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Starting Research in Interaction Design with Visuals for Low-Functioning Children in the Autistic Spectrum: A Protocol

NARCÍS PARÉS, Ph.D., ANNA CARRERAS, B.Sc., JAUME DURANY, B.Sc., JAUME FERRER, B.A., PERE FREIXA, B.A., DAVID GÓMEZ, M.A., ORIT KRUGLANSKI, M.A., ROC PARÉS, Ph.D., J. IGNASI RIBAS, B.Sc., MIQUEL SOLER, B.Sc., and ÀLEX SANJURJO, B.A.

ABSTRACT

On starting to think about interaction design for low-functioning persons in the autistic spectrum (PAS), especially children, one finds a number of questions that are difficult to answer: Can we typify the PAS user? Can we engage the user in interactive communication without generating frustrating or obsessive situations? What sort of visual stimuli can we provide? Will they prefer representational or abstract visual stimuli? Will they understand three-dimensional (3D) graphic representation? What sort of interfaces will they accept? Can we set ambitious goals such as education or therapy? Unfortunately, most of these questions have no answer yet. Hence, we decided to set an apparently simple goal: to design a "fun application," with no intention to reach the level of education or therapy. The goal was to be attained by giving the users a sense of agency—by providing first a sense of control in the interaction dialogue. Our approach to visual stimuli design has been based on the use of geometric, abstract, two-dimensional (2D), real-time computer graphics in a full-body, non-invasive, interactive space. The results obtained within the European-funded project MultiSensory Environment Design for an Interface between Autistic and Typical Expressiveness (MEDIATE) have been extremely encouraging.

INTRODUCTION

A MULTISENSORY Environment Design for an Interface between Autistic and Typical Expressiveness (MEDIATE) is an interactive environment that generates real-time stimuli (visual, aural and vibrotactile) such that low-functioning children with autism, who have no verbal communication, can hopefully express themselves and "have a bit of fun." This goal, in spite of its apparent simplicity, is actually quite demanding and ambitious, both in psychological and technological terms. This is why it must be stressed that this environment does not claim to be therapeutic or educational. In spite of previous attempts by other research projects to work in this direction,[1–5] psychologists in the consortium believe that our understanding of autism does not yet permit us to aim for such ambitious goals, especially in low-functioning persons in the autistic spectrum (PAS).

MEDIATE was a project under the FP5/IST/Systems and Services for the Citizen/Person with Special Needs (including the elderly and the disabled), lasting for 30 months. It was coordinated by the University of Portsmouth (UK). The rest of the consortium was formed by the Hogeschool voor de

Audiovisual Institute, Universitat Pompeu Fabra, Barcelona, Spain.

Kunsten Utrecht (Hilversum, Netherlands); the "Institute of Psychiatry" of Kings College London (UK); Show Connections Limited (UK); and Universitat Pompeu Fabra. In this paper, we describe the design approach, functionality, and results of the project, from the point of view of the visual interaction design, defined by our team at Universitat Pompeu Fabra.

GOALS OF MEDIATE

As defined by the National Autistic Society, UK (NAS),[6] autism is a set of disorders in intercommunication and interrelation abilities whose essential characteristics are the presence of an abnormal development in the following: (1) communication, (2) socialization, and (3) imagination. From this, a main goal and two secondary goals were defined (completely subject to ethical considerations):

- *Main goal*: For the children with autism to have fun and have the chance to play, explore and be creative in a predictable, controllable and safe space.
- *Secondary goals*: (a) For the psychologists to better understand autism and the possible underlying communication mechanisms. (b) For the parents of the children with autism to find new qualities in their sons or daughters by seeing them play in this environment.

HOW TO REACH THESE GOALS

The consortium defined four strategic concepts with which to achieve the main goal and the two secondary goals. These are defined below:

Control to achieve a sense of agency

The disorders mentioned above imply that PAS children rarely experience a sense of control with respect to their surrounding environment. Technically, it is said that they have no sense of agency; that is, they have no sense of connection between them and the surrounding world. Therefore, one of the basic concepts behind the design of MEDIATE was to provide the user with clear interaction dialogues that would hopefully give the children a sense of control of the system. If this were achieved, then they would probably gain the sense of agency that makes them feel at ease.

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 are feeling overwhelmed or when they are obsessed by something. Both attitudes are considered undesirable by psychologists, because they isolate the child from the world. Therefore, the second concept behind the design of MEDIATE was to detect repetitive patterns in any of the sensed attributes of the user and inform the rest of the system in order to try to pull the child out of this state.

Adapt to each child

Because of the wide spectrum of PAS children who could use the environment, the consortium thought it would be important to make the system adapt to each child's needs and potential. A "decision maker" module in the "brain" of the system would modulate stimuli and interaction responses, such that if the child were behaving in a novel (i.e., non-repetitive) manner, the environment would raise its complexity in each modality (visuals, sound, and vibration/touch) and eventually evolve into cross-modality. If on the other hand, the child behaved in a repetitive manner, then the environment would dim down all responses, making everything drop back to a less demanding or softer interaction mode.

High-functioning children in design team

To be able to determine whether the design decisions were on the right track, groups of high functioning children with autism, who could give verbal feedback, were incorporated in the design teams, at each participating university, as informers. They gave useful comments on the type of stimuli being designed and the type of interactions proposed.

WHY AN ENVIRONMENT?

The environment approach was chosen because the children could very easily adapt to a full body interaction, as opposed to an object-based approach (which could obsess them) or a desktop approach (that presented concentration and control issues). By simply moving through and gesticulating in the defined space, the environment could already start responding, opening small doors that could lead the child into playing with it. To make

this possible, the environment was composed of a set of sensors that capture user's actions and a set of software that generates the response stimuli based on what we call interaction models. The use of non-invasive sensors was essential such that no sensors or cables should be placed on the user. Hence, the sensors were all external—microphones, cameras, transducers, and pressure sensors—distributed throughout the environment, and analyzed and managed by the computer system in real time.

WHAT DOES THE MEDIATE ENVIRONMENT LOOK LIKE?

MEDIATE was finally designed as a hexagonal space, approximately 6 m in diameter. Inside the space several elements act as interaction interfaces (Figs. 1 and 2): the floor surface that reacts to footsteps generating sound; the tune fork wall with tube-like structures that generate sound when caressed or stroked; the two rear projection screen walls (300 $\times$ 225 cm) that support visual interaction reacting to the child's movement and touch; the impression wall with padded structures reacts to pressure and emits vibration; the sound interface based on microphones and speakers that reacts to sounds emitted by the child in the space (e.g., voice, clapping).

THE USER: CANNOT BE TYPIFIED!

When designing an interactive application, one of the first basic steps is to analyze and define the type of user to which the application is addressed (i.e., the user must be typified). In our case though, because the spectrum of disorders in autism is so wide, we had the imposed restriction of not being able to typify our user. Hence, we had to establish new strategies for interaction design. This has been our main challenge and interest in our research group and will be the focus of the design of interaction with visual stimuli for MEDIATE described below.

INTERACTION WITH VISUAL STIMULI DESIGN

Not being able to typify the user, we needed a different approach. We based it on a design strategy that our group had formalized in previous projects: the interaction-driven design (as opposed to a content-driven or user-driven approach).[7] Thus, we started by identifying the input/output interfaces, then defined interaction models and finally the visual elements to be used. Because the consortium had decided upon a full body interaction, we decided to find basic and general body behaviors that could easily cause a reaction in the system and that would be clear to the user. These very simple behaviors that any child should be able to do were: move in relation to the screen, gesticulate in front of the screen, and touch the screen. This allowed us to start thinking of very simple games to play with images. With these simple interactions, the user would hopefully understand she was in control of the situation. But we still needed to know which type of images to use or which image strategy to follow.

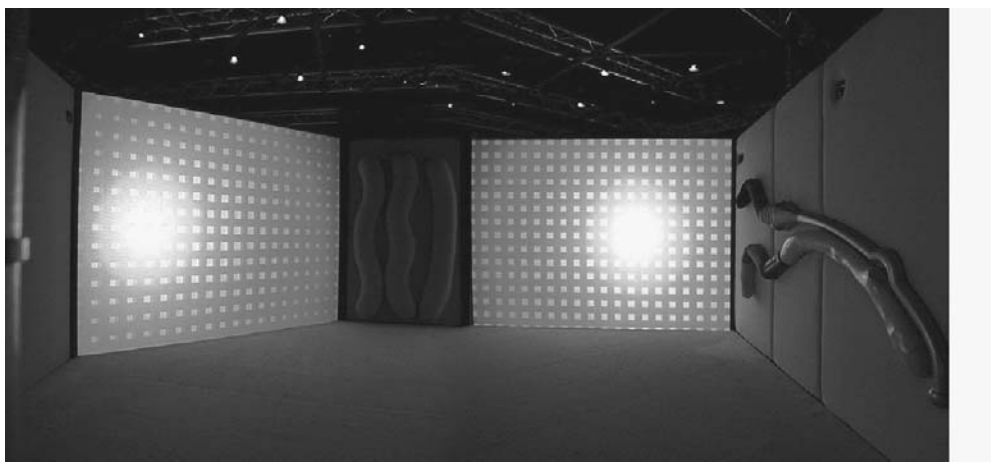

FIG. 1. Panoramic view of the interior of the environment with the interaction elements.

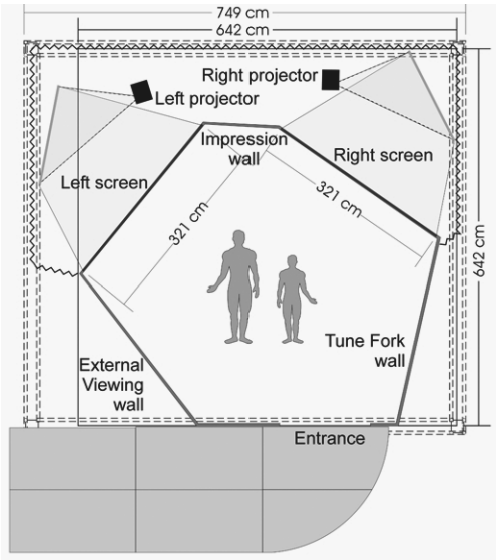

FIG. 2. Plan view of the MEDIATE physical environment.

THEORY OF VISUAL PERCEPTION: GESTALT THEORY

When we started to design the interaction with visual stimuli, we began to ask ourselves questions such as: will these children be afraid of dark spaces? Will too much light overwhelm them? Do they prefer certain color gamuts? Do they understand images for what they represent? Or rather, do they see only shapes and colors within an image? All these questions were posed from the theory of human perception and understanding of images. However, there is no literature that gives evidence that they prefer any of those options or that they interpret images in any particular way. One thing was very clear, though, the consortium 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. From this reasoning, we decided to work with abstract or non-representational images.

PARTICLE SYSTEMS

In our search for visual design, we found that, due to "weak central coherence,"[8] children with autism concentrate on the parts of a complex object rather than on the whole. A side effect of this seems to be that they are very fast at finding a shape hidden in a mesh of lines, whereas neurotypicals (non-autistic people) take quite long in finding them. Because of this we thought of working with isolated geometrical elements and this immediately reminded us of particle systems.[9] The notion of isolated particles with individual or group behaviors opened many possibilities. So how could we get the children to start playing with the particles?

INTERACTION MODELS

We designed up to 11 interactive games with particles, from which we chose four to be fully developed as preliminary work in the process of obtaining the final visual interaction for MEDIATE. These interactive games we called interaction models because they 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. Figures 3–6 show the four developed preliminary interaction models.[10]

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 thanks to the information given by the high functioning children that helped in the design and to the psychologists' comments. For example, "leaves" was not considered contingent enough, and kite was considered as demanding too much motor control of the user, as many low-functioning children have motor difficulties. Hence, the final interaction model we defined for MEDIATE takes

FIG. 3. Particles fly as dry "leaves" thrusted by virtual air currents generated by user.

FIG. 4. "Ta-to-mo": User generates waves of color on virtual tiles by touching screen.

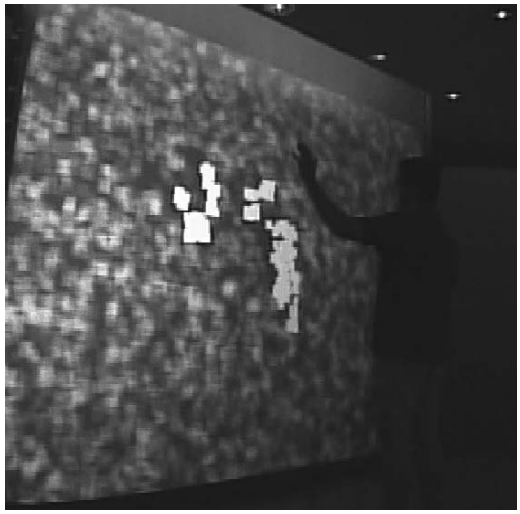

FIG. 6. User leaves "traces" of its small movements by freezing particles in a cloud.

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 is based, as Ta-to-mo, on a screen tiled with square particles (Fig. 7). Initially, though, the screens are empty, only colored with an initial color 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 small and basic game that many children have successfully discovered and enjoyed.

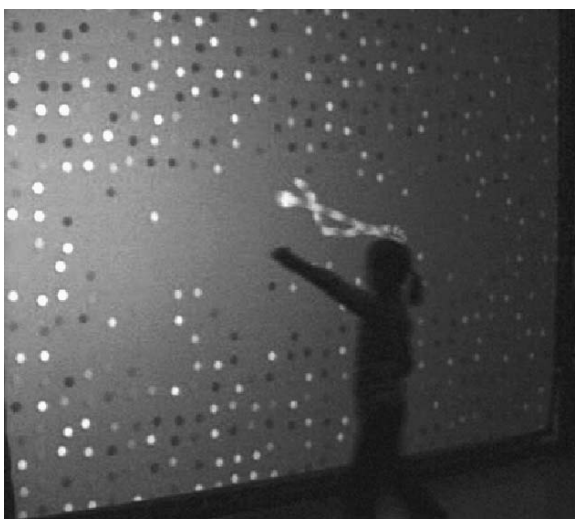

FIG. 5. The user controls the "kite" to make its tail longer by picking up scattered particles.

The particles grow as the user comes closer to the screen and shrink as the user moves away. There is a gradient in size and shade of color of the 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 that gives a sense of gelatinous material. This gives interaction a very fluid feeling. Finally, if the child comes very close to the screen and/or touches it, a wave of color is generated starting from the touched point outwards.

CONCLUSION

MEDIATE is a dismountable and transportable environment, and sessions with PAS children have been held in London, Hilversum, Barcelona, and Portsmouth. A total of over 90 children have had individual sessions in MEDIATE, and except for two children, none of them were reluctant to enter. Needless to say, the children are not in any way forced to enter. In fact, the psychologists ask the parents (who are present during interaction just outside the action space) not to push (neither physically nor verbally) their children to enter the environment. This is already a huge success for the environment: that is, children who need very rigid daily routines and who do not cope well with unknown places have actually become curious enough to enter by their own will and start playing. The time spent in the environment varied from 5 to 35 min. In every case, it was

FIG. 7. "Mo-ta-to" (final interaction model): User plays with silhouette and waves.

clear that the children found at least one of the proposed interactions and successfully played with it. None of the children experienced discomfort in the environment and only one of the sessions had to be stopped because of the child's overexcitement. Parent's feedback (from a meeting with an independent evaluator) proved that they all felt it was an extremely beneficial experience and that they would very much like to be able to periodically take their children to an environment like MEDIATE. Also, many parents felt their children had a much more relaxed and able attitude for the rest of the day after having passed through MEDIATE.

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Address reprint requests to:
Dr. Narcís Parés
Audiovisual Institute
Universitat Pompeu Fabra
Barcelona, Spain

E-mail: npares@iua.upf.edu