An Evaluation of the Speech Perception in Noise Test

Lucille P. Dickens, BA(Log) (Pretoria)
Callum M. Delaney, BA (Sp. and H. Therapy) (Witwatersrand)

Department of Logopaedics,
University of Cape Town, Cape Town

ABSTRACT
The effects of presentation level and signal-to-babble ratio (S/B) on SPIN performance were investigated for eighty normal hearing listeners. Both intensity and S/B had a significant effect on scores. Performance improved at the more favourable S/B regardless of presentation level, and scores were better at the lower presentation level regardless of S/B. Possible clinical applications of the SPIN test are discussed.

OPSOMMING
Die uitwerking van aanbiedingsvlak en sein-to-babbel-verhouding (S/B) op SPIN-toets-diskriminasietellings is ondersoek by tafig normalhorende luisteraars. Beide aanbiedingsvlak en S/B het 'n beduidende uitwerking op diskriminasietellings. 'n Hoër persentasie korrekte diskriminasie is by die meer gesigte S/B verkry, ongeag die S/B. Kliniese toepassings van die SPIN-toets is bespreek.

The routine procedure in clinical speech audiometry over the past few decades has been to obtain a speech reception threshold for spondaic words and an estimation of monosyllabic discrimination ability. These measures are generally obtained in quiet conditions. In spite of the seeming popularity of this approach, much criticism has been directed against it (Dirks, Morgan and Dubno, 1982). Discrimination tests using monosyllabic words have been criticized for a number of reasons, but most frequently because test stimuli and conditions do not represent typical listening environments, and because test forms are not equivalent (Dirks and Dubno, 1984). With this in mind Kalikow, Stevens and Elliott (1977) developed the Speech Perception in Noise (SPIN) test in order to assess the understanding of speech in noise. They recognised that in speech communication adults utilise acoustic-phonetic and linguistic-contextual information for perception. Consequently the SPIN test comprises eight lists of 50 sentences each, where the predictability of the final target or key word of each sentence is controlled. In each list 25 items are designed to be primarily identified by the acoustic-phonetic information (low predictability (LP)) and the other 25 sentences include linguistic-contextual information which could aid identification (high predictability (HP)). The following are examples of each, “I had not thought about the growl” (LP) and “The watchdog gave a warning growl” (HP). Since everyday speech communication commonly occurs in the presence of noise, the sentences are presented in a 12-voice background babble. The sentences and babble are recorded on separate channels of audio tape, thus permitting variation of the signal-to-babble (S/B) ratio.

In constructing the test Kalikow et al. (1977) chose 250 target words from an original pool of words, with each test word presented in both an HP and an LP context in complementary lists. Form equivalence for these ten lists was investigated for a group of normal listeners at 80 dB SPL and at a 0 dB S/B. Two lists were discarded, and on the basis of an analysis of variance the remaining eight were considered to be equivalent for the difference score (i.e. HP - LP). While the analysis did not show similar equivalence for HP and LP scores, Kalikow et al. (1977) did no feel that this was a serious problem.

Morgan, Kamm and Velde (1981) and Bilger, Nuetzel, Rabinowitz and Rzeckowitz (1984) who also examined list equivalence did not agree with the results of Kalikow et al. (1977) and concluded that only seven of the original ten lists were equivalent. However, the experimental design of all three studies differed with respect to presentation level and S/B, subjects (normal hearing or hearing impaired) and statistical method of analysis. Thus the results of these later studies do not necessarily contradict those of Kalikow et al. (1977).

The effects of variations in presentation level, S/B, age and hearing impairment on SPIN performance have also been investigated. A consistent finding is the expected separation between the HP and LP scores, both of which improve with improved S/B ratios (Kalikow et al., 1977; Hutcherson, Dirks and Morgan, 1979; Elliott, 1979; Owen, 1981). Kalikow et al. (1977) found a slightly smaller difference score for an elderly group as compared to young subjects and Elliott (1979) found poorer HP sentence scores for 11 and 13 year old children compared to 15 and 17 year olds, which was not apparent when the sentences were presented in quiet. This finding may lead support to Owen’s (1981) conclusion that differences found in difference scores are related to the audibility of the sentences rather than to the listener’s use of context.

From these studies no clear pattern of results or administrative protocol emerges that might make the SPIN test clinically useful. With these issues in mind the present study was designed to examine the performance of a group of audiologically normal subjects using a locally produced recording of the test material. The object was to collect data that might provide a basis for comparison with the SPIN results of hearing impaired individuals and to identify aspects of the test that might most usefully and reliably be used in a clinical context.

METHODOLOGY

AIM
To investigate the performance of a group of normal hearing subjects on the SPIN test, and to examine the effect on performance of presentation level and signal-to-babble ratio.

SUBJECTS
Eighty young adults aged between 18 and 29 years with normal hearing sensitivity (<15 dB re: ANSI 1979) at octave frequencies from 250 to 8000 Hz bilaterally, served as subjects. English was the native language of all subjects, and no subject had had any previous test experience with the SPIN materials.
An Evaluation of the Speech Perception in Noise Test

**INSTRUMENTATION**

The eight lists of the SPIN test were recorded by an English-speaking South African male. The babble was generated by recording each of six adults (3 males and 3 females) reading the same passage from a children’s story book in an anechoic chamber, mixing these six recordings and combining two repetitions of the six-voice babble to produce the final 12-voice babble. Both the sentence and babble tracks were preceded by 1000 Hz calibration signals.

During the test sessions the lists were played on a two-channel (Pioneer Stereo Cassette Tape Deck - CT-F650) tape recorder. The signal and babble outputs from the tape recorder were routed to a speech audiometer (Grason-Stadler, GSI 10) where the intensity of each was determined separately before being mixed. The mixed output was delivered to the subject via a TDH-39 ear-chamber, mixing these six recordings and combining two repetitions of the six-voice babble to produce the final 12-voice babble. The signal and babble outputs from the tape recorder were routed to a speech audiometer (Grason-Stadler, GSI 10) where the intensity of each was determined separately before being mixed. The mixed output was delivered to the subject via a TDH-39 earphone mounted in a supra-aural cushion (MX 41/AR). The audiometers were calibrated according to ANSI 1979 standards, and prior to each test session the VU meters of each channel were adjusted according to the 1000 Hz calibration signal.

All testing was conducted in a double chamber sound treated test booths.

**PROCEDURE**

Lists were presented at two intensity levels (60 and 40 dB HL) and two S/B ratios (0 and +5 dB). The 60 dB HL/S/B condition was chosen to allow comparison to the Kalikow et al. (1977) study. The 40 dB HL level was chosen because normal to loud conversational speech falls within the 40 to 60 dB HL range, and because at a 40 dB sensation level (re: SRT) testing would be possible for a larger percentage of hearing impaired individuals than at higher levels. The +5 dB S/B ratio was chosen because it is a more favourable condition as research (Pearsins, Bennett and Eidell, 1976 as cited by Dirks et al. 1982) has shown that this ratio is usually maintained for conversations in background noise.

Subjects were divided into two groups. Forty subjects were tested with the odd numbered lists, and forty subjects with the even numbered lists, thus ensuring that complementary lists were not heard by the same person. The stimuli (signal and babble) were presented to the subject's preferred ear under four listening conditions:

- 60 dB HL with a S/B of +5 dB,
- 60 dB HL with a S/B of 0 dB,
- 40 dB HL with a S/B of +5 dB, and
- 40 dB HL with a S/B of 0 dB.

The order of presentation remained constant, but the order of presenting the lists was varied so that each list was presented under each listening condition the same number of times. Subjects were instructed to write down the last word of each sentence.

**ANALYSIS OF RESULTS**

A strict scoring protocol was adopted. (Singular/plural conversions were not acceptable). Total, HP, LP and difference scores were converted into percentages. Summary statistics (means and standard deviations) were used to describe central tendencies for each of the listening conditions. Data were subjected to a two-factor analysis of variance with repeated measures of both factors (Treatments-by-Treatments-by-Subjects AOV) to assess the effects of presentation level and S/B ratio.

**RESULTS AND DISCUSSION**

Table 1 summarizes the mean scores and standard deviations found for all the lists under the different listening conditions.

The finding that all scores improve at the more favourable S/B ratio regardless of presentation level was to be expected and confirms results from previous studies (Hutcherson et al., 1979; Owen, 1981). An unexpected finding was that scores were better at the lower presentation level for both S/B conditions. This finding is contradictory to that of Hutcherson et al. (1979) who found little difference in scores at 50 dB and 80 dB SPL, and a definite improvement from 30 to 50 dB SPL. Since the order of testing under the four listening conditions was held constant it may be postulated that a learning effect produced this result. However, in such a case less of a difference would be expected between the 60/40 dB S/B conditions than the +5 S/B conditions, but examination of the results indicates that the difference is of equal magnitude. A similar intensity effect appears to be present in data reported for the normal hearing subjects for words from NU #6 lists presented in SPIN background babble (Dirks et al., 1982).
Taken together these results may suggest that there is an optimal presentation level for discrimination of speech in noise, and that an increase or decrease in this level will result in a deterioration of performance. This level may correspond to that of conversational speech (40 dB HL). The effect should be more thoroughly explored — for both the normal hearing population and those with sensorineural hearing losses. It would be interesting to determine how, for example, individuals with cochlear losses and concomitant intolerance for loud sounds would perform.

The immediate clinical implication of these results is that the SPIN test should not be administered under listening conditions for which normative data is unavailable. Regardless of the measure used, both intensity and S/B affect performance. Consequently no generalizations about scores can be made. The present findings provide a means for comparing the performance of hearing impaired individuals with that of normal listeners. For such a purpose it is suggested that the 40 dB +5 S/B protocol is adopted. At the 40 dB SL re SRT presentation level testing is likely to be possible for the majority of hearing impaired listeners, and the +5 dB S/B provides the most well defined normal performance. The good HP scores and the relatively high LP scores would allow measurement of the poorer performance by the hearing-impaired individual over a wider range than would be possible under the other three conditions. The HP and LP scores provide two sources of information. They provide an indication of performance that can be compared with normal performance. In addition the relationship between the HP and LP scores for an individual provide an indication of the extent to which he is taking advantage of sentence context, and this has important therapeutic implications. However, this relationship is only meaningful in the context of the normal HP and LP scores.

Considering that noise has a differential effect on individuals even with similar audiometric configurations and degree of loss (Plomp and Mimpen, 1979), determination of performance functions for various S/B ratios and intensity levels would give the best estimate of ability to understand speech at suprathreshold levels. However, in its present form the SPIN test would not be a cost effective or practical method for this purpose, being too time-consuming and fatiguing.

In conclusion it is suggested that the SPIN test be administered at the 40 dB +5 S/B level in order to obtain comparative and rehabilitative information. Any diagnostic application of the SPIN test among hearing-impaired individuals requires further research.

REFERENCES


INFORMATION FOR CONTRIBUTORS

The South African Journal of Communication Disorders publishes reports and papers concerned with research, or critically evaluative, theoretical, or therapeutic issues dealing with disorders of speech, voice, hearing or language, or on aspects of the processes underlying these.

The South African Journal of Communication Disorders will not accept material which has been published elsewhere or that is currently under review by other publications.

All contributions are reviewed by at least two consultants who are not provided with author identification.

Form of Manuscript. Authors should submit four neatly typewritten manuscripts in triple spacing with wide margins which should not exceed much more than 25 pages. Each page should be numbered. The first page of two copies should contain the title of the article, name of author/s, highest degree and address or institutional affiliation. The first page of the remaining two copies should contain only the title of the article. The second page of all copies should contain only an abstract (100 words) which should be provided in both English and Afrikaans. Afrikaans abstracts will be provided for overseas contributors. All paragraphs should start at the left margin and not be indented.

Major headings, where applicable, should be in the order of METHOD, RESULTS, DISCUSSION, CONCLUSION, ACKNOWLEDGEMENTS and REFERENCES.

Tables and Figures should be prepared on separate sheets (one per table/figure). Figures, graphs and line drawings must be original, in black ink on good quality white paper. Lettering appearing on these should be uniform and professionally done, bearing in mind that such lettering should be legible after a 50% reduction in printing. On no account should lettering be typewritten on the illustration. Any explanation or legend should not be included in the illustration but should appear below it. The titles of tables and figures should be concise but explanatory. The title of tables appears above, and of figures below. Tables and figures should be numbered in order of appearance (with Arabic numerals). The amount of tabular and illustrative material allowed will be at the discretion of the Editor (usually not more than 6).

References. References should be cited in the text by surname of the author and date, e.g. Van Riper (1971). Where there are more than two authors, et al. after the first author will suffice. The names of all authors should appear in the Reference List. References should be listed alphabetically in triple-spacing at the end of the article. For acceptable abbreviations of names of journals, consult the fourth issue (October) of DSH ABSTRACTS or The World List of Scientific Periodicals. The number of references used should not exceed much more than 20.

Note the following examples:


Prose. Galley proofs will be sent to the author wherever possible. Corrections other than typographical errors will be charged to the author.

Proofs. 10 proofs without covers will be provided free of charge. All manuscripts and correspondence should be addressed to:

The Editor,
The South African Journal of Communication Disorders,
South African Speech and Hearing Association,
P.O. Box 31782, Braamfontein 2017, South Africa.

Authors should submit four neatly typewritten manuscripts in triple spacing with wide margins which should not exceed much more than 25 pages. Each page should be numbered. The first page of two copies should contain the title of the article, name of author/s, highest degree and address or institutional affiliation. The first page of the remaining two copies should contain only the title of the article. The second page of all copies should contain only an abstract (100 words) which should be provided in both English and Afrikaans. Afrikaans abstracts will be provided for overseas contributors. All paragraphs should start at the left margin and not be indented.

Major headings, where applicable, should be in the order of METHOD, RESULTS, DISCUSSION, CONCLUSION, ACKNOWLEDGEMENTS and REFERENCES.

Tables and Figures should be prepared on separate sheets (one per table/figure). Figures, graphs and line drawings must be original, in black ink on good quality white paper. Lettering appearing on these should be uniform and professionally done, bearing in mind that such lettering should be legible after a 50% reduction in printing. On no account should lettering be typewritten on the illustration. Any explanation or legend should not be included in the illustration but should appear below it. The titles of tables and figures should be concise but explanatory. The title of tables appears above, and of figures below. Tables and figures should be numbered in order of appearance (with Arabic numerals). The amount of tabular and illustrative material allowed will be at the discretion of the Editor (usually not more than 6).

References. References should be cited in the text by surname of the author and date, e.g. Van Riper (1971). Where there are more than two authors, et al. after the first author will suffice. The names of all authors should appear in the Reference List. References should be listed alphabetically in triple-spacing at the end of the article. For acceptable abbreviations of names of journals, consult the fourth issue (October) of DSH ABSTRACTS or The World List of Scientific Periodicals. The number of references used should not exceed much more than 20.

Note the following examples:


Proofs. Galley proofs will be sent to the author wherever possible. Corrections other than typographical errors will be charged to the author.

Reprints. 10 reprints without covers will be provided free of charge. All manuscripts and correspondence should be addressed to:

The Editor,
The South African Journal of Communication Disorders,
South African Speech and Hearing Association,
P.O. Box 31782, Braamfontein 2017, South Africa.