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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.

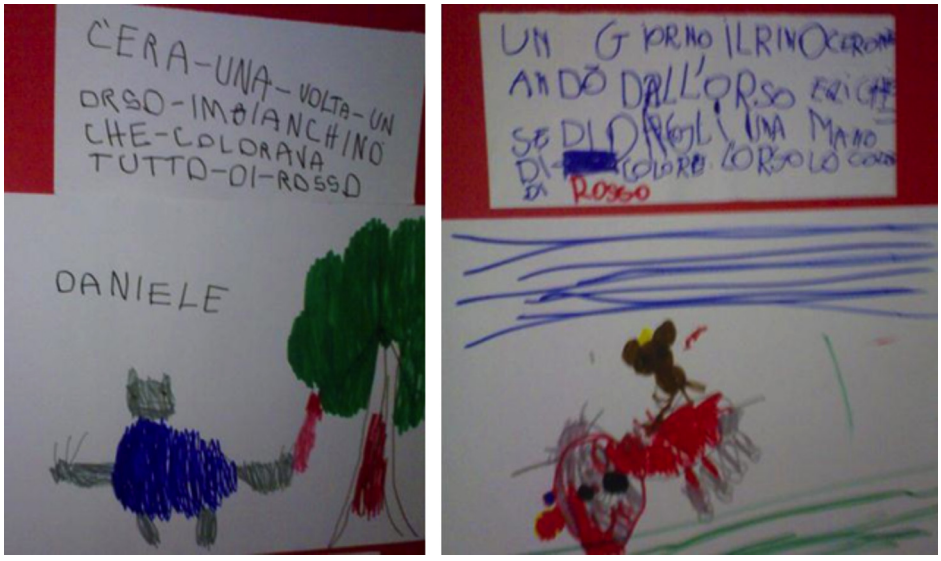

Fig. 1. Drawings from the local center.