# Effect of Noise Desensitization Training on Children with Poor Speech-In-Noise Scores

# Incidence de la pratique de désensibilisation au bruit chez les enfants ayant de faibles résultats de perception de la parole dans le bruit

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**Abstract**

The present study aimed to provide preliminary information on the efficacy of noise desensitization training in children with poor speech-in-noise scores. The participants were ten children, aged 8 to 11 years, who had poor speech perception in the presence of noise. Five children underwent training (experimental group) and five children served as a control group who did not receive training. After 15-20 sessions of noise desensitization training for the experimental group, pre- and post-training performance for three speech comprehension tests was compared within and between the two participant groups. The non-parametric Mann-Whitney U test revealed that there was a significant improvement in the scores of the experimental group following training. The experimental group had significantly higher post-training scores than the control group. These preliminary findings warrant further research on the benefits of noise desensitization training for children who have difficulty understanding speech in noisy conditions.

**Abrégé**

La présente étude avait pour but de fournir des renseignements préliminaires sur l'efficacité de la pratique de désensibilisation au bruit chez les enfants ayant de faibles résultats de perception de la parole dans le bruit. Les participants étaient dix enfants, âgés de 8 à 11 ans, qui avaient une faible perception de la parole dans le bruit. Cinq enfants ont fait la formation (groupe expérimental) et cinq enfants ne l'ont pas fait (groupe témoin). Après 15 à 20 séances de désensibilisation au bruit pour le groupe expérimental, les résultats de trois tests de compréhension de la parole effectués avant et après la formation ont été comparés dans les deux groupes participants et entre les deux groupes. Le test non paramétrique U de Mann-Whitney a révélé qu'il y avait une amélioration importante des résultats dans le groupe expérimental après la formation. Le groupe expérimental avait des résultats plus élevés que le groupe témoin après leur formation. Ces conclusions préliminaires justifient la poursuite de la recherche sur les avantages d'une formation de désensibilisation au bruit chez les enfants qui ont de la difficulté à comprendre la parole dans un environnement bruyant.

**Key words:** speech-in-noise scores, noise desensitization training, and pre- and post-therapy evaluation

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Difficulty in listening in the presence of noise is one of the most common auditory processing deficits observed in individuals with (central) auditory processing disorders [(C)APD]. Assessment tools such as the Children's Auditory Processing Performance Scale (CHAPPS; Smoski, 1990), the Children's Home Inventory for Listening Difficulty (Anderson & Smaldino, 2000), the Screening Test for Central Auditory Processing for Adults (Keith, 1995), the Screening Test for Central Auditory Processing for Children (Keith, 2000), and the Screening Checklist of Auditory Processing (SCAP; Yathiraj & Mascarenhas, 2002, 2004) have considered the distracting nature of noise as a major barrier to effective listening in individuals with (C)APD.

The distracting nature of background noise makes real-word spoken language processing one of the most demanding activities of the central auditory nervous system (Morales-Garcia & Poole, 1972; Noffsinger, Olsen, Carhart, Hart & Sahgal, 1972; Olsen, Noffsinger & Kurdziel, 1975). Listening in the presence of background noise is demanding and forces the listener to use linguistic contextual information for effective receptive communication (Chermak & Musiek, 1997).

Auditory processing disorders often coexist with learning disabilities, language disorders, attention deficit disorders, and dyslexia (Cacace & McFarland, 1998; Chermak & Musiek, 1997). Rupp and Stockdell (1978) reported that 70% of children with language or learning disorders had some form of auditory impairment. There is a need to find appropriate treatment procedures to help these children develop their auditory skills.

Two types of remediation techniques have been employed to improve a child's ability to listen in noisy conditions. These include environmental modification and deficit specific intervention. Since it is not always possible to make environmental modifications to reduce noise levels, deficit specific interventions are more feasible in most cases. Katz & Burge (1971) suggested that speech-in-noise training could be employed in the remediation of children with auditory perceptual disorders. The authors analyzed the improvement in monaural or stereo speech-in-noise performance in 49 children with learning disabilities and auditory perceptual deficits. The children were provided with eight 30-minute training sessions and showed improvement from trial to retrial for each of the lessons.

Ferre (1998) recommended a specific training procedure, which was termed noise desensitization training. Utilizing an adaptation of the Garstecki Auditory-Visual Paradigm (1981), the technique included auditory and audio-visual training. Four parameters were manipulated over a preset range from high redundancy to low redundancy. The four parameters were type of signal, type of background noise, signal-to-noise ratio (SNR), and type of visual cue made available. Ferre (1998) provided no empirical evidence that the technique improved speech perception in the presence of noise.

Masters (1998) found that noise desensitization therapy improved tolerance-fading memory in children with (C) APD. Individuals in this category are presumed to have difficulty in understanding speech in noisy situations along with short-term memory problems (Katz, 1992). The noise desensitization therapy recommended by Masters utilized noise that was introduced at a low volume, selected by the child. Stimulus materials in which the child demonstrated near 100% scores in quiet were selected for the initial training. New vocabulary, new curriculum information, or new therapy goals were introduced according to a hierarchy of therapy activities. Masters suggested that the therapy hierarchy should begin with white noise and end with the type of noise that is most problematic for the individual. It was recommended that the intervention include the type of noise present in the individual's environment, as determined by a site visit or noise checklist. The child should be permitted to use compensatory strategies for noisy environments, such as personal amplification devices, preferential seating and earplugs. Reports in the literature indicate that noise desensitization therapy may be a useful technique to improve auditory perception in children with difficulty in understanding speech in the presence of noise. However, the experimental evidence to substantiate this viewpoint is still limited. The present study reports the results of a pilot project undertaken with pediatric patients to examine the benefits of noise desensitization therapy.

## Method

### Participants

Two groups of participants, an experimental and a control group, were studied. Each group had five participants in the 8 to 11 year age range. While the experimental group received noise desensitization training, the control group did not. The participants were randomly assigned to the two groups. All participants were enrolled for at least five years in schools where the instruction was provided in English and all spoke the language fluently. Audiometric evaluation revealed pure-tone air and bone conduction thresholds within 15 dB HL from 250 Hz to 8000 Hz and 250 Hz to 4000 Hz, respectively, Type A tympanograms, and acoustic reflexes present at 90-100 dB HL. Speech identification scores were above 90%, and there were no speech and language problems. Finally, all children had Intelligence Quotients between 90 and 110 as determined by the Ravens Colored Progressive Matrices.

Participants did not pass the 'Screening Checklist for Auditory Processing' (SCAP; Yathiraj and Mascarenhas, 2002, 2004) and obtained lower than 50% scores on the 'Monosyllable Speech Identification test in English for Indian children' (Rout, 1996), administered under headphones at 50 dB Sensation Level (SL) at 0 dB signal-to-noise-ratio. The monosyllabic word test was administered to identify children who had difficulty listening in the presence of noise. The study adhered to the Ethical Guidelines for Bio-Behavioural Research Involving Human Subjects (2003) of the All India Institute of Speech and Hearing. Written consent was obtained from the caregivers prior to the study. The caregivers of children in the control group were informed about the availability of training at the end of the study.

## Instrumentation

A calibrated dual channel audiometer (Orbiter 922, GN Otometrics, Taastrup, Denmark) was utilized for pure-tone testing and for presenting the speech stimuli in the presence of noise. Test stimuli were presented through an audio CD player. All evaluations were carried out in an acoustically treated two-room sound suite fitted to ANSI S 3.1 (1991) standards. Training stimuli were played through a laptop, using the 'Audacity' freeware (available at http://audacity.sourceforge.net/) in a quiet, distraction-free environment. Immittance testing was conducted using a calibrated immittance meter (GSI Tympstar; Grason Stadler, Eden Prairie, MN).

## Materials and method

The SCAP (Yathiraj & Mascarenhas, 2002, 2004) was used to select the participants. The SCAP was developed based on several existing checklists as well as input from speech and hearing professionals. The checklists from which information was culled included the CHAPPS (Smoski, 1990), the CAPD Symptoms and Subtypes Checklist (Paton, n.d), and the (C)APD checklist by the Clarity Speech, Hearing, and Learning Centre (http://www.clarityupstate.org/capd-checklist). The checklist was comprised 12 questions related to deficits in auditory processing. The questions covered areas such as auditory perceptual processing, auditory memory and other symptoms. Each answer marked 'Yes' carried 1 point, and children who scored more than 6 points were considered to be 'at risk'. The inclusion criterion was set relatively low in order to increase the sensitivity of the checklist for identifying children with (C)APD, consistent with the inclusion criteria used in other studies (Devi, Nair, & Yathiraj, 2008; Priya, 2007; Yathiraj & Mascarenhas, 2003). The sensitivity was found to range from 75% to 80% across these studies.

The abilities of the participants to perceive speech in the presence noise were evaluated utilizing the following material:

- 'Monosyllable speech identification test in English for Indian children' (Rout, 1996).
- 'Speech discrimination test material in English for Indians' (Chandrashekar, 1972).
- English sentences from 'High frequency–English Sentence Identification Test' (HF-ESIT; Barick, 2006).

All of the tests used vocabulary that was appropriate for typically developing school-age children. The test by Rout (1996) had four equivalent phonemically balanced lists each containing 25 monosyllabic words. The test by Chandrashekar (1972) consisted of two equivalent lists containing 25 monosyllabic words each. The HF-ESIT sentence test comprised four lists of ten sentences each.

The types of noise used in this study included a commonly encountered environmental noise in India (fan noise), with a frequency range of 250 Hz to 2000 Hz and a peak frequency of 800 Hz. Speech noise was obtained by filtering white noise between 300 Hz and 3000 Hz with a rise of 3 dB/octave up to 1000 Hz and a fall of 12 dB/octave for the 1000-3000 Hz range, using the Adobe Audition software (Adobe Systems, San Jose, CA). We also used multi-speaker babble of eight speakers reading a passage, developed by Anitha (2003). Fan noise was selected because of low interference with speech perception. In contrast, speech noise and speech babble were selected since these have a greater negative effect on speech perception when compared to other kinds of noise (Garstecki, 1981).

**Table 1**
Hierarchy of noises and signal-to-noise ratios (SNR) used during training for noise desensitization

| Levels | Noise type | SNR |
|---|---|---|
| Level 1 | Quiet | Quiet |
| Level 2 | Environmental noise (fan noise) | +15 dB SNR |
| Level 3 | Speech noise | +10 dB SNR |
| Level 4 | Speech noise | + 5 dB SNR |
| Level 5 | Speech noise | 0 dB SNR |
| Level 6 | Multi-speaker babble | 0 dB SNR |

The training materials consisted of 15 English passages. Each passage had 80 to 100 words and four questions to check for the comprehension of the passage. Initially, five adults who were fluent in English checked the passages for equivalency in terms of sentence length, structure and familiarity of the vocabulary. They assessed whether the vocabulary would be familiar to children aged 8 years. Following this, the passages were read separately to five children aged 8 years to 8;11 years. These typically developing children had normal hearing and passed the SCAP. After determining that all the children were able to answer the questions, the materials were recorded using the Audacity software. These passages were read by a female speaker who was fluent in English. A sampling rate of 16 kHz was used for the recording. The clarity of the recorded material was checked on ten young adults who reported the material to be distortion-free.

Three different kinds of noises (environmental noise, speech noise and speech babble) were presented along with the passages, using a 10 dB SNR, 5 dB SNR and a 0 dB SNR. The noises were mixed with the passages using the Audacity software.

## Procedure

A baseline evaluation was carried out for the control and the experimental groups under headphones and in a sound field set-up. The participants were evaluated with the monosyllabic words (Rout, 1996) under headphones in order to measure the performance of each ear individually. Evaluations were also conducted in sound-field to obtain a measure of speech perception in a binaural listening condition, which more closely simulates of a real world listening situation. Monosyllabic words (Chandrashekar, 1972) and sentences (Barick, 2006), were presented in

**Table 2**
Mean and Standard deviation (SD) of speech identification in the presence of speech noise for evaluation I & II across groups.

| Stimuli | Transducer | SNR | Evaluation | Participants | | | |
|---|---|---|---|---|---|---|---|
| | | | | Experimental | | Control | |
| | | | | Mean | SD | Mean | SD |
| Monosyllabic words | Headphone Left | 0 | baseline | 39.2 % | 1.8 | 37.6 % | 4.67 |
| | | | final | 70.4 % | 7.8 | 36.0 % | 4.9 |
| | Headphone Right | 0 | baseline | 36.0 % | 8.0 | 32.8 % | 7.2 |
| | | | final | 67.2 % | 4.3 | 33.6 % | 6.0 |
| Monosyllabic words | Loudspeakers | 10 | baseline | 51.0 % | 4.2 | 49.0 % | 4.2 |
| | | | final | 81.0 % | 5.5 | 47.0 % | 4.5 |
| | | 0 | baseline | 37.0 % | 7.6 | 35.0 % | 3.5 |
| | | | final | 73.0 % | 5.7 | 33.0 % | 4.5 |
| Sentences | Loudspeakers | 10 | baseline | 53.0 % | 8.4 | 54.0 % | 4.2 |
| | | | final | 78.0 % | 7.6 | 52.0 % | 4.5 |
| | | 0 | baseline | 37.0 % | 11.5 | 40.0 % | 5.0 |
| | | | final | 67.0 % | 7.6 | 39.0 % | 4.2 |

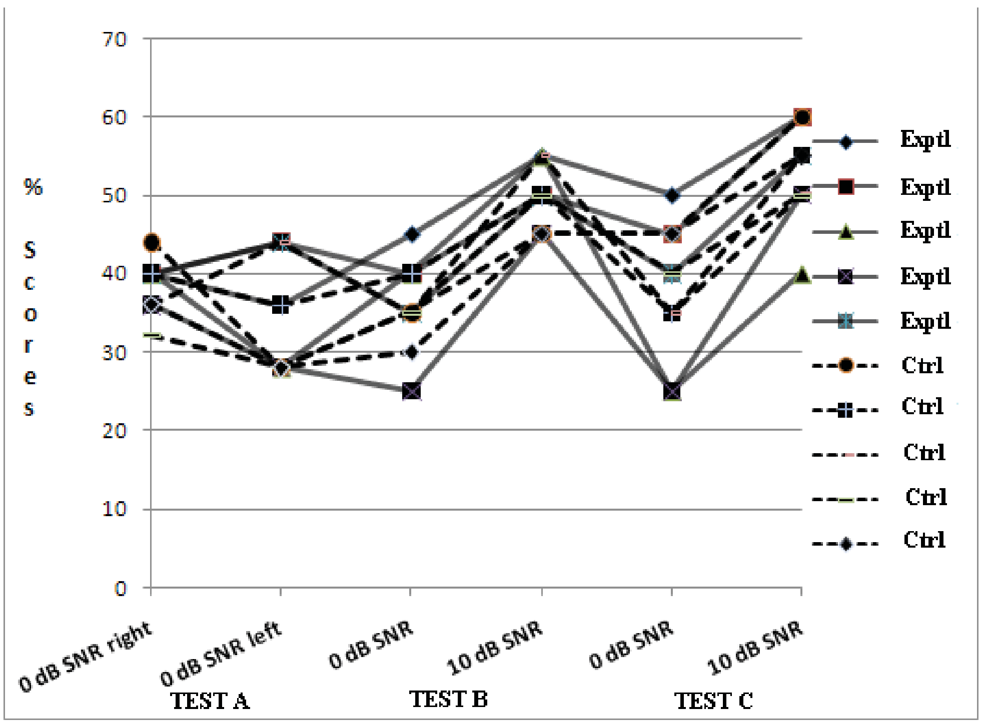


**Figure 1:**

Baseline evaluation. Comparison of individual pre-training scores for experimental and control group participants

sound field at 50 dB SL (ref. PTA) through a speaker placed at 45o azimuth and at 1 meter from the listener. The children's oral responses were noted by the tester. For the monosyllable tests, each correctly identified word was assigned a score of one. Scoring for the sentences involved noting the number of keywords correctly identified with each correctly identified keyword assigned a score of one.

During the noise desensitization training procedure, the five children in the experimental group received the training. A laptop with the Audacity software was used to present the material at various SNRs with speech noise or multi-speaker babble presented binaurally. Table 1 presents the paradigm followed for the training. The quiet condition was selected to obtain information regarding the performance of the clients in the absence of noise. The type of noise / level was chosen to include a relatively easy condition (fan noise at + 15 dB SNR) and a relatively difficult condition (multi-speaker babble at 0 dB SNR). Speech noise was presented in between these two noise conditions at different signal-to-noise ratios. This was done to enable the participants to gradually adapt to the more difficult condition. Each passage was followed by four questions, which were presented in quiet. The child's verbal response was noted. A child progressed to the next level if three out of four questions were correctly answered. Each session

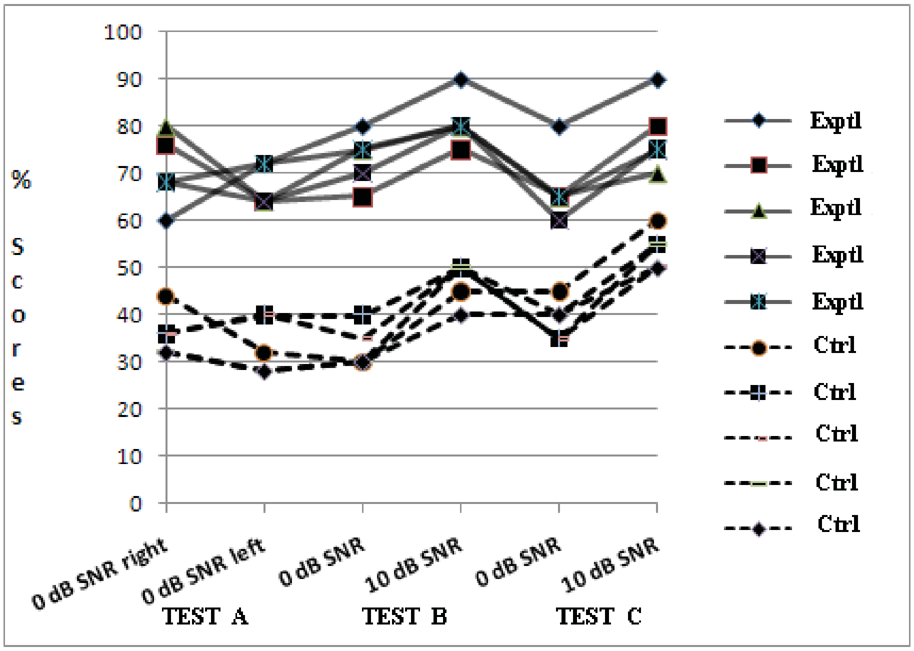


**Figure 2:** Final evaluation. Comparison of individual post-training scores for experimental and control group participants.

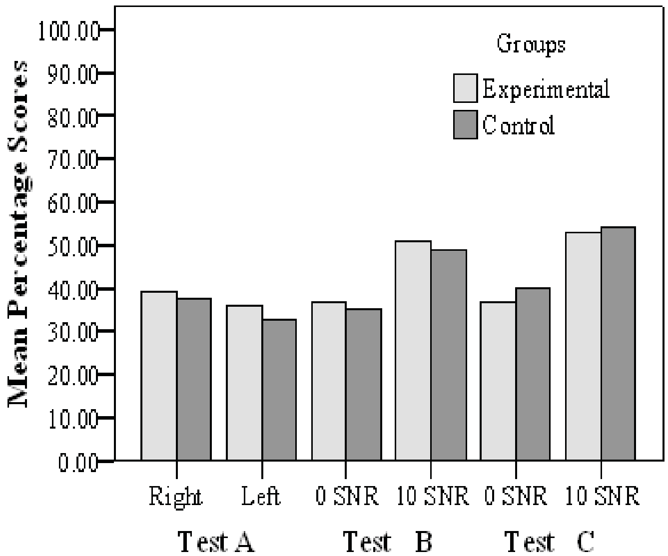


**Figure 3:** Mean scores across the experimental and control groups for the baseline evaluation for speech perception in the presence of noise using monosyllables under headphones at 0 dB (A); monosyllables through speakers (B); and sentences through speakers (C).

lasted 25-30 minutes and the number of sessions varied from 15 to 20, depending on the speech perception score of the individual child. Thus, the number of passages used per child ranged from 35 to 60. Although several of the passages were repeated, we argue that the familiarity effect was eliminated because the passages selected for repetition were those that participants were unable to perceive in the difficult listening conditions. The passages were randomly presented to avoid any practice effect. The training was carried out daily by the same therapist.

Following the training phase, the participants from the experimental group were evaluated again. For participants in the control group the evaluation was carried out three weeks after the baseline evaluation. The same three tests used during the baseline evaluation [Monosyllabic words (Rout, 1996) under headphones, monosyllabic words (Chandrashekar, 1972) through sound-field speakers and sentences (Barick, 2006) through sound-field speakers] were administered. Different equivalent lists were used while evaluating the child with the material developed by Rout and Barick. The material developed by Chandrashekar was randomized to reduce the effect of familiarity.

## Results

### Comparison across Experimental and Control group for Evaluation-I and Evaluation-II

All analyses were completed using SPSS (version 10.0) software. Individual scores are provided in Figures 1 and 2 for the baseline and final evaluations, respectively. As shown in Figure 1 the scores of all the participants for the baseline evaluation were clustered. However, a marked difference in scores is apparent between the two groups of participants in the final evaluation (Figure 2). The group

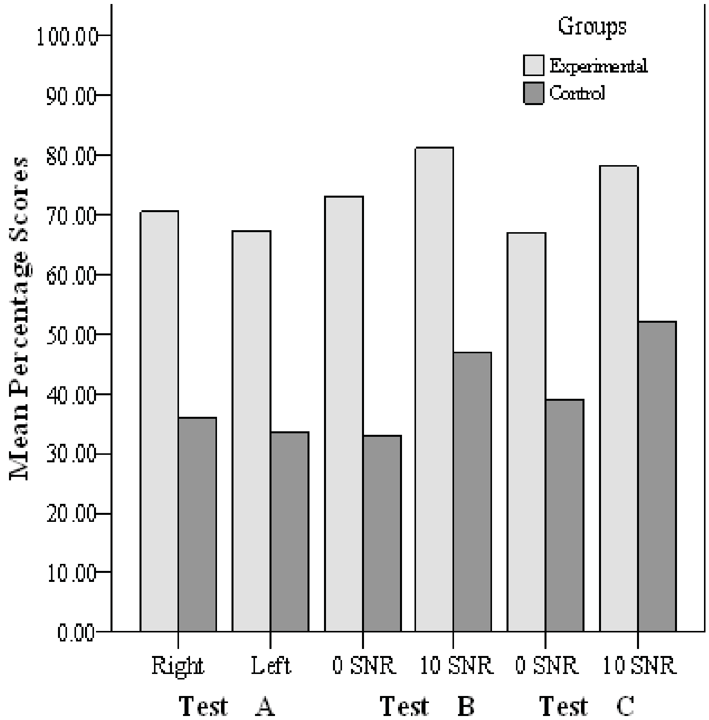


**Figure 4:** Mean scores across the experimental and control groups for the final evaluation for speech perception in the presence of noise using monosyllables under headphones at 0 dB (A); monosyllables through speakers (B); and sentences through speakers (C).

that received training obtained higher scores on all the tests that were administered.

Similar findings were obtained for group comparisons as shown by the mean and standard deviation in Table 2. Similar mean scores were obtained by both the participant groups for all three tests (monosyllabic words under headphones, monosyllables and sentences through loudspeakers) and each of the SNRs (10 dB SNR and 0 dB SNR) during the baseline evaluation. However, the experimental group obtained higher mean scores compared to the control group during the final evaluation. This difference was observed for all three tests and at both signal-to-noise ratios.

To determine whether the mean scores between the experimental and control groups for evaluations I and II were significantly different, a non-parametric Mann-Whitney U test was employed. Non-parametric statistics were used as the number of the participants was small. There was no significant difference between the experimental and control group for the baseline evaluation for all three tests, as shown in Table 2 and Figure 3. In contrast, there were statistically significant differences across the groups in the final evaluation. As shown in Table 2 and Figure 4, the experimental group performed significantly better than the control group on all three speech tests that were presented in the presence of noise ($p < 0.05$).

### Comparison of performance between evaluations I and II in the experimental and control groups

The scores obtained by the experimental group during the baseline and the final evaluations on the three speech tests performed in the presence of noise were compared (Table 2 and Figure 5). The non-parametric Wilcoxon Signed Ranks test results revealed a statistically significant difference between the baseline and final scores ($p < 0.05$) for all three tests. The improvement was observed for the scores obtained in each ear for the monosyllable test done under headphones. The two tests administered in sound field showed that improvement was not only noted in the +10 dB SNR, but also in the 0 dB SNR condition (Figure 5).

Comparison of results for the control group, who did not receive any noise desensitization training revealed no significant difference in the scores on the speech-in-noise tests between the baseline and final evaluations.

## Discussion

The findings of this study point to an improvement in performance following training in the presence of noise. These results are consistent with those of Katz and Burge (1971) who reported improvements on closed-set speech perception tasks in a group of children with learning disabilities and auditory perceptual deficits who received training in the presence of noise. While Katz & Burge (1971) observed improvements for a closed-set task, the present study found similar improvements for open-set tasks for both words and sentences. Our study also indicated that noise desensitization training could result in an improvement during binaural listening, a condition similar to a real life situation. In a binaural listening situation, the improvement was observed for less linguistically redundant material (words) as well as more linguistically redundant material (sentences). In addition, the current study revealed that performance improved in each ear separately based on the scores for monosyllable words obtained under head phones. These preliminary findings suggest that noise desensitization training can have a positive effect on individuals during listening

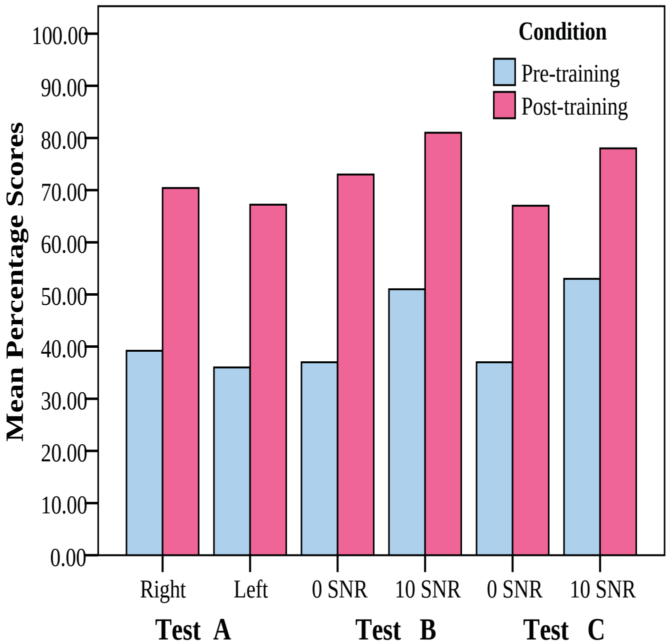


**Figure 5:** Pre and post training mean speech identification scores in the presence of noise in the experimental group for monosyllables under headphones (A); monosyllables through speakers (B); and sentences through speakers (C).

activities that involve different types of speech material in the presence of noise.

Although Ferre (1998) discussed an improvement in performance in children having difficulty in processing in the presence of noise, this claim was not based on actual test results. The present study however, provides preliminary evidence for an improvement in speech perception in noise following noise desensitization training. It is possible that the noise desensitization training could have resulted in neurophysiological changes in the auditory system which could account for the improvement following training, similar to the effect observed subsequent to tinnitus retraining therapy (TRT). Jastreboff and Hazell (2004) postulated that the TRT prevents a signal from reaching the limbic and autonomic nervous systems and from activating high cortical areas involved in tinnitus awareness. The authors proposed that the difference between the signal and background could be used in a positive manner to facilitate habituation of tinnitus. By enhancing the environmental sound to which a patient was exposed, an effective reduction in the strength of tinnitus occurred. Jastreboff and Hazell (2004) attributed this to a reduction in the activation of the limbic and autonomic nervous systems. We speculate that similar phenomena may occur when noise desensitization training is provided. The training may prevent the noise from reaching the limbic and autonomic nervous system thereby preventing it from being perceived and from interfering with the speech signal.

Another possible explanation for the improvement in scores subsequent to training may be related to the neuroplasticity of the central auditory nervous system (CANS). Support regarding the plastic nature of the brain has been demonstrated using functional magnetic resonance imaging by several authors (Elbert, Pante, Wienbruch, Rockstroh, & Taub, 1995; Huckins, Turner, Doherty, Fonte, & Szeverenyi, 1998; Jancke, Gaab, Wustenberg, Scheich, & Heinze, 2001). Further, studies have confirmed through auditory evoked potentials that neurophysiological changes occur following auditory experiences (Gordon, Papsin & Harrison, 2003, 2006; Jirsa, 1992; Kraus, McGee, Carell, King, Tremblay, & Nicol, 1995; Tremblay & Kraus, 2002). The above studies provide evidence that experience and stimulation can lead to reorganization of the cortex, improved synaptic efficiency, increased neural density and associated cognitive and behavioural changes.

The present preliminary study adds to the corpus of studies regarding improvement in auditory perception following auditory training. The findings of the study suggest that noise desensitization training may be beneficial for individuals who have difficulty in listening to speech in the presence of noise. Systematic training, using a hierarchy of noise types and SNRs may result in significant improvement in the performance of these individuals. Such a training program may offer a far better option than recommending that individuals who experience difficulty in listening in the presence of noise avoid noisy situations.

## Conclusion

The results of this preliminary study demonstrated that noise desensitization training was effective in training children who have difficulty in listening in noisy conditions. The experimental group showed significant improvement ($p < 0.05$) for both right and left ears. Significant improvement was also seen in the presence of noise for both monosyllables and sentences at +10 dB SNR as well as 0 dB SNR. These findings suggest that training children who have difficulty in understanding speech in the presence of noise may improve their auditory perceptual skills.

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# Book Reviews/ Évaluation des livres

## Pediatric Test of Brain Injury.

**Author:** Gillian Hotz, Nancy Helm-Estabrooks, Nickola Wolf Nelson and Elena Plante
**Publisher:** Brookes Publishing Inc
**Cost:** $349.95
**Reviewers:** Kim Bradley PhD, Reg. CASLPO (University of Toronto );
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The Paediatric Test of Brain Injury (PTBI) was developed to "estimate a child's ability in applying neurocognitive-linguistic skills that are vulnerable to paediatric brain injury and relevant to functioning well in school. The test is intended to permit tracking of recovery starting in the acute phase " (PTBI Manual, p 2 ).

The authors all have clinical backgrounds in speech-language pathology. In addition, they bring specific expertise in paediatric acquired brain injury (ABI; Hotz), head injury (Helm-Estabrooks,) developmental language and its disorders (Wolf-Nelson) and paediatric language assessment (Plante). The authors' range of specialization speaks to the complexity and diversity of the target population. There are many challenges involved in developing a test for a child with a brain injury because, on one hand, the child's skills are changing predictably following developmental patterns, and, on the hand, ther is unpredictable change due to the recovery process. The PTBI addresses a clear clinical need. A standardized test is a much needed contribution to this field.

### Development of the PTBI

The authors partnered with 14 clinical centres across Canada and the United States to develop and standardize the PTBI. The test is designed for children with brain injury between the ages of 6-16. The authors present a standardization sample that includes children with traumatic brain injury(TBI; n=134), non-traumatic acquired brain injury (ABI; n=46) , and typically developing children (n=77). The PTBI targets a clearly defined ABI/TBI population and offers comparative information on differing patterns of deficit between the TBI and ABI groups. This is a unique comparable set of assessment data that would not be available elsewhere.

The PTBI is comprised of ten subtests: Orientation, Following Commands, Word Fluency, What Goes Together, Digit Span, Story Retell – Immediate and Delayed, Naming, Yes/No/Maybe, and Picture Recall. The subtests have been chosen to reflect areas of cognitive communication deficit typically seen in children with brain injuries.

The PTBI is the first evidence-based tool that allows the clinician to document the quickly changing language skills of a child with a brain injury in an efficient way. The PTBI's use of Item Response Theory is impressive and innovative: Each individual item in a subtest is assigned a score that reflects how difficult it is in relation to the easiest item in the subtest. The authors argue that "the advantage of this method is that examiners are able to calculate an ability score for a test that reflects a child's current level of functioning more accurately than a simple count of items passed, leading to a superior ability to track change" (p. 1).

### Clinical Use of the PTBI

The manual competently and concisely communicates the theoretical background, test development, and relevant conceptual framework to the practicing clinician. Another welcome innovation is the detailed presentation of the statistical background. Information is presented using clinical questions (e.g. "How do I interpret the criterion categories?"), and the authors provide an interpretative answer, followed by a summary of the evidence that supports the answer. It is an effective, practical, and refreshing way to explore the technical framework of the test.

The test is typically completed within 30-40 minutes, as suggested by the authors. The completion of ten subtests in approximately half an hour necessitates a frequent change of activity and minimizes boredom in the children tested. This is an important consideration in the TBI population where attention deficits, fatigue and testing ennui can limit the patient's ability to cooperate. In clinical use, we found that the test was easily administered by clinicians, with little need for cajoling.

The test booklet encourages clinicians to document behavioural observations and the time taken for each subtest. Below each subtest on the test form, a variety of possible behavioural observations are listed along with notes to direct the clinician. Consequently, patterns of behaviour across subtests and changes in speed of task completion over time become apparent.

One of the subtests included (Picture Recall) is a visual memory picture drawing task. The PTBI was developed by Speech-Language Pathologists for use by "SLPs, psychologists and others" but it is primarily a language test. Most of the subtests have a language basis so the rationale for the inclusion of a drawing task is unclear. Certainly, the information available from this subtest is not information a speech language pathologist is trained to interpret or remediate.

The Word Fluency subtest includes an animal name generation task that is not only used in other speech language pathology tests but in neuropsychology and occupation therapy testing. In the Canadian health care system, a child with a head injury will often be tested concurrently by different professionals disciplines. We fear that this type of test may be overused to the point of being meaningless.

In the Story Retell task, the inclusion of a delayed recall (5-10 minutes) in addition to the immediate recall is a relevant task. Additional space for verbatim recording on the form would have been helpful. The scoring of content items does not allow for an exploration of a disordered narrative, such as inappropriate extraneous information, sequencing, syntax or word finding difficulties. This information would be available from a verbatim transcription of the narrative.

The test claims to give literacy as well as language-based information. However, the only reading required in the test is done in conjunction with the examiner and there is no writing component. There is not enough information gathered to provide relevant details for literacy intervention planning.

The test reports excellent inter-rater reliability (pp.52), but in practice the instructions for scoring in subtests such as Story Retell, What Goes Together, and Picture Recall are not completely clear. There was variation in scoring between the authors of this review. It would have been helpful if examples of possible responses and specific scoring were included in the manual.

**Test Interpretation**

The ten subtests have been chosen to give a picture of how the child is functioning with regard to cognitive communication. Selective clinical judgement is needed to interpret the subtests' ability scores and how they relate to cognitive communication areas for each child. Clinicians need to investigate each subtest performance and determine which areas of cognitive communication (ie. memory, attention, comprehension, processing, etc.) are impacting the child's functioning. In clinical practice, goal setting for specific deficits and baseline information would need to be established with ongoing diagnostic therapy and could not be done solely from the PTBI. The authors do state that the purpose of the PTBI is not to generate therapy goals or comprehensive rehabilitation programs for children.

It is important to note that this is a criterion based test. This means that the test looks at whether the participant is able to complete the tasks. The test is not a norm-referenced test, which would compare participants to a pre-defined TBI or ABI population. The test allows children completing the PTBI to be placed in performance categories of high, moderate, low and very low. These categories are based on the performance of the standardization sample of typically developing children on each task. The classification of the four performance categories as it relates to severity can be confusing and potentially problematic: In the context of TBI, where lawyers and insurance companies need to understand how a child is performing, an "average" child would be in the "high" category which makes the relative performance of the head injured child unclear.

The test employs a standard error measurement, which is used to establish that a change in ability is significant and not just a practice effect from multiple administrations of the same test. However, this standard error measurement can make it difficult to establish a clear severity level. For example, if a 6-year-old completes the Digit Span subtest, astandard error measure of 9 is assumed. However, this means that a child can move from a "very low performance category" to a "moderate performance category", but this change would not be outside the SEM and therefore would be non-significant. While this is an extreme example, the standard error measurement may affect some subtests or ages to a certain degree.

**Conclusion**

The PTBI is an effective tool for measuring change in cognitive communication ability for the pediatric TBI and ABI population. The authors have designed a test with the purpose of establishing current cognitive communication ability levels and to track changes over time. In this they have succeeded.

The PTBI has limitations. A complete language assessment using traditional testing tools remains a necessity for reintegration into the school system. Diagnostic therapy remains indispensable for establishing baselines for focussed therapy goals. The PTBI would be most effective showing cognitive communication change following a brain injury for the child in an acute hospital or acute rehabilitation setting.