Enhancing children with hearing impairment with virtual reality

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ABSTRACT

Integrating technology in the teaching and treatment process of children with hearing impairment is supporting the potential implementation. It is more significance when we relate to the integration of those children in mainstream education. The author of this paper has conducted several studies focused on the enhancement of different cognitive and language abilities of children with hearing impairment.

This paper discusses the results of these several studies and discusses the benefit of virtual reality technology. The paper concludes with conclusions and implications that might be useful for others in this field.

Categories and Subject Descriptors

D.3.3 [**Programming Languages**]:

General Terms

Human Factors

Keywords

Education, Children with hearing impairment, Virtual reality

1. INTRODUCTION

Children with special needs are coping with difficulties and disabilities that might make the acquisition of the require skills for school difficult, in a mainstream class as well in a special education class. The use of assistive technologies might be a substitute and compensation to the missing abilities and helping in potential implementation that require achieving several goals. A supporting mean and an accelerator that allow development in the learning process of children with special needs [1].

Assistive technology is any item, piece of equipment, or system, whether acquired commercially, modified, or customized, that is commonly used to increase, maintain, or improve functional capabilities of individuals with disabilities [2]. For example, people with limited hand function may use a keyboard with large keys or a special mouse to operate a computer, people who are blind may use software that reads text on the screen in a computer-generated voice, people who are deaf may use a TTY (text telephone), or people with speech impairments may use a device that speaks out loud as they enter text via a keyboard.

The fast progress in communication and information technologies is creating the strongest effect on the life of a person with hearing impairment. The use of various communication tools such as text telephones, pagers, email, cell phones, videophones, Smartphone and most notably the Internet, has revolutionized interaction opportunities for people. Access to information and ease of interaction is possible by visual communications, services supplied in sign language, relay services and other technology. The school environment has also benefit from the technology's progress. There are FM systems in the classes, auditory perception software, etc.

One of the advance technologies is Virtual Reality (VR), a term that applies to computer-simulated environments that can simulate physical presence in places in the real world, as well as in imaginary worlds. VR uses a computer to create an interactive simulated three-dimensional world and enables the user to be an active part in the environment and not just a passive observer [3]. Immersive VR, as opposed to VR Desktop, uses HMD (Head Mountain Display) in purpose to be immersed in the virtual world. There is a tremendous potential in this technology for children with hearing impairment.

2. IMPROVING TIME SEQUENCE PERCEPTION

Over the years, research has offered various theories about the development and cognitive functioning of children with hearing impairment. Hearing loss, per se, has been shown not necessarily to be an indication or a cause of cognitive difficulties. Children with hearing impairment are similar to hearing children in cognitive structure and ability with regard to most cognitive abilities, although differences in measurement can be found between the two groups. These differences seem to stem from general gaps, mainly in the areas of communication and language [4] [5] [6].

The aim of this study was to test whether the representation modality has any effect on time sequence among children with hearing impairment. Time is a central and essential dimension of our lives. Without relating it to time it is hard to describe modern life, especially in a Western technological society. Yet, one of the areas where children with hearing impairment experience difficulty is in this perception, in particular, the proper arrangement of events in a logical, temporal order (time sequence) [7] [5] [8].

Usually, temporal order is examined and taught by 2D pictorial scripts. Following the representation stages by Bruner [9] [10] [11], the research examined whether children with hearing impairment perceive a temporal sequence differently under different representational modes. We compared the effect of five modes of representation:

1. Pictorial representation—colored cartoon scenes of four or five pictures each were used to create the different scripts.
2. Textual representation—one or two lines were written to describe the event in each picture. No time or cause words (connectors), such as before, later, and then, etc., were used to avoid hinting at the temporal or causal sequence.
3. Aural representation—the written text was read aloud.
4. Signed representation—the text was translated into Signed Hebrew, the language that educators used in learning settings and that the children were used to.
5. Immersive 3D VR—using SuperScape VR technology, the scripts of the pictorial mode was transposed into 3D simulations. The simulations enabled interactive experiential learning

We studied 134 participants (65 hearing children and 69 children with hearing impairment) aged 4–10, who were divided into two age groups: kindergarten and school age. We included six scripts that were adapted to the five different modes of representation and thus created a sum of 30 scripts. Each participant received four scrambled episodes of a single script and was tested with five modes of representation. The scripts and modes of representation were randomized and varied from child to child. Each child had to arrange the episodes of the script according to the story. For example, a script for the planting of an orange tree has been divided into four different episodes: the first episode depicts a small child digging hole to plant a small seedling; the second depicts a large seedling being watered by a young boy; the third depicts a teen watering a bigger tree; and in the final episode, a man is standing under a fully grown orange tree. This script has a temporal order in which one can't water the plant before it is planted.

Transposing the scripts to a 3D simulation was done in two stages. First, virtual worlds built with SuperScape. Each virtual world had an opening screen with a picture depicting the script and name of the story. At the side, in random order, each scene of the script was represented. Clicking on a card took the user into the virtual world of that specific scene. The user navigated this world using HMD, activated various objects, heard voices and became immersed in the scene.

Figure 1. Virtual world: felling a tree

For the second stage, we used Flash to assess the child's ability to place the cards in the correct order. The script arrangement screen was composed of four green squares, above each of which there was a number and a red circle for visual identification of the number for those children who did not yet read numbers. At the bottom of the screen were the four cards that belonged to this script. The child had to drag the cards and place them in the right place in the green squares. After he/she had finished, the child clicked on the red action button and watched a Flash clip according to the sequence created.

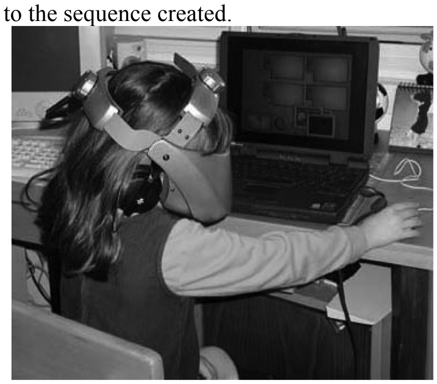

Figure 2. Participant using VR

The findings demonstrate that all the children, hearing and hearing-impaired, kindergarten as well as school age, grasped time sequence significantly better through the VR representation. The signed representation enabled the second best perception of sequential time for the children with hearing impairment, followed by the aural representation for all children. The next representation was the pictorial mode, indicating that this form of representation is not as easy as expected. The poorest results were for the textual representation.

Recently we developed an intervention program, aiming to improve time sequence and storytelling among children with hearing impairment [12]. The aims of the study were (a) to examine the effect of a structured pictorial scenario intervention program Vs. 3DVR scenarios intervention program on young deaf and hard-of-hearing children's perception of time sequence and storytelling ability, and (b) to investigate the effect of spoken-language level on their sequential time and storytelling ability by comparing deaf or hard of hearing children who had a language gap of less than 1 year with children with a language gap of more than 1 year. The study participants were 65 Israeli kindergartners (38.5% boys, 61.5% girls), whose hearing loss was identified early in life and who had no additional disabilities. The sample was divided into two groups according to spoken-language delay: those lagging behind their age norm by less than 1 year, and those lagging by more than 1 year. Each group was divided into two intervention group: (1) Pictorial mode—three illustrated temporally logical scenarios, each consisted of four illustrated color pictures, which formed an everyday story with a time sequence. (2) 3DVR mode- the same scenarios were adapted to VR Desktop.

The intervention was conducted over a 3-month period in the children's kindergarten, in individual weekly meetings of about 20 minutes' duration every week. Before and after the intervention the children were tested in the pictures series subtest of the second edition of the Kaufman Assessment Battery for Children to measure temporal sequence perception. We also used the storytelling subtest of language screening test.

The results suggests, that all children with hearing impairment, those in the pictorial group as well in the VR group, improved there temporal sequence perception. But the improvement was much more significant in via VR Desktop. Regarding the storytelling ability, the children in the VR mode improved there storytelling ability significantly (mean-score 6.95 to 14.91). The children in the pictorial mode demonstrated a small improvement (7.94 to 9.44).

Theoretically, the studies suggests with caution that young deaf and hard-of-hearing children's accomplishments in sequencing tasks are dependent on the mode of representation, and that a 3D environment is an important and efficient mode of representation in attaining a higher level of abstraction.

On the practical level, educators should try using the mode of representation that is most efficient in producing sophisticated abstractions, so that the children would be able to utilize their cognitive abilities in the most rewarding way. Eventually, curriculum planners should consider the need to practice with young children those concepts which seem to be the most difficult, in order to facilitate progress in those areas as early as possible.

3. IMPROVING THE INDUCTION SKILL

Another cognitive ability that was examined among children with hearing impairment is the induction skill. Many researchers e.g. [13] [14] have suggested that *abstract thinking* of children with hearing impairment to be an area about which educators should be concerned. The current research deals with *inductive processes*. Trochim [15] defined the inductive method as "bottom up"—i.e., a process which goes through the stages of making specific observations, creating testable hypotheses that lead to generalization and create generalized conclusions. Glanz [16] reports on "induction of laws", a process in which induces leads to the inference of common rules that dictate the order of components within a given system. The purpose of this study was to investigate whether the practice of rotating VR 3D objects will have a positive effect on the ability of children with hearing impairment to use inductive processes when dealing with shapes. Here, a series of shapes is provided and the child's goal is to suggest the next shape in the series after inferring the given law.

Three groups were involved in the study:

(1) Experimental group, which included 21 children with hearing impairment, who played a VR 3D Tetris game

(2) Control group I, which included 23 children with hearing impairment, who played a similar 2D Tetris game (not VR)

(3) Control group II of 16 hearing children for whom no intervention was introduced.

Before and after the intervention, the children were evaluated using Cattell and Cattell's [17] sub-test of "Structural Sequences", in order to establish whether practicing rotation exercises with VR has an effect on the structural inductive processing of the children.

The VR hardware (fig.3) used in this research was a virtual reality interactive game, with a unique system able to create a dramatic three-dimensional world. The VR program (fig.4) included three similar games (Tetris, Puzzle, Center-Fill), with the objective, in all three, to fill a large 3D cube with small blocks of different shapes. The subject had to place dropping blocks into the right spaces. In order to accumulate a high score, the children had to act both accurately and quickly.

Figure 3. The VR hardware

The optimal solution was reached by a combination of selecting the most appropriate shapes and rotating them as required. The subject had to complete the blank locations on the "board" according to an induced rule which he had inferred and fit the appropriate shape in the blank locations. Control Group I practiced using a "routine" Tetris style 2D game (not VR game).

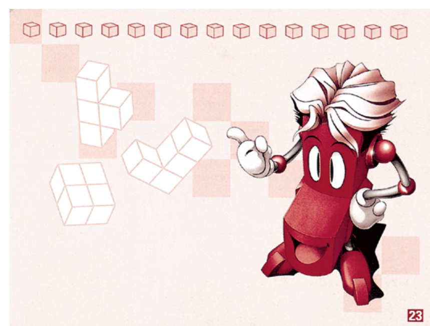

Figure 4. The VR Tetris game

The results clearly indicate that practicing with VR 3D spatial rotations significantly improved inductive thinking used by the experimental group for shapes as compared with the first control group, who did not significantly improve their performance.

The results indicated that practicing with VR 3D spatial rotations significantly improved inductive thinking as compared with 2D rotations (first control group), who did not significantly improve their performance. Also, while prior to the VR 3D experience, the children with hearing impairment attained lower scores in inductive abilities than the hearing children (control group II). The results for the experimental group, after the VR 3D experience, improved to the extent that there was *no noticeable difference* between them and the hearing children.

4. CONCLUSION AND IMPLICATIONS

Children with hearing impairment are coping with hearing deficiencies, lingual limitation and other difficulties, which might make the acquisition of the required skills for school more difficult, in a mainstream class as well as in a special education class. The use of technologies might be a substitute and compensation to the missing abilities, as well as helping in implementing the lingual, communicative and cognitive potential. Substantial part of the technological usage for children with hearing impairment is designate to treat the hearing loss and other auditory aspects in the child surroundings, while other enable access to information and communication with both hearing and hearing impaired people. Also, there is a growing use of technology by people with hearing impairment at leisure time. The technologies are becoming more portable, smaller and cheaper, and as a result of that they become more accessible.

In this paper we tried to focus on technologies in the educational environments for pedagogical purposes. Few studies have been present, which examined the influence of VR technology on specific cognitive skills among children with hearing impairment. The results showed that interventions, which made use of VR, can enhance cognitive and lingual aspects whereas those children have difficulties in. VR does not limit the designer in the manner in which the information is presented or limit his/her movements, so that the user of the technology is able to immerse within the learning environment. The children where immersed in the games, and the abstract became less vague and more concrete. One key attribute of VR is its interactivity – it allows users to take a very active role. The increased liveliness and interactivity allows the user to become part of a virtual world.

The results of the studies are influencing directly to the educational field and the technological field. Theoretically, we suggests with caution that hearing and hearing impaired children's accomplishments in sequencing tasks are dependent on the mode of representation, and that a 3D environment is an important and efficient mode of representation in attaining a higher level of abstraction.

On the practical level, educators should try using the mode of representation that is most efficient in producing sophisticated abstractions, so that the children would be able to utilize their cognitive abilities in the most rewarding way. Eventually, curriculum planners should consider the need to practice with young children these concepts which seem to be the most difficult, in order to facilitate progress in those areas as early as possible. Teachers should also encourage children to compose their own scripts and stories.

Further work in this area will continue and this will be used to inform revision and discussion.

5. REFERENCES

[1] Hetzroni, O. E. 2004. AAC and literacy. *Disability and Rehabilitation, 26*, 1305-1312

[2] Edyburn, D.L. 2010. Understanding the quality of the science supporting the special education technology evidence base. *Journal of Special Education technology, 25*(1), 63-68.

[3] Burdea, G. C., & Coiffet, P. 2003. *Virtual reality technology* (2nd ed.). New Brunswick, NJ: Wiley-IEEE Press.

[4] Marschark, M. 2003. Cognitive Functioning in Deaf Adults and Children. In M. Marschark & P. E. Spencer (Eds.) *Deaf Studies, Language, and Education* (pp. 464-477). Oxford, New-York: Oxford University Press.

[5] Marschark, M., Lang, H. G., & Albertini, J. A. 2002 *Educating Deaf Students: From Research to Practice*. New York: Oxford University Press.

[6] Moores, D. F. 2001. *Educating the Deaf: Psychology, Principles, and Practice*s. Boston: Houghton Mifflin.

[7] Kaiser-Grodecka, I., & Cieszynska, J. 1991. The Understanding of Time by Deaf Pupils. In D. S. Martin (ed.), *Advances in Cognition, Education and Deafness* (pp.201-204). Washington: Gallaudet University Press.

[8] Senior, G. 1989. Temporal Orientation in Hearing-Impaired People. *Disability, Handicap and Society*, *3*(3), 277-290.

[9] Bruner, J. S. 1973. The Growth of Representation Processes in Childhood. In J. Anlin (Ed.), *Beyond the Information Given: Studies in the Psychology of Knowing* (pp. 313-324). New York: Norton.

[10] Bruner, J. 1986. *Actual Minds, Possible Worlds.* Cambridge, MA: Harvard University Press.

[11] Bruner, J. 1990. *Acts of Meaning* Cambridge. Cambridge, MA: Harvard University Press.

[12] Ingber, S. & Eden, S. 2011. Enhancing Sequential Time Perception and Storytelling Ability among Deaf and Hard-of-Hearing Children. *American Annals of the Deaf*, *156*(4), 391–401.

[13] Friedman, J. 1985. Classification Skills in Normally Hearing and Oral Deaf Preschoolers. A Study in Language and Conceptual Thought. In D. S. Martin (ed.), *Cognition, Education and Deafness* (pp. *70-72).*Washington: Gallaudet College Press.

[14] Rittenhouse, R.K., Morreau, L.E. , & Iran-Nejad, A. 1981. Metaphor and Conservation in Deaf and Hard of Hearing Children. *American Annals of the Deaf, 126* (1), 450-453.

[15] Trochim, W. M. 1996. Deductive and Inductive Thinking. http://trochim.human.cornell.edu/kb/dedind.htm

[16] Glanz, J. 1989. *Thinking as a Three-directional Function.* Tel Aviv: Gomeh.

[17] Cattell, R.B., Cattell, A.K.S. 1965. *Calture Fair Intelligence Test: Scale 2*. Champaign , IL: Institute for Personality and Ability Testing.