but also define a philosophy behind the game that states what we are looking for in the child's play.

INTERACTING WITH VISUALS

In this section we will describe in depth the visual interaction design approach defined by the team at Universitat Pompeu Fabra to achieve creative and expressive activity in the PAS children.

The usual procedure in the design of interactive systems is to start by defining the type of user and application, then the data or contents that the user will need and the processes involved, and finally the interaction and the interfaces (known as content-driven design). Because the spectrum of disorders in autism is so wide we had the imposed restriction of not being able to typify our user in MEDIATE and hence a new approach was needed. As formalised in previous artistic VR projects the interaction-driven design [7][8], as opposed to a content-driven or user-driven approach, was chosen as a solution to this issue.

Non Invasive Sensing Technology

The idea of not invading the user's body was important so that she would not feel anxious or disturbed by sensors or cables and to enhance natural full body interaction. We could not even consider the child wearing markers nor dressing in any specific manner.

Now, apart from this notion of letting the user move freely within the space without restricting elements, there was also the concept of letting the environment react to the user's actions without an explicit element like a button, a leaver, a joystick or similar element. These sort of elements often make PAS children obsessed and reduce their creativity; like turning on and off the light of a room through the wall switch. Also, there was the idea of trying to make the environment almost as if it were a living thing or a live ecosystem where interactions are developed not by specific elements, but by a dialogue set out by a "relationship" between the user and the environment.

These led us to develop an artificial vision system based on 9 cameras that captures the user's attitudes and that has been found to be extremely adequate and successful [6], Fig. 3.

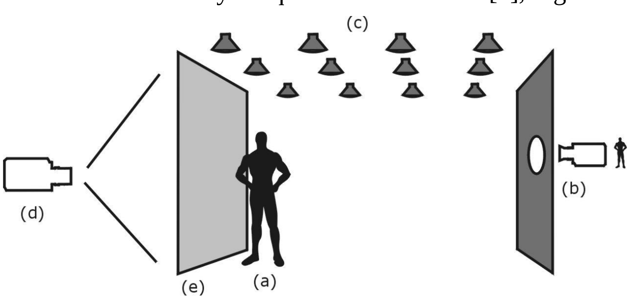


Figure 3: Artificial vision system for capturing gesticulation and position of the user. (a) the user's image is captured by cameras (b) behind the environment's walls. The environment and user are lighted by near-infrared lights (c) such that the camera can clearly capture the user, without disturbing the correct visualization of images projected by the rear projection (d) on the screens (e).

Non Representational Visuals

When we started to design the visual stimuli responses, we began to ask ourselves questions such as: will these children be afraid of dark spaces? Will they be overwhelmed by too much light? Do they prefer certain colour gamuts? Do they understand images for what they represent? Or rather, do they see only shapes and colours within an image? Do they prefer abstract or representational images? All these questions were posed from the theory of perception and understanding of images by humans. But the answers given by the psychologists to these questions were always: "there is no literature that gives evidence that they prefer any of those options" or "there is no evidence that they interpret images in any particular way". This of course did not help us in typifying our user and left too many options open.

We wanted the children to accept the environment because of the sense of control gained through the proposed interaction, ruling out the possibility of accepting the environment based on specific content presented within it. What this meant in the visual stimuli context, was that, if for example we placed the image of a dog within the environment and a child had had a bad experience with dogs in the past, then the environment would be a failure for that child because of that single identified object. Similarly, if a child loved dogs, then the environment would also be a failure because the child would be fond of the environment mostly because of the dog and not because of the interaction dialogue proposed. Or even worse, the child could become obsessed by the dog and forget about the rest of the environment. From this reasoning, we decided to work with abstract or non-representational images. But, which type of images should they be?

Particle Systems

At a cognitive level, children with autism have difficulties integrating parts of objects into complex objects, what is known as weak central coherence [3] that impairs an adequate integration of the stimuli that surround them. For example, when a child with autism is given a toy car she will probably play with the wheels, making them spin with her finger, but she will not understand the whole object and its functionality, hence will not use it as a toy car.

On the other hand, children with autism are apparently very fast at finding a shape hidden in a mesh of lines, whereas neurotypicals (non-autistic people) take quite long in finding them, Fig. 4.

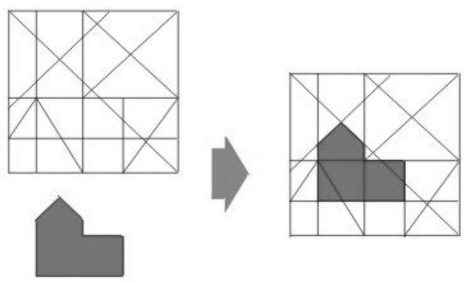


Figure 4: Shape hidden in a mesh of lines.

Because of these two issues, we thought of working with isolated geometrical elements and this immediately reminded us of particle systems [2]. We thought that each particle could have its own particular behaviour, or the whole group of particles could have a group behaviour, or the group could have a global behaviour that came from the sum of individual behaviours. We also thought that particles could be individual isolated elements, or they could be grouped to form larger objects, or they could be spread out forming a background, or even leave holes in the background where each hole is in fact a shape. This provided a huge potential for designing creative experiences. Now, how could we get the children to start playing with the particles?

Natural full body interaction

To get children encouraged to start playing and exploring we thought of promoting their natural body actions. By natural we mean to express that they are ergonomically, culturally and socially adequate for the type of users and the type of activities. Now, because low functioning PAS are not capable of assimilating cultural and social conventions, we decided to base naturalness on human factors and hence, find basic and general body behaviours that could easily cause a reaction in the system and that would be clear to the user.

These very simple behaviours that any child should be able to do were: move laterally in relation to the screen, move towards the screen or away from it, gesticulate in front of the screen, touch or lean on the screen. This allowed us to start thinking of very simple games to play with images like making them appear or disappear, making them grow or shrink, make them mimic the user, etc. With these simple interactions, the user would hopefully understand she is in control of the situation. In consequence we centred the interaction on two large rear projection screens (300 x 225 cm) inside MEDIATE environment which are the support for visuals, Fig. 5.

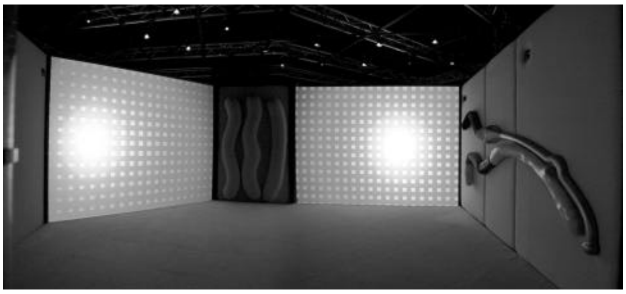


Figure 5: Panoramic view of the interior of the environment.

CREATIVE ACTIVITY IN PRELIMINARY INTERACTION MODELS

In the process of obtaining the final visual interaction for MEDIATE we designed up to eleven interaction models from which we chose four to be fully developed as preliminary work. They all promoted a creative activity based on an atypical use of particles as visual elements (based on the findings and hypotheses mentioned above), and their relationship with full body user's actions.

Ta-to-mo (Come close – Touch – Move)

In this interaction model, the user finds a screen fully "tiled" with large square particles. When the user moves laterally, the particles rotate to orient themselves towards the position of the user; as if the particles cuddled the user. The user's distance from the screen affects the size of the particles (when close they grow, when far they shrink). On touching the screen a wave of colour is generated from that point outwards, Fig. 6.

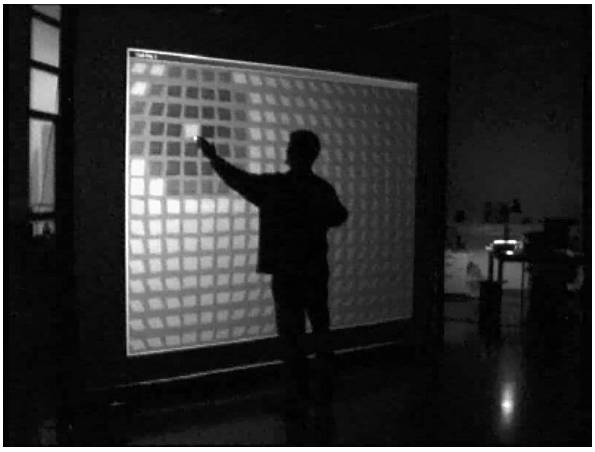


Figure 6: A wave of colour being generated in Ta-to-mo.

The waves were designed to be a strong clear (contingent) response to the user screen touch and hopefully lead the user to a creative state. The game can be played as an instrument, spreading colour waves all around the screen, with size, time duration, intensity and overlapping of waves depending on how long the user touches the screen and on which parts of the body she uses.

Fullaraca (Leaves)

In this interaction model, the lower part of the screen is full of particles, like "leaves" that have piled up on the floor.

Figure 7: The silhouette of the user is revealed by the particles (leaves) that are blocked by it.

When the user passes in front of the screen the particles are thrusted upward as if by "air currents". When they lose energy and fall, they can collide with the projection of the user and collect around it to reveal the user's silhouette. The game naturally adapts to user intensity of interaction. In other words, it is self regulated: if the user moves a lot around the space the flying of particles is more intense, whereas if the user becomes less active the environment calms down and the particles again come to rest at the bottom of the screen. If the user is passive for too long, the system makes invisible "gnomes" appear, moving through the piled particles, shaking them slightly to make the user curious and hopefully make her become active, Fig. 7.

Fullaraca proposes a game where full body interaction is extremely important, both in moving around and in body gestures (legs, arms, etc.). It offers the user the opportunity to find herself within the particle world as a revealed silhouette. Either impeding the movement of the particles or moving them generating currents the user can play with the holes and shapes created by the “leaves”.

Kite

In this interaction model, one particle is differentiated from the rest (the "kite") following the hand of the user that is furthest from her body or, if she does not use her arms, following her at eye level. The rest of the particles are scattered throughout the screen creating a dynamic background. The particles in the background are shaped as compass needles and always orient themselves towards the “head” of the kite. As the "kite" moves through the screen and passes over the particles it picks them up and places them at the end of its "tail", hence the tail grows longer the more the user plays. If the user stands still, the kite and its tail freeze to show the path of movement last done by the user. But if the user stands still for too long, the particles of the tail begin to leave it, starting from the end, and go back to their original position in the background. This means to signal the user that the game is not fun anymore, thus encouraging her to move again and become active to avoid the tail from disintegrating, Fig. 8.

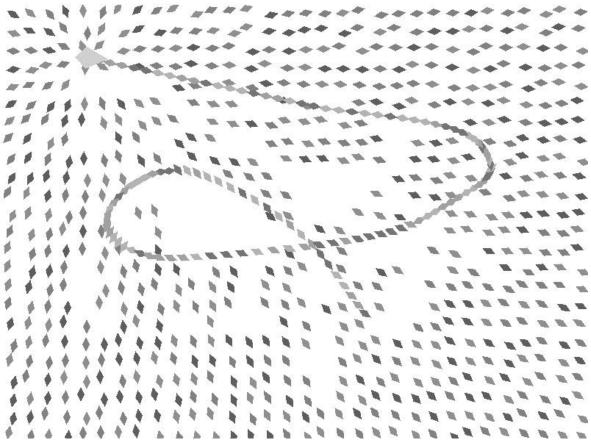


Figure 8: The tail of the kite makes the trace of movement of the user visible.

This interaction model gives priority to "gestures"; the idea of drawing in the air. The user can play with the kite creating paths as an orchestra director or she can play with the background particles moving and rotating them in soft swinging movements when making them point at the driven kite.

Traç/en (Traces)

This proposal tries to empower visual integration through small movements of the user (hands, head, etc.) and to achieve this it distinguishes them from large movements through space. A cloud of particles moves across the screen. The large movements of the user cause the cloud to change direction. The small movements of the user "freeze" a group of particles in front of her forming an object that falls to the bottom of the screen. After a while, the object is "eroded" by the cloud that swallows back its particles. Any number of objects can be created at any one time, but they are always generated only by the small movements of the user, Fig. 9.

Traç/en makes the user aware of its often unconscious movements proposing her to use them consciously. These movements generate clusters of particles that jump to the foreground proposing a game of “figure and background”. Here the cloud is a translucent ethereal structure that gives an idea of weightlessness and hence moves easily with the large body movements. Whereas the clusters are solid and give a sense of heaviness and become objects to play with. Thus the aesthetics of this interaction model proposes a new visual treatment with respect to the others.

Figure 9: The small movements of the user “freeze” particles that join to form objects.

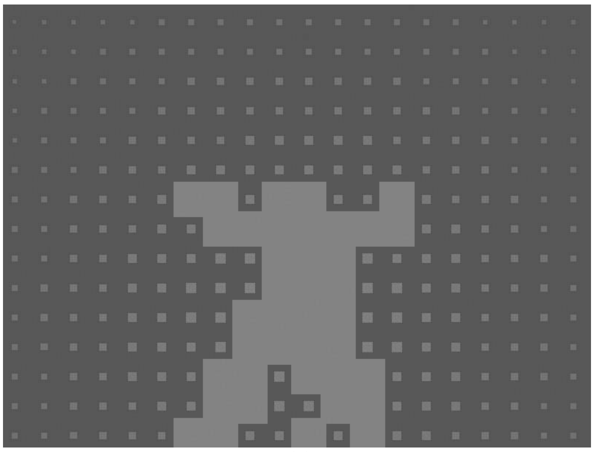
THE FINAL INTERACTION MODEL: MO-TA-TO (MOVE – STAIN ME – TOUCH ME)

Some of the preliminary interaction models were found to be inadequate for children with autism according to the information given by the high functioning children that helped us in the design process (informers) and to the psychologists’ comments. For example, Kite was considered as demanding too much motor control from the user as many low functioning children have motor difficulties. Similarly, Fullaraca was not found to be contingent enough because, as a high functioning informer said, “particles have too much a life of their own”. Finally, Traces was thought to be too dense in visual stimulation.

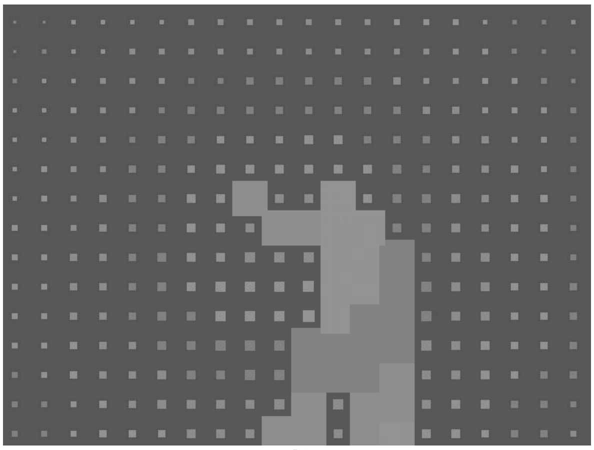
The final interaction model we defined for MEDIATE takes some of the aspects that seemed most successful from some of the preliminary models and picks up some of the suggestions made both by informers and psychologists.

This final interaction model, called Mo-ta-to, is based, as Ta-to-mo, on a screen tiled with square particles. Initially though, the screens are empty, only coloured with an initial colour that sets the interaction gamut. When the child enters the environment, the system detects her presence and presents a grid of small tiled particles. This is already a very effective and contingent basic game that many children have successfully discovered and enjoyed. As the user comes closer to the screen the particles grow and as the user moves away they shrink, thus promoting user displacement as a game. This tiled background presents a gradient in size and shade of colour of its particles from the user's position to the edges of the screens, creating a constant sense of shelter wherever the child moves to.

When the child is in front of the screen, the particles that fall within the area of what would be her projected silhouette, grow and join to create a blocky silhouette giving a sense of gelatinous material. This gives interaction a very fluid feeling allowing the user to create different shapes with the blocky silhouette, Fig. 10a.



(a)



(b)

Figure 10: Mo-ta-to interaction model. (a) a view of the gelatinous silhouette of the user. (b) a wave colour generated.

Finally, if the child comes very close to the screen and/or touches it, a wave of colour is generated starting from the touched point outwards, Fig. 10b.

Motato's particles behaviour suggest a simple creative play on changing their size and colour by just asking the user to move around the space. At the same time the user can use her own silhouette to create forms and shapes on the screens generating interesting and funny images. This generates interesting dances of the user and her gelatinous partner around the environment in a very expressive and creative scenario. Combining these with the colour waves, the user can create and spread different figures throughout the screens giving a multi-layered visual game that adapts to each child's potentiality and preferences, Fig. 11.

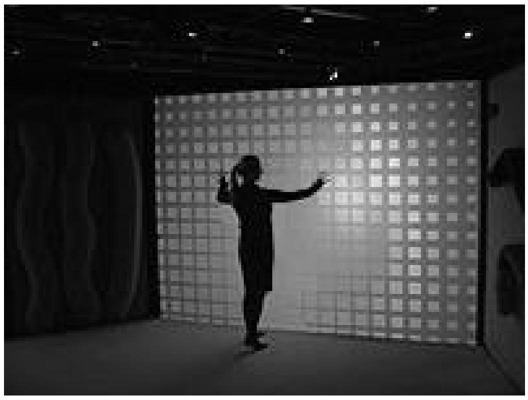


Figure 11: A view of the gelatinous silhouette of the user playing with Mo-ta-to.

RESULTS

MEDIATE is a transportable environment. Thus, sessions with autistic children have been held in London, Hilversum (Netherlands), Barcelona and Portsmouth, with a total of more than 90 PAS children having had sessions in the environment. All children went through MEDIATE once, except in Barcelona where each child had three sessions to assess evolution of interaction. The acceptance of the environment has been remarkable as only one girl in Barcelona refused to enter on her first visit. These PAS children, that need very rigid daily routines and that do not cope well with unknown places, have actually become curious enough to enter by their own will and start playing. This is already a huge success for the experience. The time spent in the environment has varied from 5 minutes to 35 minutes. In every case, it has been clear that the children have found at least one of the proposed interactions and have successfully played with it. For example many children found the simple and clear game of making the particles appear and disappear on entering and exiting the environment, playing at the entrance threshold, which greatly helped them in gaining a sense of control.

Current results are based on qualitative assessment by the psychologists. The methodology was based on two raters who were blind to the initial hypotheses. Psychologists will obtain quantitative results in the future from data extracted from the system. This is data logged by the "brain" of the system corresponding to the user's sensed behaviour during each session.

According to the qualitative results, none of the children felt uneasy or uncomfortable in the environment (only one of the sessions had to be stopped because of overexcitement of the child) and most appeared to gain the desired sense of control and agency. Feedback from parents and carers of children who have used MEDIATE, shows they felt it was a hugely beneficial experience and they would like to be able to continue to use the environment.

From our observations, we confirmed that the visual interaction design yielded excellent results in the expressivity of the children. For example, many children danced around the space playing with their gelatinous silhouette and generating all sorts of shapes. The generation of diverse wave patterns was also seen as very successful. MEDIATE experience allowed many children for the first time to be completely on their own and be safe to make their own choices, enjoy their behaviours and get some recognition from the environment as to what they were doing. Moreover, this was achieved taking careful consideration of their particular sensory needs and communication difficulties. Finally, in the MEDIATE environment, many of the children could do as they pleased, totally up to them, without having to meet the expectations or demands of others, including their parents or carers, allowing them to be independent and have freedom. We understand this freedom and novel activity leads them into a creative attitude.

CONCLUSIONS

Because of the encouraging results obtained in this first phase, ongoing work is being undertaken at University of Portsmouth and run by the Portsmouth Education Authority Psychology Service as a second phase to MEDIATE. Sessions with a small group of low functioning children are being held weekly to observe whether a periodic use of the environment reflects any changes in the children's daily life. Results on this are expected by the end of this year.

Future evolution of this project involves several tasks. On the one hand, it is important to achieve greater integration of the hardware that controls the system to make it more accessible to non-technical personnel. On the other hand, the environment must pass the current prototype status to make it more available to special education centers. Finally, many more interaction models can be designed and made available to low functioning PAS children to analyse which are more successful in generating a creative activity and a good sense of control.

ACKNOWLEDGEMENTS

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REFERENCES

1. Dautenhahn, K. Design issues on interactive environments for children with autism. *Proc. 3rd Intl Conf. Disability, Virtual Reality & Assoc. Tech.* (Alghero, Italy, 2000), 153-159.
2. Foley, J. et al. Computer Graphics Principles and Practice., *Reading, MA: Addison-Wesley, 2nd. ed.* (1990).
3. Happé, F. Autism, an introduction to psychological theory. *Psychology Press Ltd, Taylor & Francis Group*. (1999).
4. MEDIATE official project web site: http://web.port.ac.uk/mediate/ (last accessed January 2005).
5. NAS, National Autistic Society UK, URL: http://www.nas.org.uk/, last accessed 27/02/05, 2005.
6. Parés, N.; Carreras, A; Soler M. Non-invasive attitude detection for full-body interaction in MEDIATE, a multisensory interactive environment for children with autism. *Proceedings of Vision, Modeling, and Visualization 2004.* (Stanford, California, USA, 2004).
7. Parés, N.; Parés, R. An Interaction-driven Strategy for Virtual Reality Applications. *Abstract Proceedings of the VR World Congress, El.pub, IST, EC*. (Barcelona, 2001).
8. Parés, N.; Parés, R. Interaction-driven virtual reality application design. A particular case: 'El Ball del Fanalet or Lightpools'. *PRESENCE: Teleoperators and Virtual Environments.* (2001). Cambridge, MA: MIT Press, Vol 10.2. 236-245. http://www.iua.upf.es/~npares/publicacions/interaction-driven.pdf (last accessed January 2005).
9. Robotic and Virtual Interactive Systems in Autism Therapy. A two-day workshop at University of Hertfordshire, Hatfield, UK. 27-28 September 2001. http://homepages.feis.herts.ac.uk/~comqkd/AutismWorkshop.htm (last accessed January 2005).
10. Robotic and Virtual Interactive Systems in Therapy of autism and other psychopathological disorders. A two-day international workshop at Hospital La Salpêtrière, Paris. 27-28 September 2002.
11. Strickland, D. Virtual Reality for the Treatment of Autism. *Virtual Reality in Neuro-Psycho-Physiology. Giuseppe Riva (Ed.)*. (Amsterdam, Netherlands, 1997, 1998), Ios Press.