A STUDY CONDUCTED IN INDIA TO ASSESS VALIDITY OF *Fast ForWord*®

LANGUAGE GATEWAY EDITION

MAPS for Learning: Research Reports 12(1): 1-63

Project Report

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step one

Ⓟ April, 2008

Price: Rs 300.00 (in India)
US$ 20.00 (in all other countries)
shipping charges extra

Intending buyers may contact the publisher by email/Fax.

Published by Anjan Kumar Basu, Executive Secretary
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Publisher's Note

It is a great honor for a little-known organisation like ours to be able to complete this ground-breaking research study and publish the report.

We convey our heartfelt thanks and gratitude to:

Professor Paula Tallal
Co-Director
Center for Molecular & Behvioral Neuroscience
Rutgers-Newark University

Professor Sankar K Pal,
Director
Indian Statistical Institute

Dr. Barbara Calhoun
Scientific Learning Corporation

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Mrs. Paula Ghosh
St. Mary's Orphanage & Day School

This project would not have been possible without continuous support and encouragement from the above persons of eminence.

We would also like to thank the research assistants, psychologists, parents and students who enthusiastically partcipated in the project and made it successful.

Board of Trustees
14th April, 2008 Step One Foundation for Child & Youth Welfare

Acknowledgement

I am deeply indebted to Professor S. K. Pal, esteem Director of the Indian Statistical Institute for his administrative support to conduct this research. I am grateful to Dr. (Mrs.) Anjali Ghosh, Head of the Psychology Research Unit for her encouragement in this research. I am very much thankful to Professor Paula Tallal, Dr. Barbara Calhoun and Mr. Peter Carabi of Scientific Learning Corporation of USA for their initial evaluation of the report and other sorts of help. I would like to thank esteemed Brothers, Principal and teachers of St. Mary's Orphanage and Day School for their active cooperation. Mrs. Kakali Basu (Special Educator and Research Assistant), Miss Rituparna Basak (Psychologist and Research Assistant), Mrs. Manjira Mitter (Special educator) and Mr. Sukumar Roy (Management) of Step One Foundation for Child & Youth Welfare assisted in collection of data. I am grateful to them. They were trained by Dr. Madhumita Puri, authorised *Fast ForWord* trainer in India. I am thankful to her. I would also thankfully acknowledge the active cooperation of Mr. Anjan K. Basu, Executive Secretary of Step One Foundation who coordinated the project. And finally, I want to thank the students who took part in the program daily with tremendous enthusiasm and also the concerned parents who throughout the project kept their patience and provided active support.

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14th April, 2008

Contents

Executive summary

Children who are poor in school performance often lack the cognitive abilities like listening accuracy, phonological awareness, working memory, comprehension etc. Listening accuracy is the ability to discriminate acoustic sweeps. Phonological awareness is ability to distinguish parts of speech, such as syllables and phonemes presented auditorily. Working memory implies a system for the temporary holding and manipulation of information during the performance of a range of cognitive tasks. *Fast ForWord* Language Gateway Edition product software of Scientific Learning Corporation aims to improve above abilities through it's CD-ROM and internet based 7 training exercises. These are Block commander (BC), Old MacDonald's Flying Farm (OM), Phoneme Identification (PI), Phonic Match (PM), Phonic Words (PW), Language Comprehension Builder (LCB), Block Commander (BC). Aim of this study was to assess criterion related validity of the said product following request from the Scientific learning corporation, USA. Here, validity refers to the extent of content completion of above 7 exercises at the base, middle and terminal level of training. Initially, Step One foundation for Child and Youth Welfare trained 25 students of St. Mary's Orphanage & Day school, Kolkata with *Fast ForWord* Language Gateway Edition product. Training response data were used in this analysis. Before the training auditory discrimination ability was assessed by GFW test.

Base level analysis:

As expected 72% of the total trainees were limited within 15% completion irrespective of exercise wise differences. This suggests three things - (i) the product is useful for the students with age range from 9 to 11 years; (ii) difficulty level of stimuli for each exercise is arranged in such a fashion so that no one can achieve the desired outcome at the initial level; (iii) good base level validity of the product.

Middle level

Middle level refers to the period between initial and terminal level of training. The analysis represents changes in cognitive field of trainees during the training. Middle level training performance data analysis is very complex as results may be affected by two types of errors - (a) criteria contamination and (b) confounding effect. Any training performance is affected by one's initial level of competency. This should be properly accounted in training analysis otherwise there will be high possibility for criteria contamination. Like criteria contamination, training is affected by confounding variable. A confounding variable (also confounding factor, lurking variable, a confound, or confounder) is an extraneous variable in a statistical model that correlates (positively or negatively) with both the dependent variable and the independent variable. In this analysis, confounding variable is auditory discrimination capacity of the trainees as most of the exercises are based on auditory stimuli. Therefore, to evaluate the data, three specific questions are addressed : (a) What is happening within cognitive field of the trainees? (b) Do the students with high base line competency show much proficiency than their counterparts ? (c) Do the students with high auditory discrimination ability show much proficiency than the students with relatively low ability ? For the first question, box plot analysis was used. It revealed usual plateau stage before achieving the target of different exercises. Plateau was high in case of BC exercise. Trainees experienced much difficulty in case of two phonic based exercises, namely, PI and PW.For the second question, total trainees were classified into two groups based on their initial level of performance. Next mean proficiency levels of both groups across each exercise was compared.

It is noted that at the initial stage, mean difference was high; gradually it was reduced. However, this reduction was high in case of the PM exercise suggesting proficiency improved with training in the low ability group. In the case of the PW exercise, the difference was high during later sessions suggesting difficulties experienced by the students of low ability group as they developed proficiency.

To answer the third question, total trainees were classified into two groups- (a) good auditory discrimination and (b) poor auditory discrimination. Like above mean differences in proficiency between the groups was estimated. It is noted that trainees with good auditory discrimination was able to complete more contents in CS, OM,PM,PW and BC exercises than the poor auditory discrimination group.

Terminal Level

Terminal level success was measured in two ways: as 100% proficiency and more than 93% proficiency as all the trainees could not achieve 100% proficiency in all the exercises. More number of trainees achieved 100% proficiency in PM, OM,and CS exercises. When 93% proficiency was accounted, besides the above three, more number of trainees showed success in BC, LCB exercises.

To summarize, by the end of the sessions, most trainees reached the desired outcome in at least half of the exercises suggesting usefulness of the product. The analysis reveals differential pattern of criterion validity of different exercises of the product. It is noted that PI and PW exercises possessed poor criterion related validity. This two exercises needed more restructuring in considering Indian accent and pronunciation.

Overview

THE *Fast ForWord* LANGUAGE GATEWAY EDITION

The ***Fast ForWord*** family of products are CD-ROM and internet-based training software that helps children rapidly build oral language comprehension and other critical skills necessary for learning to read or becoming better readers. ***Fast ForWord*** products evolved from the work of noted neuroscientists Professor Michael Merzenich and Dr. William M. Jenkins from the University of California San Francisco, and Professor Paula Tallal and Dr. Steven L. Miller of Rutgers-Newark University, experts on the neurological basis of language. Professor Merzenich, Professor Paula Tallal, Dr. Steven L. Miller and Dr. Jenkins are internationally known for their research in the science of *brain plasticity,* the concept of which is, that the brain changes as people learn new skills. Brain plasticity has been instrumental in understanding improved learning strategies for children with language and reading problems [see Appendix II]. More specifically, that adaptive training techniques such as frequency, reward, intensity and motivation allow for more rapid learning. The collaboration of Merzenich, Jenkins, Tallal and Miller resulted in a key finding, that with the help of computers, speech sounds can be altered, allowing them to be more easily differentiated by children with language difficulties. Using this technology in an intensive, adaptive training program, or *optimal learning environment,* the scientists discovered that students can develop a wide range of critical language skills such as phonemic awareness, auditory processing speed, phonological awareness, working memory, syntax, grammar, sequencing and other necessary reading skills. (http://www.ecs.org/clearinghouse/18/84/1884.htm).

One of the most widely used products of the ***Fast ForWord*** family is the ***Fast ForWord*** Language Gateway Edition. It is a series of computer-delivered exercises designed to improve students' cognitive abilities such as working and long term memory, attention on tasks at hand and the ability to ignore distractions, auditory processing, auditory discrimination, and sequencing (Table 1). Exercises can be classified into two groups: sound exercises (Circus sequence, Old McDonalds Flying Farm) and word exercises (Phonic Match, Phonic Words, Language Comprehension Builder and Block Commander). Table 1 shows descriptions of each exercise. The ***Fast ForWord*** products have specified protocols. The students in this study used the ***Fast ForWord*** Language 50-Minute Protocol. In this protocol, students spend 50 minutes per day, five days per week continuously for eight weeks using the product. There are seven exercises (or modules) in the product. Between three and five exercises are assigned to the student during each day's session with students spending between 7 and 17 minutes on each exercise. Progress through individual exercises is adaptive; correct responses to the stimuli result in forward progression while incorrect responses result in additional opportunities to master the stimuli and/or easier stimuli.

Validity studies

Fast ForWord Language edition products were evaluated on a variety of student populations in USA and other countries (http://www.scilearn.com/results/). Some selective studies are dicussed below:

1. Pre-Post studies

1.1 Clinical Study : In 1994 and 1995, founding Scientific Learning scientists from the University of California San Francisco (UCSF) and Rutgers University conducted initial controlled studies to measure the effectiveness of the technology, methods and applications that formed the basis of Fast ForWord(R). Their clinical results, published in the January 1996 issue of the peer-reviewed journal Science, demonstrated rapidly improved language skills, including auditory processing speed, speech discrimination, phonemic and phonological awareness, grammatical and syntactic comprehension, overall language comprehension and other receptive and expressive language skills.

1.2 Lab to Land studies: In 1996, the National Field Trial was conducted in collaboration with more than 60 independent professionals at 35 sites across the United States and Canada. An important objective of the study was to confirm that Fast ForWord(R) would be successful outside of the laboratory in real-world settings. At each site, independent speech and language professionals and other education professionals selected students 4-14 years old, who exhibited difficulties in either listening or language comprehension skills. These professionals administered the Fast ForWord(R) program to the children in a conventional clinic, private practice, school or home setting. Each of the 35 sites reported conclusive validation of Fast ForWord's(R) effectiveness. Ninety percent of the students who participated in the Field Trial achieved significant gains in one or more tested areas. Most students made statistically significant gains in multiple tested areas, including improvements in auditory word discrimination, the ability to follow spoken directions, listening and speaking fundamentals, auditory processing speed, speech discrimination, language processing, grammatical comprehension and overall language comprehension

The results included: Auditory Word Discrimination: The Goldman Fristoe Woodcock Test of Auditory Discrimination measures a child's ability to discriminate between similar sounding words in both quiet and noisy situations. Overall, children in the study demonstrated significant gains in these abilities following Fast ForWord(R) training. Following the training, the percentage of the children scoring at or above the level expected for their age rose from 7% to 39%. Following Directions: The Token Test for Children measures a child's ability to follow spoken directions. Prior to Fast ForWord(R) training, the childrens' ability to follow spoken directions was well below average, almost two standard deviations below the mean for the test. After training, the children's ability moved from below average to average, with an average gain of over one standard deviation on the Token Test.

Overall Language Development (1): The Clinical Evaluation of Language Fundamentals (CELF-3) is a comprehensive test that measures a wide range of receptive and expressive language skills, including a child's ability to understand spoken words and sentences, follow directions, recall and formulate sentences, and understand relationships between words and categories. After Fast ForWord(R) training, the percentage of children scoring at or above the standard mean

on expressive tests rose from 5% to 20%; on the receptive tests, the percentage was raised from 7% to 27%. Overall Language Development (2): The Test of Language Development, Primary, is a comprehensive test that measures a child's ability to combine sentences, understand work meanings and sentence structures, and make generalizations. Prior to training, only 15% scored at or above the standard mean. This improved to 42% following the training.(http://www.ecs.org/clearinghouse/18/84/1884.htm).

1.3 Changes in reading ability: In assessing effect of the products, attention was paid to change in reading abilities between pre and post administration of the products. For example,Killeen Independent School District, TX noted changes in reading abilities assessed by Gates-MacGinitie Reading Test after sequential use of the Fast ForWord products. Their reading improvements continued even after they finished the products. Ocatello/Chubbuck School District assessed reading ability with the Idaho Standards Achievement Test (ISAT) before and after Fast ForWord participation. The ISAT is a computerized, standards-based state assessment that contains multiple choice questions and is appropriate for grades 2 through 10. The test has reading, language arts, and math sections. The school noted improvement of reading abilities for use of the products (http://www.scilearn.com/alldocs/rsrch/30196PocatelloEduRpt4.pdf).

1.4 Changes in language skills for bilingual students in India: This study was conducted by the Nalanda Institute in Mumbai, India. The design of this study was a case study using nationally normed assessments. Study participants were students attending a school for children with learning disabilities in Mumbai, India. The Fast ForWord product was implemented at the Nalanda Institute as part of the educational curriculum. Before and after Fast ForWord participation, students had their cognitive skills, as well as their English language and reading skills, evaluated with a battery of tests: the Comprehensive Test of Phonological Processing (CTOPP), the Woodcock Reading Mastery Tests (WRMT), and the Goldman-Fristoe-Woodcock Test of Auditory Discrimination (GFW). Results revealed that on average, students significantly improved their cognitive, language, and reading skills following Fast ForWord participation. Phonological Awareness improved from the 29th to the 41st percentile and reading ability improved by an average of 7 months during the 5 months between assessments. Student listening skills improved from the 4th percentile to the 17th percentile.

2. Comparison with Control group: In fall 1997, Scientific Learning conducted the School Pilot Study in collaboration with nine school districts in California, Texas, Illinois, Indiana and Nebraska. The goal of this study, which included more than 400 students, was to determine the efficacy of Fast ForWord(R) training for students at risk for failure in reading and language skills. Kindergarten-3rd grade classroom teachers at each participating district identified students at risk for failure in reading or language arts. These students were randomly assigned to an experimental group that trained with Fast ForWord(R) and a comparison group (matched to the experimental group for age and gender) that remained in their regular classroom program and did not train with Fast ForWord(R).

The following tests were used to evaluate the effectiveness of the training program:

1. Test of Auditory Comprehension of Language, which examines comprehension for spoken language

2. Phonological Awareness Test, which is designed to assess phonological processing abilities.

Two of the eight subtests were administered. The Isolation subtest measures a child's ability to identify the initial, medial or final sound in a spoken word; the Deletion subtest measures a child's ability to delete specific sound parts.

The study revealed the following results: Prior to training, the language comprehension performance for both the control group and the group using Fast ForWord(R) was well below average, approximately the 12.5 percentile for normal distribution, a finding consistent with the at-risk status assigned by their classroom teachers. Post-testing showed that control-group performance had improved to the 21st percentile, while the training group improved to the 49th percentile. The number of children performing at or above the median in age-corrected language comprehension performance improved for the trained group from 11.3% to 39.3% as compared to 11.9% to 14.8% for the control group. Significant gains in language comprehension performance were identified for 71% of individuals that received the speech and language training with an average improvement of 1.8 years. This is significantly larger than would be expected by chance or that was observed in the control group. Approximately 75% of children who received training were effectively removed from the "at-risk" category. In additionally, positive behavioral changes in attention, cognitive flexibility and distractibility paralleled these language advances.

3. Repeated Measurement: This design was followed by the Mora School District of Mora, Minnesota (MAPS for Learning, Educator Reports, 8(19): 1-4) in order to investigate the effects of Fast ForWord Language product on the language skills of elementary school students who used the product within the curriculum in a school setting. A repeated measures multivariate analysis of variance (MANOVA) was used to evaluate changes in the students' oral language skills, as well as differences between the skills of students who used Fast ForWord products and students in a comparison group. Study participants were 23 students in the third grade who were in the Mora School District of Mora, Minnesota. Students who used Fast ForWord products were randomly chosen from one of the classrooms where the products were used; a comparison group was randomly chosen from a classroom where the products were not used. Before and after participation on the Fast ForWord Language product, student language abilities were evaluated with the Test of Language Development-Primary, Third Edition (TOLD-P3). Results noted that on average, after using the Fast ForWord Language product, the oral language abilities of students who used the products showed significant improvements relative to a comparison group, with the average improvements in Quotients ranging from one-half to two-thirds of a standard deviation.

The product have 7 exercises. Efficacy of each exercise in improvement of reading competencies has not been studied in the above studies. Current study focused on this issue.

The Research

Research objectives

This study is the initial step in an evaluation as to whether an American-English language development product with auditory and pictorial stimuli is suitable for students in India. This first step analyzed whether the students understood the tasks and could complete them. Therefore, the aim of this initial study was to assess the validity of the ***Fast ForWord*** Language Gateway Edition product using evidence from product use.

It is quite challenging to estimate the validity of web-based training exercises as the estimation procedure is not like estimating the validity of psychological instruments or tests. In estimating test validity, researchers assess the content, the construct and the predictive validity of the instrument. In the current study, the focus was on the amount of content completed by each trainee across the different sessions. Therefore, the research objective in this study will be to determine criterion validity of the exercises.

CRITERION RELATED VALIDITY

Test validity pertains to what the test measures and how well it does so. It tells us what can be inferred from test scores (Anastasi, 1990). Following the analogy of test validity, validity of a training program may be defined as the skills that the training program develops and its effectiveness at developing those skills. This definition suggests an evaluation of content completion over the duration of product use. Since the products are adaptive, content completion would indicate how much the trainees improved their performance over time.

The current product was developed on the basis of numerous studies showing that students with reading difficulties had challenges with several cognitive skills including phonemic awareness, memory, and rapid auditory processing. The aim was to develop proficiency in cognitive functioning through successive problem solving by the respondents. Therefore, in assessing criterion related validity, three levels were assumed – base level, terminal level and middle level.

Base level validity

Base level refers to initial level or the performance at the end of the first session on a specific exercise. Base level validity refers to whether or not the individual trainee can show success at the initial phase. It was measured in terms of the percentage of trainees who showed success at the initial level where success is defined as whether the subjects can complete the content of exercise or not.

Terminal level validity

Terminal level validity refers to whether or not the individual trainee can reach a level of 100% content completion by the end of the sessions. It was measured in terms of the percentage of trainees who reached 100% of content completion on each specific exercise.

Middle level validity

Middle level validity refers to whether or not an individual trainee can show successive improvement across different treatment levels. The desired outcome varies with the trainee's ability. Therefore, the role of individual differences in ability on the successive increase in performance levels will be investigated. In this context, the outcome measured is whether or not discrepancies in proficiency level between the high and low ability groups are reduced over the sessions.

Fast ForWord training program

Fast ForWord Language is an adaptive computer training program, based on the acoustically-modified speech and language training described in detail previously (Merzenich et al., 1996, Nagarajan et al., 1998). A participating child wears headphones to hear the instructions or stimuli and uses the computer mouse to respond. The training program consists of seven exercises presented in the form of computer games which are organized such that the child first trains on basic acoustic reception abilities and progresses to exercises that are designed to improve the child's syntactic and semantic skills. Each training exercise (game) began with training on that exercise and at a level at which most children can perform. The difficulty level continuously adapted so that the child got the majority (about 80%) of answers correct. Initially, brief, rapidly changing acoustic elements of speech (Block Commander, Language Comprehension Builder, Phonic Match, and Phonic Word) or acoustic signals (Circus Sequence, Old McDonald's Flying Farm, and Phoneme Identification) were stretched in time or amplified. The acoustic elements and signals adaptively approached normal speech speeds as the child progressed. The ending level for all of the training exercises was normal unmodified speech or acoustic signals. During the exercises the child received trial by-trial feedback. After an incorrect response was given, the correct response was shown before the next trial was presented. Correct responses were rewarded by sounds, lights, progress indicators, on-screen animations, and points. The points were converted to tokens for exchange in the child's local token economy.

Block Commander (BC) · *Language Structures*
It taught listening comprehension and syntax, and trained short term memory through the use of increasingly complex sentence structures. In this exercise, the child touched or moved objects on the computer screen in response to increasingly more complex verbal instructions similar to the Token Test for Children (DeSimoni, 1978). Objects vary in size (large, small), color (red, blue, white, yellow, green), and shape (circle, square). The exercise begins with acoustically modified speech (1.5x normal duration; fast elements amplified by +20dB) and changes adaptively through 5 processing levels. The processing algorithm prolonged speech in time by 1.5, 1.25, or 1.0 times normal, and amplified brief acoustic elements by +20, +10, or +0 dB (Nagarajan et al, 1998).

Old McDonald's Flying Farm (OMDFF) · *Phonological Awareness*
It taught children to distinguish sound changes at the level of individual phonemes. In this exercise the child captured a flying farm animal which started a phoneme stream. The phoneme stream was consist of a random number of foil phonemes plus a target phoneme from one of the following sets of consonant-vowel (CV) pairs: /gi/ vs. /ki/, /chu/ vs. /shu/, /si/ vs. /sti/, /ge/ vs. /ke/, or /do/ vs. /to/. The child was required to release the animal within 125 ms of the presentation of the target CV. Voice onset time (VOT) and fricative-vowel gaps were extended and then systematically shortened to natural speech rates. There were also five levels of ISI decreasing from 500 to 300 ms.

Circus Sequence (CS) · *Listening Accuracy*
It increased the rate of processing abilities both within and between nonverbal sounds. The child was trained to discriminate between a sequence of two brief successive acoustic sweeps which are separated by a specified inter-stimulus-interval (ISI). The sweeps are frequency-modulated (FM) glides that sweep upward from a base frequency or sweep down to the same base frequency, thus there were four possible combination of glides: down-down, down-up, up-down, and up-up. There were three base frequencies, 0.5, 1, or 2 kHz, six stimulus durations, stepping from 80

to 25 ms., and 45 inter-stimulus-intervals stepping from 500 to 0 ms. The child began with the longest sweep durations and ISIs, cycles through the base frequencies, and progressed to shorter sweep durations and ISIs following progressively more accurate performance.

Phoneme Identification (PI) · *Phonological Awareness*
It taught children to identify specific phonemes. The consonant-vowel (CV) and vowel-consonant-vowel (VCV) stimulus pairs that were used are /ba/ vs. /da/, /be/ vs. /de/, /bi/ vs. /di/, /va/ vs. /fa/ , and /aba/ vs. /ada/. The child heard a target stimulus which was one of the stimulus pairs, then one of a pair of animated characters vocalizing either the target or foil syllable. The child's task was to identify which animated character vocalized the target syllable. There were three presentation orders: target stimulus alone, target followed by foil, and foil followed by target; and 26 levels differentiating where the ISI, speech length, and amplification of frequency transitions was varied.

Phonic Match (PM) · *Working Memory*
It reinforced memory and reasoning skills within simple word structures that differed from each other by a single phoneme. The task was to match CVs by pressing the correct two tiles in succession in a 2x2 grid game board (3x3, 4x4, or 5x5 grid at higher levels). Pressing a tile evoked an aural CV, so the child had to accurately hear each CV and remember its location on the game board. The stimuli were 96 CVCs and CVs. The degree of confusability of the CVs and CVCs was included in constructing a task difficulty continuum. Speech length was stretched 1.5, 1.25, or 1.0 times normal speech and the brief acoustic elements were amplified by +20, +10, or +0 dB. The maximum number of responses for each grid size was set below a level determined by a Monte Carlo sampling procedure to achieve the correct answers by random play. Completing a game board with fewer presses resulted in extra game points. Fewer presses indicated that the child reliably heard and remembered the CV and CVC speech.

Phonic Words (PW) · *Phonological Awareness*
It **c**hallenged the child to distinguish between words that differed only by an initial or final consonant. The child heard the word and then chose the picture that best depicts the word from a choice of two pictures. Speech length was stretched 1.5, 1.25, or 1.0 times normal speech and the brief acoustic elements were amplified by +20, +10, or +0 dB.

Language Comprehension Builder (LCB) · *Language Structures*
It introduced increasingly complex sentences to develop higher-level language skills, including phonology, morphology, syntax, and grammar. The LCB exercise was adapted from the Curtiss-Yamada Clinical Language Evaluation (Curtiss and Yamada, unpublished). After hearing a sentence, the child pointed to the target picture out of 2-4 pictures. The sentences varied in grammatical structure and complexity and systematically presented more than 40 syntactic and grammatical structures. Sentences were initially presented with the speech length prolonged 1.5 times and with fast elements differently amplified by +20 dB, +10 dB or +0 dB, then systematically progressed in 4 steps to natural speech.

Methods

Prerequisites

(a) TESTS

Since administration of auditory stimuli is the part and parcel of the training, initially, ability to discriminate sounds was assessed by using Goldman Fristoe Woodcock Test of Auditory Discrimination GFW. The GFW is a screening measure of speech sound discrimination ability for students in quiet and noisy situations. Words were presented by means of a cassette tape in the absence of any noise and also in the presence of distracting background noise. The student heard a word and then pointed to a picture. Similar words such as lake, make, rake, and wake were presented as foils.

The test was administered both before and after the program.

(b) INFORMED CONSENT

Informed consent in prescribed format was obtained from parents of each participant. The consent form clearly stipulated all conditions for participation and were explained to the parents before commencement of the program. Parents of participants willingly signed the form along with Principal of St. Mary's Orphanage and Day School.

(c) MEDICAL CLEARANCE

A certificate of medical fitness from a registered medical practitioner for each participant was obtained from concerned parents in a prescribed format before commencement of the program.

SAMPLE

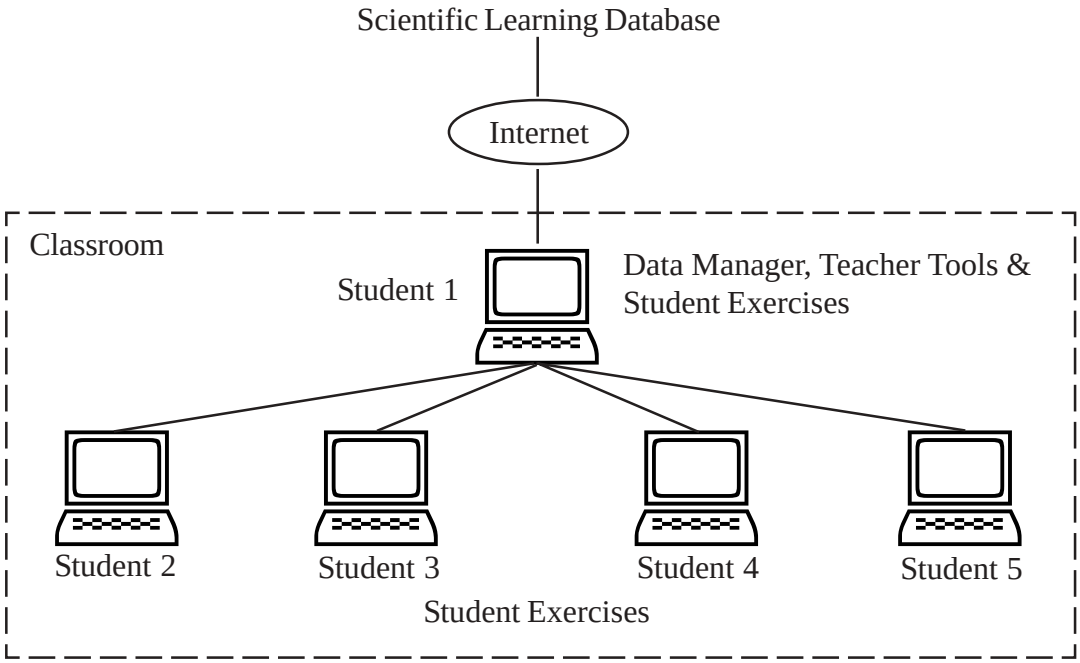
Data were collected by the Step One Foundation, Kolkata, from 30 students randomly selected from the pool of students at St. Mary's Orphanage & Day School, Kolkata. Out of them, 5 students failed to attend most of the sessions, therefore, their responses were not analyzed in this study. Current analysis was based on data of 25 students only. Their first language was English. They could read, speak and write in English. Their age ranged from 9 to 11 years.

The school was selected as the authorities were agreed to provide all sorts of infrastructure (almost noise-free spacious separate room with five computers and internet connection, separate room with adequate computers and internet connection, required manpower) for collection of data. Besides, the school has a very big campus and the students are coming from mixed communities with different socio-economic backgrounds.

TECHNICAL ARRANGEMENTS

As per the protocol (www.scilearn.com/gateway/updates), networked configuration was made. Data storage was centralized on Data Manager installed oncomputer No.1 while Student Exercises and Teacher Tools of ***Fast ForWord*** Language Gateway Edition were installed on Computer No.1 and remaining 4 client computers. Additionally, *Progress Tracker* was installed in computer no. 1 to download each particpant's performance score from Scientific Learning Corporation's server every day. The client computers were networked with Computer No.1 using a network hub. The computer No.1 was connected by ADSL modem for 256 Kbps broadband internet connection using TCP/IP protocol. Internet connection was made in such a manner so that proper transmission of data for administration of stimuli and storing the responses could be made and uploaded to the Scientific Learning Corporation's servers in USA.

Each computer was equipped with one professional-quality stereo headphones (SONY) with padded headband and ear-cups that completely covered the ears of each participant. An additional stereo headphone for the training coach to plug in and hear what the student heard.was attached to each computer using Y-adapter.



The training

The program was imparted in 6 batches, each batch comprising 5 students, each day. Daily program was supervised by four Fast ForWord Coaches who were previously trained by the authorized Fast ForWord Trainer in India. Standard protocol was followed in administering the stimuli and storing the responses systematically through computer network system. Protocol was maintained by the Scientific Learning Corporation, USA through internet connection. Step One Foundation downloaded the result after the training at a scheduled time every day. Trainees were invited to the school.

The program was imparted at a closed room with adequate space provided by the school authorities. The room was large, well furnished, and because of its distance from the main building the environment was almost noise-free. Five computers were provided by the school. Specification of the computers was strictly maintained according to instruction of Scientific Learning Corporation. Additionally each of the computer had professional-quality headset. Seating arrangement was maintained in such way that no participant could see what others were doing during the program. Also, no participant was allowed to talk or gossip with others or go out of the room during their participation. Each trainee followed 50 minute protocol. At the end of each day all data were uploaded to Scientific Learning Corporation's *Progress Tracker* portal through internet from the PC no.1. Reports from *Progress Tracker* was downloaded each day and saved appropriately. Hard copies of students' attendance records, program completion sheet, case history, parents' and teachers' opinion, were maintained.

Trainees were provided with motivational reinforcements like tokens of different values to be exchanged for gifts. Motivational posters, banners and decorated scoreboards as per protocol were also displayed. They also received continuous encouragement and all sorts of help from the supervisors.

Data set

The data set for analysis included (a) the percent of content completed by each trainee each session on each exercise and (b) the data of GFW test. All data for analysis were supplied by Step One Foundation.

Participation of trainees

Out of the 25 randomly selected trainees, 22 trainees participated on all the exercises every day as they were assigned (Table 2). Out of these 22 trainees, 2 trainees were absent on one day each in one exercise, and one trainee was absent in two days. One trainee missed a session in two exercises (PM and BC) and two trainees missed a session in one exercise (PI). None of the trainees missed an assigned session on four exercises (CS, OM, PW and BC).

No. of presentation of stimulus by exercises

Students used the exercises for more sessions in the case of the CS and LCB exercises (Table 3). This is according to the protocol which prescribes specific exercises during each session.

Results

Base Level Changes

After the initial session on the exercises (Table 4), a majority of trainees performed well (as defined by at least 15% of the content completed) on 3 exercises (PI (n=19 of 25, 83%), OM (n=15 of 25, 60%) and BC (n=15 of 25, 60%).) On the other hand, a majority of trainees struggled on four exercises: LCB (nobody completed more than 7% of the content during the first session), CS (nobody completed more than 11% of the content during the first session), PW (nobody completed more than 15% of the content during the first session) and PM (96% of trainees completed at least 10% of the content). Irrespective of exercise wise differences, 72% of the total cases completed less than 15% of the content suggesting more difficulty at the initial levels in solving the problems of different exercises. To summarize, trainees initially failed to reach the desired outcome in most of the exercises.

Terminal Level Changes

The terminal level success was measured in two ways: as 100% proficiency and as more than 93% proficiency.

100% proficiency

Table 5 shows that more trainees achieved 100% proficiency in three exercises: PM (67%), OM (64%) and CS (56%). In LCB (13%) and BC (12%) fewer trainees achieved 100% proficiency.

More than 93% proficiency

Table 5 shows that more than 93% success was noted on five exercises: PM (92%), BC (84%), LCB (83%), CS(80%) and OM (72%). In the case of PW exercise, only 32% of the trainees completed more than 93% of the content. Nobody completed more than 72% of the content in the PI exercise. To summarize, by the end of the sessions, most trainees reached the desired outcome in at least half of the exercises.

Middle Level

Table 7 represents means and SDs across the sessions for each exercise. Figure 2 shows comparative line charts of the exercises based on average distribution. It is noted that in comparison with other exercises, completion patterns in the PI and PW exercises were very poor (below 50%). On the other hand, more than 50% completion within 7 trials was noted in the case of the BC, OM and PM exercises.

BOX-PLOT ANALYSIS

Outliers

No outliers were noted in any box plots (Figures 3-9), therefore, all data were used in the analysis.

Box size reduction

Box sizes were systematically reduced across presentation of stimulus in the case of CS (Figure 3), OM (Figure 4), PM (Figure 6) and LCB (Figure 8) suggesting gradual increase in proficiency level by presentation of stimulus in corresponding modules. In case of BC (Figure 9), box sizes were initially large and remained large for several sessions after crossing the reference point. After continued sessions, the sizes were reduced suggesting a plateau stage in proficiency before achieving the target.

Location of median

Good training provides systematic change in performance. The exercises should not be too difficult or too easy. Out of 7 modules, the median was below the 50% completion level in case of the PI (Figure 5) exercise. In case of PW (Figure 7), the median was above the reference point at the end of the sessions. This suggests high difficulty experienced by the students in those 2 exercises. On the other hand, students experienced less difficulty in solving problems of 3 exercises namely, BC (Figure 9), OM (Figure 4) and PM (Figure 6).

Length of whisker

The length of the whisker was large hanging well below the lower hinge of the box in the case of CS (Figure 3), OM (Figure 4), PM (Figure 6), and LCB (Figure 8) suggesting that a few students showed much slower progress through the content than was typical. However, this lower whisker was small in the case of the BC (Figure 8) exercise suggesting less difficulty experienced by almost all of the trainees. In the case of PI (Figure 5), the length of whisker above the upper hinge of the box was high suggesting better performance by a few students in comparison with most of the students. But no one reached the target as no whisker reached the 100% success level. Again, the length of the whisker below the lower hinge of the box was long suggesting very poor performance of a few students in comparison with most of the students in the PI exercise. In the case of PW (Figure 7), few whiskers above the upper hinge of the box reached the target suggesting excellent performance of few students. Like, PI, whiskers below the lower hinge of the box did not lie below the 10% success level suggesting relatively less difficulty experienced by the few students in solving problems of the PW exercise.

Fluctuation in box size

After achieving the target, the size of the box varied suggesting possible concentration difficulty in solving problems of same exercise. This was noted in OM (Figure 4)and PM (Figure 6) exercises.

DIFFERENCES BETWEEN HIGH AND LOW ABILITY GROUPS BASED ON BASELINE TRAINING DATA

The variation in different parameters of the box plot analysis revealed possible within group variability in the performance of the trainees under study. Therefore, it may be assumed that individual differences in ability play a critical role in changing responses from one level to another. This will lead to criteria contamination. In considering such limitation, high (above the third quartile in baseline performance) and low ability (below the first quartile in base line performance) groups were compared using means and SD wise differences. Quartile was computed for each exercise.

Mean differences

Individual difference in ability plays a critical role in changing responses from one level to another. Box plots provide insight about the distribution of data irrespective of ability wise differences. Figures 10, 12, 14, 16, 18, 20 and 22 represent the graphical distribution of average performance across trials by high and low ability groups. In all the exercises, mean difference between the groups was noted suggesting appropriateness about the categorization. At the initial stage, mean difference was high; gradually it was reduced. However, this reduction was high in case of the PM exercise suggesting proficiency improved with training in the low ability group. In the case of the PW exercise, the difference was high during later sessions suggesting difficulties experienced by the students of low ability group as they developed proficiency.

SD wise differences

Mean differences provide average distribution patterns but fail to provide insight about the pattern of errors committed by individuals. Figures 9,11, 13, 15, 17, 19, 21, 23 provide insight about within group variability or the pattern of errors experienced by each ability group across treatments. Figures 15 (PI) and 17 (PW) show that SDs of both high and low ability groups remained fairly similar across trials suggesting more difficulty experienced by the students in the two groups.

DIFFERENCES BETWEEN HIGH AND LOW ABILITY GROUPS BASED ON AUDITORY DISCRIMINATION DATA

Initially, quartile test was computed based on noise and quite subtests data of GFW in order to identify the students who committed more errors in auditory discrimination for both subtests. Students who scored higher than 17 and 12 in noise and quite subtests respectively committed more errors. On the other hand, students who scored less than 14 and 9 in noise and quite subtests respectively committed less errors. Former was called poor auditory discrimination group (PADG) and the later was called good auditory discrimination groups (GADG) in this study.

Noise Subtests

Table 17 shows that GADG in noise subtest was able to complete more contents in CS (99.8%), OM (99.2%), PM(100%),PW(81.8%) and BC(98%) exercises than the PADG. On the other hand PADG in noise subtests was able to complete more contents in the PI (50.77%) exercise. In case of LCB exercise, PADG in noise subtest completed more contents across trials than GADG but finally it failed (95.15%) to cross GADG (97.2%) in content completion.

Quiet Subtests

Table 18 shows that GADG in quite subtest was able to complete more contents in CS (100%), OM (100%), PM (100%), PW (93.4%) and BC (97.8%) exercises than the PADG. On the other hand PADG in quite subtests was able to complete more contents in the PI (47%) and LCB exercises (95.75%).

Discussion

As per the request of Scientific Learning Corporation, current study examined the validity of ***Fast ForWord*** tools. Seven tools of ***Fast ForWord*** Language Gateway Edition product contains a set of problems which are assigned to the trainees during training. Here validity is defined as extent of content completion at the base line, middle and terminal level of training. Different measures of the content completion provide insight about extent of proficiency of the trainees or how much the trainees improved their performance over time.

Initial experience of the tool was good to the trainees as all of them noticed success in solving some content of different exercises though some differences were noted. For example, they performed well initially on 3 exercises out of 7. These were PI, OM and BC exercises. In terms of the level of difficulty, LCB, CS, PW and PM were more difficult to them at the initial period.

Though BC exercise was least difficult to them at the initial period, very few trainees achieved 100% content completion in this at the end. PM was appeared as more difficult at the initial level, but finally, they performed well in this exercise. LCB exercise was appeared as more difficult at both the initial and terminal level. This suggests Zeigarnick effect on trainees.

Changes in extent of content completion across sessions were examined through box plot analysis. Gradual increase in proficiency level was noted in four exercises namely, CS, OM, PM and LCB over the sessions. Trainees experienced more difficulty in content completion in case of PI and PW exercises and less difficulty in case of BC, OM and PM exercises. Concentration difficulty was noted in OM and PM exercises after achieving the target of content completion.

It would be misnomer to assume that increase in performance level was only due to the training as performance level was affected by the proficiency level and auditory discriminating abilities of the trainees. During ability wise comparison, it was noted that high ability group performed better than low ability group of trainees. However, repeated exposure of training at the lower end reduced the gap between the two suggesting good efficacy of the training tools.

Besides ability, training performance was affected by auditory discrimination ability of the trainees. Trainees who committed more mistakes performed poor in some training exercises than the trainees who committed less mistakes.

Finally, it is concluded that except PI and PW exercises, trainees showed significant improvement in their performance across different levels of training.

Suggestions and future research

In considering poor criterion-related validity, some training modules (PI and PW specifically) might be restructured due to poor criterion-related validity. It might improve the criterion-related validity to use an Indian accent and pronunciation. However, the criterion-related validity should first be evaluated on American-English speakers to determine whether the difference between the exercises is due to the accent, or is inherent in the exercises. Current study was limited to the criterion related validity of the product. Further study was necessary to assess the predictive validity of the product that requires more multivariate analysis as training was affected by pre training competencies.

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Scientific Learning Corporation

Appendix I

Appendix II

Professor Paula Tallal's Letter to Dr. D. Dutta Roy of Indian Statistical Institute

22/11/2005

Dear Dr. Dutta Roy,

Please excuse my delayed response. I have been preparing for the Presidential Symposium at the Society for Neuroscience that I was invited to present.

I enclose a recent review paper that should help get you started in reviewing my work and the neuroscience that led to the development of *Fast ForWord.*

I am happy to help you with your interests in pursuing Fast ForWord research in India in whatever way that would be of use. I also understand that my colleague from our company Scientific Learning Corporation, Dr. Barbara Calhoun, recently visited India to help deliver more information about the science behind Fast ForWord and its possible implementation in India. This would be a very exciting possibility for all of us who have seen the benefits that American children have received from our training programs. *Fast ForWord* has proven to be particularly helpful to children with weak spoken or written English language skills, including those who are learning English as a second language and those struggling to learn how to read.

Please let me know in more detail what I can do to help.

Sincerely,

Paula Tallal Ph.D.
Board of Governor's Professor of Neuroscience
Center for Molecular and Behavioral Neuroscience
Rutgers-Newark University
197 University Ave.
Newark, NJ 07102

Dr. Barbara Calhoun's Letter to Prof. Sankar Kumar Pal, Director of Indian Statistical Institute

Fast ForWord
by Scientific Learning
300 Frank H. Ogawa Plaza, Suite 600
Oakland, CA 94612-2040

February 12, 2006

Professor Sankar Kumar Pal
Indian Statistical Institute
203, B.T. Road
Kolkata – 700 108
India
FAX: + 91 33 2577 6925

Re.: Project on "Assessing Effectiveness of Computerized Exercises to Develop Cognitive Skills"

Dear Mr. Pal,

This is to draw your attention to work by a group of distinguished neuroscientists at Rutgers University in Newark, New Jersey, USA, and at the University of California, San Francisco, in San Francisco, California, USA. The neuroscientists developed unique technology on which computer and internet based cognitive skill development tools (the *Fast ForWord family of products*) for students were based. These tools incorporate the learning from over 30 years of research on learning and language. Several research studies have shown their effectiveness on the language and reading competency of students in the USA.

Recently, I conducted a workshop in Mysore on Neuroscience-based Interventions to Learning Disabilities using *Fast ForWord* under the aegis of the University Grants Commission Innovative Program on Learning Disabilities and in collaboration with Mysore University. The workshop developed interest in the introduction of the Fast ForWord software for Indian school students.

We are interested in doing some cross cultural work on this issue in collaboration with the Psychology Research Unit of your institution, as we understand that the unit is engaged in developing different instruments for the development of reading and writing motivation for school students. In this connection, we want to assess the validity of the *Fast ForWord* tools for school students in India. Step One Foundation for Child & Youth Welfare, a registered non-profit organization working in Kolkata, is engaged in arranging all relevant data in collaboration with St. Mary's Orphanage & Day School in Kolkata and has already entered into a research agreement with us. Dr. D. Dutta Roy of your Psychology Research Unit has expressed interest in this project.

While we are not in a position to provide any direct financial assistance for the assessment, we will contribute related psychological instruments and all the data to the Psychology Research Unit of your esteemed institute for further study on this issue.

We hope to receive your active cooperation and support in conducting this ground-breaking research on child education in India.

Sincerely,

Barbara Calhoun, Ph.D.
Director of Research
Scientific Learning Corporation

cc: Dr. D. Dutta Roy, Psychology Research Unit, Indian Statistical Institute, 203, B.T. Road Kolkata – 700 108, India. **FAX: +91-33-2577 6680**

The Collaborators

Indian Statistical Institute, Kolkata, India

Indian Statistical Institute (ISI) is an institution devoted to the research, teaching and application of statistics, natural sciences and social sciences. Founded by Professor P.C. Mahalanobis in Kolkata on 17th December, 1931, the institute gained the status of an Institution of National Importance by an act of the Indian Parliament in 1959.

Professor Mahalanobis set up the Statistical Laboratory in the Presidency College in 1920. On 17 December 1931, the Indian Statistical Institute was founded as a learned society and housed in the Statistical Laboratory. The Institute was registered on 28 April 1932, as a non-profit distributing learned society under the Societies Registration Act and is now registered under the West Bengal Societies Registration Act. The ISI later moved to its current location, at the property owned by Professor Mahalanobis which also housed his residence known as "Amrapali" (a name given by Rabindranath Tagore).

Since its inception the institute has recognized the need for development and use of accurate and fast computing equipment for the processing and analysis of data. In 1956, the Institute acquired a HEC-2M machine from the U.K., which was the first digital computer in India. Since 1956 till the mid-sixties, the Institute had been serving as a de facto national computer centre for the country. In the early sixties the Institute, in collaboration with the Jadavpur University, undertook the design, development and fabrication of a fully transistorised digital computer, called ISIJU-1 which was commissioned in 1966. The Institute has been maintaining its tradition of high quality research and development in the field of computer science.

In recognition of its contributions in the field of computer science, the Government of India in collaboration with the United Nations Development Programme established one of the five national Nodal Centres for Knowledge-Based Computing Systems at the ISI in 1988. Also, a new division emphasises research in theory and application of computer science, pattern recognition, image processing, artificial intelligence, machine intelligence, computer vision, natural language processing, documentation analysis and remote sensing.

The Psychology Research Unit is a part of the Social Sciences Division of the Indian Statistical Institute. Scientists of this unit conduct researches regularly on application of Statistics and Mathematics in explaining different psychological phenomena and psychological test development through different internal and external funding projects, sometimes in collaboration with scientists of other units of I.S.I. or other organizations. Besides, the faculties of the unit are involved in teaching and training activities and are providing Ph.D. guidance to research fellows selected through All India Examinations of the Institute. Scientists are also providing services in statistical or psychometric analysis of Psychological data.

The Headquarters of ISI is located in the northern fringe of the metropolis of Kolkata. Additionally, there are two centres located in Delhi and Bangalore.

Rutgers, The State University of New Jersey, Newark, USA

Rutgers, The State University of New Jersey, is the premier public university of New Jersey and one of the oldest and most highly regarded institutions of higher education in the USA. With nearly 50,000 students and over 9,000 faculty and staff on its three campuses in Camden, Newark, and New Brunswick, Rutgers is a vibrant academic community committed to the highest standards of teaching, research, and service.

Chartered in 1766 as Queen's College, the nation's eighth institution of higher learning, Rutgers is one of only nine colonial colleges established before the American Revolution. In 1825, Queen's College became Rutgers College to honor trustee and revolutionary war veteran Colonel Henry Rutgers. In 1924, Rutgers College officially became Rutgers University and subsequently in 1945 and 1956, state legislative acts formally designated Rutgers as The State University of New Jersey. The Newark campus of Rutgers officially came into existence in 1946, when the New Jersey State Legislature voted to make the University of Newark part of Rutgers University. Today, Rutgers-Newark is a doctoral-granting research institution that has evolved into one of New Jersey's leading education and research centers.

Rutgers-Newark (http://www.rutgers.edu/) is among the northeast's leading research universities, and is ranked the most diverse national university in the nation by U.S. News and World Report. The Rutgers Graduate School-Newark is one of the seven schools that comprise Rutgers University in Newark. The Graduate School offers 17 master's programs and 15 Ph.D. programs, in the arts and humanities, sciences, management, nursing, and criminal justice. The Graduate School-Newark is dedicated to the advancement of scientific and human knowledge in an environment that encourages scholarly inquiry and intellectual growth. Graduate students are expected to develop the analytical and creative skills required for original scholarship, research, and problem solving, as well as a thorough understanding of an academic discipline.

The Center for Molecular and Behavioral Science (CMBN) was established by the Board of Governors of Rutgers University in 1985 as the University's Neuroscience Center. The aim of the center to study at all levels from the molecular to the behavioral.

Professor Paula Tallal is the founder and Co-Director of Rutgers University's Center for Molecular and Behavioral Neuroscience (http://www.cmbn.rutgers.edu/) as well as a founder of the Scientific Learning Corp (http://www.scilearn.com/), creators of the award-winning ***Fast ForWord*** family of products.

Scientific Learning Corporation, Oakland, USA

The origins of Scientific Learning go back more than 30 years to the work conducted by the founders, noted research scientists Professor Michael Merzenich and Dr. Bill Jenkins at the University of California, San Francisco, and Professor Paula Tallal and Dr. Steven L. Miller at Rutgers-Newark University. Their research collaboration established several key findings:

- The core cognitive and linguistic attributes that allow a student to learn can be improved through intensive intervention.
- Acoustically modified speech technology can help build a wide range of critical language and reading skills.
- Computers can be used to create interactive, adaptive learning interventions based on a neuroscience foundation that yields years of growth in as little as a few weeks.

Based on this research work, Professor Merzenich, Dr. Jenkins, Professor Tallal, and Dr. Miller created the ***Fast ForWord*** family of reading intervention products. These products use patented technology to create an optimal learning environment that exercises and trains the brain to process more efficiently.

In March of 1997, after an extensive field trial with 500 children at 35 sites, Scientific Learning launched their first product, ***Fast ForWord*** Language. Later that year, a second field trial replicated earlier results, showing gains, on average, of 1-2 years in 8 to 12 weeks. Today, more than a million ***Fast ForWord*** products have been used in schools and clinics across the US and around the world.

Scientific Learning holds the rights to over 79 issued patents in the U.S. and other countries, with 32 more pending in the U.S. and abroad.

Scientific Learning applies advances in neuroscience and cognitive research to increase human potential.

The portfolio of patents is unique in the educational software field and reflect the high standards of the research and trials conducted in neuroscience, human cognition, and technology, which are the foundation of the company's approach and the framework of all ***Fast ForWord*** products. ***Fast ForWord*** programs develop and strengthen memory, attention, processing rate, and sequencing — the cognitive skills essential for learning and reading success. The strengthening of these skills results in a wide range of improved critical language and reading skills such as phonological awareness, phonemic awareness, fluency, vocabulary, comprehension, decoding, working memory, syntax, grammar, and other skills necessary to learn how to read or to become a better reader.

St. Mary's Orphanage & Day School, Kolkata

St. Mary's Orphanage traces its origin to the Catholic Male Orphanage (C.M.O.) which was established in 1848 at Murgighata, Kolkata (previously, Calcutta). In 1840, Dr. Patrick Joseph Carew, Vicar Apostolic of Bengal approached Br. Michael Paul Riordon, the Superior General of the Christian Brothers and subsequently Francis Fitzpatrick and Thomas Tolan, trained in the Christian Brothers' Novitiate in Ireland, were sent to take responsibility for the Cathedral School and the Orphanage in Murgighata. They were known as Calcutta Borthers and were filled with the spirit of Edmund Rice. In 1890 the Calcutta Brothers amalgamated with the Christian Brothers.

In 1947, it came to the present expansive campus in Dum Dum and was renamed as St. Mary's Orphanage and Day School. Thereafter, the school started to serve day scholars from all strata of the society irrespective of caste and religion.

The Day School is affiliated to Indian Certificate of School Education. The school also prepares students for the National Open School Examination.

Step One Foundation for Child & Youth Welfare

Step One Foundation is a non-profit organisation registered under Public Charitable Trust Act with the following main objectives:

1. To uphold, consolidate, protect, secure and promote the cause and process of education and health for children with special needs without any discrimination.
2. To conduct research studies in the fields of education and health.
3. To organize seminars, workshops and awareness campaigns.
4. To provide parental counseling.
5. To publish periodicals and newsletters.
6. To cooperate, collaborate, associate with similar institutions/bodies in India and outside.

The Learning as also the Research Center of the Foundation located in the midtown of the city was formally inaugurated by Mrs. Lee-Alison Sibley on 17th February 2005 in presence of Mr. George M. Sibley, the outgoing Consul General of Univted States of America and several other distinguished guests.

The center aims to provide support to children with special needs and to conduct researches in the field of education and health. It also housed the Administrative Office of the Foundation.

The Neuroscientists

Michael Merzenich, Ph.D.
Professor Merzenich is widely recognized as one of the world's leading experts in brain plasticity, brain mechanisms, and integrative neuroscience. Since 1990, Dr. Merzenich has been a professor in Neuroscience, Physiology, Biomedical Engineering and Otolaryngology at University of California San Francisco. He is currently the Francis A. Sooy Professor of Otolaryngology at UCSF. In May 1999, Dr. Merzenich was elected a member of the National Academy of Sciences, USA for distinguished and continuing achievements in original research. He has been awarded the Ipsen Prize, Zülch Prize of the Max-Planck Institute, Thomas Alva Edison Patent Award, the Purkinje Medal, and Karl Spencer Lashley Award. Dr. Merzenich has published more than 200 articles.

Paula Tallal, Ph.D.
Professor Paula A. Tallal is a world-recognized authority on language-learning disabilities. A cognitive neuroscientist and a board-certified clinical psychologist, Dr. Tallal is founder and Co-Director of the Center for Molecular and Behavioral Neuroscience at Rutgers-Newark, the State University of New Jersey. In 2001, Dr. Tallal was named a Board of Governors Professor in Neuroscience. She is an active participant in many scientific advisory boards and government committees for both developmental language disorders and learning disabilities.

Dr. Tallal has over 25 years experience managing multi-site, multi-disciplinary, federally funded contracts and grants that have resulted in over 150 publications as well as national and international honors.

William M. Jenkins, Ph.D.
Dr. William M. Jenkins is an expert in learning-based brain plasticity, behavioral algorithms, and psychophysical methods, as well as multimedia and internet technology. He was Associate Professor at the Keck Center for Integrative Neurosciences at the University of California San Francisco.

Dr. Jenkins is author or co-author of more than 100 publications and his work was recognized by Discovery Magazine in their 1996 annual Awards for Technology Innovations and most recently by the Year 2000 Thomas Alva Edison Patent Award.

Steven L. Miller, Ph.D.
Dr. Steven L. Miller is a neuropsychologist with expertise in the assessment and treatment of developmental language and reading impairments. He was a Research Associate Professor at Rutgers-Newark University.

Dr. Miller has extensive experience in organizing multi-site clinical studies and conducting longitudinal studies of children and adults who have language and reading problems in the U.S. and internationally. His work has resulted in numerous scientific publications, software products, patents and awards.

Informed Consent received from parents

Medical Clearance Certificate for the Participant

Table 1

Exercises	Benefits
Sound Exercises	
Circus Sequence (CS)	It helps to improve listening accuracy.
Old MacDonald's Flying Farm (OM)	It helps to improve phonological awareness, listening accuracy and working memory skills.
Phoneme Identification (PI)	It helps to improve phonological awareness skills, listening accuracy, and working memory.
Word Exercises	
Phonic Match (PM)	It helps to improve working memory, listening accuracy, phonological awareness and auditory word recognition.
Phonic Words (PW)	It helps to improve phonological awareness, listening accuracy, and auditory word recognition.
Language Comprehension Builder (LCB)	It helps to improve understanding of the relationship between words, grammar, and meaning (language structures).
Block Commander (BC)	It helps to improve working memory, language structures and listening accuracy.

Table 2

No. of cases participated into each exercise

Sl	Subject ID	CS	OM	PI	PM	PW	LCB	BC	All Groups
1	FFRK0305001	1	1	1	1	1	1	1	7
2	FFRK0305004	1	1	1	1	1	1	1	7
3	FFRK0305008	1	1	1	1	1	1	1	7
4	FFRK0305009	1	1	1	1	1	1	1	7
5	FFRK0305010	1	1	1	1	1	1	1	7
6	FFRK0305011	1	1	1	1	1	1	1	7
7	FFRK0305012	1	1	1	1	1	1	1	7
8	FFRK0304013	1	1	1	1	1	1	1	7
9	FFRK0304014	1	1	1	1	1	1	1	7
10	FFRK0305008	1	1	1	1	1	1	1	7
11	FFRK0305016	1	1	1	1	1	1	1	7
12	FFRK0305017	1	1	1	1	1	1	1	7
13	FFRK0305018	1	1	1	1	1	1	1	7
14	FFRK0305019	1	1	1	1	1	1	1	7
15	FFRK0305031	1	1	1	1	1	1	1	7
16	FFRK0305032	1	1	1	1	1	1	1	7
17	FFRK0104022	1	1	1	1	1	1	1	7
18	FFRK0105023	1	1	1	1	1	1	1	7
19	FFRK0105024	1	1	1	1	1	1	1	7
20	FFRK0105025	1	1	1	1	1	1	1	7
21	FFRK0105027	1	1	1	1	1	1	1	7
22	FFRK0105029	1	1	1	1	1	1	1	7
23	FFRK0305005	1	1	0	1	1	1	1	6
24	FFRK0303020	1	1	1	0	1	1	1	6
25	FFRK0305019	1	1	0	1	1	0	1	5
	Totals	25	25	23	24	25	24	25	171
Sl	Subject ID	CS	OM	PI	PM	PW	LCB	BC	All Groups

Table 3
Number of presentations of stimulus for each exercise

Exercises	Number	%
CS	34	20%
OM	20	12%
PI	23	14%
PM	22	13%
PW	20	12%
LCB	27	16%
BC	24	14%

Table 4

Percent of content completed at the base level period

	CS		OM		PI		PM		PW		LCB		BC		All	
% of success rate	No. of cases	%	No. of cases	%	No. of cases	%	No. of cases	%	No. of cases	%	No. of cases	%	No. of cases	%	No. of cases	%
0	0		0		2	9%	6	25%	0		0	0%	0		8	5%
2	2	8%	0		0		0		0		0	0%	0		2	1%
3	4	16%	0		0		0		0		0	0%	0		4	2%
4	2	8%	0		0		0		0		3	13%	0		5	3%
5	1	4%	0		0		12	50%	0		8	33%	1	4%	22	13%
6	2	8%	1	4%	0		0		0		9	38%	0		12	7%
7	0	0%	1	4%	0		0		0		4	17%	0		5	3%
8	6	24%	2	8%	0		0		0		0		0		8	5%
9	5	20%	2	8%	0		0		0		0		1	4%	8	5%
10	2	8%	0	0%	0		5	21%	2	8%	0		1	4%	10	6%
11	1	4%	1	4%	1	4%	0		5	20%	0		0		8	5%
12	0		1	4%	0		0		8	32%	0		0		9	5%
13	0		1	4%	0		0		5	20%	0		1	4%	7	4%
14	0		1	4%	0		0		3	12%	0		3	12%	7	4%
15	0		0		1	4%	1	4%	2	8%	0		3	12%	7	4%
16	0		1	4%	0		0		0		0		3	12%	4	2%
17	0		2	8%	2	9%	0		0		0		1	4%	5	3%
18	0		3	12%	0		0		0		0		1	4%	4	2%
19	0		0		0		0		0		0		2	8%	2	1%
20	0		5	20%	0		0		0		0		2	8%	7	4%
21	0		1	4%	0		0		0		0		4	16%	5	3%
22	0		2	8%	0		0		0		0		1	4%	3	2%
23	0		0		1	4%	0		0		0		0		1	1%
24	0		1	4%	2	9%	0		0		0		0		3	2%
25	0		0		1	4%	0		0		0		1	4%	2	1%
26	0		0		1	4%	0		0		0		0		1	1%
27	0		0		3	13%	0		0		0		0		3	2%
28	0		0		1	4%	0		0		0		0		1	1%
31	0		0		1	4%	0		0		0		0		1	1%
32	0		0		3	13%	0		0		0		0		3	2%
33	0		0		1	4%	0		0		0		0		1	1%
34	0		0		1	4%	0		0		0		0		1	1%
35	0		0		1	4%	0		0		0		0		1	1%
38	0		0		1	4%	0		0		0		0		1	1%
	25	100%	25	100%	23	100%	24	100%	25	100%	24	100%	25	100%	171	100%

Table 5

Percent of content completed at the Terminal level

Exercises	Rate of success	No. of cases	Cumul %	Exercises	Rate of success	No. of cases	Cumul %
CS	20	1	4%	OM	20	1	4%
	71	1	4%		48	1	4%
	77	1	4%		63	1	4%
	78	1	4%		67	1	4%
	81	1	4%		76	1	4%
	93	1	4%		77	1	4%
	94	1	4%		82	1	4%
	97	1	4%		96	1	4%
	99	3	12%		99	1	4%
	100	14	56%		100	16	64%
PI	18	1	4%	PM	70	1	4%
	24	1	4%		90	1	4%
	25	1	4%		95	6	25%
	27	1	4%		100	16	67%
	29	1	4%	LCB	6	1	4%
	32	1	4%		77	1	4%
	39	1	4%		90	1	4%
	42	2	9%		91	1	4%
	49	1	4%		94	4	17%
	50	2	9%		95	1	4%
	51	1	4%		96	3	13%
	55	3	13%		97	1	4%
	61	2	9%		98	2	8%
	66	1	4%		99	6	25%
	68	1	4%		100	3	13%
	70	1	4%	BC	72	2	8%
	71	1	4%		78	2	8%
	94	1	4%		94	2	8%
PW	13	2	8%		95	3	12%
	15	3	12%		96	2	8%
	16	3	12%		97	5	20%
	17	1	4%		98	1	4%
	37	3	12%		99	5	20%
	57	3	12%		100	3	12%
	75	1	4%				
	77	1	4%				
	95	1	4%				
	97	1	4%				
	98	3	12%				
	99	3	12%				

Table 6

Class interval wise Percent of content completed

Class Interval	CS	%	OM	%	PI	%	PM	%	PW	%	LCB		BC	%
<13	0	0	0	0	0	0%	0	0%	0	0	1	4%	0	0
13-22	1	4%	1	4%	1	4%	0	0%	9	36%	0	0%	0	0%
23-32	0	0%	0	0%	5	22%	0	0%	0	0%	0	0%	0	0%
33-42	0	0%	0	0%	3	13%	0	0%	3	12%	0	0%	0	0%
43-52	0	0%	1	4%	4	17%	0	0%	0	0%	0	~~0%~~	~~0~~	~~0%~~
53-62	0	0%	0	0%	5	22%	0	0%	3	12%	0	0%	0	0%
63-72	1	4%	2	8%	5	22%	1	4%	0	0%	0	0%	2	8%
73-82	3	12%	3	12%	0	0%	0	0%	2	8%	1	4%	2	8%
83-92	0	0%	0	0%	0	0%	1	4%	0	0%	2	8%	0	0%
93-100	20	80%	18	72%	0	0%	22	92%	8	32%	20	83%	21	84%
Total	25	100%	~~25~~	100%	23	100%	~~24~~	100%	25	100%	~~24~~	100%	25	100%

Table 7
Distribution of Means and SDs of performance across presentations of stimulus

Sessions		CS	OM	PI	PM	PW	LCB	BC	All Grps
T1	Means	6.60	15.60	24.48	5.21	12.32	5.58	16.64	12.29
T1	Std.Dev.	2.84	5.45	10.26	4.03	1.38	0.93	4.53	8.19
T2	Means	11.12	26.56	32.17	14.79	14.60	10.71	39.48	21.32
T2	Std.Dev.	5.33	10.42	14.91	8.27	1.58	1.37	10.27	13.61
T3	Means	16.32	41.40	36.61	23.96	17.24	16.96	65.84	31.25
T3	Std.Dev.	6.90	16.09	16.40	13.91	5.08	2.12	16.55	20.98
T4	Means	22.16	58.08	39.61	33.33	20.20	14.79	81.44	38.67
T4	Std.Dev.	9.36	20.47	19.38	17.30	10.12	6.63	18.42	26.99
T5	Means	25.08	67.92	40.57	43.54	23.00	17.13	82.84	43.04
T5	Std.Dev.	10.77	22.71	19.92	19.75	14.78	8.46	19.56	28.53
T6	Means	27.80	74.00	43.65	53.33	25.12	25.08	84.56	47.80
T6	Std.Dev.	12.05	23.39	19.91	22.54	18.40	10.98	19.00	29.09
T7	Means	31.84	79.08	43.91	63.75	28.52	29.13	86.76	52.01
T7	Std.Dev.	13.71	23.48	21.04	24.24	23.50	18.07	16.77	30.52
T8	Means	35.56	82.48	42.91	73.13	31.60	38.83	87.24	56.12
T8	Std.Dev.	15.03	23.22	20.49	25.23	27.77	20.43	15.15	30.79
T9	Means	38.88	83.64	43.52	80.42	32.72	44.21	89.04	59.06
T9	Std.Dev.	16.35	22.52	20.39	23.86	29.04	24.88	15.24	31.42
T10	Means	44.16	85.84	45.09	85.63	35.52	53.96	89.96	63.01
T10	Std.Dev.	18.20	21.72	19.99	21.48	31.88	27.60	12.40	31.14
T11	Means	49.48	87.56	44.78	89.79	37.24	61.58	90.84	66.03
T11	Std.Dev.	19.79	20.10	18.55	18.15	33.03	29.01	10.92	30.83
T12	Means	54.00	87.52	43.39	92.29	37.88	69.50	92.00	68.22
T12	Std.Dev.	21.21	21.22	18.09	16.61	33.32	31.77	10.71	31.38
T13	Means	58.24	88.28	42.78	92.08	40.64	73.42	91.68	69.75
T13	Std.Dev.	22.39	19.71	18.27	14.59	34.72	29.87	10.80	30.68
T14	Means	62.28	89.52	41.83	92.92	43.92	77.33	92.24	71.62
T14	Std.Dev.	23.44	19.89	19.14	13.51	35.73	28.89	10.60	30.64
T15	Means	66.68	90.44	41.70	94.79	47.64	79.58	92.96	73.61
T15	Std.Dev.	24.16	19.91	18.83	12.64	36.12	29.01	9.82	30.44
T16	Means	69.76	89.32	43.26	96.67	48.80	81.63	93.88	74.96

T16	Std.Dev.	23.98	21.64	19.26	10.49	36.16	26.67	9.05	29.98
T17	Means	73.08	89.24	44.70	95.83	51.16	84.04	93.20	76.09
T17	Std.Dev.	23.91	20.67	19.27	10.49	36.70	26.10	10.68	29.34
T18	Means	75.16	88.76	45.96	94.38	52.56	84.88	93.72	76.69
T18	Std.Dev.	23.70	21.86	19.64	9.70	36.80	23.72	9.38	28.65
T19	Means	76.92	88.84	47.57	96.25	53.56	87.17	93.36	77.85
T19	Std.Dev.	23.76	21.12	19.27	9.12	36.49	23.82	10.30	28.39
T20	Means	80.20	89.12	48.96	93.96	54.12	87.67	92.96	78.33
T20	Std.Dev.	23.02	20.46	18.83	7.66	35.88	23.70	9.36	27.51
T21	Means	82.52		48.96	95.00		89.42	93.68	82.29
T21	Std.Dev.	22.10		18.08	8.47		21.96	9.30	23.74
T22	Means	84.32		49.13	97.08		89.33	94.40	83.24
T22	Std.Dev.	21.12		18.81	6.41		20.73	8.58	23.54
T23	Means	86.04		49.30			90.67	92.76	80.21
T23	Std.Dev.	20.84		18.50			19.36	9.62	24.62
T24	Means	86.80					91.33	93.72	90.61
T24	Std.Dev.	20.46					19.30	8.62	16.96
T25	Means	88.00					91.63		89.78
T25	Std.Dev.	20.08					17.51		18.76
T26	Means	88.96					93.21		91.04
T26	Std.Dev.	19.51					17.56		18.51
T27	Means	90.36					92.08		91.20
T27	Std.Dev.	18.90					18.98		18.76
T28	Means	91.12							91.12
T28	Std.Dev.	18.26							18.26
T29	Means	91.48							91.48
T29	Std.Dev.	18.00							18.00
T30	Means	91.84							91.84
T30	Std.Dev.	17.89							17.89
T31	Means	92.20							92.20
T31	Std.Dev.	17.75							17.75
T32	Means	92.40							92.40
T32	Std.Dev.	17.38							17.38
T33	Means	92.36							92.36
T33	Std.Dev.	17.25							17.25
T34	Means	92.32							92.32
T34	Std.Dev.	17.37							17.37

Table 8
Summary Table of Box and Whisker plots

	CS	OM	PI	PM	PW	LCB	BC
	(n=34)	(n=20)	(n=23)	(n=22)	(n=20)	(n=27)	(n=24)
Median crossed Ref.point	11	4	22	6	20	10	3
Median touched Q3	25	12	no	11	no	21	7
Min. range crossed Ref.point	No	no	no	18	no	6	10
Max. range touching target	15	10	no	7	8	10	5
Q3 touching target	21	8	no	9	no	23	no

Table 9

Mean Differences between High and Low ability groups in CS exercise

	Low		High		
Presentations of stimulus	Mean	SD	Mean	SD	D (Mean)
T1	3.73	1.42	8.86	0.95	5.13
T2	6.36	3.64	14.86	2.85	8.49
T3	10.45	5.03	20.93	4.05	10.47
T4	14.45	7.81	28.21	5.01	13.76
T5	16.45	9.09	31.86	6.18	15.40
T6	18.45	10.39	35.14	7.28	16.69
T7	21.64	12.03	39.86	8.87	18.22
T8	24.73	13.75	44.07	9.72	19.34
T9	27.36	15.32	47.93	10.62	20.56
T10	31.27	17.32	54.29	11.41	23.01
T11	35.91	19.32	60.14	12.57	24.23
T12	39.36	20.65	65.50	13.38	26.14
T13	43.45	21.94	69.86	14.99	26.40
T14	47.09	23.48	74.21	15.55	27.12
T15	51.27	25.28	78.79	15.09	27.51
T16	55.00	26.11	81.36	14.42	26.36
T17	58.55	26.25	84.50	14.37	25.95
T18	60.82	26.59	86.43	13.49	25.61
T19	62.73	27.17	88.07	13.02	25.34
T20	67.00	27.47	90.57	11.59	23.57
T21	69.36	26.43	92.86	10.14	23.49
T22	71.91	25.81	94.07	8.85	22.16
T23	74.36	26.16	95.21	8.33	20.85
T24	75.18	26.02	95.93	6.91	20.75
T25	77.18	26.17	96.50	6.38	19.32
T26	78.73	25.93	97.00	5.19	18.27
T27	81.00	25.68	97.71	4.48	16.71
T28	82.27	25.01	98.07	4.03	15.80
T29	82.64	24.73	98.43	3.08	15.79
T30	83.09	24.66	98.71	2.67	15.62
T31	83.73	24.69	98.86	1.99	15.13
T32	84.27	24.26	98.79	2.26	14.51
T33	84.09	23.92	98.86	2.41	14.77
T34	84.18	24.21	98.71	2.37	14.53

Table 10
Mean Differences between groups in OM exercise

	Low		High		
Presentations of stimulus	Mean	SD	Mean	SD	D (Mean)
T1	9.70	2.67	19.53	2.20	9.83
T2	15.30	5.27	34.07	4.17	18.77
T3	25.10	11.08	52.27	6.98	27.17
T4	37.80	15.86	71.60	8.20	33.80
T5	46.00	18.69	82.53	9.37	36.53
T6	52.00	20.50	88.67	9.57	36.67
T7	58.40	24.04	92.87	8.05	34.47

T8	62.40	24.80	95.87	7.01	33.47
T9	64.80	24.80	96.20	7.18	31.40
T10	69.00	25.69	97.07	6.82	28.07
T11	72.30	24.79	97.73	4.51	25.43
T12	70.30	25.28	99.00	2.83	28.70
T13	72.70	23.95	98.67	2.85	25.97
T14	74.30	24.99	99.67	0.82	25.37
T15	76.90	26.75	99.47	1.25	22.57
T16	74.20	28.69	99.40	1.40	25.20
T17	74.60	27.11	99.00	2.27	24.40
T18	73.20	28.51	99.13	2.85	25.93
T19	73.80	27.38	98.87	3.64	25.07
T20	75.10	26.81	98.47	4.67	23.37

Table 11
Mean Differences between groups in PI exercise

	Low		High		
Presentations of stimulus	Mean	SD	Mean	SD	D (Mean)
T1	14.56	9.34	30.86	3.55	16.30
T2	18.56	12.74	40.93	8.08	22.37
T3	22.33	12.85	45.79	11.05	23.45
T4	23.11	12.48	50.21	15.17	27.10
T5	23.67	12.25	51.43	15.96	27.76
T6	26.44	13.53	54.71	14.88	28.27
T7	26.00	13.14	55.43	16.67	29.43
T8	26.56	13.42	53.43	17.19	26.87
T9	26.89	13.04	54.21	16.86	27.33
T10	29.56	14.80	55.07	16.35	25.52
T11	30.11	13.54	54.21	14.99	24.10
T12	30.11	14.03	51.93	15.23	21.82
T13	30.44	16.01	50.71	15.30	20.27
T14	28.11	16.50	50.64	15.45	22.53
T15	29.44	15.60	49.57	16.71	20.13
T16	30.56	13.49	51.43	18.23	20.87
T17	30.67	14.29	53.71	16.69	23.05
T18	33.78	15.90	53.79	18.12	20.01
T19	37.11	17.11	54.29	18.01	17.17
T20	38.22	16.41	55.86	17.41	17.63
T21	39.33	16.90	55.14	16.50	15.81
T22	41.22	20.44	54.21	16.44	12.99
T23	42.89	18.99	53.43	17.63	10.54

Table 12

Mean Differences between groups in PM exercise

	Low		High		
Presentations of stimulus	Mean	SD	Mean	SD	D (Mean)
T1	3.33	2.43	10.83	2.04	7.50
T2	11.67	6.42	24.17	5.85	12.50
T3	18.89	11.70	39.17	7.36	20.28
T4	27.50	15.17	50.83	10.21	23.33
T5	37.22	17.59	62.50	12.94	25.28
T6	46.39	20.64	74.17	13.93	27.78
T7	56.94	23.71	84.17	11.14	27.22
T8	66.94	26.07	91.67	8.16	24.72
T9	75.83	25.62	94.17	9.17	18.33
T10	81.94	23.77	96.67	2.58	14.72
T11	86.39	19.91	100.00	0.00	13.61
T12	90.00	18.71	99.17	2.04	9.17
T13	91.39	16.70	94.17	4.92	2.78
T14	91.94	15.35	95.83	4.92	3.89
T15	94.72	13.98	95.00	8.37	0.28
T16	96.67	11.76	96.67	6.06	0.00
T17	95.28	12.06	97.50	2.74	2.22
T18	92.78	10.74	99.17	2.04	6.39
T19	95.83	10.33	97.50	4.18	1.67
T20	93.61	8.37	95.00	5.48	1.39
T21	95.00	8.91	95.00	7.75	0.00
T22	96.39	7.24	99.17	2.04	2.78

Table 13
Mean Differences between groups in PW exercise

		Low		High		
PW	Presentations of stimulus	Mean	SD	Mean	SD	D (Mean)
	T1	11.40	0.74	13.70	0.82	2.30
	T2	13.60	0.91	16.10	1.10	2.50
	T3	14.87	1.13	20.80	6.60	5.93
	T4	16.27	3.17	26.10	13.90	9.83
	T5	17.93	10.31	30.60	17.61	12.67
	T6	19.07	14.43	34.20	20.64	15.13
	T7	20.87	18.43	40.00	26.45	19.13
	T8	23.20	22.23	44.20	31.53	21.00
	T9	23.80	23.19	46.10	32.86	22.30
	T10	24.20	23.27	52.50	36.53	28.30
	T11	23.73	23.33	57.50	36.08	33.77
	T12	24.60	24.38	57.80	36.07	33.20
	T13	25.60	26.25	63.20	34.65	37.60
	T14	28.00	28.86	67.80	32.45	39.80
	T15	30.67	29.04	73.10	31.09	42.43
	T16	31.93	28.79	74.10	31.82	42.17
	T17	33.67	29.84	77.40	30.51	43.73
	T18	34.47	29.73	79.70	29.55	45.23
	T19	35.20	30.54	81.10	26.36	45.90

	T20	35.87	30.14	81.50	25.15	45.63

Table 14
Mean Differences between groups in LCB exercise

	Low		High		
Presentations of stimulus	Mean	SD	Mean	SD	D (Mean)
T1	4.73	0.47	6.31	0.48	1.58
T2	9.64	1.29	11.62	0.51	1.98
T3	16.00	1.41	17.77	2.31	1.77
T4	14.55	3.27	15.00	8.68	0.45
T5	13.27	2.15	20.38	10.40	7.11
T6	19.36	4.25	29.92	12.67	10.56
T7	18.55	11.86	38.08	17.87	19.53
T8	26.91	14.42	48.92	19.64	22.01
T9	29.55	19.54	56.62	22.46	27.07
T10	37.73	23.39	67.69	23.62	29.97
T11	45.55	26.12	75.15	24.68	29.61
T12	52.27	32.46	84.08	23.53	31.80
T13	57.91	32.13	86.54	21.05	28.63
T14	64.00	33.30	88.62	19.37	24.62
T15	66.64	32.78	90.54	20.84	23.90
T16	71.55	32.46	90.15	17.69	18.61
T17	72.82	32.70	93.54	14.19	20.72
T18	75.82	31.55	92.54	10.49	16.72
T19	76.64	31.81	96.08	7.50	19.44
T20	77.82	32.73	96.00	4.38	18.18
T21	80.18	30.36	97.23	3.44	17.05
T22	80.27	28.49	97.00	2.89	16.73
T23	82.36	26.65	97.69	3.15	15.33
T24	84.00	27.17	97.54	2.79	13.54
T25	85.18	24.73	97.08	2.78	11.90
T26	87.73	25.24	97.85	3.02	10.12
T27	87.73	27.88	95.77	3.22	8.04

Table 15
Mean Differences between groups in BC exercise

	Low		High		
Presentations of stimulus	Mean	SD	Mean	SD	D (Mean)
T1	13.23	3.30	20.33	2.06	7.10
T2	32.00	8.32	47.58	4.12	15.58
T3	55.15	14.55	77.42	9.24	22.26
T4	71.38	19.05	92.33	9.78	20.95
T5	71.92	20.79	94.67	8.36	22.74
T6	75.00	21.14	94.92	8.64	19.92
T7	78.85	18.70	95.33	8.81	16.49
T8	80.00	16.55	95.08	8.52	15.08
T9	81.54	17.41	97.17	6.13	15.63

T10	82.92	13.05	97.58	5.30	14.66
T11	83.85	11.25	98.42	1.24	14.57
T12	85.31	11.30	99.25	0.87	13.94
T13	85.31	11.86	98.58	1.16	13.28
T14	86.15	11.82	98.83	1.19	12.68
T15	87.23	10.85	99.17	1.11	11.94
T16	89.23	10.67	98.92	1.16	9.69
T17	88.08	12.93	98.75	1.29	10.67
T18	89.15	11.27	98.67	1.50	9.51
T19	88.15	12.25	99.00	1.04	10.85
T20	88.23	11.00	98.08	2.02	9.85
T21	90.00	11.42	97.67	3.65	7.67
T22	90.38	10.45	98.75	1.29	8.37
T23	88.46	11.71	97.42	2.64	8.96
T24	90.00	10.65	97.75	2.05	7.75

Table 16
Mean differences between by exercise and by presentations of stimulus.

	CS	OM	PI	PM	PW	LCB	BC
T1	5.13	9.83	16.3	7.5	2.3	1.58	7.1
T2	8.49	18.77	22.37	12.5	2.5	1.98	15.58
T3	10.47	27.17	23.45	20.28	5.93	1.77	22.26
T4	13.76	33.8	27.1	23.33	9.83	0.45	20.95
T5	15.4	36.53	27.76	25.28	12.67	7.11	22.74
T6	16.69	36.67	28.27	27.78	15.13	10.56	19.92
T7	18.22	34.47	29.43	27.22	19.13	19.53	16.49
T8	19.34	33.47	26.87	24.72	21	22.01	15.08
T9	20.56	31.4	27.33	18.33	22.3	27.07	15.63
T10	23.01	28.07	25.52	14.72	28.3	29.97	14.66
T11	24.23	25.43	24.1	13.61	33.77	29.61	14.57
T12	26.14	28.7	21.82	9.17	33.2	31.8	13.94
T13	26.4	25.97	20.27	2.78	37.6	28.63	13.28
T14	27.12	25.37	22.53	3.89	39.8	24.62	12.68
T15	27.51	22.57	20.13	0.28	42.43	23.9	11.94
T16	26.36	25.2	20.87	0	42.17	18.61	9.69
T17	25.95	24.4	23.05	2.22	43.73	20.72	10.67
T18	25.61	25.93	20.01	6.39	45.23	16.72	9.51
T19	25.34	25.07	17.17	1.67	45.9	19.44	10.85
T20	23.57	23.37	17.63	1.39	45.63	18.18	9.85
T21	23.49		15.81	0		17.05	7.67
T22	22.16		12.99	2.78		16.73	8.37
T23	20.85		10.54			15.33	8.96
T24	20.75					13.54	7.75
T25	19.32					11.9	
T26	18.27					10.12	
T27	16.71					8.04	
T28	15.8						
T29	15.79						
T30	15.62						
T31	15.13						

T32	14.51						
T33	14.77						
T34	14.53						

Table 17
Average percentage of content completion by the high and low auditory discrimination groups based on Noise subtests of GFW test

	CS		OM		PI		PM		PW		LCB		BC	
	G	P	G	P	G	P	G	P	G	P	G	P	G	P
1	9.00	6.36	19.80	15.00	18.80	23.92	9.00	3.46	14.00	12.14	4.80	5.85	21.40	16.64
2	14.80	10.93	35.20	25.36	22.20	34.00	23.00	11.54	16.40	14.14	9.40	11.15	50.40	40.29
3	20.20	16.50	53.80	39.57	30.00	37.38	37.00	18.46	22.20	16.57	15.40	17.62	83.00	67.00
4	27.60	22.07	72.00	56.36	30.40	40.31	50.00	26.15	31.80	18.14	12.00	16.69	95.20	82.71
5	30.40	25.14	87.00	66.07	29.60	42.38	61.00	36.15	37.40	21.21	13.00	20.00	94.20	84.86
6	33.20	27.86	92.20	72.93	38.20	43.08	73.00	44.62	39.20	24.36	21.00	28.23	94.20	85.93
7	37.40	31.93	95.20	78.43	39.60	43.08	82.00	54.62	46.80	26.93	20.80	34.31	94.80	87.71
8	41.40	35.79	97.00	81.57	37.20	42.23	91.00	63.08	53.80	28.71	29.80	44.15	94.80	87.86
9	44.80	39.36	97.80	83.21	38.20	42.08	95.00	71.15	54.40	29.43	33.60	49.23	95.00	90.50
10	51.80	44.86	98.20	86.86	38.40	43.77	98.00	76.92	62.60	31.29	41.20	60.31	96.00	90.57
11	57.60	50.36	98.00	89.29	39.40	43.69	98.00	83.46	66.20	33.50	47.20	67.31	98.60	90.36
12	63.20	54.64	100.00	88.07	39.60	42.85	99.00	86.54	66.60	33.71	53.20	76.23	99.40	92.07
13	68.60	58.21	99.80	89.71	41.40	41.62	94.00	89.23	65.60	37.86	56.80	80.77	98.40	91.93
14	72.80	62.07	99.80	91.07	40.40	40.23	99.00	88.85	66.40	40.36	59.20	84.77	99.00	92.43
15	77.00	66.43	99.80	92.93	41.00	39.54	98.00	91.92	70.20	44.43	65.40	86.69	99.80	93.14
16	80.40	69.36	99.80	91.57	39.40	42.85	97.00	95.00	69.60	46.00	69.40	87.92	99.20	95.00
17	84.80	72.64	99.80	90.36	41.60	43.85	98.00	94.23	73.60	48.43	74.60	90.08	98.60	94.64
18	87.20	74.86	100.00	90.07	40.40	46.31	97.00	93.08	77.80	49.79	75.60	90.38	98.60	95.43
19	89.60	76.71	100.00	90.00	42.60	49.54	98.00	94.23	80.60	49.29	77.20	93.08	99.40	94.57
20	93.00	80.36	99.20	91.57	44.20	49.92	95.00	93.85	81.80	49.57	82.00	92.46	98.80	94.07
21	95.80	82.57			42.00	50.31	95.00	93.46			83.40	94.77	99.20	95.21
22	97.00	84.50			41.80	50.31	100.00	95.38			85.60	93.08	99.20	96.07
23	98.20	86.64			42.40	50.77					85.20	95.62	97.40	94.43
24	98.60	87.79									91.80	95.15	98.00	95.64
25	99.00	89.21									90.00	96.00		
26	98.80	90.43									96.60	96.23		
27	99.60	92.07									97.20	95.15		
28	99.80	92.79												
29	99.80	93.14												
30	99.80	93.64												
31	99.60	94.14												
32	99.80	94.43												
33	99.80	94.43												
34	99.80	94.57												

Note: G: Committed less errors (GADG)
P: Committed more errors (PADG)
1, 2….34: Order of presentation of stimulus

Table 18

Average percentage of content completion by the high and low auditory discrimination groups based on Quiet subtests of GFW test

	CS		OM		PI		PM		PW		LCB		BC	
	G	P	G	P	G	P	G	P	G	P	G	P	G	P
1	7.00	6.06	16.20	14.82	21.00	25.25	9.00	3.75	14.00	11.76	4.80	5.81	20.60	15.06
2	11.40	10.24	29.20	24.53	24.20	34.69	20.00	12.81	16.60	14.00	9.60	11.06	47.60	36.18
3	17.40	14.94	44.80	38.41	30.60	38.56	32.00	20.31	22.20	16.06	15.40	17.50	80.00	60.65
4	24.60	19.88	62.00	54.41	29.40	42.38	43.00	29.06	29.60	18.29	13.60	15.88	97.20	75.71
5	28.40	22.53	75.80	63.35	24.20	45.13	53.00	39.06	34.80	20.76	13.20	18.81	98.00	76.94
6	31.80	24.88	84.20	69.00	26.40	47.81	64.00	49.06	41.00	22.18	20.40	26.63	98.00	79.53
7	36.60	28.53	91.00	74.18	26.80	48.19	73.00	59.06	51.80	23.76	20.80	31.75	99.40	82.35
8	41.20	31.82	95.00	77.47	28.80	46.25	79.00	69.06	62.40	25.18	29.80	41.50	98.40	83.53
9	45.40	34.76	97.40	78.47	30.00	46.75	84.00	76.56	65.00	26.12	32.00	47.25	99.00	85.65
10	51.80	39.65	97.60	81.41	31.60	47.44	88.00	83.13	69.60	28.82	37.00	58.19	99.40	86.82
11	58.20	44.47	98.20	83.24	32.20	46.56	93.00	88.13	70.40	30.29	42.80	66.06	97.80	87.53
12	63.40	48.76	99.80	82.35	31.60	45.38	93.00	90.63	72.40	30.24	44.80	75.00	99.40	89.12
13	68.60	52.53	99.80	83.47	31.80	43.81	92.00	91.25	78.40	32.24	49.60	78.63	97.80	88.76
14	72.80	56.53	99.80	84.71	30.80	43.13	97.00	90.94	82.00	34.94	48.80	84.44	98.80	89.29
15	77.60	60.94	99.80	86.18	32.20	42.88	98.00	93.13	86.20	38.29	52.60	85.63	99.40	90.18
16	81.20	64.06	99.80	84.59	31.40	45.25	97.00	95.94	86.20	39.71	55.40	87.38	99.60	91.59
17	86.00	67.29	99.60	84.71	31.00	46.31	96.00	95.00	90.00	41.12	56.00	90.00	98.80	90.94
18	88.20	69.53	100.00	84.12	30.40	46.63	99.00	92.81	93.20	42.35	59.80	90.06	98.00	91.65
19	91.20	71.24	100.00	84.41	32.80	48.19	94.00	96.56	94.20	42.88	60.80	93.38	99.20	90.76
20	95.20	74.41	100.00	85.29	35.40	49.63	94.00	94.38	93.40	43.35	64.20	93.19	98.60	90.82
21	97.20	76.76			35.00	49.69	96.00	94.38			67.00	94.88	99.00	91.41
22	98.60	78.71			37.40	47.88	100.00	95.94			69.20	94.00	99.60	92.35
23	99.60	80.71			43.20	47.00					70.20	95.94	97.20	90.71
24	99.20	81.76									73.40	95.69	97.80	91.82
25	99.80	83.12									76.20	95.88		
26	99.80	84.35									80.00	96.19		
27	99.80	86.18									79.00	95.75		
28	99.80	87.24												
29	99.80	87.65												
30	99.80	88.12												
31	99.80	88.71												
32	100.00	89.18												
33	100.00	89.12												
34	100.00	89.12												

Note: G: Committed less errors (GADG)
P: Committed more errors (PADG)
1, 2….34: Order of presentation of stimulus

Figure 1

Histogram of Exercise at the first trial

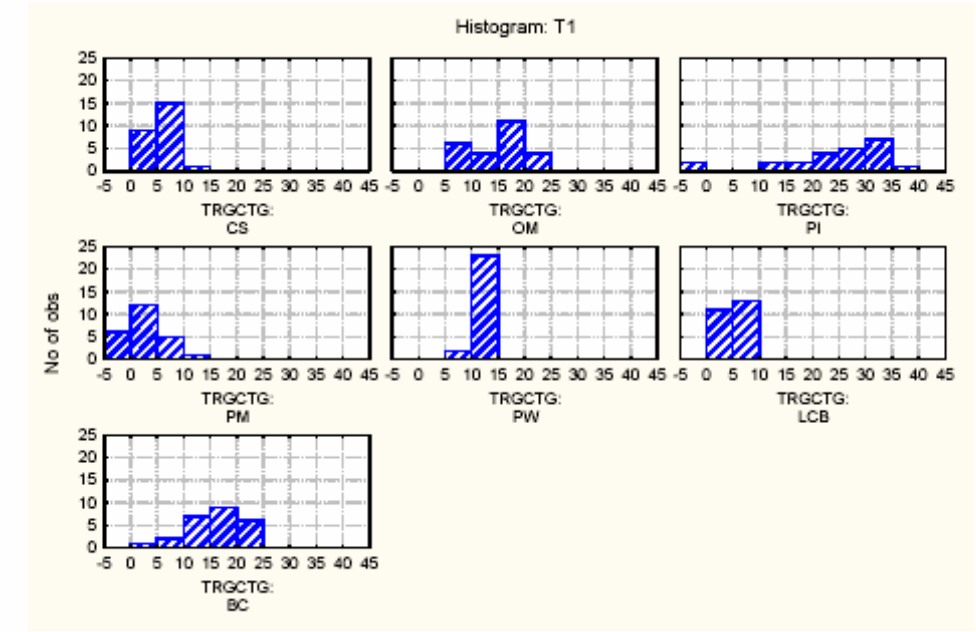
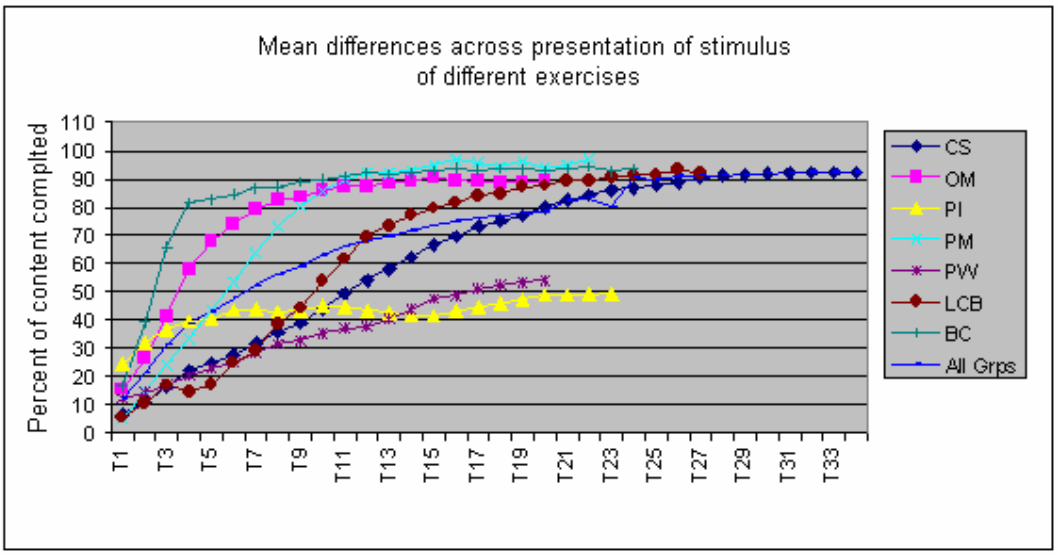


Figure 2
Mean differences across presentations of stimulus of different exercises



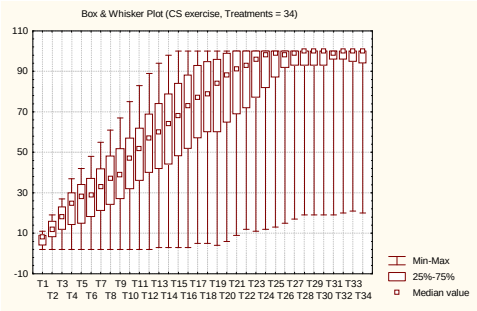


Figure 3
Box and Whisker Plot of CS exercise

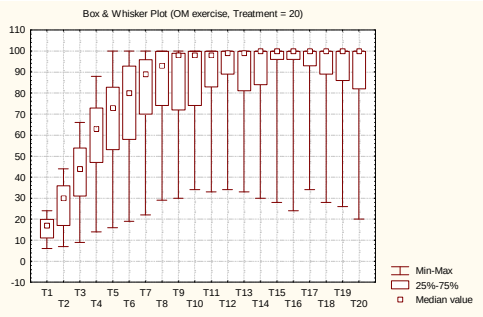


Figure 4
Box and Whisker Plot of OM exercise

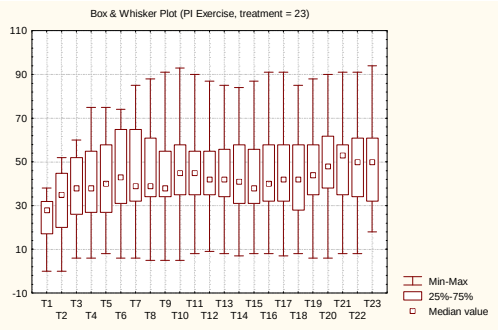


Figure 5
Box and Whisker Plot of PI exercise

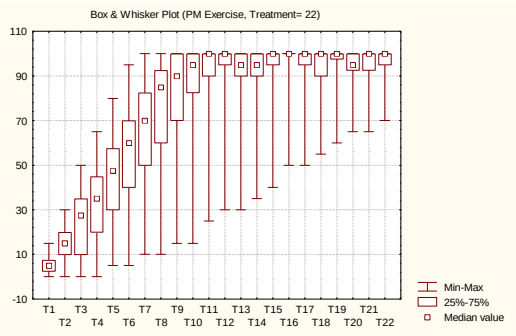


Figure 6
Box and Whisker Plot of PM exercise

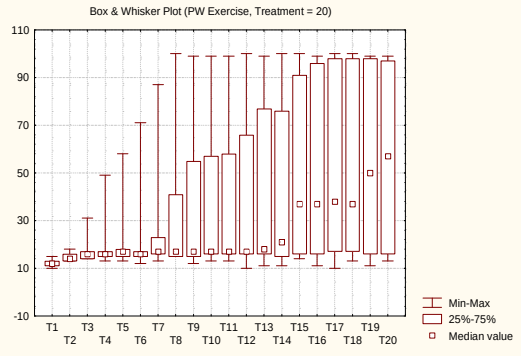


Figure 7
Box and Whisker Plot of PW exercise

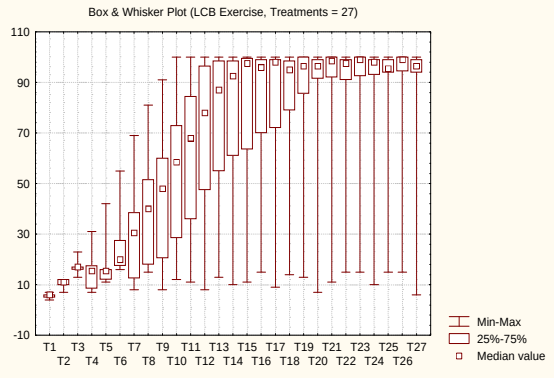


Figure 8
Box and Whisker Plot of LCB exercise

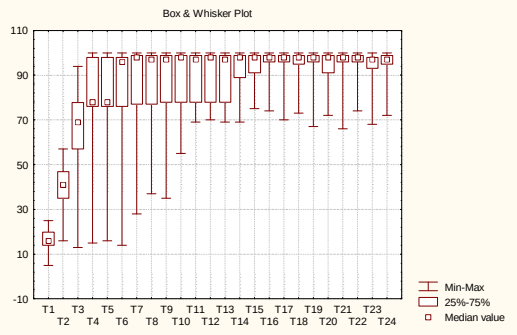


Figure 9
Box and Whisker Plot of BC exercise

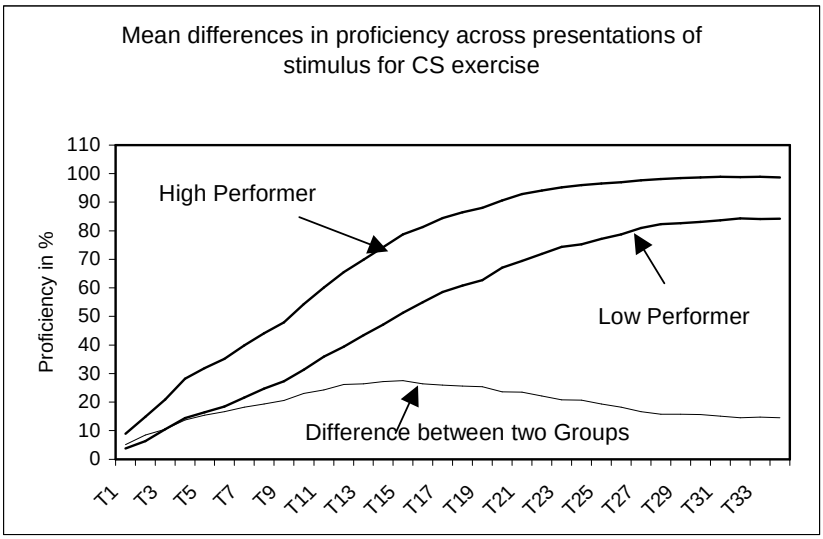


Figure 10
Mean differences in proficiency across presentations of stimulus for CS exercise

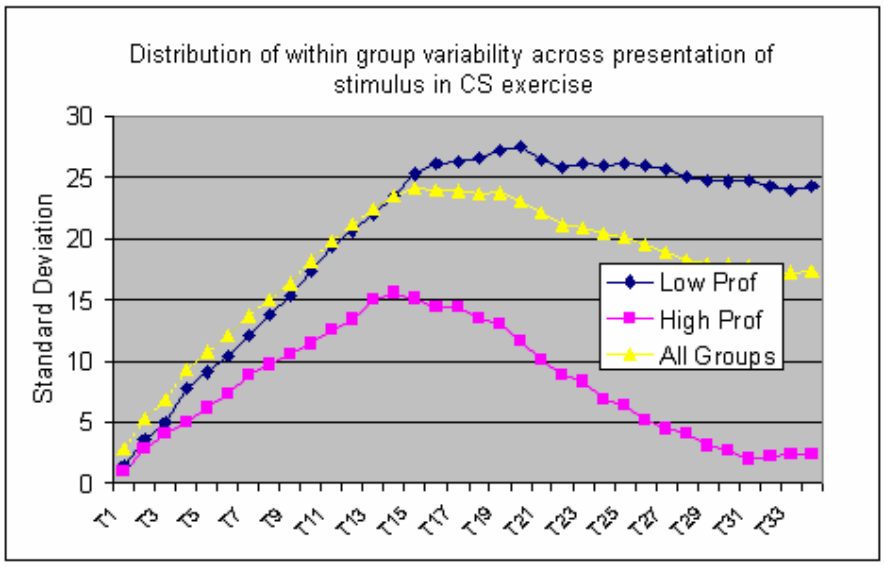


Figure 11
Within group variability wise differences in proficiency across presentations of stimulus for CS exercise

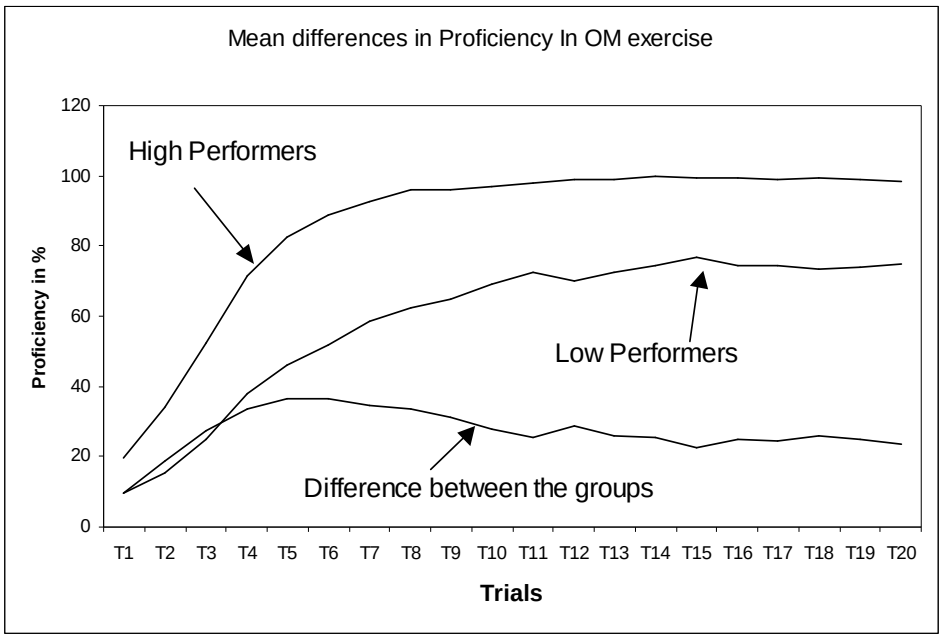


Figure 12
Mean differences in proficiency across presentation of stimulus for OM exercise

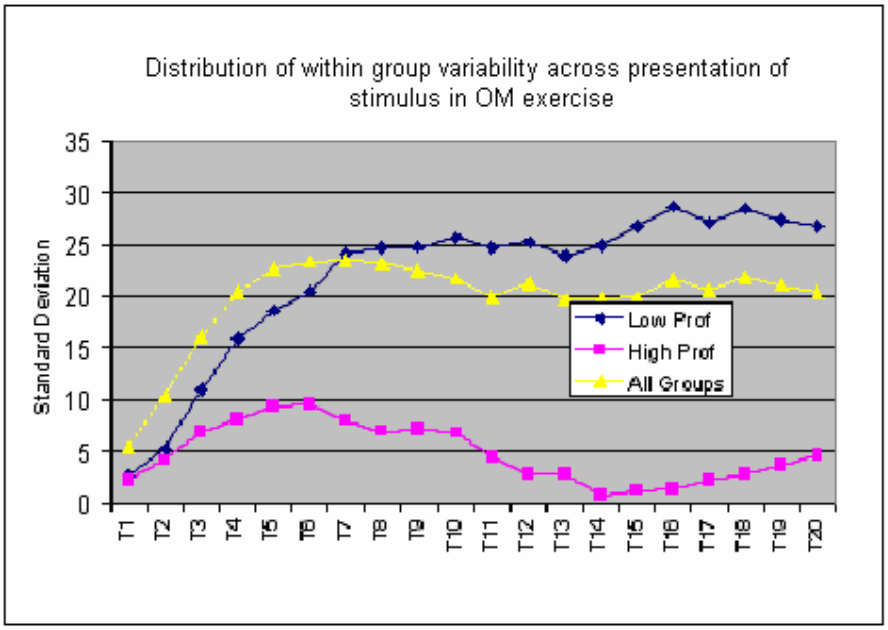


Figure 13
Within group variability wise differences in proficiency across presentation of stimulus for OM exercise

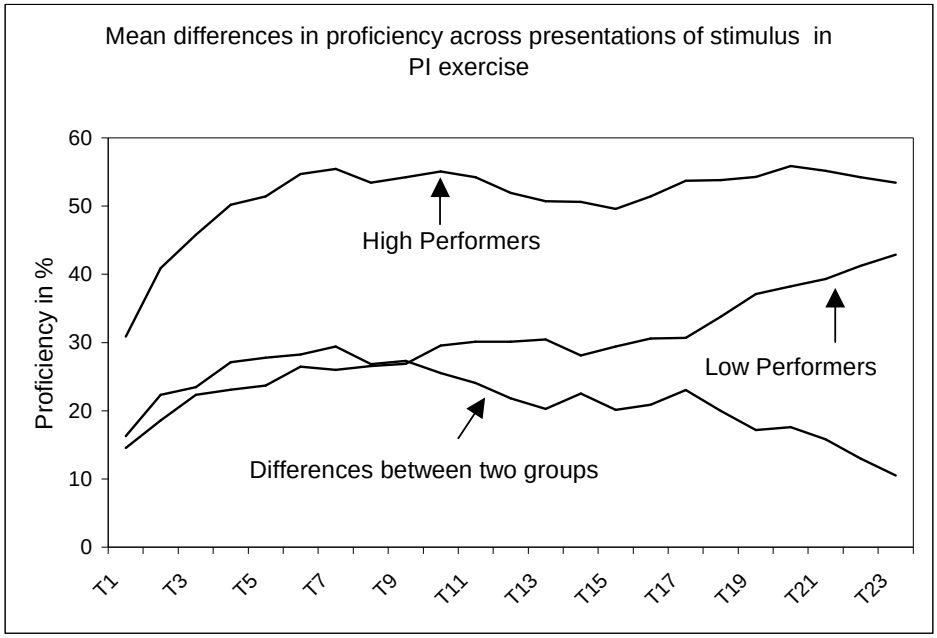


Figure 14
Mean differences in proficiency across presentations of stimulus for PI exercise

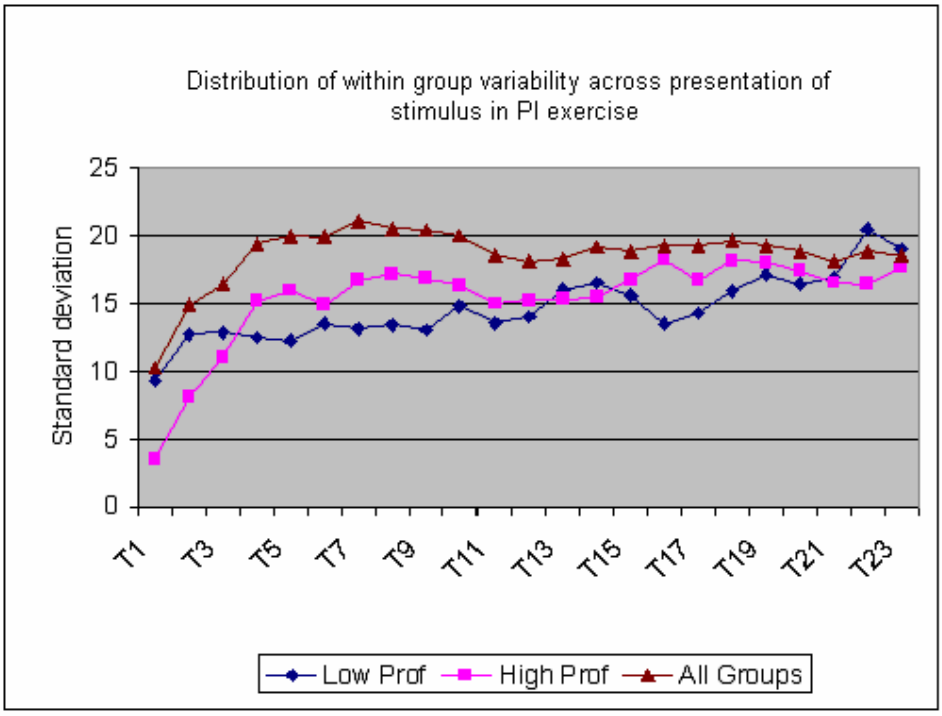


Figure 15
Within group variability wise differences in proficiency across presentations of stimulus for PI exercise

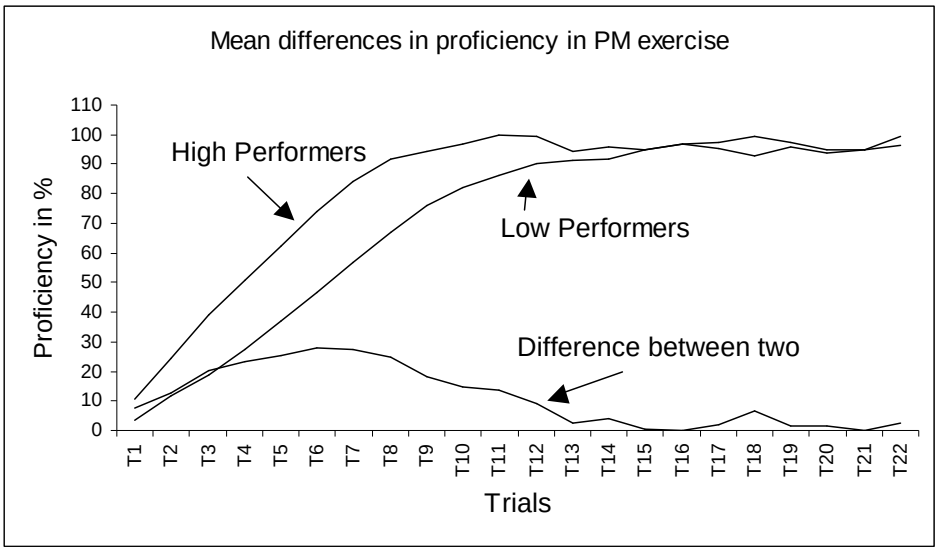


Figure 16
Mean differences in proficiency across presentation of stimulus for PM exercise

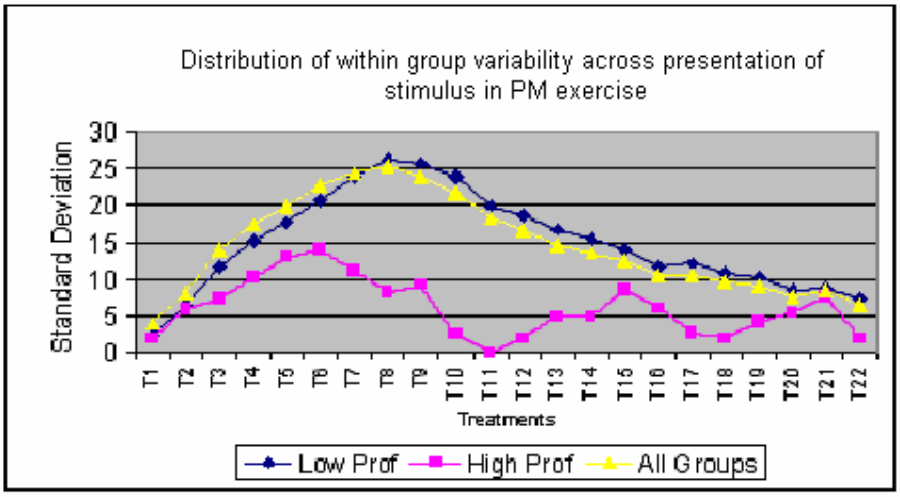


Figure 17
Within group variability wise differences across presentation of Stimulus for PM exercise

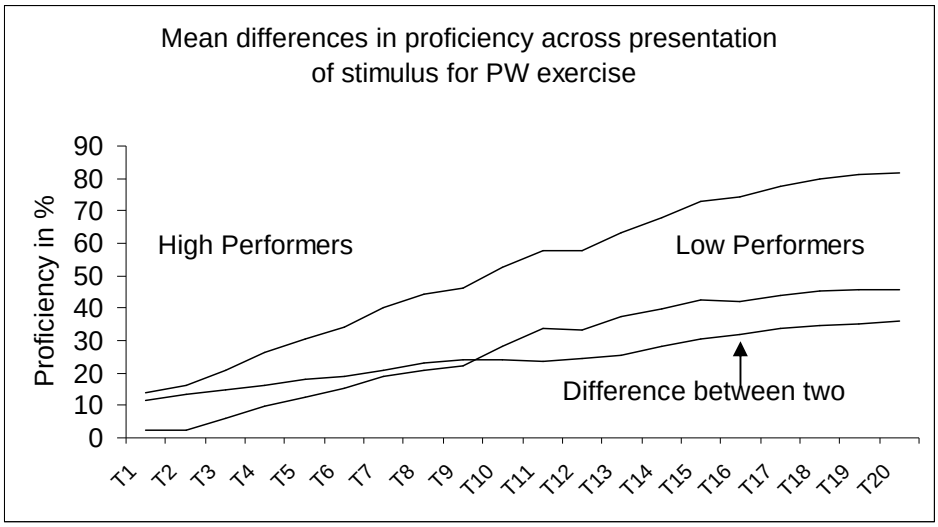


Figure 18
Mean differences in proficiency across presentation of stimulus for PW exercise

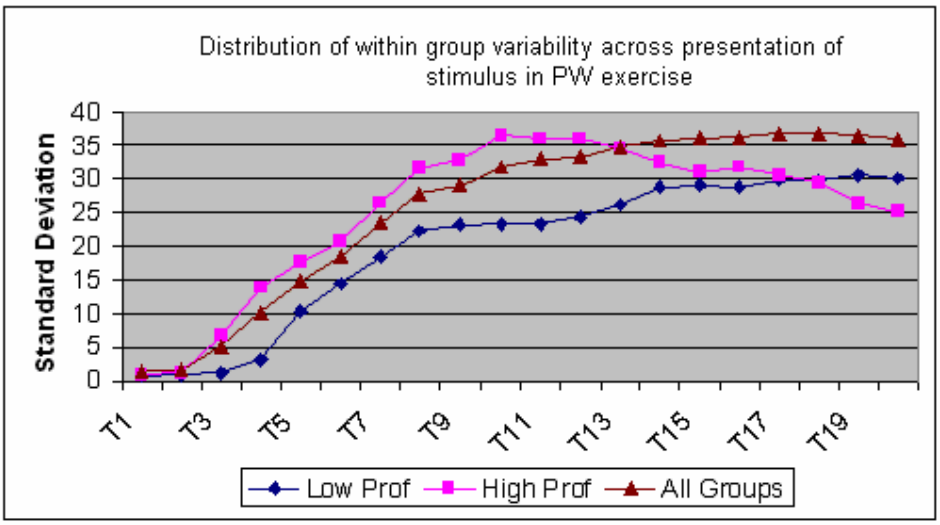


Figure 19
Within group variability wise differences across presentation of Stimulus for PW exercise

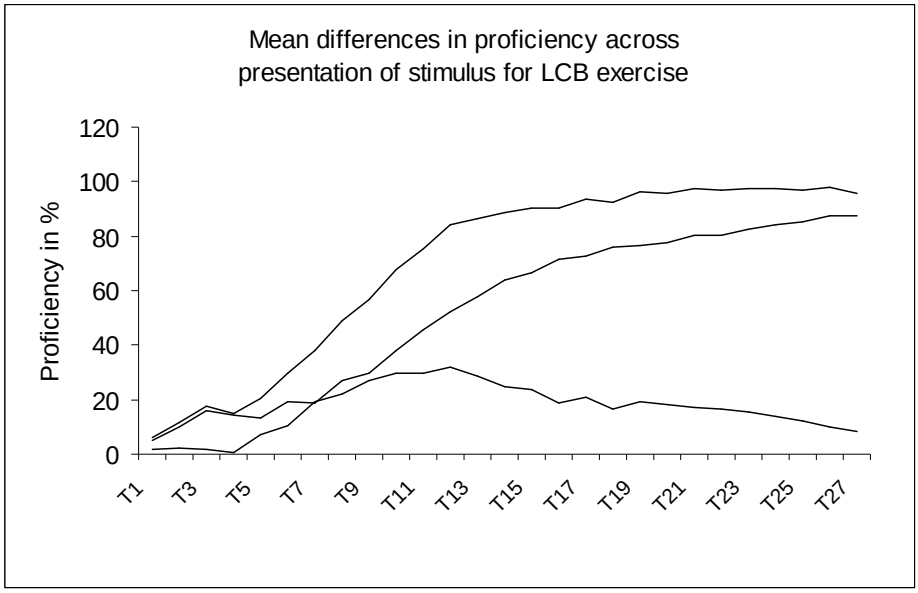


Figure 20
Mean differences in proficiency across presentation of stimulus for LCB exercise

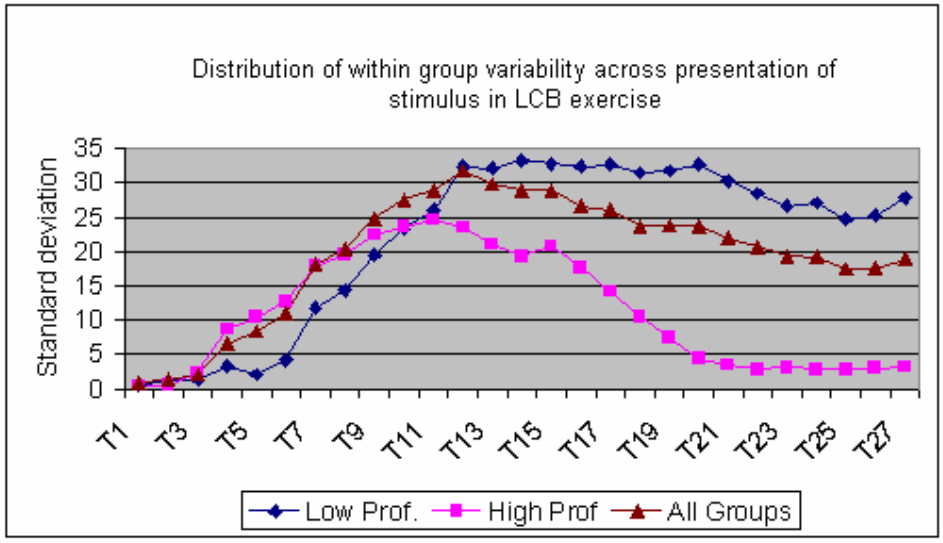


Figure 21
Within group variability wise differences in proficiency across presentations of stimulus for LCB exercise

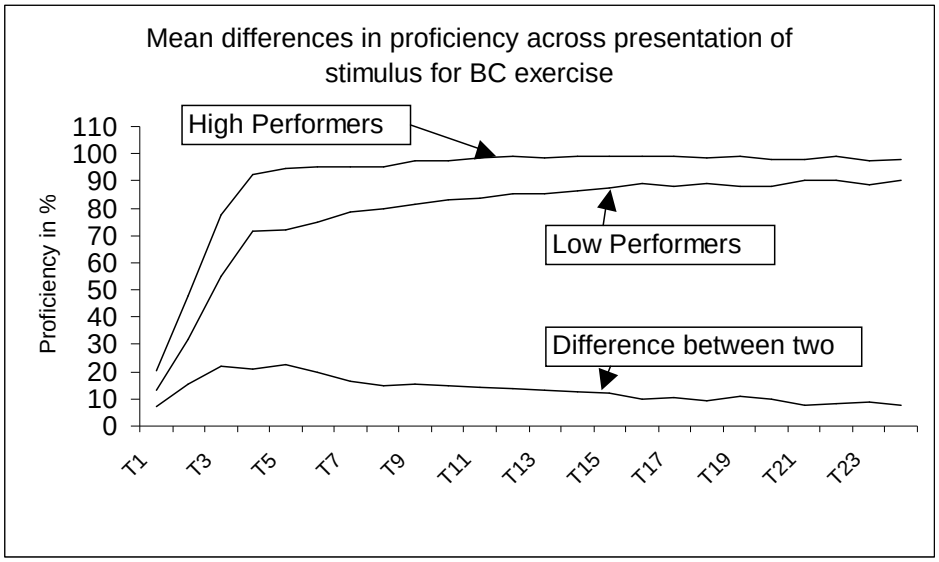


Figure 22
Mean differences in Proficiency across presentation of stimulus for BC exercise

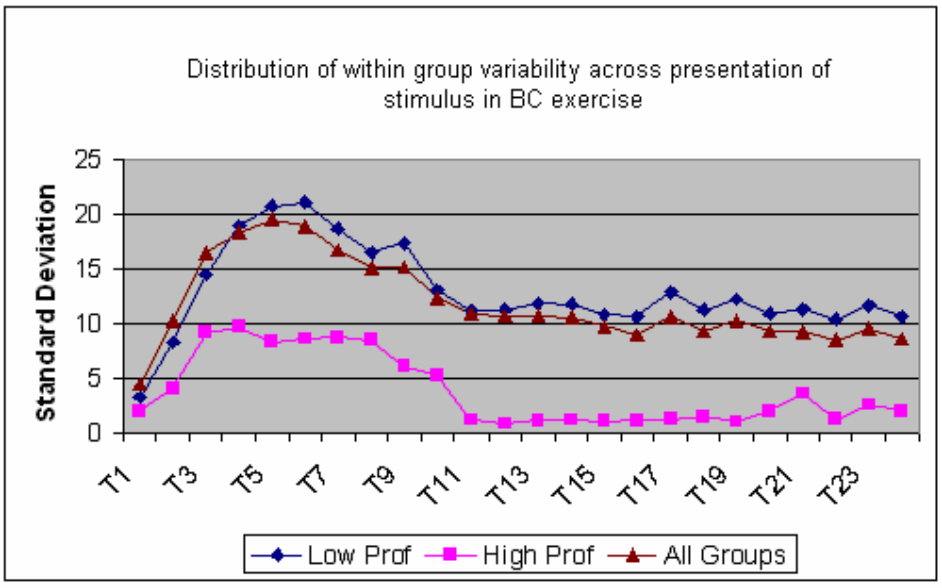


Figure 23
Within group variability wise differences in proficiency across presentation of stimulus for BC exercise

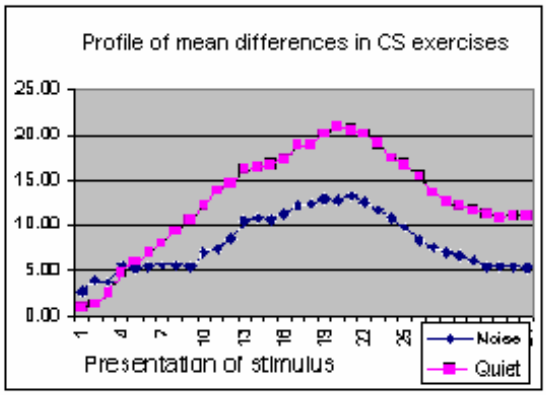


Fig.24
Mean differences between high and low auditory discrimination groups in CS exercises

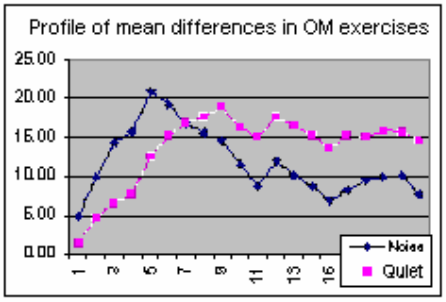


Fig.25
Mean differences between high and low auditory discrimination groups in OM exercises

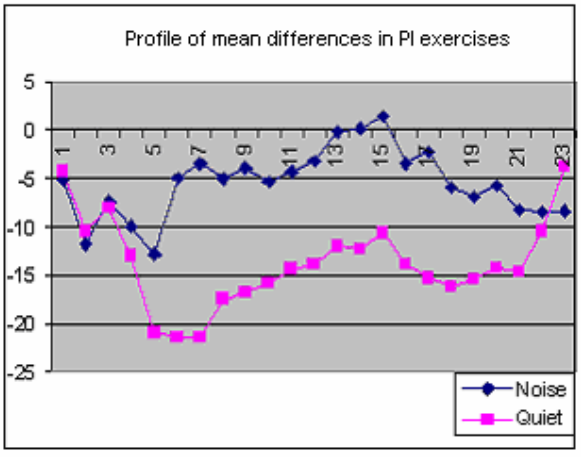


Fig.26
Mean differences between high and low auditory discrimination groups in PI exercises

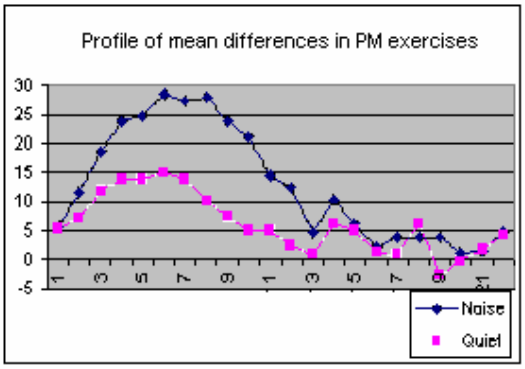


Fig.27
Mean differences between high and low auditory discrimination groups in PM exercises

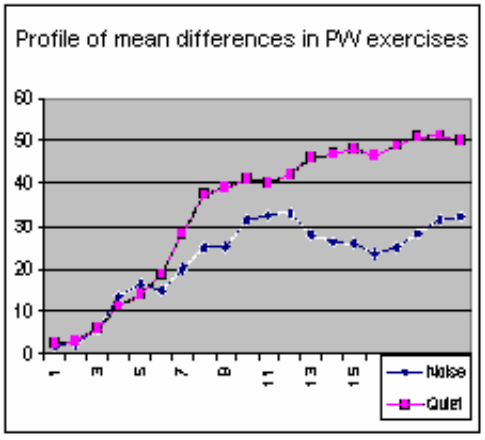


Fig.28
Mean differences between high and low auditory discrimination groups in PW exercises

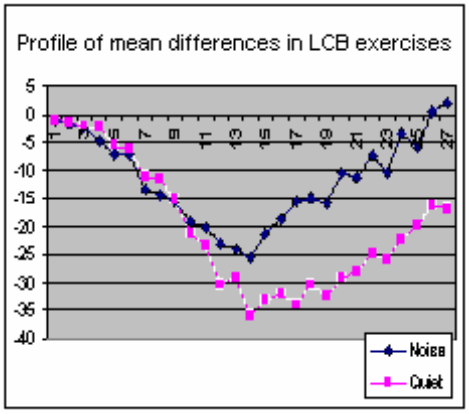


Fig.29
Mean differences between high and low auditory discrimination groups in LCB exercises

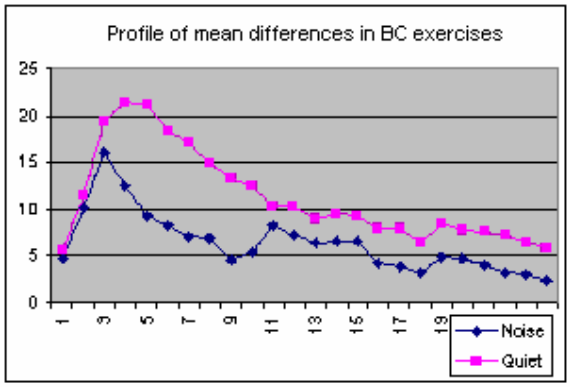


Fig.30
Mean differences between high and low auditory discrimination groups in BC exercises

Appendix III