Original Article

Development of indigenous innovative visual reinforcement system for hearing screening among young children

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Abstract

Visual reinforcement audiometry (VRA) is the gold standard hearing assessment procedure. It is a combination of both visual and auditory stimuli uses conventional toys and speakers to estimate hearing. The aim of the study is to develop digital animated VRA instrumentation and to test the feasibility of the tool in screening young children. The study was carried out in two phases, wherein the development of the age appropriate digital video animated clips and the VRA system as a part of phase I. Phase II focused on exploring the feasibility of the newly developed instrument with digital images. Two groups of 21 typically developing children underwent VRA hearing testing in a sound treated room. Children of three different age groups (7-12 month, 13-24 months, 25-36 months) were included in the study. Results indicates that older children (13 to 36 months) demonstrated greater interest and anticipation for the newly developed system of VRA. It is evident that the newly developed VRA system is a clinically plausible option for testing hearing in young children.

Keywords: Visual Reinforcement Audiometry (VRA), Auditory stimulus, Visual stimulus, Digital animated images, Hearing screening.

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INTRODUCTION

Visual Reinforcement Audiometry (VRA) is a routinely used technique described by Suzuki and Ogiba (1961) to evaluate the hearing ability in young children (age range 7 months - 3 years)[2]. It works on the principle of operant conditioning specified by Liden and Kankkonen (1961)[4]. This is a simple and powerful behavioural assessment tool that is based on associating sound stimulus to the light source, eliciting auditory behavioural responses. Only when the child turns toward the auditory signal the visual stimulus is illuminated as a visual reward. The reinforcement motivates the child to look for the source of the sound after every presentation of the auditory signal. Thus the minimum hearing response level (MRL) of hearing is assessed through this procedure[4]. In clinical practice, flashing of lights and/or toys are generally used to provide visual reinforcement to the child during VRA. New technology capable of generating an animated video image is now available for providing visual reward to children during testing. It is presumed that video images have greater novelty and complexity (Kopyar, 1994) that sustains the interest level in children during the test[5]. Primus &Thompson, (1985) reported that children are easily habituated to conventional mechanical reinforcers and this is predominantly observed in younger age group[5]. It is agreed that the current generation of children are highly influenced by the digital revolution, the traditional VRA system using conventional mechanical reinforces fail to maintain the interest level of the child (Schmida and Peterson, 2003)[5].

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MATERIAL AND METHOD

Participants

This research was developed as a part of the Chancellor's summer research fellowship of Sri Ramachandra University with the approval of the Institution Ethics Committee (CSP/14/JUN/35/83). The participants were children who were referred for hearing screening to the Department of Speech, Language and Hearing Sciences. They were recruited for the study with appropriate consent from the parents and or caretakers.

Inclusion Criteria

- Age range from 7 months to 3 years
- Children with no concern in speech, language and hearing

The study was carried out in two phases:

Phase I was to develop the indigenous, innovative Visual Reinforcement System.

Phase II was to explore the functioning and feasibility of the newly developed system for clinical use. Also the other objective of the study was to develop age appropriate digital images to be used as visual reinforcers in the VRA system.

Phase I: Development of digital images to be used as visual reinforces

Images were selected from test materials and age appropriate books. The selected images were animated with the help of a professional creative designer, following which; three different video clips were developed for three different age groups. Video clip - 1 (7 months to 12 months): A rocking cradle with a rattle, Smiling baby, A fish swimming, Bouncing ball, Baby dresses. Video clip - 2 (13 months to 24 months): Cake with a glowing candle, Elephant walking, Sun, star & moon in the sky, Duck swimming in the pond, An apple falling from a tree. Video clip - 3 (25 months to 36 months): A boy running, A bird flying, A child brushing teeth, A bus going on the road, A butterfly in a garden. Development of the instrumentation to display the visual reinforcement**.** The equipment was built using two 18'' LED monitors, a Video Graphic Array (VGA) toggle switch, a CPU and three connecting wires, whereas the conventional VRA system had a complex circuitry built using mechanical toy reinforcers placed inside plexiglass models which were illuminated at the time of stimuli presentation.

Test Environment and stimuli

Room setup: The VRA requires proper acoustics with two room set up for testing children. The test room is a sound treated room with fully carpeted flooring with the walls covered by highly absorbent materials to reduce the reverberation. The ambient noise levels of the rooms are maintained to be approximately 20dBA – 25dBA (ASHA guidelines)[1]. The sound treated room regulated special attention of the children to the stimuli without visual distraction. During the procedure, the child will be seated on the mother's lap with the loudspeakers on both sides of the child at an angle of 45 degrees with a distance of one metre between the speakers. A pure tone that will be modulated with single frequencies (250Hz – 8KHz) at an intensity level of 60dBSPL was presented through the audiometer from one room to the loudspeaker of the test room (Figure 1). Once the child was conditioned to associate between the auditory stimuli and reinforcement the hearing level of the child can be determined. The room designed for audiometric testing is shown in the photograph below

Figure 1: Clinical set-up

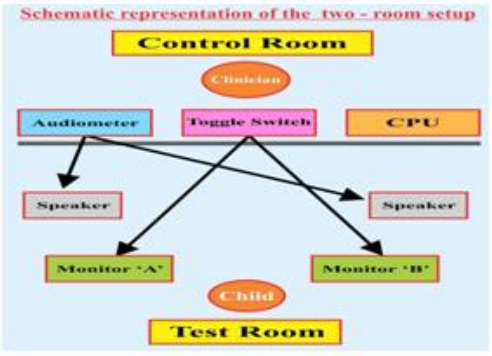

Figure 2: Schematic representation of sound treated room

Newly developed VRA instrumentation

Development of VRA using high technology devices with visual animated images categorized for children between the age group 7 months - 3 years. Traditionally, used lighted plexiglass models were replaced by monitor screens and the VGA toggle switch in place of the clinician control switch. The monitors were connected to the Central Processing Unit (CPU) where the age appropriate animated visual images are stored. During the testing, the clinician controls the VGA port that aids to switch the toggle of the visual reinforcement between the left and right monitors. The monitor (A) on the right side

is connected to the port A and the monitor on the left side is connected to the port B of the toggle switch. There is a provision on the wall between the two rooms for the wires to pass to the test room without any hindrance (Figure 2). The visuals that are to be presented as reinforces are stored in the memory of the central processing unit. The keyboard and mouse are connected to the central processing unit to help the clinician navigate the images stored on the folders better. The output of the Central processing unit is connected to the input of the VGA Toggle switch through wires. The power to the monitors and central Processing Unit is supplied by the general power board. When the toggle switch A is pressed, the visual animated image appears on the right monitor and when the left toggle switch is pressed, the visual animated image appears on the left monitor.

Materials

The materials used for developing the low cost VRA instrument are as follows

- Two 17'' LED monitors
- VGA Toggle switch
- VGA Connecting wires
- Central Processing Unit
- Mouse

PHASE 2

PROCEDURE: Audiometric testing

Two groups of 21 typically developing children underwent VRA testing in sound field. Group A was tested using the animated VRA and group B was tested with conventional VRA system. During the testing phase, only the auditory stimulus was presented and the child responded to the stimulus through head turn and localising the side of auditory stimulus. As soon as the child responded, the visual reinforcement was provided (Figure 3).

Figure 3: During the testing procedure

The child was made to sit in a comfortable position on the lap of the parent or caretaker in the test room. During the conditioning phase, the auditory stimulus and visual reinforcement are presented simultaneously. When the child is conditioned, only the auditory stimulus was presented during the testing phase and the child responded as expected. As soon as the child responded, the visual reinforcement was provided thereby estimating the hearing.

Scoring and Data Analysis

The hearing screening was carried out using the new VRA system on children who were reported to have normal hearing sensitivity. The MRL were estimated to be within 55dBHL which is considered as Pass criteria as per American Speech and Hearing Association (ASHA) Guidelines[1]. Since the testing was carried out in a calibrated sound field, the result does not yield ear specific information. The finding of the screening procedure is then augmented with the diagnostic VRA, which is accepted as standard practice.

RESULTS AND DISCUSSION

Independent unpaired sample t-test and Mann-Whitney U test was carried out to statistically analyse the data between the two groups. The results indicated that there was no significant difference between group A (mean: 307.14 sec; SD: 26.67) and group B (mean: 297.14secs ; SD:61.41) in the time taken for testing between the newly developed VRA and the standard mechanical conventional VRA. Similarly, there was no significant statistical difference in the MRL between the sex variable of both the groups. However, it is evident that the newly developed animated VRA can also be correspondingly used along with the conventional VRA in clinical setting.

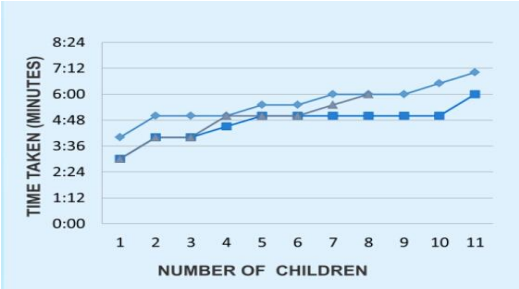

Figure 4: Total number of children and the time taken for the VRA response

Analysis of age wise report show that, the plethora of research (Culpepper & Thompson, 1994; G. Thompson et al., 1992; M. Thompson et al., 1989)[3] endorsing conventional and video reinforced groups of 2 year olds were congruent with the findings of the current results. Also, it was observed that the children of group A between the age group 13 months – 36 months to have exhibited more interest and anticipation towards the newly developed video image reinforcement. Similar findings were reported by Schmida and Peterson, 2003[5]. Parents also reported that during the testing, children were more engaged and attentive.

CONCLUSION

From the current study the following conclusions were established.

1. The newly developed VRA system is a viable and easy option in carrying out hearing screening in young children clinically.
2. The mechanical conventional VRA system has been proven to provide clinically useful yet the newly developed VRA system can be low cost option with digital images used as reinforcers.
3. Children showed better interest and attention during the testing process. This will allow the clinician to carry out the hearing assessment with ease and reduce the time of testing.

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