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Audio-augmented paper for therapy and educational intervention for children with autistic spectrum disorder ☆

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ABSTRACT

Autism affects children's learning and social development. Commonly used rehabilitative treatments are aimed at stimulating the social skills of children with autism. In this article, we present a prototype and a pilot study on an audio-augmented paper to support the therapy of children with autism spectrum disorder (ASD). The prototype supports audio recording with standard sheets of paper by using tangible tools that can be shared between the therapist and the child. The prototype is a tool for the therapist to engage the child in a storytelling activity. We use a progressive design method based on a dynamic process that merges concept generation, technology benchmarking and activity design into continuously enriching actions. The paper highlights the qualities and benefits of using tangible audio-augmented artefacts for therapy and educational intervention for children with ASD. The work describes three main qualities of our prototype: *from building cooperation to attention control*, *flow control*, and *using the children's own voices to foster attention*.

1. Introduction

Autism spectrum disorder (ASD) is a developmental, neurobiological condition that affects the ability to communicate, interact socially and be imaginative (Kanner, 1943; Jordan, 1999). The severity and range of disordered thought processes, communication interactions and behaviors vary from one child to another, ranging from very low to very high functioning. Children on the low-functioning side of the spectrum usually have little or no language use, severe intellectual disability and little awareness of other people and their expectations. The syndrome is lifelong, and its causes are still unknown.

Interventions for individuals with autism typically begin early in life and are usually aimed at teaching social and communicative strategies. These interventions include the use of visual supports such as images and drawings to represent both concrete and abstract real-world concepts (Cohen and Sloan, 2007).

Among the various techniques and approaches, the social story intervention is commonly employed to address the acquisition of new social skills and improvement of existing social behaviors.

Social stories are individualized, short narratives written from a child's perspective that explain challenging social situations and describe socially appropriate responses (Gray and Garand, 1993). Although social stories were originally conceived for children on the high-functioning side of the autism spectrum, Swaggart et al. (1995) expanded their application to children and youth with moderate to severe autism.

In social stories, visual cues are often used to assist students in their understanding of oral language; the use of pictures and written words combined with spoken language enables children to abstract meaning from information (Quill, 1997). Furthermore, children who have difficulty responding to verbal instruction are more able to respond to pictures (Krantz and McClannahan, 1993).

Child-specific interventions consist of the teacher providing direct instruction, although in some cases, teaching peers are involved to prompt or provide reinforcement to students with disabilities (Odom, 1994). The strengths of social story treatments are that they can be implemented in informal environments, are extremely flexible and adaptable to individual children's needs and characteristics, and stimulate and enrich children's experiences during rehabilitation sessions through the use of physical artefacts (i.e. drawings, pencils and other materials).

Our aim is to provide a tool for the caregivers (therapists, special education teachers or even parents) to discuss social stories (or similar materials) with children on the autistic spectrum. The paper first introduces a preliminary framework for future development of this research area, then it reviews related projects and previous studies. Next, the design process used in this work is

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presented. Then the research method used in a preliminary ecological study is described, and research findings are discussed. Finally, conclusions are drawn, and suggestions are offered for further study.

2. Related literature and works

In the last decade, numerous technologies and systems have been designed for therapy and educational intervention for children with ASD. Empirical supported computer-based interventions are grounded on the cognitive-behavioural therapy (CBT) procedure, based on applied behavioural analysis principles (Hart and Morgan, 1993; Lovaas and Smith, 2003). Computer-based interventions include virtual reality (Lányi and Tilinger, 2004; Parsons and Cobb, 2011); robotics (Dautenhahn, 1999; Kozima et al., 2005); tabletop computer interfaces (Hourcade et al., 2012); and tangible artefacts (Alessandrini et al., 2013; LeGoff, 2004; Farr et al., 2010; Garzotto and Bordogna, 2010). For the purposes of this work, we only report literature on tangible interventions for autism; for a more general review, refer to (Hourcade et al., 2012).

In human–computer interaction, windows, icon, menu, pointer (WIMP) interfaces denote a style of interaction developed for personal use in office settings. For decades, this interaction style has fostered personal activities rather than social ones. In fact, when the mouse and keyboard are being used in front a screen, it is unclear to an observer whether the user is chatting with friends or working on a complicated music application. The WIMP interfaces standardize activity and hide social and cooperative cues (i.e. on a personal computer). Over the last decade, the tangible user interface (TUI) interaction paradigm has supported the interplay between social exchanges in a given context and properties of digital artefacts. According to Ullmer and Ishii, "TUIs will augment the real physical world by coupling digital information to everyday physical objects and environments." (Ullmer and Ishii, 2000, p. 235). It is well understood how the mediation of a tangible interface may promote colocated cooperative work for people (Ullmer and Ishii, 2000). In fact, tangible interfaces add not only grasping and manipulating aspects to interfaces, but also the ability to share and pass them among people (Yuill and Rogers, 2012). Additionally, recent research focusing on TUIs for children demonstrates the social benefits of designing tangible systems (Antle, 2007; Antle et al., 2009; Price et al., 2003).

In recent years, authors have reported an increase of cooperative behaviors in children with ASD using tangible technologies. For example, LeGoff (2004) demonstrated the benefits of using LEGO© as a therapeutic medium for improving social competence in children with autism. Farr et al. (2010) highlighted the advantages of Topobo, a 3-D constructive assembly system embedded with programmable kinetic memory (Raffle et al., 2004) in fostering collaborative and cooperative behavior among children with ASD. Garzotto and Bordogna (2010) described the benefits of the 'talking paper' to support children with disabilities and therapists in associating physical objects with multimedia resources. Moreover, Farr et al. (2010) emphasised the positive effects of augmenting configurable objects with children's or therapists' own voices. In this kind of intervention, the role of caregivers is very important.

Several works in the existing literature involve the use of paper as an active medium. Back et al. (2001) described an augmented book that uses radio frequency identification; our approach is somewhat similar, but we focus on recording more than on listening (although, as explained below, the therapists also considered this use). Piper et al. (2012) proposed the use of a digital pen for audio annotation of paper-based materials (drawings, photos, etc.); our approach is very similar, although the technological approach is quite different. In this case also, our goal is to merge the recording and listening activities in a more natural way. TinkerLamp (Zufferey et al., 2009) used fiducial markers to build paper-based interfaces for tangible simulations; our work shares the same idea of recognizing elements by visual markers, but it is more focused on a specific activity. LuminAR also uses fiducial markers to build tangible interactions (Linder and Maes, 2010).

Although these studies demonstrate interesting opportunities to design TUI technologies, scarce information exists on the benefits of using situated audio-augmented social stories for the treatment of children with autism. In order to address this gap, we have designed an audio-augmented, tangible interactive environment to support and promote audio narrative and descriptive activities for children with ASD. In our research, we investigate the roles and benefits of using situated audio recording in narration and description tasks, as well as the advantages of using our prototype to support therapy sessions. The rest of this article describes the design process for the prototype development and the results of our ecological study with children and therapists.

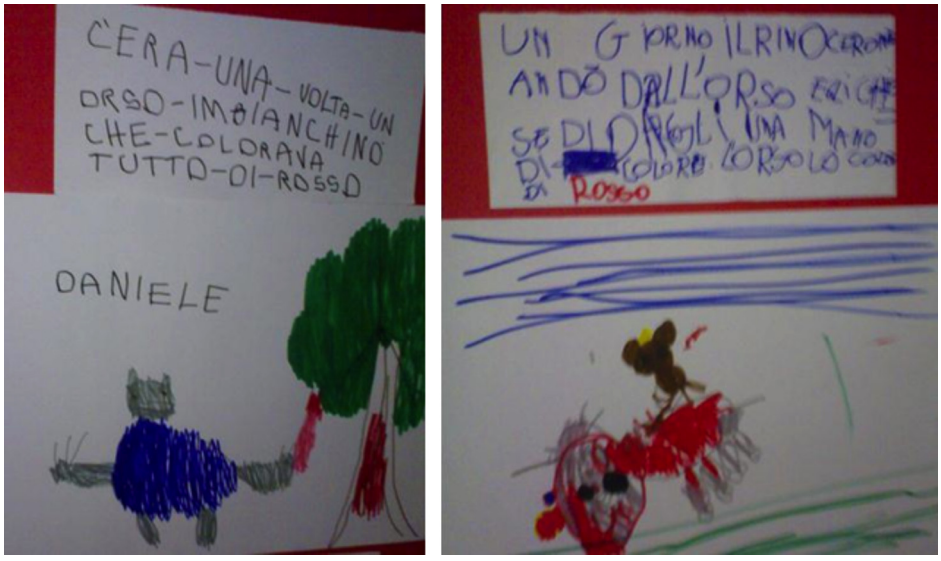

Fig. 1. Drawings from the local center.

3. Design process

The design process, grounded on principles of user-centered design (UCD) and scenario-based design (Carroll, 2003), adopts a dynamic methodology that merges concept generation, technology benchmarking and activity design into continuously enriching and progressive actions.

The project began with a field study conducted at the local center for the education of children with autism. The center, routinely uses a variation of the social story approach, organized around a drawing activity collaboratively done by a therapist and a child. The therapist employs the drawing activity as a framework to present and discuss a social story or other types of educational activities. Often, verbal content is written on the sheet of paper (by either the child or the therapist) as a memory aid for continuation of the activity at a later time, or for the parents to become aware of their child's activities (Fig. 1). In several cases, the therapist lets the child initiate the storytelling by just prompting the latter to help verbalize his or her thoughts.

In describing their work and the possible use of technologies to support it, the therapists showed enthusiasm at the possibility of using multitouch tabletop devices or tablets. Yet they also praised the use of paper for the following reasons: (i) its readiness: no need to set up the equipment or schedule its use; (ii) the possibility of using various colors and implements with different "feelings" and expressive potentials (watercolors, crayons, etc.); particularly in particular with children on the low-function side of the spectrum, the comfort of using their preferred ways of coloring is extremely important; and (iii) the ease of sharing the task of drawing (for helping the children or prompting new material). The therapists also expressed minor worries in using advanced technologies, particularly their cost, the possibility of damaging the devices in case of the children's aggressive behavior, the issue of children with motor impairments, and a possible distracting factor introduced by the computer itself.

Based on the field study, the design team (composed of a computer scientist, a senior researcher and an interaction design researcher) decided to focus on the tangible dimension of paper. The reason is that although it is possible to design a tabletop interface for a narrative activity based on a drawing task, there are several advantages for children with autism to work with physical artefacts rather than with computer representations. For example, physical artefacts allow the using of a richer set of materials (pencils, watercolors, etc.), and they are cheaper.

We decided to explore the design space by starting with simple sheets of paper and defining the following objectives:

> Design objective 1: augment standard sheets of paper with the possibility of recording audio from the oral narration of the child and the therapist: this would allow the therapist to introduce the story or involve the child in presenting his own story without the need to write on the paper (although writing may still be a possibility if needed).
> Design objective 2: make the computer completely disappear from the user experience – this would reduce the child's distraction and maintain the naturalness of the therapist/child interaction.
> Design objective 3: easy to configure – the system should require no calibration or cumbersome preparation activities: as discussed above, the readiness of the paper was one of the key aspects highlighted by the therapists.

Concurrent to the field research, we benchmarked the tagging and audio technologies to explore enabling ones and inspirational projects. Parallel to this, the design team conducted concept generation sessions inspired by the field study and informed from technology benchmarking. An initial range of concepts was produced and organized into narrative forms in order to create a scenario, shareable by the design team along the design process (Carroll, 1995). At the end of this initial phase, we selected the *Hide me!* concept for further elaboration in the design process.

3.1. Hide Me! Concept

Hide me! is an interactive environment that enables the child and the therapist to augment an ordinary sheet of paper with audio content. This concept aims to enable and support audio narrative and descriptive activities in rehabilitative contexts. The first proof-of-concept design focused on paper-based interaction and audio content. We found the choice of the tangible, paper-based interaction a rich solution because: (1) the expressive use of paper is quite infinite; (2) its physical interactions might favor sociality between child and the therapist; and (3) it might encourage cooperation and turn-taking. Next we presented the first brief scenario created to guide the proof-of-concept prototype:

> *Using a sheet of paper augmented with two visual tags, the child draws on it, along with the therapist. The software and video camera capture the sheet's surface and contents drawn on it. When the user's hand hides the "rec" tag, the video captures drawings on the sheet of paper, together with the audio. When the user's hand hides the "play" tag, the system plays audio content linked to the sheet of paper.*

The first *Hide me!* proof-of-concept prototype used a vision sensor (a webcam) and an A4-sized sheet of paper, augmented by two pairs of unique tags recognizable by the sensor. One pair of tags printed on opposite corners of the sheet of paper was used to uniquely identify it. The other two tags were printed closer to each other along the center of the paper's vertical orientation as "buttons" with playback and recording functionalities when hidden from the vision sensor (Fig. 2).

The scenario and the proof-of-concept prototype were presented at a critique session attended by a multidisciplinary audience comprising a sociologist, a computer scientist, a

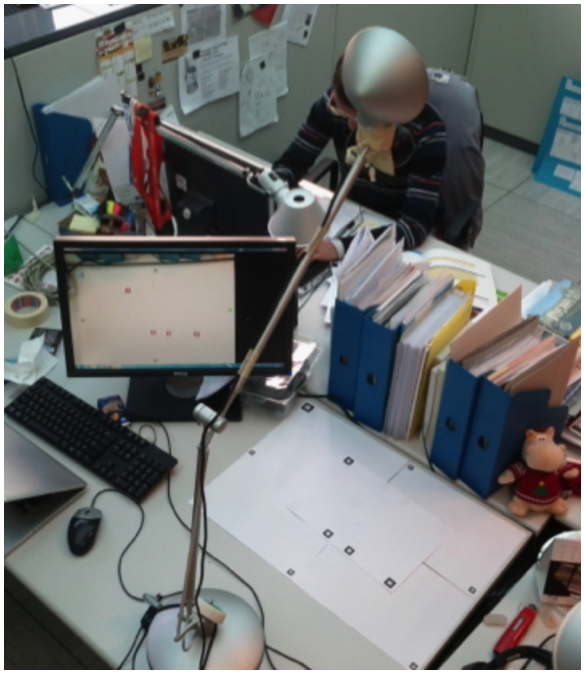

Fig. 2. First prototype.

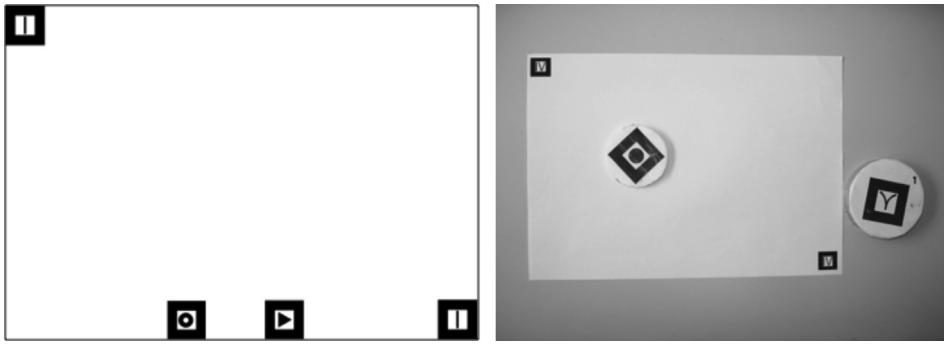

Fig. 3. First *Hide me!* sheet (left) and tokens (right).

psychologist and engineers, some of whom were experts on autism. The critique focused on gaining insight and feedback from diverse perspectives. The feedback showed that the proposed model of interaction was based on a unique artefact – the sheet of paper – which neither supported nor improved social interactions between the therapist and the child, nor enhanced the imaginative expression of the paper medium. We hypothesized that to foster social interaction, we should redesign the interaction model to enable sharable control by multiple users. Consequently, we revised the prototype to support a more dynamic and expressive interaction based on tangible tokens for the control of the playback and recording functionalities of the audio content. The new model of interaction introduced a dimension of control anchored to the space of interaction, which required little social negotiation dynamics to control the system.

3.2. First concept refinement

We refined the concept by introducing two tokens, one for the recording and the other for the playback functionality (Fig. 3). The new model of interaction reorganized the space and flow of artefacts under the vision system of the lamp in three ways: (1) an anchor artefact (the sheet of paper) was required to start the interaction with the system; (2) the two tangible tokens affected the sheets of paper exclusively, in a sense that one token might exist only at one time; and (3) each token has privileged behaviors with respect to the sheet of paper. In other words, to record on a sheet, the child or the therapist placed a sheet of paper under the lamp, then he or she placed the recording token over it ; removing the token ends the recording. Additionally, the playback token allowed users to create a sequence, enabling the concatenation of audio files just by successively placing a new sheet over the previous one. We supposed that by separating the playback and recording functionality from the medium (sheet of paper), the therapist and the child were given a greater entry point for negotiation, stimulating social interaction, imitational learning, and awareness of each other's actions.

The concept refinement was followed by two parallel activities: (1) the creation of storyboard and video scenarios and (2) the development of a wireframe and an interactive prototype. In the storyboard and video scenarios, we highlighted three key aspects of the prototype: (1) the tangible control functionalities that may be easily controlled by the child and the therapist; (2) the possibility of using multiple sheets to create an audio sequence by laying under the lamp the sheets of paper over others in successive order; and (3) the system requiring common sheets of paper, printed from a common printer. For the first prototype, both a state machine diagram and an interaction wireframe were created; the first described the software components and implementation, and the second the user's interactions. The new prototype was based on a webcam embedded in an ordinary desktop lamp. The software application, running on a standard personal computer, detected tags in the captured scenes and generated simple event of their presence. This task was executed by the *ARToolkit*[1] library. Although the preliminary tests produced acceptable results, the library missed some features that were fundamental to our objectives. Because of the ARToolkit's limited resources, we decided to switch to a technology more tailored to TUI scenarios, and we focused on frameworks that supported new or alternative human interface devices.

The new prototype applied the *TUIO* framework,[2] coupled with *reacTIVision* fiducial tracker. This engine reduces the incidence of missed detection, increasing the stability of the marker-tracking process. The presence or absence of a marker in the scene generated events that transitioned between states. The *Processing*[3] environment was used for combining blocks with specific functionalities, such as audio, tracking and serial communication.

The new prototype was evaluated with a heuristic evaluation (Nielsen, 1994) by field experts from different backgrounds, consisting of cognitive science, psychology, computer science, engineering, design and sociology.

The following is a brief summary of the results:

- The active area cannot be determined only by an audio feedback, but should also be visual.
- The audio feedback was excessive, and some were too arbitrary for children with autism.
- Greater audio control could be achieved with the introduction of a third tangible functionality for erasing the audio sheet's contents.

Based on the heuristic evaluation, the prototype was refined as follows: (1) light was provided to highlight the visual area (Fig. 4); (2) annoying feedbacks were removed; (3) tokens were redesigned to communicate their unique functionalities; (4) consistency and manipulability of tokens were redesigned by increasing their weight and thickness; and (5) two LEDs were embedded into the base of the lamp to describe the system status: system okay (green) or system error (red). Minor refinements were also implemented.

3.3. Final prototype

The final prototype (Fig. 5) is based on a common desktop lamp with a camera in place of the bulb. A laptop computer connected to the lamp via a USB port runs a program that performs the recording, storage and playback of the audio files and other related

[1] http://www.hitl.washington.edu/artoolkit.
[2] http://www.tuio.org.
[3] http://www.processing.org.

operations. The camera is used to "see" the fiducial markers (visual images with some specific properties that facilitates their automatic recognition). The reacTIVision (http://reactivision.sourceforge.net) open source framework is currently used.

The fiducial markers are printed on the sheets of paper to recognize the presence of a sheet below the lamp and to assign a unique code to each sheet. Two identical markers are printed on opposite corners of each sheet of paper to minimize the cases in which both are covered by the user's hands or arms. When a sheet of paper with fiducial markers is placed under the lamp – in the camera's field of view – the system recognizes the paper's presence and identity. Children or therapists may record with the sheet of paper by placing the recording token on the sheet. If the sheet of paper already contains audio, the new audio is appended to the end of the previous one. In this way, a long audio description can be added to a drawing piece by piece. Two therapists and a physiologist at a local center for the education of children with autism further evaluated the final prototype. During the session, therapists explored the prototype by simulating a rehabilitation situation. This session was not only helpful for the therapist to understand and learn the prototype's main features, but it also favoured a brainstorming session in which ideas were jointly explored. For example, this further evaluation not only suggests reducing audio feedback (because children with autism may be very sensitive to it), but also recommended having a set of three cards describing sequential images of a simple story (Fig. 6). The next section describes in detail the results of the pilot study.

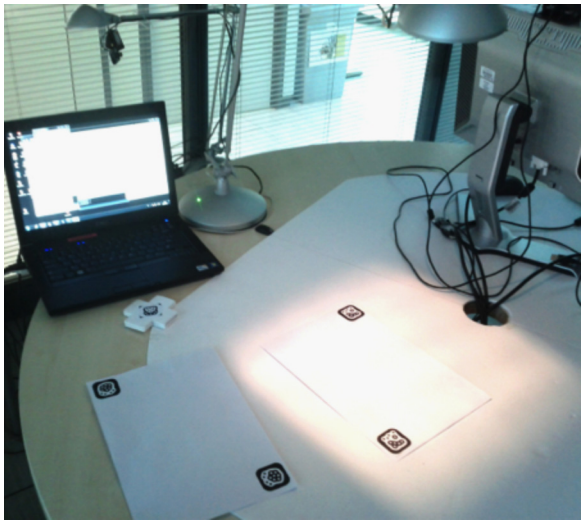

Fig. 4. Refined prototype with lit area.

4. Pilot study

The prototype was evaluated in a pilot study at the same local center mentioned earlier. This first study was not intended to be a final evaluation, but to explore the strengths and weakness of our prototype. The following dimensions were worth investigating: (1) how the therapists use the prototype, (2) how the prototype supports the therapists' learning objectives, and (3) the children's level of engagement.

4.1. Method

The pilot study was divided into three phases: use of the prototype by the children and the therapists, semi-structured interviews with the therapists, and final focus group discussion with therapists. These three phases were all conducted at the same local centre mentioned earlier. In each use session, the therapist used the prototype together with a child for 30–40 minutes. The therapists already knew the children, and the former were already conducting educational activities based on drawings and storytelling with the latter. In the semi-structured interviews (around 10 min), the study facilitator asked questions about therapists' experience using the prototype. The children's families were informed about the study and its objectives and gave permission for their children's participation. The whole study was approved and supervised by the director of the center and the psychologist who was treating the children.

The study involved four low-functioning male subjects with verbal abilities (8–12 years) led by four therapists. Each child was involved on two different sessions, where the leading therapist differs at each session. At the beginning of each session, the study facilitator described to the therapist the functionalities of the lamp, tokens and sheets. During each session, the therapist was free to choose the activities that best responded to the child's needs. All sessions were video-recorded. At the end of each session the study facilitator interviewed the therapist. The pilot study

Fig. 5. Final prototype on two different settings.

Fig. 6. Three cards augmented with tags.

concluded with a focus group in which selected video clips were discussed in a focus group with therapists and the psychologist at the local center. In general, the therapists appreciated the prototype and were able to use it without problems. However, they most often used the prototype to engage the children in a description activity rather than in a storytelling activity. This preference might be due to the therapists' limited experience with the system or because the system is too limited for a storytelling activity. The therapists adopted three different uses throughout the study: describing pre-printed, social story visual cards; drawing on blank sheets; and drawing on a sequence of sheets.

4.2. Description of visual cards

Therapists showed to the children the social story visual cards. (Fig. 7) and created a remarkably rich activity. For example, the therapist asked the child to describe the content of the card, to determine whether the subject on the card was happy or sad, or to explain the reason for a certain action depicted on the card. While the child talked about the card, the therapists used the recording token to capture the child's voice. In this activity, the situated audio recording was mainly used to allow the child to listen back to his voice, to verify his statements and as a reward.

In this first phase, only the therapists act on the tokens; they gave little importance to explaining to the children the prototype and its functionalities: “I will explain this [recording token] to you later” or “This [recording token] will record your voice”. Moreover, the therapists initially assigned a “magical” value to the prototype, often using statements such as “Now listen to the magic lamp” or “It is like magic”. In all sessions, the children were surprised to hear their own voices. Listening was often gratifying, both for the child and for the therapist. The children were apparently amused and engaged by the ability to record and listen to their own voices. The video analysis and semi-structured interviews confirmed such reaction among the children, but more importantly, the latter were focused on listening. In fact, therapists randomly checked the children's attention to listening, for example, asking “Whose voice is this?” or unexpectedly removing the play token and asking the child the answer to the question just heard from the system. Furthermore, when therapists asked “Whose voice is this?” or “Who is speaking?”, the children only answered, “It is mine!” or “Me!” when the therapist suggested “It is us” or “Lorenzo and Giovanna”. High levels of involvement and attention were present in almost all the children.

At the end of this first initial “magical” experience, the therapists gave the children more details on the prototype's functionalities. For example, they explained, “The triangle is used for listening”, and “The circle is for recording your voice”. Following this first discovery phase, the therapists created, together with the children, more collaborative and cooperative actions through tokens and sheets. For example, therapists said to the children, “Can you do it?”, “Put it here”, or “Now try to listen to it”. In one case, the therapist agreed with the child to record his voice again for a better sound“ …so that your friends can hear it [later]”.

4.3. Drawing on blank sheets

In all sessions, the therapist and the child used augmented blank sheets for free-style drawing (Fig. 8). The space on the table was occupied with augmented blank sheets, penholders filled with colored marker pens, books with illustrations, and other materials. From the therapists’ point of view, the children might have varying needs. It was observed that the therapists easily adapted the prototype to the children's specific needs. The children were highly engaged in this drawing activity. For example, the child and therapist would often draw together on the same sheet, building an authentic collaborative activity. At the end of drawing exercise, the therapist would ask the child to describe it , for example, “Tell me what is in this sheet”, or “What are they wearing?”.

In many cases, the prototype gave the therapists the opportunity to control easily the flow of the activity. In fact, they appreciated the opportunity to “stop” and “rewind” the activity to permit the children to elaborate on their tasks better. For instance, in many cases, the recording token was removed as soon as a problem occurred or if the children did not answer correctly what the therapist had asked. All the therapists used the situated audio recording of the children's own voices to enhance their engagement in the reelaboration of the task. For example, a therapist said, “I asked you to describe what the three pigs are wearing, but you described where they lived…let's listen again to what you said”. Sometimes, the therapists would scaffold the children's description, “The first pig is wearing a blue hat, yellow pants and a blue pullover; the second is wearing…”. All the therapists found that the children's voices were a powerful means for the reinforcement and reelaboration of their tasks. In this manner, the prototype was recognized as an effective tool for the therapist to control the flow and pace of the educational activities.

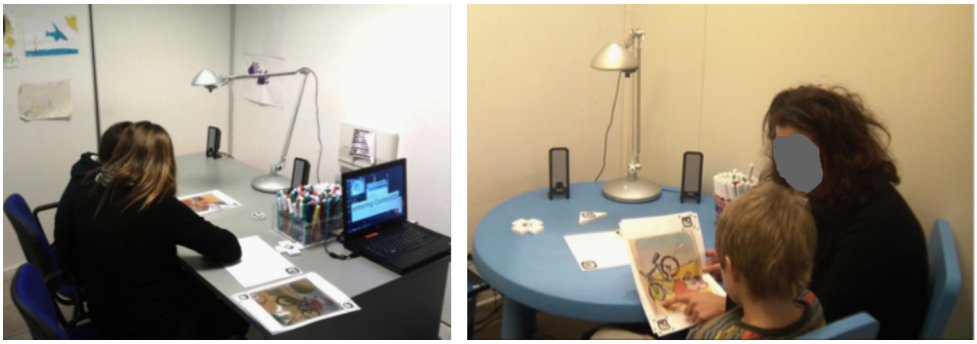

Fig. 7. Image description.

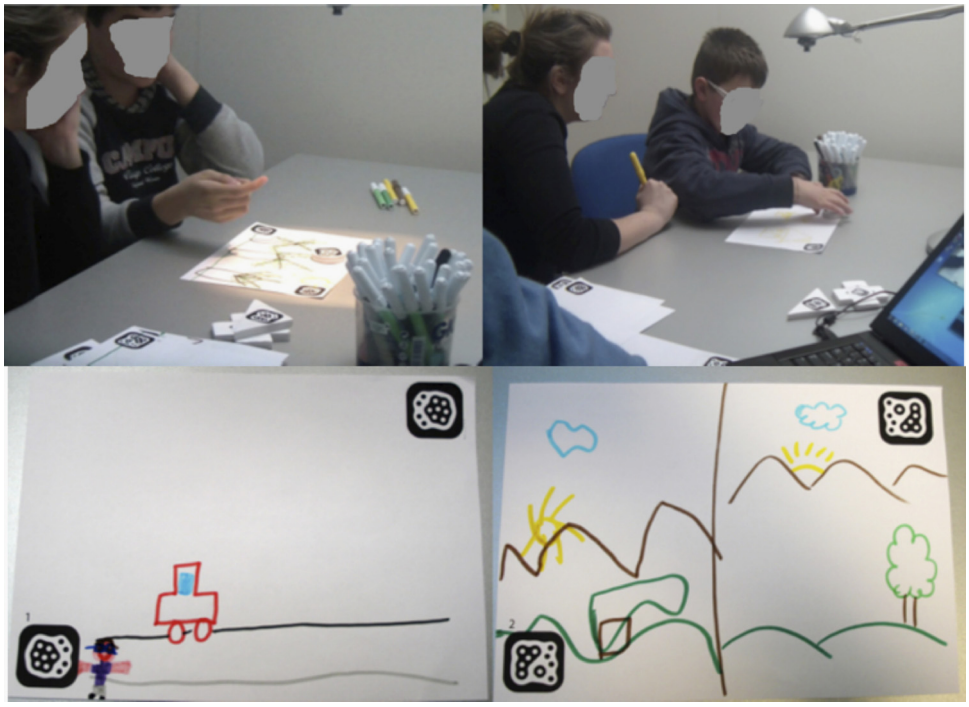

Fig. 8. Uses of blank sheets.

4.4. Sequences of drawings

Lastly, the least applied method was the particular use of blank sheets for the creation of a custom sequence. In this activity, the therapist created a short social story by drawing a scene on each blank sheet. To speed up the scene-drawing process, the therapist drew almost all the scenes, and the child was only marginally involved, since the therapist had a limited time per session. Only in this circumstance was the prototype used to listen to the custom sequence of social story through the sequential playback mode. Often, at the end of the session, the child would request to take their sheets for showing at home.

5. Discussion

The research investigates the role and benefits of using audio-augment paper to support therapy and educational intervention for children with ASD. Our challenges of using audio-augmented paper indicate some advantages for both children and therapists.

Humans have a well-known repertoire of physical actions with objects. Actions such as passing, grasping and sharing objects emerge quite early in the development of children's cultural background (Tomasello, 1999). The remarkable characteristic of the tangible interfaces is the capacity to link computation with a physical object (Ishii and Ullmer, 1997). This work highlights several advantages and qualities of using simple tangible materials to support educational intervention for children with autism. The study focuses on the three main qualities of our prototype, which are described below.

5.1. From building cooperation to attention control

In several cases, the therapists used the prototype's tangible tokens as an aid to engage the children. During the focus group discussion with the therapists, this aspect was considered interesting and important, not only as a means to control the interaction but also to empower the children in the therapy. The prototype enabled the therapists to gain the three basic dimensions of their activities simultaneously: cooperation, anchoring attention and controlling attention.

Sheets and graspable tokens were used to create opportunities for the children's active participation. Through the construction of a cooperative action, the therapist and the child used the same

tool to achieve a goal together. For example, explaining to the child what the token was for and letting him use it helped the therapist attain the rehabilitative goal through collaboration. The fact that the child could be the protagonist of this action together with the therapist was a moment of mutual exchange. Yuill and Rogers (2012), as well as Ullmer and Ishii (2000), already highlighted the cooperative qualities of tangible interfaces in colocated activities.

The prototype supported the therapists in recalling and controlling the children's attention. The therapists used prototype's graspable tokens and sheets as physical anchors to center the children's attention on the task and to support it. For example, if the therapists perceived that the children's attention was too firmly anchored to the prototype, this meant that the children were distracted and not focused on the task.

It is worth noting that the fiducial markers were not considered a distraction by either the therapists or the children. Furthermore, since the collaboration and the ability to share the space of the sheet of paper were deemed highly relevant by the therapists, the use of tangible tools could allow a further dimension of cooperation by sharing the tools themselves.

5.2. Flow control

The simplicity of the interaction model and familiarity with the materials used – the shape of lamp, paper, and simple forms – facilitated the understanding of the prototype, and consequently, its use and control (Yuill and Rogers, 2012). The prototype enabled control of the "flow" of the educational tasks for the therapists. They appreciated the opportunities to "stop" and "rewind" the activity to permit the children to elaborate on a task better. In many cases, the therapist interrupted the activity by removing the token from the sheet if a problem occurred or if the child failed to perform the task correctly.

5.3. Using the children's own voices to foster attention

From the children's perspective, they were apparently amused and engaged by the opportunity to record their own voice and listen to the playback. The prototype stimulated fun and consequently aided the children's attention to listening tasks. Listening to their own voices made the task more enjoyable and easier for the children. The therapists often used children's voices to reinforce awareness of their answers. These same conclusions emerged from the focus group discussion with the therapists and the psychologist. According to our initial design challenges, one of the most significant results of this work is that hearing their own voices serves as an incentive to the children's attention, which would not be obtainable with a typical, unaugment sheet of paper.

6. Conclusion

The prototype meets the design objectives and suggests an interesting line of investigation for the benefits it may bring to the therapeutic or educational setting. In particular, it demonstrates the potential of being a flexible tool that the therapist can easily appropriate. More formal evaluation along the dimensions discussed in this paper is planned in the near future, as well as implementation of the proposed new functionalities.

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