Effect of Training on Dichotic CV and Dichotic Digit Scores

Asha Yathiraj[1] and Priyadarsini K[1]

Abstract

The aim of the study was to determine whether long term diotic listening training had an effect on dichotic performance. Sixteen children who were undergoing training in two different abacus programs (experimental groups) were compared using two different dichotic tests with a group of children who had not undergone such training (control group). A part of the training that the two experimental groups underwent required them to carry out specific movements of the beads of the abacus using both hands on listening to orally dictated arithmetic problems. The dichotic digit (Shivashankar & Herlekar, 1991) and the dichotic CV (Yathiraj, 1999) tests were administered on the children. The results showed no significant difference between the three groups on the scores obtained for the dichotic digit test. However, a significant difference in scores for the dichotic CV test was observed between the control and two experimental groups. This study shows that intensive diotic auditory stimulation can possibly result in better dichotic performance when the participants are tested on a dichotic test with less redundancy.

Key words: Dichotic CV, Dichotic digit, diotic listening training.

Several neurophysiological and cognitive mechanisms and processes have been noted to be necessary for the accurate decoding of auditory signals. Much of central auditory processing has been found to be preconscious, occurring without the listener being aware of it (ASHA, 1995). Morley and Happe (2000) noted that auditory processing involved a complex set of neuro-chemical activities. These neuro-chemical activities resulted in the structure and function of the brain. It has been reported by ASHA (1995) that even the simplest auditory event is influenced by higher cognitive factors such as memory attention and learning. Auditory perception ultimately takes place after a complex set of activities.

The left hemisphere was found to be responsible for the precise sequencing in space and time of the actions of widely separated muscles, for the purpose of communication by gesturing, speaking or writing. On the other hand the right hemisphere has been found to generate a more holistic style of control, less fraction in time and has been considered responsible for guiding the movements of the whole animal in relation to the outside world and for expression of emotions (Sperry, 1968).

Further, it has been found that the left hemisphere controls the right side of body and right hand touch, math, language science and writing. It has also been noted to control the functions of the visual system, auditory system, language (speech, reading and writing), and movement. In addition, it has been observed to control functions like memory, spatial processes, arithmetic and remembering names and jokes accurately. In contrast, the right hemisphere was found to control the left side of the body, non-verbal areas such as recognition of patterns and drawings as well as emotion expression. The right hemisphere was also observed to enable the visual system to recognize complex geometric patterns; the auditory system to perceive non-language environmental sounds; somatosensory system to recognize complex tactual patterns; visual memory and left hand touch (Riza, 2002).

Coordinated activities of the body have been made possible due to inter-hemispheric interaction. Bimanual co-ordination of skilled finger movements is an outstanding capability of the human motor system. The effect of bimanual skill acquisition on inter-hemispheric interaction systems has not received much importance. Andres et al. (1999) assessed the functional coupling between brain regions during bimanual skill acquisition in humans. The bimanual skill involved the fusion of two over-learned unimanual finger-tapping sequences into one novel bimanual sequence. They studied learning related changes in inter-hemispheric coupling in the sensorimotor system before and after a 30-minute training period in 18 normal volunteers.

1. *All India Institute of Speech and Hearing, Mysore, India*

The result showed that inter-hemisphere functional coupling between human premotor and sensorimotor areas was enhanced during the acquisition of the novel bimanual skill.

In India, commercial programs have mushroomed where school-going children are trained to use an abacus to improve their mathematical abilities. Coordinated movements of the fingers of both hands are required for these calculations. Two such commercial programs available are 'Genius Education and Learning Systems Pvt. Ltd. (GELS) ABACUS Program' and 'Universal Concept Mental Arithmetic System (UCMAS) Brain Gym'. In the GELS Abacus program, a series of simple body movements are used to integrate all areas of the brain to enhance learning and to build self-esteem. A manual describing the program reports that it is based on a Chinese method of teaching abacus to achieve whole brain development and to improve numerical skills. It teaches the application of the abacus for mathematical calculations, and various other abilities such as speed-writing, calculation on dictation, visualization, planning, and mind gym. The training also includes various movements / exercises involving different parts of the body. The children are taught to manipulate the abacus instrument with the index and middle fingers of the left hand and the index finger and thumb of the right hand. The training consists of six levels. From the second level onwards, the training also involves some calculations without the use of the abacus, but with a visual image of the abacus.

In the UCMAS Brain Gym program the abacus instrument is used to develop mathematical skills, but no prior exercises for the rest of the body are taught. The children are given speed-writing exercises in the initial stages. They learn to write numbers on fast dictation, which is expected to help in concentration, memory and listening. At the third of the eight levels, the instrument is removed and the children are required to practice carrying out calculations while visualizing the instrument.

In both programs the auditory skill training involves having the children carry out arithmetic computations using both hands on listening to sums that were dictated. It has been reported by Musiek (2004), that with intensive auditory training, auditory processing abilities improve. There is a need to know whether training through the above two methods to teach mathematical calculations, brings about a change in the auditory processing in both the hemispheres of the brain. One way of studying the functioning of each of the hemispheres is through the use of dichotic tasks. A variety of researchers in the early 1960's documented the existence of a cerebral dominance effect in dichotic listening, indicating a pre-existing ear asymmetry in normal right-handed listeners in which the scores for the right ear were consistently higher than the scores for the left ear on dichotically presented signals (Dirks, 1964; Kimura, 1961; Satz, Achenback, & Fennell, 1965).

The present study aimed to determine whether children who were trained to carry out systematic activities using both hands in coordination, to auditory stimuli, performed differently from children who had not undergone such training, when tested on dichotic tasks. This was done by comparing a group of children who were undergoing training in the GELS Abacus program or the UCMAS Brain Gym with a group of children who had not undergone such training.

Method

Participants

The study evaluated two experimental groups and a control group. Each experimental group comprised of eight children in the age range of 7-12 years who were matched in terms of age, gender and the duration of training. While one group (Experimental 1) had undergone training for the GELS Abacus program, the other group (Experimental 2) had undergone the UCMAS Brain Gym program. In both experimental groups the children had undergone intensive training for a period ranging from 6 months to 2 years. A majority of the children had undergone the training for less than 1 year. The control group consisted of eight children who were matched in terms of age and sex. These children had not attended either the GELS Abacus or the UCMAS Brain Gym training programs nor had they undergone any other special training that focused on improving their listening skills. None of the participants in the study had any history of middle ear effusion or hearing problem. They all had age appropriate reading-writing abilities with average scholastic performance, as reported by their school teachers and based on their school assessment. They were also all naturally right handed, as evident from their writing / other manual skills as well as the report given by their caregivers.

Instrumentation

The audiological testing was carried out using a two-channel clinical audiometer, Madsen, Orbiter 922 version-2 with TDH 39 supraaural earphones housed in audiocups. A Philips 729K DVD player was used to play the recorded test material. Immittance evaluation was performed using GSI-Tympstar middle ear analyser.

Test Environment

All tests were carried out in a sound treated double room. The ambient noise levels were within permissible limits as recommended by ANSI S 3.1 (1991).

Test Material

The material used included the 'Screening Checklist for Auditory Processing' (SCAP) developed by Yathiraj and Mascarenhas (2002, 2004). This checklist comprised of 12 questions concerning the symptoms of deficits in auditory processing. It consisted of three aspects, namely auditory perceptual processing, auditory memory and other miscellaneous symptoms. The checklist was scored on a two point rating scale as 'Yes/No'. Each answer marked 'Yes' carried 1 point and each 'No' was marked 0. Children who scored more than 50% (i.e. 6 or more, out of 12) were considered to be 'at-risk' for auditory processing problems.

The dichotic tests used were the 'Dichotic Digit Test' developed by Shivashankar and Herlekar (1991) and the 'Dichotic CV Test' developed by Yathiraj (1999) for the Indian population. The former dichotic test had two pairs of digits, with a pair being presented to each ear. The latter dichotic test had six different stops (/p/, /t/, /k/, /b/, /d/, /g/) used in combination with the vowel /a/.

Test Procedure

The presence of a central auditory processing disorder was ruled out using the SCAP. The checklist was answered by the class teacher in a face-to-face interview. Further, to ensure that the participants had normal hearing, pure-tone air conduction and bone conduction thresholds were obtained for the octave frequencies from 250 Hz to 8 kHz and 250 Hz to 4 kHz respectively. To exclude the presence of any middle ear pathology, immittance testing was done. Both tympanometry and reflexes were checked. Only those with A-type tympanograms and ipsilateral as well as contralateral acoustic reflexes present at least at 90 dB HL in the frequencies 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz were selected.

The CD versions of the dichotic digit and dichotic CV tests were administered. Each test had a total of 30 stimuli. The output from the DVD player was routed to the tape input of the two-channel audiometer. The signals from the two different tracks in the CD were routed to the two different channels in the audiometer. A 1 kHz calibration tone, recorded in the test material, was used to adjust the VU meter to zero in both the channels. Both dichotic tests were carried out using a '0' ms lag condition at 40 dB SL. The output from the audiometer was presented to the participants through headphones. The children were asked to write down what they heard in both ears. Prior to administration of the tests, the children were instructed that they would hear two different words/speech sounds in each ear. After listening carefully they had to write down what they heard in both ears on the sheet of paper provided to them. An example of what they were expected to do was demonstrated. However, no practice with the actual test material was provided since the tests did not have provision for such rehearsal. Written responses were preferred over oral responses to avoid the auditory perception of the tester biasing the results.

The responses were scored in terms of single correct scores and double correct scores. Single correct scores were given when the digits or syllable given to only one ear were correct. A double correct score was given when a participant correctly identified the digits or syllable in both ears. A one-way ANOVA was used to analyze the data obtained from the participants.

Results and Discussion

The means and confidence intervals (CI) for the single correct and double correct responses for both the dichotic digit test (Figure 1) and dichotic CV test (Figure 2) were determined. This was obtained for all three participant groups. From the figures it is evident that the control group obtained lower mean scores compared to the two experimental groups. This trend was seen for the single and double correct scores for both dichotic tests.

All the participants obtained higher scores on the dichotic digit test when compared to the dichotic CV test (Figures 1 & 2). This could be attributed to the higher level of redundant information in the dichotic digit test when compared to the dichotic CV test. Although the performance of the control group was poorer than that of the two experimental groups on the dichotic digit test, a one-way ANOVA revealed that there was no significant difference between the scores of these groups for the right ear.

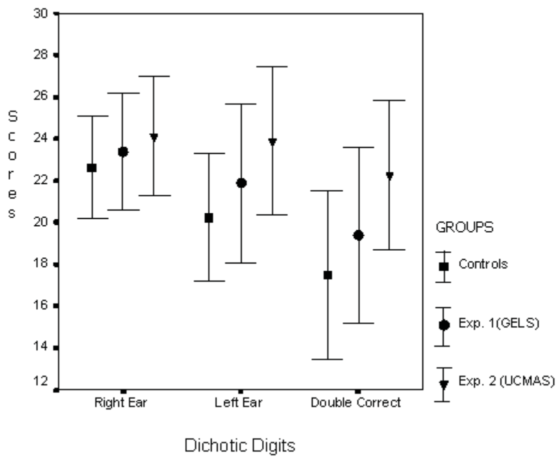

Fig. 1. Mean and 95% confidence interval of the dichotic digit test scores.

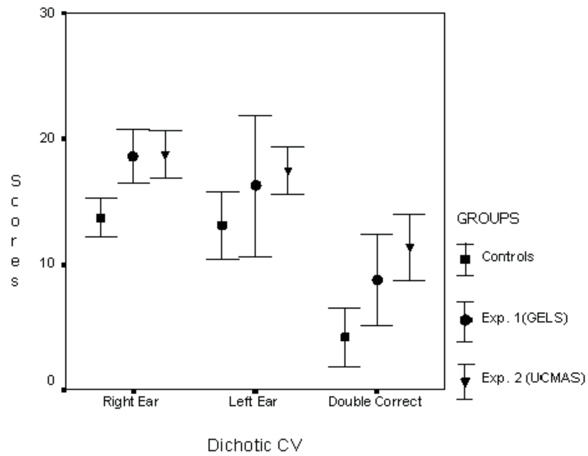

Fig. 2. Mean and 95% confidence interval of the dichotic CV test scores

On the dichotic CV test, the control group obtained much lower scores than both the experimental groups. This was evident in the single correct responses (Table 1) and the double correct responses (Table 2). To check if this difference was statistically significant a one-way ANOVA was carried out. A significant main effect was observed with the groups combined for the right ear [$F(2, 21) = 8.284$, $p < 0.001$] and the left ear [$F(2, 21) = 5.9$, $p < 0.005$]. Further, the post hoc Duncan test showed that while the control group and the two experimental groups performed differently, there was no significant

Table 1. *Mean, Standard Deviation and Confidence Interval of single correct scores for the dichotic CV test*

Groups	Single correct scores	Mean score (Maximum score = 30)	Standard Deviation	Confidence Interval
Control	Right ear	13.75	1.803	12.21 – 15.28
Experimental 1 (GELS Abacus)	Right ear	18.63	3.42	15.76 – 21.48
Experimental 2 (UCMAS Brain Gym)	Right ear	18.75	2.89	16.31 – 21.18
Control	Left ear	13.13	4.16	9.59 – 16.66
Experimental 1 (GELS Abacus)	Left ear	16.25	8.44	9.35 – 23.14
Experimental 2 (UCMAS Brain Gym)	Left ear	17.50	3.25	14.74 – 20.25

Table 2. *Mean, Standard Deviation and Confidence Interval of double correct scores for the dichotic CV test*

Groups	Mean score (Maximum score = 30)	Standard Deviation	Confidence Interval
Control	4.13	3.79	1.24 – 7.001
Experimental 1 (GELS Abacus)	8.75	5.05	4.58 – 12.91
Experimental 2 (UCMAS Brain Gym)	11.38	3.79	8.37 – 14.37

difference between the two experimental groups.

As evident from the data in Table 1, both experimental groups had a greater mean right ear score compared to the control group. The higher right ear score in the two experimental groups could be on account of the intensive math training provided to them. It has been noted by Riza (2002) that the left hemisphere controls the function of math.

Besides evaluating the scores obtained across the three groups, a comparison of the scores obtained in the left and right ear in each of the groups was also done. Though the right ear scores were higher in the two experimental groups when compared to the control group, paired t-tests revealed that in all three groups there was no statistically significant difference between the left and right ear scores. This was observed in the control group [$t(7) = 0.401$, $p > 0.05$], experimental 1 [$t(7) = 0.746$, $p > 0.05$] and experimental 2 [$t(7) = 1.213$, $p > 0.05$].

According to the claims of the GELS Abacus program, the training was supposed to improve the whole brain activity. However, the present study did not support their claim since the difference in the right ear scores was significantly higher than that of the left ear in both the experimental groups when compared to the control group. Had the training resulted in an improvement in a whole brain activity, the scores should have been proportionally higher in both ears in the experimental groups, in relation to that obtained by the control group.

The finding of the present study shows that when tested with a dichotic task that uses less redundant material, such as the dichotic CV test, the effect of the additional training the experimental group underwent is highlighted. Despite the drawbacks reported about the dichotic CV test (Bellis, 2003; Roeser, Millay, & Morrow, 1983) the present study highlights that it is more sensitive to detecting the subtle changes seen in auditory perception following intensive listening training compared to the dichotic digit test. Thus, the effect of additional intensive listening training when auditory signals are presented can be noted only when a dichotic CV test which is less redundant is used. This difference is not evident when an easier dichotic task which is involved in the dichotic digit test. This study goes to show that intensive diotic stimulation of the auditory system can result in better dichotic performance.

The better performance observed in the experimental groups, when compared to the control group, can be primarily attributed to the additional training received by them. This can be construed since the experimental and control groups were matched in all aspects and the only difference in the two groups was the training provided. It is possible that the training provided to the experimental groups could have resulted in reorganization of the cortical function thereby resulting in changes that were reflected in performance on certain auditory tasks. Several studies in literature have shed light on the plastic nature of the auditory cortex which results in changes in its function consequent to auditory stimulation. This has been proven through the use of magnetic resonance imaging (Elbert, Pante, Wienbruch, Rockstroh, & Taub, 1995; Huckins, Turner, Doherty, Fonte & Szeverenyi, 1998;

Jancke, Gaab, Wustenberg, Scheich, & Heinze, 2001) and auditory evoked potentials (Carell, King, Tremblay, & Nicol, 1995; Gordon, Papsin & Harrison, 2003, 2006; Jirsa, 1992; Kraus, McGee, Menning, Roberts, & Pantev, 2000; Tremblay & Kraus, 2002). Further, Song, Skoe, Wong, and Kraus (2008) demonstrated the presence of plasticity in the auditory brainstem by studying the frequency following response in a group of adults who were trained using foreign lexical pitch patterns. Similar to the outcomes of the above mentioned studies, intensive listening training could have resulted in cortical reorganization in the two experimental groups in the present study. This could account for the better performance on the dichotic CV test in the experimental groups when compared to the control group.

Conclusion

It can be concluded from the present study that intensive auditory stimulation results in children obtaining better auditory performance. This is evident from the higher scores on the dichotic CV test in children who had undergone abacus training. These children not only obtained higher dichotic scores, but they also had higher right ear scores when compared to the children who did not undergo any training. Such a difference was not observed for the left ear score. Based on the findings of the study it can be construed that subtle auditory skills in children could be enhanced through training activities which involve intensive auditory stimulation.

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Address for Correspondence: Dr. Asha Yathiraj, Professor and Head, Department of Audiology, All India Institute of Speech and Hearing, Mysore -570006, India Email: ashayathiraj@rediffmail.com

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Reference List

The reference list should be alphabetical in order of the last name of the first author. Each entry should be alphabetized by the last name of the first author. The last name of each author should be followed by the author's initials. Every author should be named unless the work has more than six authors in which case name the first six authors and then use et al. after the sixth author's name to indicate that there are more authors.

If there are two works by the same author(s) in different years, then list them chronologically beginning with the oldest. If there are multiple works by the same author in the same year, then follow the year with alphabets in lower case as is done for the in-text citations. The listing for such references should be in the same sequence as that for the references in the text. For each listing in the reference list, the second line onwards should be indented in by 3 spaces (hanging indent). Use single line spacing within a reference and a double line spacing between two consecutive references.

Given below are examples for some common types of reference list entries.

Books

General format for books

Author, I. I. (Year of publication). *Title of book: Subtitle.* Location: Publisher name.

Edited book, without author

Editor, I. I. & Editor, I. I. (Eds.) (Year of publication). *Title of book: Subtitle.* Location: Publisher name.

Chapter in an edited book
Author, I. I. (Year of publication). Title of Chapter. In I. Editor & I. Editor (Eds). *Title of book: Subtitle* (pp: Insert pages numbers of chapter separated by hyphen). Location: Publisher name.

Book edition other than the first: e.g.
Cranberg, I. J. & Duffy, J. V. (1987). *Consequences of Disability (4th ed.)*. Boston MA: Burton and King.

Journal articles
Author, I. I., Author, J. J., & Author, K. K. (Year). Article title. *Journal Title, volume* (issue), pages.

Unpublished Masters Dissertation
Author, I. I. (Year). *Title of the dissertation.* Unpublished Masters Dissertation. University name.

Article from an online journal article
Author, I. I., & Author, J. J. (Date of publication). Article *Title. Journal Title, volume number.* Retrieved month day, year, complete URL of website.

If an article that you have accessed online, is also available as a printed version, the URL is not necessary. Say "Electronic version" in brackets after the title of the article.

Author, A. A. & Author, B. B. (Year). Article Title [Electronic version]. *Journal title, volume number* (issue number), pages.

Web Document
Author, I. I., & Author, J. J. (Date of publication). *Document Title.* Retrieved month day, year, from …….(give complete URL of website)..

Computer software
Inventor, I. (Year). Name [computer software]. Location: Company name.
For reference types not covered in the above list, kindly follow the 5th edition of the Publication Manual of the American Psychological Association.

Tables and Figures

Tables and figures should be in a separate sheet at the end of the document. Each table / figure should be on a separate sheet. The table title should be mentioned above the table next to the table number. The table number should be followed by a full stop. The title of the table should follow immediately in sentence case, italics and must end with a full stop. An example is given below:

Table 2. Demographic data of participants in the study.

If additional explanation is needed, a note can be added below the table.

The figure number should be italicized and followed by a full stop. The figure caption should follow immediately in sentence case. An example is given below:

Fig 2. Diagrammatic representation of the process of communication.

Table titles and figure captions should be concise but self-explanatory. The reader should not have to refer to the text to decipher the information. **All figures must be in black and white.** Only those figures that require the extra dimension of color to convey essential information will be published in colour. The editor will determine the need for colour.

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If the author/s wish to reproduce any material that is protected by the copyright laws of any country, including material from the internet, the manuscript must be accompanied by a note acknowledging that the copyright holder has granted permission to publish the matter protected under copyright laws. It is the responsibility of the author to obtain letters granting such permission. These letters must be submitted in original to Editor, JISHA, at the time when the manuscript is accepted for publication.

Other guidelines

All spellings should be checked for UK spelling.

The International Phonetic Alphabet (IPA) should be used to represent material in languages other than English.

Acknowledgments should be on a separate page after the references. If the research work has been funded by any institution/s the same should be stated and duly acknowledged.

Acceptance Process for Submitted Manuscripts

The article will be reviewed by an editorial board. A blind peer review will be conducted. Reviewers will be finalized by the editorial board. At the time of manuscript submission, authors may suggest up to 3 names of reviewers for their article, giving the contact details of such persons. However the editor is not bound to consider any of those names and reserves the authority to make decisions on the choice of reviewers for any manuscript submitted for publication in JISHA. Subsequent to the review process, the decision on revision and acceptance of the manuscript will be communicated by the chief editor to the corresponding author.

The following references are recommended to know more about how to write a scientific article:

American Psychological Association (2003). *Publication Manual of the American Psychological Association* (5th ed.). Washington, DC: American Psychological Association.

Hegde, M.N. (2003). *A Course Book on Scientific and Professional Writing for Speech Language Pathology.* New York: Thomson Delmar Learning.