Augmented reality-based video-modeling storybook of nonverbal facial cues for children with autism spectrum disorder to improve their perceptions and judgments of facial expressions and emotions

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ABSTRACT

Autism spectrum disorders (ASD) are characterized by a reduced ability to understand the emotions of other people. Increasing evidence indicates that children with ASD might not recognize or understand crucial nonverbal behaviors, which likely causes them to ignore nonverbal gestures and social cues, like facial expressions, that usually aid social interaction. We used an augmented reality (AR)-based video modeling (VM) storybook (ARVMS) to strengthen and attract the attention of children with ASD to nonverbal social cues because they have difficulty adjusting and switching their attentional focus. In this research, AR has multiple functions: it extends the social features of the story, but it also restricts attention to the most important parts of the videos.

Evidence-based research shows that AR attracts the attention of children with ASD. However, few studies have combined AR with VM to train children with ASD to mimic facial expressions and emotions to improve their social skills. In addition, we used markerless natural tracking to teach the children to recognize patterns as they focused on the stable visual image printed in the storybook and then extended their attention to an animation of the story. After the three-phase (baseline, intervention, and maintenance) test data had been collected, the results showed that ARVMS intervention provided an augmented visual indicator which had effectively attracted and maintained the attention of children with ASD to nonverbal social cues and helped them better understand the facial expressions and emotions of the storybook characters.

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1. Introduction

Autism spectrum disorders (ASD) are characterized by repetitive and stereotyped behavior, and by impairments in verbal and nonverbal communication and in social behavior (Boelet & Hallmayer, 2013). In particular, social reciprocity defects are one of the core deficits in social interaction for people with ASD (American Psychiatric Association, 2000; White, Keong, & Schall, 2007). Social reciprocity depends upon the ability to empathize with (attribute mental states to) others, to be aware of emotional and interpersonal cues, and to respond appropriately (Sucksmith, Allison, Baron-Cohen, Chakrabarti, & Hoekstra, 2013; it requires using both joint attention and nonverbal social skills (Constantino et al., 2003). Although some people with high-functioning autism (HFA) are relatively adept at social communication involving complex emotions, they find nonverbal communication a barrier (Elder, Caterino, Chao, Shacknai, & De Simone, 2006).

In addition, among the most characteristic early symptoms of ASD are atypical eye contact and atypical joint attention, which profoundly impair the development of social communication skills (Senju & Johnson, 2009). Children with ASD typically have behavioral difficulties that suggest problems with visual attention. It is unclear whether this attention deficit causes the other symptoms of ASD or is a consequence of the disorder (Koldewyn, Weigelt, Kanwisher, & Jiang, 2013). Most studies which aim to identify the eye-tracking locus of young children with ASD report an emerging consensus that detailed characterizations at the level of eye movements in response to fixating and tracking visual stimuli are important (Falck-Ytter, Bolte, & Gredeback, 2013). Other research
(Durham University News, 2013) says that children with ASD might be missing crucial nonverbal indicating behaviors, which likely causes them to not recognize or understand nonverbal gestures and social cues like facial expressions and relevant gestures that usually aid social interaction. Missing these cues generally has a negative effect on their social interaction skills and the flow of their communication (Mundy, Sigman, Ungerer, & Sherman, 1986), because people with ASD cannot judge other people’s expressions and emotional states, or understand the intentions and internal activities of others (Krasny, Williams, ProvencaI, & Ozonoff, 2003). Neither can they respond with appropriate gestures, postures, or proximity (Ryan & Ni Charragain, 2010)—a defect in what researchers have called Theory of Mind ability: the skill to view things from other people’s perspective and to understand the mental states of others (Smith, 2006)—i.e., the ability to empathize (Baron-Cohen & Belmonte, 2005; Baron-Cohen, Leslie, and Frith (1985)).

Therefore, children with ASD, who normally pay more attention to inanimate objects than to nonverbal social cues, need to be taught specific visual indicating behaviors involved in social interactions, and must learn to pay attention to the nonverbal social cues of the people they meet and talk with in order to understand social reciprocity (Martins & Harris, 2006; McPartland, Webb, keehn, & Dawson, 2011). That is why we believe it necessary to teach children with ASD to pay attention to some pivotal social signals and ignore others.

The motivation of this research is derived from a practical problem that helps improve the social interaction of children with ASD. Autism remains a medical mystery. No single approach is effective for alleviating its core symptoms. Children with ASD find it difficult to focus on specific social cues. They tend to pay attention to insignificant objects. Other studies, without considering the entire context, used only static or dynamic images as the learning materials to train children with ASD. However, using static or fragmented images is too limited and not ecologically valid. Dynamic videos are advantageous, but children with ASD have trouble focusing their attention on dynamic videos. Because of this, children with ASD cannot always be attracted by the media. Therefore, we used augmented reality (AR) technology to attract their attention. In addition, to decrease their visual stress and loading, we chose suitable content that was less than 45 s long, focused on specific social signals, and combined the AR technology with a video modeling (VM) strategy. Although other researchers have already provided evidence that AR is useful for training typically developing children (Chen, Wu, & Zhung, 2006; Chen & Su, 2011), using AR is a novel approach for training children with ASD to make judgments about the facial expressions and emotions of others. Moreover, AR learning activities have been proposed in many studies which demonstrate that an AR system not only provides students the basics and is flexible and innovative (Chang, Wu, & Hsu, 2013; Pan, Cheok, Yang, Zhu, & Shi, 2006), but that it also positively increases the motivation to learn (Diserio, Ibanez, & Kloos, 2013). AR attracts the attention of children with ASD and encourages them to maintain their focus on nonverbal social cues. Other experiments (Escobedo, Tentori, Quintana, Favela, & Garcia-Rosas, 2014) support that claim. However, few studies have used AR as a training tool for autistic children’s social skills. Because of the developmental deficit in children with ASD that prevents them, in social situations, from easily and correctly judging and understanding the emotions of other people, we used AR to strengthen their attention on achieving this goal, and enabling them to understand the perceptions and judgments of facial expressions and emotions. We hypothesized that adding AR to VM with a storybook (ARVMS) to augment virtual visual hints that indicate and amplify the nonverbal social cues in videos will improve VM and encourage children with ASD to focus on specific parts of the videos.

2. Related work

Of all the assistive technologies used to support people with autism, the most thoroughly researched is VM, an evidence-based instructional strategy and a medium-tech assistive technology (Odom, Collet-Klingenberg, Rogers, & Hatton, 2010) and a form of observational learning in which desired behaviors are acquired by watching a videotape demonstration and then imitating of the target behavior of the model (Charlop-Christy, Le, & Freeman, 2000). However, VM may have some weak points for training children with ASD in social skills. Evidence shows that computer technology-based interventions (CBIs) like VM used on the iPod Touch, iPad, and other tablet computers are therapeutically effective for teaching functional, social, and behavioral skills to children with ASD (Ayres & Langone, 2005; Bellini & Akullian, 2007). The flexibility and portability of modern devices make it much easier for them to learn and develop new skills. For example, Cihak, Fahrenkrog, Ayres, and Smith (2010) evaluated the efficacy of VM delivered through a handheld device (video iPod) and of using the system of least prompts to assist elementary school students to transition between locations and activities within the campus. Four students with autism learned to manipulate a handheld device to watch video models. An A-B-A-B withdrawal design was used to assess a functional relationship between VM and the performance of independent transitions by the student. The A-B-A-B design represents an attempt to measure a baseline (the first A), a treatment measurement (the first B), the withdrawal of treatment (the second A), and the re-introduction of treatment (the second B). In other words, the A-B-A-B withdrawal design involves two parts: (1) gathering baseline information, using a treatment, and then measuring its effects; and (2) measuring a return to baseline or what happens when the treatment is removed, repeating the treatment, and then measuring the change. After the intervention began, all participants began transitioning more independently, but their percentage levels fell when the intervention was withdrawn, which showed that VM methods with a video iPod were useful for intervention.

Moreover, Young and Posselt (2012), using the Transporters DVD as a VM learning tool to attract the attention of children with ASD, focused on the expressions of animated human faces on toy trains, buses, and other vehicles (transporters) that are characters in a video story which illustrates, names, and describes emotions in some common social situations. They reported that their participants’ ability to judge the emotions of others had significantly improved. This showed that modeling is a key way for humans to learn behavior (Mason & Ganz, 2011). In related VM applications for teaching children with ASD how to identify nonverbal social reciprocity cues, Blum-Dimaya, Reeve, Reeve, and Hoch (2010) used various facial expressions in photos and videos to develop the communication skills of people with ASD, which enabled them to focus on the specific visual representations and facial cues from which the facial emotions of others can be determined. Moreover, Axe and Evans (2012) used VM to train 5 year-olds with pervasive developmental disorder not otherwise specified (PDD-NOS), an ASD, to respond to 8 facial expressions. The training material was a video of an adult modeling a response to each facial expression. Two of the children correctly responded to all facial expressions after viewing the video models once or twice. This suggested that VM was effective for helping the children observe and imitate simple feature points such as facial expression. Tetraault and Lerman (2010) showed that VM in a multiple baseline across contexts design was useful for teaching 3 children diagnosed with an ASD to initiate and maintain a conversation with a conversant. The children were taught to make eye contact and to initiate a conversation without being prompted. The treatment included both presenting a target video and reinforcing the target
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