“Look to Remove”: A Virtual Reality Application on Word Learning for Chinese Children with Autism

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Abstract. Till now, very few works have studied Virtual-Reality (VR) based intervention on Chinese children with Autism Spectrum Disorder (ASD), which motivates our study here. In particular, we designed a VR room where players learn new words through the ‘look’ of its visual form on one of the walls of the room. The integration of audio and visual modalities in the VR environment further promotes children’s word-recognition skills. This study offers early insights into the acceptability of such intervention technique among Chinese parents and their children with ASD. Moreover, the study also attempts to examine how children explore and scan their field of view, and how these eye-gaze patterns relate to their word-learning skill.

Keywords: Virtual reality · Word learning · Chinese · ASD

1 Introduction

Virtual reality (VR) is a computer based simulation where real-life elements are projected as virtual visual elements to enable users to manipulate and interact. Various intervention techniques using VR have been applied to help both children and adults with Autism Spectrum Disorder (ASD) (Herrera et al. 2008; Kandalaft et al. 2013).

Till now, to the best of our knowledge, no published works have examined VR intervention on Chinese children with ASD. Based on current research and interviews with children and parents at two autism centers, the majority of them still rely on the traditional teacher-children and teacher-parent-children interactions in the classroom, while technology-based intervention (TI) at home is rare (Tang et al. 2015). Therefore, it is unclear how existing TI techniques used in the developed countries can be directly applied in China, because some cultural, developmental and environmental settings unique to this population may alter the effectiveness of these interventions (Lu et al. 2015). The first contribution of this study is to provide early insights into the acceptability of such intervention technique among Chinese parents and their children with ASD. The second contribution is to examine how children explore and scan their field of view, and how these eye-gaze patterns relate to their word-recognition skill.

To this end, we designed a VR environment where some typical daily items are put on the walls in a simulated room where a player wearing a VR headset will be

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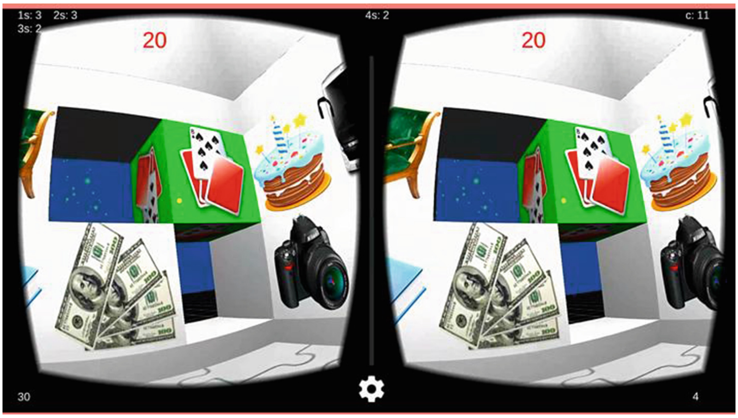

Fig. 1. The game as viewed from wearing the eye-glass

immersed (Fig. 1). The goal of such an environment is to train children's word identification skill (a key process in making sense of text) which is a cognitive skill that is commonly delayed in children with ASD (Randi et al. 2011).

2 Related Work

2.1 VR in ASD Research

The effectiveness of VR as an intervention tool has been examined and demonstrated in prior works to help both children and adults overcome fear, anxiety, and stress (Riva 2005), including adolescents and adults with ASD (Strickland et al. 1996; Herrera et al. 2008; Kandalaft et al. 2013). One notable advantage with its extensively use in healthcare is that it offers a natural and safe environment under a controlled and consistent protocol (Bellani et al. 2011; Aresti-Bartolome and Garcia-Zapirain 2014).

Earlier works examined the degree of acceptability and usability of the VR and virtual environments for individuals with ASD (Parsons et al. 2004; Strickland et al. 1996; Strickland 1997), which had laid the ground for later studies aim at applying various intervention techniques (Kandalaft et al. 2013; Parsons et al. 2005; Cheng and Ye 2010).

Two types of VR equipment are commonly used in ASD research: highly immersive (e.g. VR headset with 3D glasses) and less immersive ones (e.g. desktop PC). Many studies have shown that using highly immersive VR equipment can cause symptoms of motion sickness (LaViola 2000). Hence, many prior works adopt the less immersive ones. However, with the massive availability of VR headsets in recent years, our work aims to study the acceptance and feasibility of the highly immersive VR headsets among parents and children.

2.2 Multisensory Information Binding Skills, Word Recognition Skills and Speech Comprehension for Individuals with ASD

Individuals with ASD are known to lack of a strong ability to combine information pieces from various sources into a unified perceptual whole, a prominent theory describing autism known as the weak central coherence (Happé and Frith 2006). Previous research has indicated that such failure to bind discrete information from multiple sensory modalities could impair the individuals' abilities to identify a single object or event which typically requires both the visual and auditory modalities. Such impaired processing of complex stimuli might in turn offer solid interpretations in their deficit in speech perception and comprehension (Iarocci and McDonald 2006). In particular, for example, (Woynaroski et al. 2013) found that children with ASD exhibited reduced speech perception for matched audiovisual stimuli; while (Stevenson et al. 2014) were able to demonstrate a strong link between multisensory temporal function and speech perception abilities among individuals with ASDs: the larger the gap between an individual's temporal acuity across auditory and visual processing (a so-called large temporal binding window), the poorer their overall perceptual binding abilities, which could in turn greatly affect their speech comprehension.

Although in our current research we do not intend to evaluate autistic children's abilities in recognizing matched or unmatched audiovisual stimuli, our future experiments intend to train children with ASD to improve their overall perceptual binding abilities, which might offer an early and yet additional observations along this research avenue. For examples, by putting associative images together (e.g. poker cards and money, or camera and birthday cake) may help children to build association among various words.

3 The Virtual Reality Game

3.1 The Design Rationale

Unfortunately, little previous empirical evidence can directly inform us of the design for such a VR-enabled environment specifically for Chinese children with ASD. However, due to our on-going experiences with these children, we will offer our design rationale in this section.

We have been working with one of the children's autism educational development center for almost a year and have observed the various culturally-specific factors that have been inspiring our design:

- TI at school is rare;
- systematic TI at home has not been applied;
- TI at both home and school is welcome by special education teachers;
- TI at both home and school is deemed suspicious by parents/grandparents; and
- VR based intervention is rare at home and school.

During one of our testing sessions, we were invited to participate in a 45 min Lovass session in which the children learn to pair words with visual objects and are rewarded with toys when they successfully match a word with an object (Lovaas 1987).

The only technology used during the entire session is a desktop computer. The situation at government-funded special education center is relatively better; however, the number of children who can be admitted to these centers is extremely limited (Autism Daily Newscast 2015; Compton 2015). Therefore, 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.

3.2 The Hardware

A pair of an affordable 3D VR glass (around US$12) is attached to a wide-screen Android phone, which are commonly used by many people in China today, as shown in Fig. 2. Figure 3 shows the look of the player wearing the eye glasses.

Fig. 2. The 3D glass (around US$12)

Fig. 3. The player wearing the glass does not need to take off his/her eye glasses

3.3 The Software Development

The game was developed using Unity 3D for Android phones.

3.4 The Game

Figure 4 shows the screenshots 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), including apple, banana, bed, etc. Head movement from the player is used as the only game control to shift the game's view, with a small yellow dot at the center of it. When player 'look' at an item for a certain time duration (5 s in our current setting), the system will pronounce the item's Chinese name and then disappear from the game (replaced by the starry sky, see the right image in Fig. 4). 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 (Sasson and Elison 2012). 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.

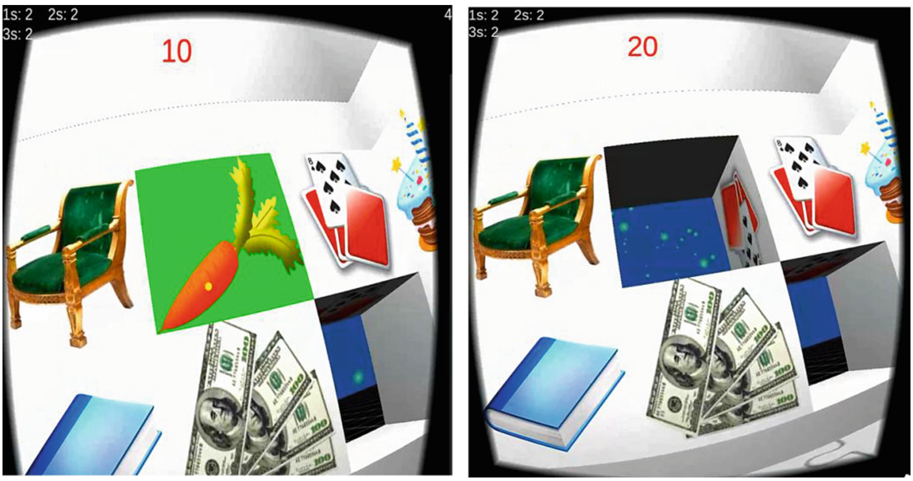

Fig. 4. Game-playing moment: (left) the player is currently looking at the carrot as highlighted in green, and with a small yellow dot; (right) the carrot disappeared (Color figure online)

4 Preliminary Experiment Results

A questionnaire-based study and a pilot experiment are conducted separately in our feasibility study.

4.1 Methodology and Participants

In the first study, a questionnaire containing seventeen questions with answers in 7-point Likert scale is used, where a score of 1 for very much dislike, 4 for neutral, and 7 for very much like. The questions can be categorized into four groups: technology exposure (telescope, game, 3D movies, etc.), items children like (fruits, furniture, animals, etc.), activities children like (drawing, playing card, etc.), and a question on health risk (motion/travel sickness).

The questionnaire in Chinese is distributed to parents in an autism educational development center; sixteen parents of children age two to ten fill the questionnaire. Five children are toddler age two to three, and three children are preadolescence age ten.

In the second pilot study conducted four months later, we invite a 12-year-old boy with high-functioning autism and his parent to try the VR game in our lab. The testing on VR game is limited to a two-minute trial after a short pre-adjustment trial (watching a short animated 3D movie), followed by a short picture recognition session. In the picture recognition session, the researchers mix some printed pictures used in the game with unused ones, and ask the participant to identify all pictures seen/selected in the VR game. We also ask the participant some questions.

All activities are video-taped and recorded for analysis. The participant is accompanied by his parent in the whole process, and answers all questions by himself. Their participation is voluntary.

4.2 Results

Questionnaire. From the questionnaire, only three children out of sixteen have watched 3D movie(s) before, and only one 5-year-old boy likes it very much. However, more than ten children like animated movies and playing games (their answer score is either 6 or 7 in the Likert scale).

Only three children have used telescope but only two toddlers have not used computer. Out of fourteen who have used computer, eleven like it very much, one dislike it, and two are neutral. Hence, we may safely conclude that most children with ASD in this learning center have been moderately exposed to technology, and most of them like it.

With respect to the health risk, none of the parents have observed motion sickness on their children before. Nonetheless, it does not guarantee that using VR equipment may not cause motion sickness.

Finally, on the items and activities the children (dis-)like, a large variation of answers are given, in which some like animals, plants, starry night, drawing, etc. These results are used to help us in selecting the cards/pictures used in the game.

Pilot testing. The participant of the pilot testing identifies himself as a good spatial-game player and has used mobile phones and watched 3D movies, but has not used a VR headset before. He has a prior experience of motion sickness, but no symptom is reported during and after the testing.

After the testing, the followings are positively checked in the questionnaire:

- "I can close my eyes and easily picture a scene."
- "I felt involved in the displayed environment."
- "I enjoyed learning in the application."
- "The sound should be softer."

From the recorded video, 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. 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 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. Note: 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 min).

5 Conclusion and Future Work

Our pilot study documented in this paper contribute to the autism research in China in understanding the first and yet critical question on the acceptability of the use of VR intervention in children with ASD. The future research following this path is to pursue the intertwined associations among eye-gaze pattern, both the density and intensity of visual stimulus in the VR environment, and the word-learning skill. We hope the HCII community could replicate our study and we call for more research in China where the awareness and acceptance of autism remains to be much lower than its western counterparts (Compton 2015).

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