Reflections on the Adoption of Virtual Reality-based Application on Word Recognition for Chinese Children with Autism

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Abstract
Deficiency of attention and sensory overload have been well documented in individuals with Autism Spectrum Disorder (ASD); yet attention impairments could preclude children from developing social, cognitive and literacy skills. On the other hand, To address this limitation, virtual reality (VR)-mediated instruction could provide an *isolated* and *focused* learning space where noises can be faded out and in turn facilitate the integration of additional visual and auditory cues, thus improve children's learning skills. Unfortunately, most of the prior works of VR-based applications had focused on constructing a safe controllable immersive environment to enable children with ASD to develop useful social and communication skills; published research along this path is even rare in mainland China, which motivates our on-going research. In particular, in this short paper, we report a qualitative observation of the acceptability of such an application in trials involving a twelve-year old boy with high-functioning autism (though is now in a public school) and his mother. Although it is their first encounter with such a technology, and both show high enthusiasm on it; but when it comes to its deployment, mixed results were obtained.

IDC '16, June 21-24, 2016, Manchester, United Kingdom
ACM 978-1-4503-4313-8/16/06.
http://dx.doi.org/10.1145/2930674.2936001

Author Keywords
Autism spectrum disorder; virtual reality; word-learning, China.

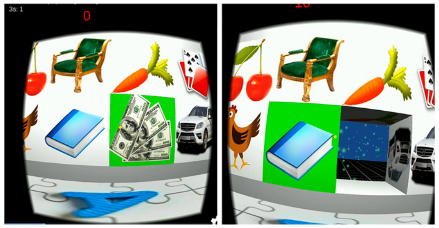

Figure 1: The game as viewed from the boy wearing the eye-glass during testing.

Figure 2. The testing environment separated as four areas.

Figure 3. The testing moment when the observer wearing Google glass attempted to capture the experiment at a closer range.

ACM Classification Keywords

H.5.m. Information interfaces and presentation.

Introduction

Attention deficiency and sensory overload have been well documented in individuals with Autism Spectrum Disorder (ASD) [3]; yet attention impairments could preclude children from developing social, cognitive and literacy skills. Among these, it could especially cause a cascading long-term effect on young children's learning paths when they enter adulthood. Since not all information arrived at the scene will be processed simultaneously, the individual must allocate their attention so as to attempt to focus on current task; meanwhile, the information might contrast with each other if processed in different sequence, which could lead to serious distraction to the users [1].

On the other hand, virtual reality is well-known to provide users a safe and immersive environment to interact and manipulate [11, 17, 24, 25]. Its appealing aspects have been effectively demonstrated in special education (among many, [11, 17, 23, 24], including autism [8, 13, 18, 19, 23, 25]. Most of these prior works had focused on constructing a safe controllable immersive environment to enable children with ASD to develop useful social and communication skills [4, 5, 13, 14, 19], which differs from our approach in constructing a *focused* and *isolated* virtual space to support children on word recognition; and thus our study adds depth to the findings of these previous experimental studies of such technology. Notably, some of our findings contrasted with those of previous studies, but some are aligned with those of studies, which added richness into our understanding of the adoption of the related technology.

The following four factors lead us to develop such a VR-based Android application for Chinese children with ASD to recognize word: 1). The immersive virtual environment can isolate other external factors that might interfere with children's learning and cognitively constrain the user to keep focused while easily move around in the large space at ease [11] as distraction in the VR-based environment could be minimized; hence, additional visual signals might facilitate fine-tuning of the environment in the desired direction; 2). Children's performances during the entire learning process could be recorded and could be played back for the teacher and therapist to assess their learning performances; 3). The affordable headset (USD$10) can easily be deployed in private autism educational centers where the majority of individuals with ASD can receive education in mainland China; 4). Familial factors might alter the effectiveness or even the applicability of the related technology particularly when it will be deployed in a culturally different population [28], which could lend credence to the findings of previous works that had been largely conducted in the western world.

To the best of our knowledge, our research is one of the first for children with ASD in mainland China and one of the few adopting such technology to improve word recognition skills. While our previous focused on the design of the system [26], in this short paper, we will report our detailed findings of a recent experiment of the application on a boy with high-functioning ASD and his self-taught professional mom who is the director of one of the city's two biggest children's autism educational centers. Mixed, yet exciting results were obtained.

Experiment Participant and Testing Environment

Participant: A boy with high-functioning autism and his mother were invited to participate in the experiment. The boy is 12 years old, and is now in the primary school for TD children due to his mother's more than 10-years' persistent and professional supports (self-taught) and care; the mother is the director of one of the city's oldest children's educational center for autism. Because of the unique background and experiences of the mother, we conducted two rounds of questionnaires both before and after the experiment.

Experiment environment: The experiment was conducted in our IoT room which contains four small areas (see Figure 2). The room is decorated as a living room of a family with young children. Four corner-positioned IP cameras have been installed to record the entire testing sessions, with all parties' consent. In additions, a researcher wears a Google Glass was standing right beside the Interview area to capture the testing moments at a closer range (Figure 3, with consents from all parties).

Related Work

Virtual Reality in Autism Research

Most of prior works had focused on constructing a safe controllable immersive environment to enable children with ASD to develop useful social and communication skills [5, 13, 14, 19]. For example, Fabri et al constructed a virtual model to help children and adults (ages from 6 to 16 years) recognize emotions [5]. Mitchell et al developed a "Virtual Café" to train teens with ASD how to behave in public [19]. A similar study was conducted by Ke and Im to create a cafeteria where young children (ages from 4 to 5) must learn how to recognize the body language and facial expressions and interact with them accordingly [14]. Jung et al developed a program of sensory integration therapy based on the Virtual Reality-Tangible Interaction System (VR-TIS) model so as to assess children with ASD and provide intervention accordingly [13]. The VR-TIS system aims to make sense of human body movement (in a physical environment) via unfolded continuous visual feedbacks (in a computer). Most of these prior works had focused on constructing a safe controllable immersive environment to enable children with ASD to develop useful social and communication skills [21] which differs from our approach in constructing a *focused* and *isolated* virtual space to support children on word recognition; such a relatively isolated environment afforded by the VR-based environment could help mediate the attention deficiency in children with ASD.

Exiting technology-based intervention for word recognition skills for children with ASD

Laz pointed out that besides recognizing word, different perspective on literacy including computer assisted visual strategies (i.e. picture communication systems) might be needed [15]. It has been known that individuals with ASD have shown improved vocabulary learning when using technology-mediated intervention compared to teacher-delivered [16]. In the next section, we present the system, its running environment and report initial findings on the acceptability of such a VR-based game.

Our Study

Design Motivation

Currently in mainland China, the majority of private institutions on autism have been using the traditional flash card for word recognition including in the city where this research has been conducting [6]. The majority of children with ASD have to rely on government-subsidized private educational center for early invention and therapy session. Meanwhile, for these educational centers which receive limited government funding, their facilities are extremely lag behind their counter-parts in the West or even such neighboring countries and regions as Hong Kong, Japan and Korea. Our conversations with the special education teachers and parents at the two privately owned autism centers have led us to believe that technology-based interventions are welcomed with certain degree of skepticism. Hence, affordable applications are the most desirable.

The Application and Apparatus

The application was developed using Unity 3D for Android phones. Figure 1 left shows the screenshot of the game moment as viewed from the player's perspective. The game simulates a 3D room, where pictures of our daily products (as familiar to the children) are displayed on the walls (excluding floor and ceiling). Head movement from the player is used as the

Figure 4: At the end of the testing, the subject was seen completing 13-item questionnaire on his own at his request.

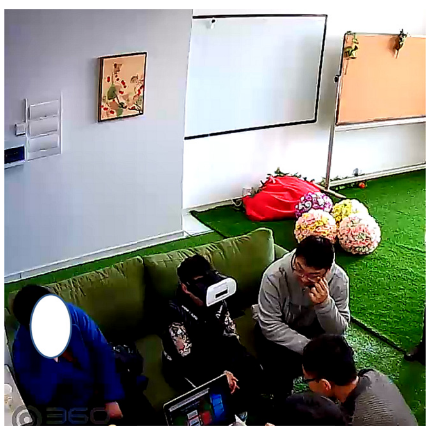

Figure 5: One moment when the boy was trying on the application.

only game control to shift the game's view, with a small yellow dot at the center of it. When the player 'looks' at an item for a certain time duration (5 second in our current setting), the system will pronounce the item's Chinese and English name (the previous version of our game only has Chinese version, see [26]) and then disappear from the game (replaced by the starry sky, see the right image in Figure 1). By 'look' here, we mean the center of the view (yellow dot) points to the item. Note, it is possible that the player is actually not looking straight at the center of the view, such as during the excessive blinking or eye-wandering, both of which might occur due to less visual stimuli exhibited from the images [22]. However, since the aim of our game is not to study children's eye-gaze behaviors, therefore, the item will still disappear when the player is not looking straight at the center of the item block. A pair of an affordable 3D VR glass (around US$12) is attached to a wide-screen Android phone.

Experiment procedure

Before the experiment we interviewed the subject's mother about some of his background information including assessment score and his technology usage (computer, tablet, smartphone, and previous experience of watching 3D movies). We also obtained consent from the mother, after explaining the possible risk of motion sickness, testing and recording procedure, and their right. Then, we demonstrated the use of VR to both our subject and his mother, allowing her to use our VR gadget to watch a short 3D animation in front of the subject (in Chinese to facilitate communication with English subtitles). After that, we arranged him to use it for a preliminary adjustment (less than a minute). Then, we asked the subject to fill a paper-based questionnaire, including whether or not he feels comfortable with the VR and willing to proceed with the testing. We then demonstrated the game app to both of them, including a short demo on how to play it. About 5 minutes later, we started the testing that lasts in two minutes (see Figure 3 on one of the testing moment). Then, the subject was shown with a set of flash cards with pictures on the desk and asked to identify those seen in the VR. Finally, he filled a post-test questionnaire (see Figure 4) and we interviewed his mother again. Figure 5 captures a moment when the boy was attempting the questions in the VR-enabled application.

Results and Discussions

We observe that the participant understands well the rule of the game in a very short time. After trying the first two pictures he can play very well. We also observe that he stares at buildings and bridges longer than others. However, no special order is followed; which means he is looking at the pictures randomly from one side to another. He also explores the roof of the virtual room. During the picture recognition session, we observe that he is able to recall all pictures selected by him in the game, and some other pictures shown in the game. His post-test answers show his great confidence that he could remember visual details, enjoy the learning game, and did not feel any motion sickness. He was also aware of real world (less immersive) as he frequently expressed his feeling verbally during the 2-minute testing. The only negative comment from him is that the sound should be softer or it should be adjustable, because the VR gadget we used does not support such a function. It is worthy to note that the participant of this pilot testing is a preadolescent with high-functioning autism who is indistinguishable from children with typical

Acknowledgement

Thanks to Adam Zhu and Clerk Xu for deveoping the application and their time and efforts during the testing. Thanks also go to Aonan Guan, Yongfu Wang, and Tiffany Tang for their assistance during the experiment preparation and testing. The author acknowledges the financial support from the Wenzhou Kean University Student Partnering with Faculty (SpF) Research Program.

Experiment Measurement

We developed 13 items with questions: 1) 4 items adapted from the Object-Spatial Imagery Questionnaire (OSIQ) which is used to measure a person's preferences on using object and spatial visualization [2]; 2) 6 items adapted from the Independent Television Commission Sense of Presence Inventory (ITC-SoPI) [9], 3 items to measure presence and 3 items overall satisfaction with the VR system [10, 12, 27].

development. In conclusion, the participant enjoys the game and can do the task very well. From the conversation with the participant's parent, we observe that her primary concern of using VR glasses as a learning tool is its perceived health risk, especially myopia. As a special-education teacher, she believes such a VR-based learning tool could be used to enrich children's learning experience, but not as a primary tool. Note that it is commonly believed by people in China that watching TV or mobile phones causes myopia among children. Hence, wearing VR glasses may only be allowed for a short learning activity (less than 10 minutes) which might greatly reduce the acceptability any VR-based application.

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