

AUTOMATIC GAIN CONTROL AND HEARING AIDS

The influence of different attack and release times on speech intelligibility for hearing impaired with recruitment.

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This work was supported by the Swedish Board of Technical
Development. STU-75-3631, STU 75-3634

SUMMARY

Amplitude compression, AGC, is used in hearing aids in order to reduce the dynamic range of speech especially for people with loudness recruitment. The influence of the release time on the intelligibility of nonsense syllables of the cvc type has been studied with normal hearing subjects and hard of hearing subjects with loudness recruitment.

The experiments were carried out at most comfortable level over a laboratory unit with a compression ratio of 30 dB to 5 dB, release times 10-1000 ms and S/N 5dB and 60 dB.

To allow weak speech sounds following loud elements (vowels) to be perceived the release time should not exceed some 100 ms.

INTRODUCTION

Hearing aids with automatic gain control (AGC) were introduced during the 1950's. Unexpected negative results on patients with varying types of hearing impairment have been reported. Different groups of users who might benefit from AGC may be recognized:

1. Hard of hearing listeners who may need compression of the dynamic range of the speech to fit a narrow hearing span.
2. People who may need a long time average level equalizing for their listening comfort.
3. Hard of hearing who prefer an output limiter with a minimum of amplitude distortion instead of peak clipping.

For the three main groups of users described above different AGC characteristics are needed and therefore it is not sufficient to label the function AGC only. If hearing aids are used for the experiments it is very important that other parameters than those of interest, the AGC ones, are kept under control.

There is a great need for an international standardization resulting in the use of a common vocabulary. An IEC document, IEC Publ. 118:2 Hearing aids with automatic gain control circuit may assist in such a direction. It is impossible to compare results from different investigators without a careful physical description of the instruments. Three major factors of the physical performance of an AGC aid have to be specified in order to fully describe the AGC function:

- a. Steady-state input/output function and normal operating levels.
- b. Attack time and possible distortion and/or output limitation of the overshoot.
- c. Release time (s).

Recent investigations

Compression has been expected to be of great value for people with loudness recruitment, but most experiments have failed, in recent years reported by Caraway and Carhart (1967), Flemming and Rice (1969), Burchfield, Rintelmann and Carter (1971), Ruhrberg and Esser (1972), Vargo and Carhart (1972), and Nabelek (1975). One important reason for these less encouraging results might be the attack times, mostly longer than 5 ms. In fact nobody has examined the influence of attack and release times carefully. Lynn and Carhart (1963) have dealt with attack and release times but only for AGC as a limiter with attack times from 6 ms and upwards. Krebs (1972) and Nabelek (1973, 1975) stress the importance of another complicating factor, namely distortion during overshoot, especially for long attack times.

Clinical evaluations of compressor hearing aids versus conventional hearing aids have been performed by among others Yanick (1973), Blegvad (1974), and Kemp and Blegvad (1975). Yanick is positive, the others more negative, but it is a difficult task to determine which performance characteristics make a patient prefer a certain hearing aid.

Spreng and Keidel (1972), Villchur (1973, 1974), and Robinson and Huntington (1973) are experimenters practising more unusual methods. Villchur adjusts the compression in different frequency bands to the loudness function of the listener.

Spreng and Keidel

work along the same line, examining the loudness function by ERA.

Robinson and Huntington use the average power of the speech signal integrated over 30 ms to determine the gain, suggesting this to suit the function of the ear better than momentary regulation. More experiments have to be performed to test the idea.

OWN EXPERIMENTS

Listening conditions

The speech material was processed using a compressor amplifier manufactured by Spectra Sonics type 610 Complimiter. The steady state input-output characteristics used in all experiments are described in figure 1. The speech level was monitored by a peak indicating instrument capable of showing peaks of the duration of 1 ms or longer. The maximum peak level was set to 6 dB below the output level where peak-clipping occurs, giving a compression range of about 30 dB. This may be considered to be high enough to permit weak speech sounds to fall into the range where compression is effective.

The experiments were conducted with different attack and decay times. Photographs of typical actions are shown in figure 2. The tests were performed at two signal-to-noise ratios, $S/N = 60$ dB and $S/N = 5$ dB, the first representing a good transmission. For $S/N = 5$ random white noise was low-pass filtered at 6 kHz and mixed with the speech signal at the output of the compressor, the purpose being to make the test situation more difficult. The signal-to-noise ratios were measured using a noise level meter (IEC 179) dB(C), fast response. The level of the speech material is the average over the complete set of words.

The speech material was recorded on magnetic tape at 38 cm/s giving an overall performance measured electrically at the terminals of the earphone of 50 to 1200 Hz (\pm 1.5 dB) and S/N = 60 dB. The stimuli were presented monaurally (except for the impaired group in Experiment III) over earphones TDH 39 with cushions MX 41 AR. The test subjects were sitting in a sound-insulated booth with a noise level at the eardrums below threshold.

Test material

The speech material used was nonsense syllables, logatoms, of the cvc type and phonetically balanced according to available statistics of the Swedish language. The initial and the final consonants as well as the vowels were balanced. The total set of words was divided into 20 lists of 50 words each. In these experiments ten of the lists were used. One test list is given as an example in Appendix B. The test words were embedded in a carrier phrase (Det är..... vi hör). The levels of the individual test items were equalized by measurements of the carrier phrases only, Sjögren (1973). The reference articulation function was measured with normal hearing listeners and is shown in figure 3.

Subjects

The experiments were performed with normal hearing and hearing impaired subjects. The hearing of all subjects was carefully examined. The normal hearing subjects had a hearing level of less than 20 dB (125-8000 Hz) and showed no sign of pathology.

The hearing impaired subjects had presumably cochlear hearing losses. Their pure-tone audiograms were reasonably flat within the frequency range 500-2000 Hz. A recordable stapedius reflex when stimulating the test ear in the frequency range 500-2000 Hz was also required. All subjects were less than 50 years of age.

The individual pure-tone audiograms and stapedius reflex threshold of the subjects of the pathological group in Experiment I are shown in figures C-1 and C-2. The corresponding results for subjects studied in Experiment II and III are shown in Appendix C, figures C-3, C-4, C-5, and C-6, respectively.

Description of experiments

For the normal hearing subjects a sound pressure level of 75 dB was used for the presentation of the test lists. For each of the hearing impaired subjects the most comfortable level for speech was determined and used at the tests.

Training sessions were performed, using training logatom lists, and each experimental session was always started with one or two training lists. Maximally four test lists were presented at each session.

Experiment I:

Ten normal hearing and seven hearing impaired subjects were studied. The compressor was used on-line with a fixed ratio, 1/200, between attack and release times. The following denotations define the five combinations of attack and release times.

Table I

	t_a (ms)	t_r (ms)
T_1	0.05	10
T_2	0.15	30
T_3	0.5	100
T_4	1.5	300
T_5	5.0	1000

Signal-to-noise ratios (S/N) of 5 dB and approximately 60 dB (only internal noise of the test equipment) were used for all combinations of time constant. The normal hearing subjects responded by means of a set of pushbutton switches, directly connected to a computer for storage and analysis. The pushbutton board included the necessary combinations to form one-syllable Swedish words. The hearing impaired subjects responded verbally. These responses were written down by the experimenter and also recorded on tape for later computer analysis.

Experiment II:

In this experiment ten normal hearing and six hearing impaired subjects were investigated. Tape recordings of the amplitude compressed

speech material were used. For the normal group the same attack and release time combinations were used as in Experiment I, while for the pathological group only the combinations denoted by T_3 , T_4 and T_5 were studied. The S/N of 5 dB was used in the normal hearing group only. The verbal responses of the subjects were written down and also recorded on tape for later computer analysis.

Experiment III:

Ten normal hearing and six hearing impaired subjects were used. A fixed attack time of 0.5 ms was used with the compressor connected on-line. The release time was set to different values in the range of 10-1000 ms according to the following table.

Table II

	t_a (ms)	t_r (ms)
T_1	0.5	10
T_2	0.5	30
T_3	0.5	100
T_4	0.5	300
T_5	0.5	1000

The S/N used as well as the method of recordings of the subjects' responses were the same as in Experiment I.

Results

The subjects' responses have been evaluated by means of computer analysis. The computer has been programmed to analyse the results

with regard to the discrimination of the complete logatoms as well as to the three separate parts of the logatoms (initial consonant, vowel and final consonant). Furthermore, confusion matrices have been studied in some cases. The data have been evaluated with regard to the individual results as well as to the group results. When evaluating group results, normalized data have been used. The normalization was performed for each S/N by searching the maximum discrimination (D_{\max}) at T_1 - T_5 for each subject separately. The normalized discrimination scores at T_1 - T_5 were then calculated dividing by D_{\max} .

The results of Experiment I, II and III are presented separately. All data are given in figures and tables in Appendices D and E, respectively.

Experiment I:

The tables E-1 to E-IV show the resulting normalized discrimination of the normal group for complete logatoms, initial consonants, vowel and final consonants, respectively, for the two S/N values. The maximum absolute discrimination scores for each subject are also presented. The mean value and standard deviations of the discrimination of the normal group are presented in figure D-1 for five combinations of attack and release times and the two signal-to-noise ratios.

The corresponding results for the pathological group are presented in tables E-V to E-VIII and in figure D-2.

No statistically significant difference (Student's t-test $p < 5\%$) in the discrimination was found between the different combinations of attack and release times for the no-noise condition. This is true for both the normal and the hearing impaired group. However, when background noise was added ($S/N = 5$ dB), a significant deterioration of the discrimination of the complete logatoms was found in the normal hearing group at the time constant combination T_5 ($t_a = 5$ ms and $t_r = 1000$ ms) as compared to the other combinations ($p < 1\%$). This result is mainly explained by the decreased discrimination of the final consonant at T_5 as shown in figure D-1. No clear influence of the discrimination of the initial consonant and the vowel from the variations of the time constants is seen. The mean discrimination tends to be highest at the time constant combination T_3 . The results are in good agreement with a pilot study by Johansson and Kringlebotn (1961). In the group with hearing impairment the same qualitative results are obtained. The discrimination of the complete logatoms and the final consonants deteriorated significantly at T_5 . The best overall discrimination was obtained at the time constant combination T_3 for the pathological group and for both S/N values (table E-V).

Confusion matrices for the final consonant discrimination with $S/N = 5$ dB of the pathological group at time constants T_1 and T_5 are presented in Appendix F, figure F-1 and F-2. A decreased discrimination for the consonants P, T, K, S, and J is evident in T_5 as compared to T_1 . For M, N, NG, L, and R no significant differences could be found.

Experiment II:

The normalized discrimination of the complete logatons, initial consonants, vowels and final consonants for the two noise conditions for the normal hearing group is shown in tables E-IX, E-X, E-XI, and E-XII and in figure D-3. Figures F-3 and F-4 show the confusion matrices for the final consonants at the time constant combinations T_1 and T_5 with $S/N = 5$ dB.

The results of the pathological group, where only the time constants combinations T_3 , T_4 , and T_5 were used, are shown in tables E-XIII, E-XV, and E-XVI and in figure D-4.

As was the case in Experiment I there is no significant influence on the discrimination from the different time constant combinations and the normal hearing group for the no-noise condition. When S/N was 5 dB, however, increasing time constants gave rise to decreasing discrimination. Thus, the discrimination of complete logatons was significantly lower ($p < 1\%$) for T_5 than for $T_1 - T_4$. The confusion matrices in figures F-3 and F-4 show that the most important differences in the discrimination of the final consonant at T_1 and T_5 concern the consonants P, B, G, T, and J. The mean discrimination scores tend to be highest at T_3 when $S/N = 5$ dB.

In the pathological group, where only $S/N = 60$ dB was used, a significantly decreased discrimination ($p < 1\%$) was obtained at T_5 . T_3 gave rise to the highest mean discrimination scores also for the hearing impaired group. The confusion matrices for the final consonants of the pathological group at the time constant combinations T_3 and T_5 are presented in figures F-5 and F-6.

Experiment III:

This experiment, where the attack time was kept at 0.5 ms, while the release time was varied, gave the normalized discrimination scores for the normal group shown in tables E-XVII - E-XX. The mean values with the standard deviations indicated are presented in figure D-5.

The corresponding results for the pathological group are presented in tables E-XXI - E-XXIV and in figure D-6.

No significant influence on the discrimination from varying the release time was obtained for the no-noise condition. However, with $S/N = 5$ dB the normal hearing group yielded a significantly lower discrimination at T_4 and T_5 as compared to $T_1 - T_3$ ($p < 1\%$).

This effect on the discrimination of the complete logatoms is related to the decreased discrimination not only of the final consonants but also to the initial consonants and the vowels. The overall discrimination for the normal hearing group with background noise tended to be highest at the time constant combination T_1 .

Similarly a decreased discrimination score was observed in the pathological group for long release times. This was related to decreased discrimination of the final consonant with the most pronounced effect on P, T, K, S, and J. No influence could be noted on the discrimination of the final consonants M, N, NG, L, and R. Under no-noise conditions the pathological group tended to yield a slightly increased discrimination at the time constant combination T_4 .

Discussion

This work, started in the early seventies and finished in 1975, con-

cerns the action times of automatic gain control devices for hearing impaired with recruitment. In the first two experiments there was a fixed ratio between the attack and the release times, as was usual in hearing aids at that time. There is no doubt that the attack time should be as short as possible. Nowadays this does not introduce any difficult technical problems. Therefore the third experiment and our discussion concern only the release time. The release time, however, must be chosen for a distinct purpose; limitation, long time average level equalizing or compressing the dynamic range of speech.

Our three experiments, all with both normal hearing and hearing impaired test subjects show no decrease in discrimination for normal hearing subjects without noise for the release times chosen (10-1000 ms). With noise ($S/N = 5$ dB) or a hearing impairment with recruitment the discrimination, mainly of the final consonants, is affected.

The results from all three experiments show that the release time in compressor amplifiers for hearing impaired listeners with recruitment, should be chosen with about 100 ms as a maximum.

PROBLEMS FOR FURTHER STUDIES

Highest acceptable attack time.

Influence of oscillations during attack and release.

Suitable release time for level averagers.

Multichannel compression.

Subjective quality rating.

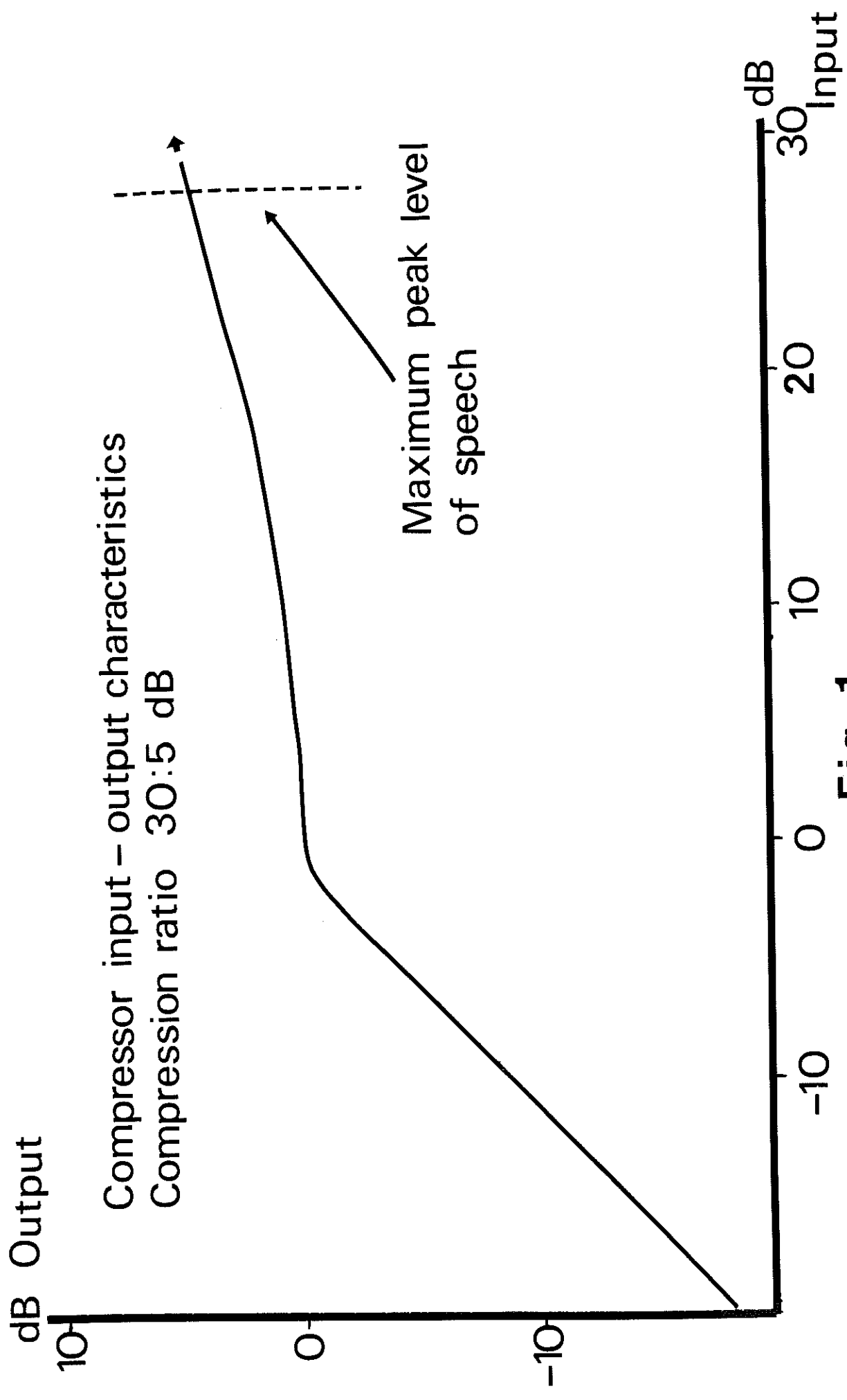


Fig 1

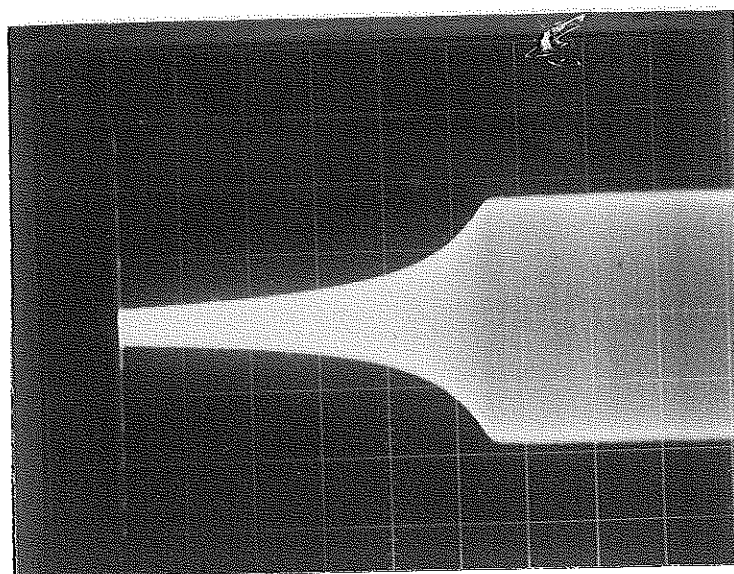
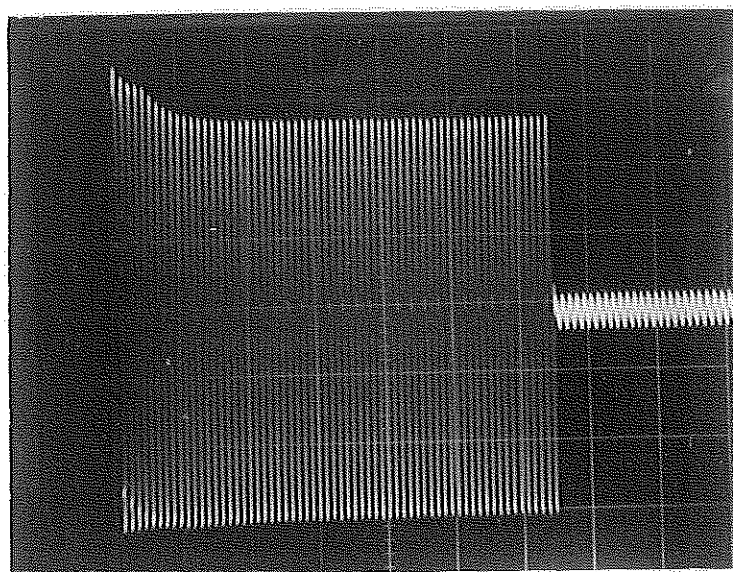


Fig. 2. Typical compressor actions. Here the attack time is 0.5 ms and the release time 100 ms for 25 dB steps from compressor knee-point.

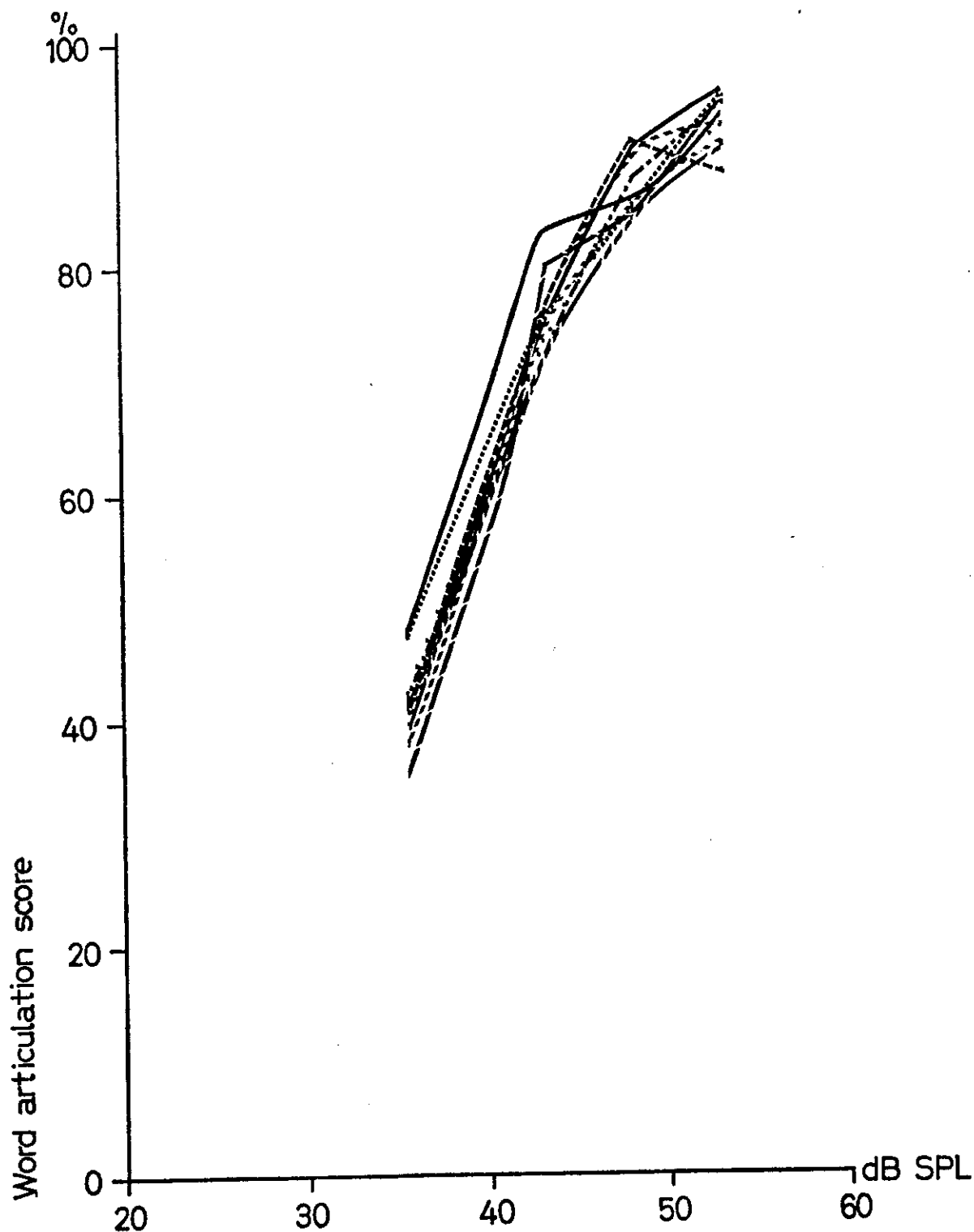


Fig. 3. Articulation score for nonsense syllables. Each curve, representing the score of one list of 50 words, measured at 36, 44, 49 and 54 dB SPL. Subjects: 10 normal-hearing listeners for each test point; ages: 17-48 years. Presentation: binaural, TDH 39, MX 41 AR. (from Sjögren, 1973)

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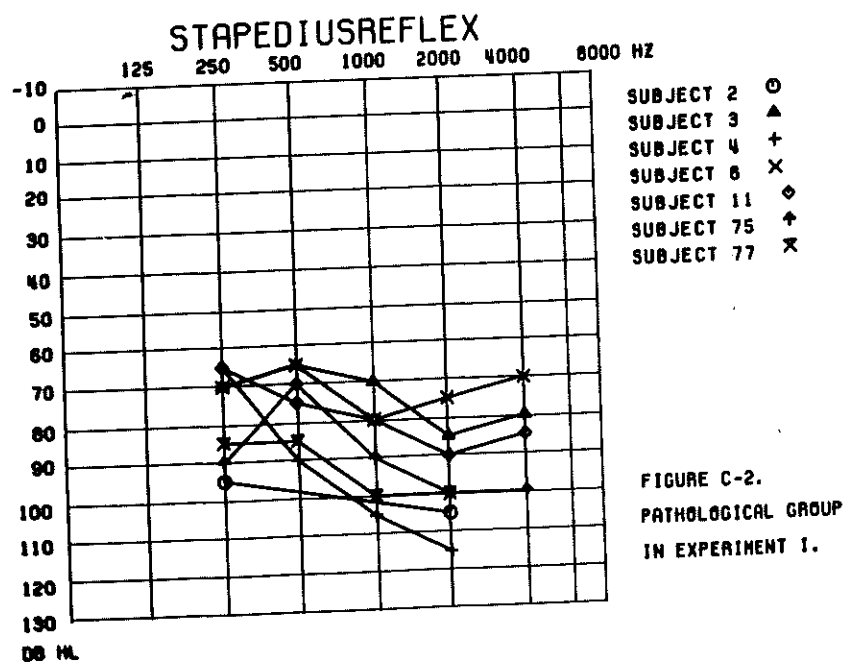
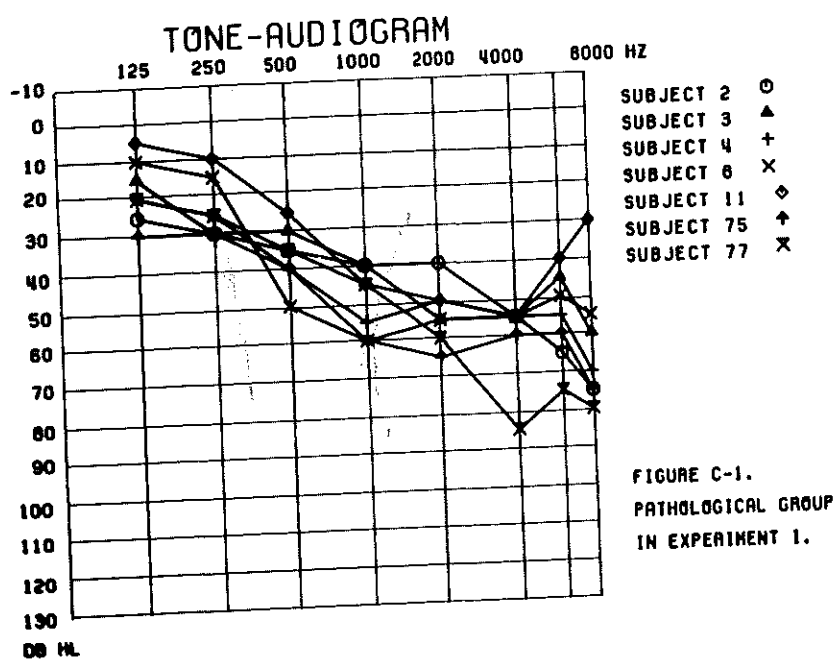
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Test list no. 67

TRA RP	SE:K	KRÅ NT	GO:S	FRÅ G
GA:T	FLY LV	SJA:M	SVA:T	LI T
FRA LT	SNI ST	FLÅ P	TJA:P	SKÅ:D
VU D	KLA KT	VU NG	KLA:T	TRU R
KA RV	PLÅ:K	BÅ RN	PLÅ RT	PE:K
BÅ:N	PU:N	TRI F	BLI:T	GRÅ KS
MA NT	SPY RT	FÅ J	KU NT	NÖ LT
STÅ:S	FJE:K	LY MT	SO:R	STA ST
BÅ L	HI D	MU NS	SNÅ RN	DA:T
VÅ LK	KI G	PÖ NGK	STÅ:S	FLE:K



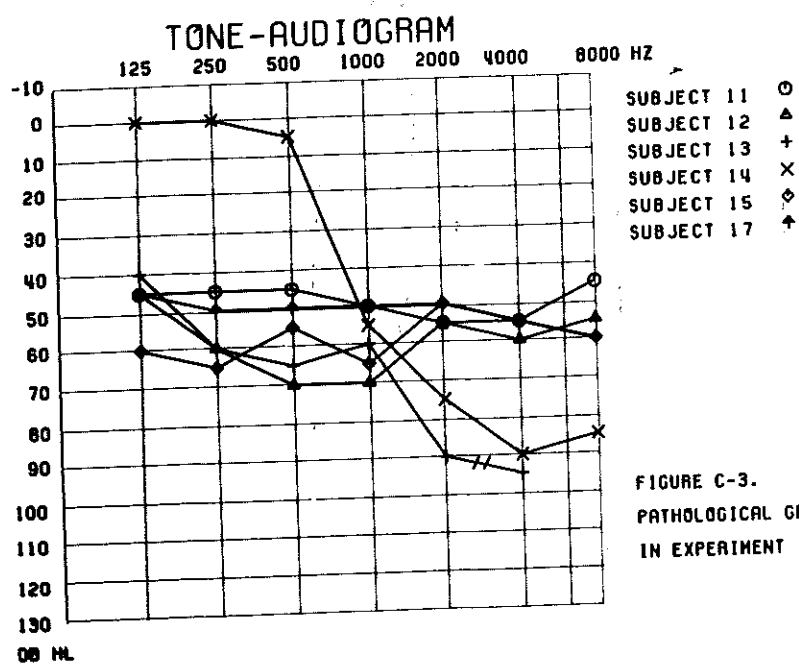


FIGURE C-3.
PATHOLOGICAL GROUP
IN EXPERIMENT II.

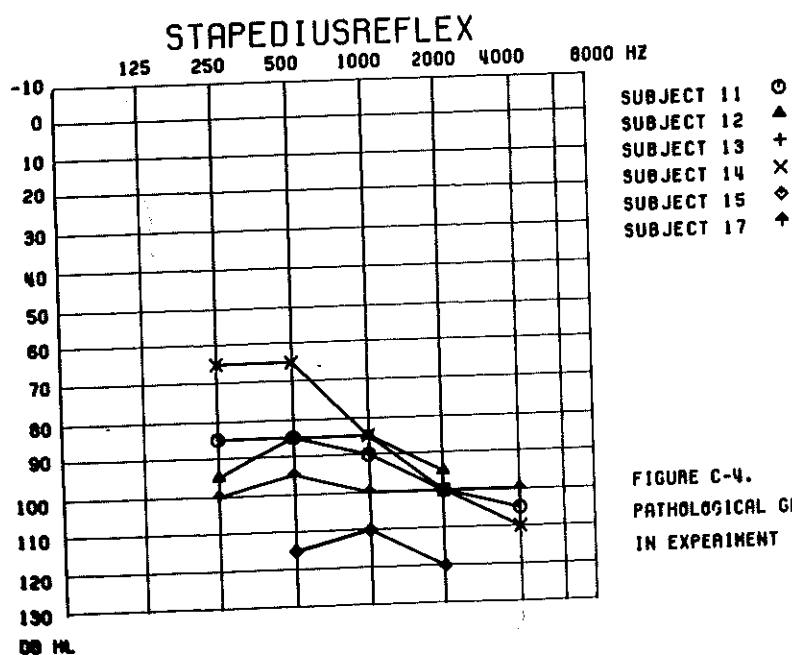
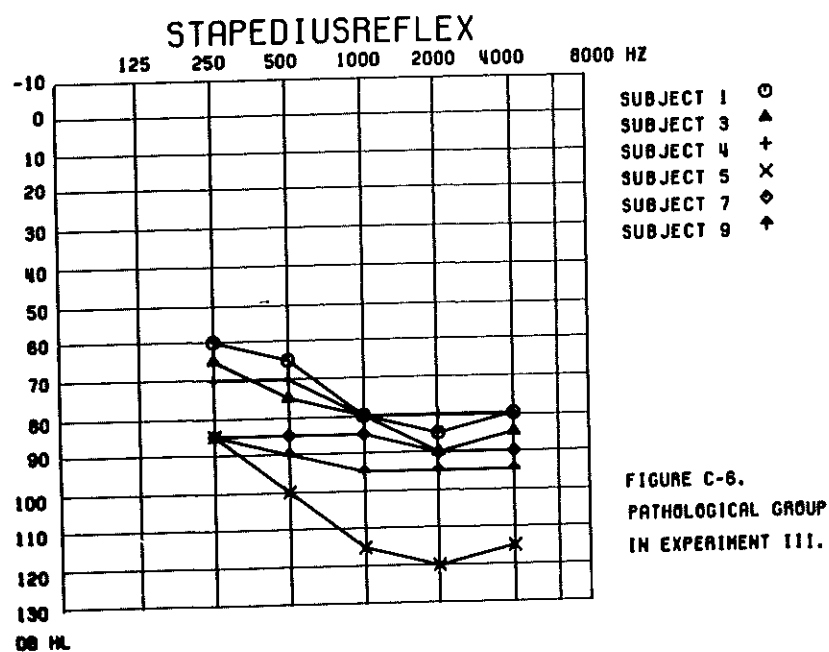
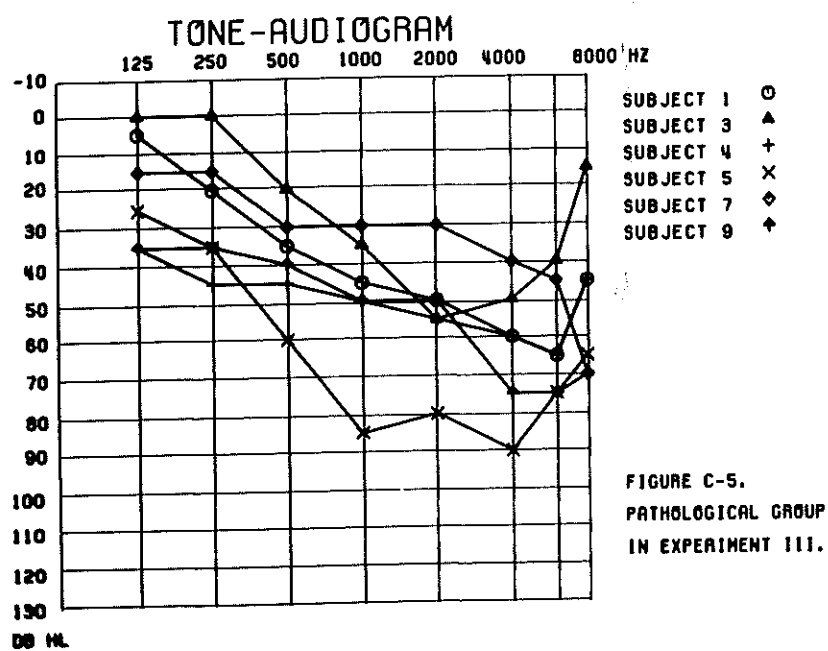


FIGURE C-4.
PATHOLOGICAL GROUP
IN EXPERIMENT II.



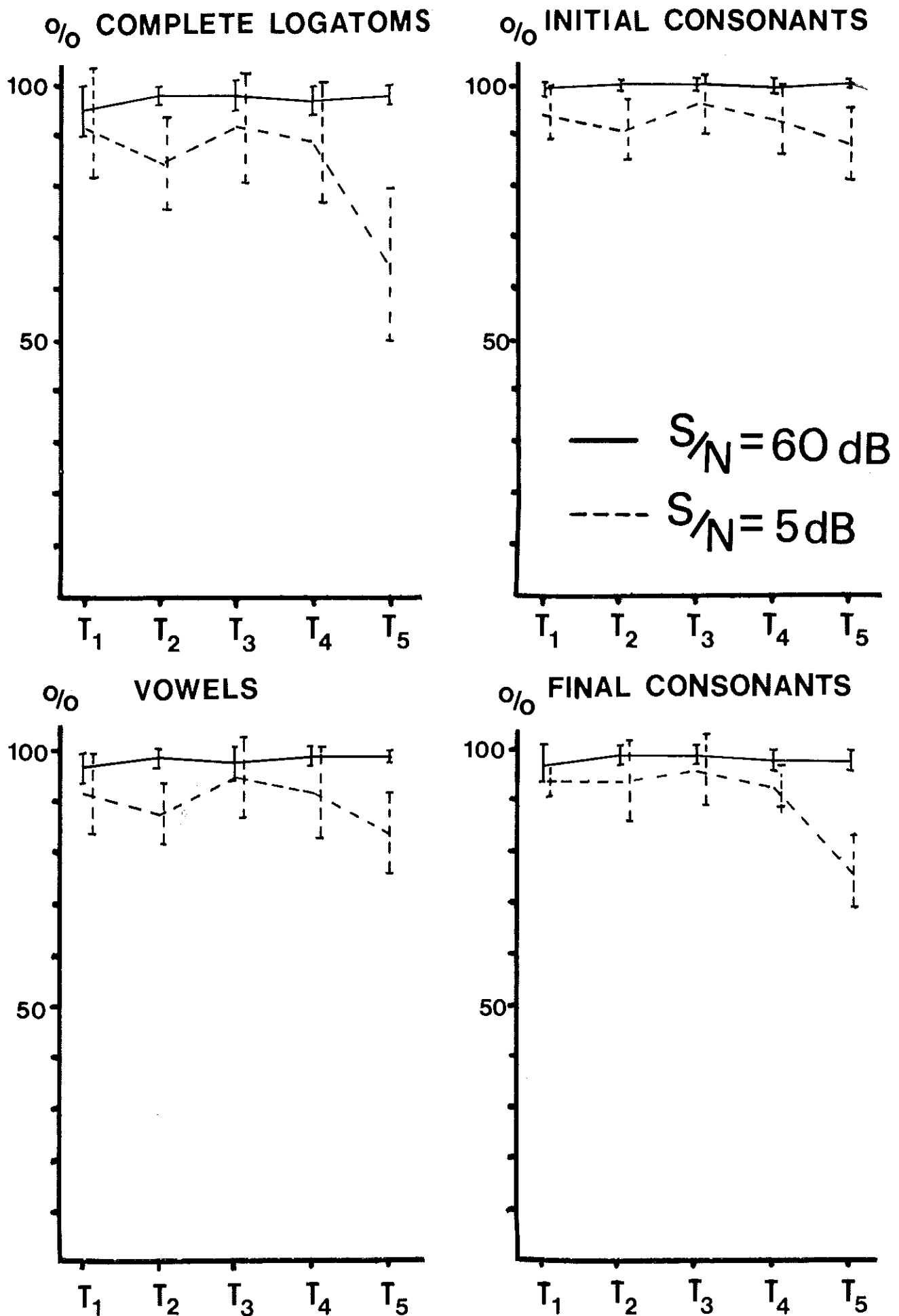


Figure D-1. Normalized discrimination of the normal hearing group in Experiment I. Time constants according to table I.

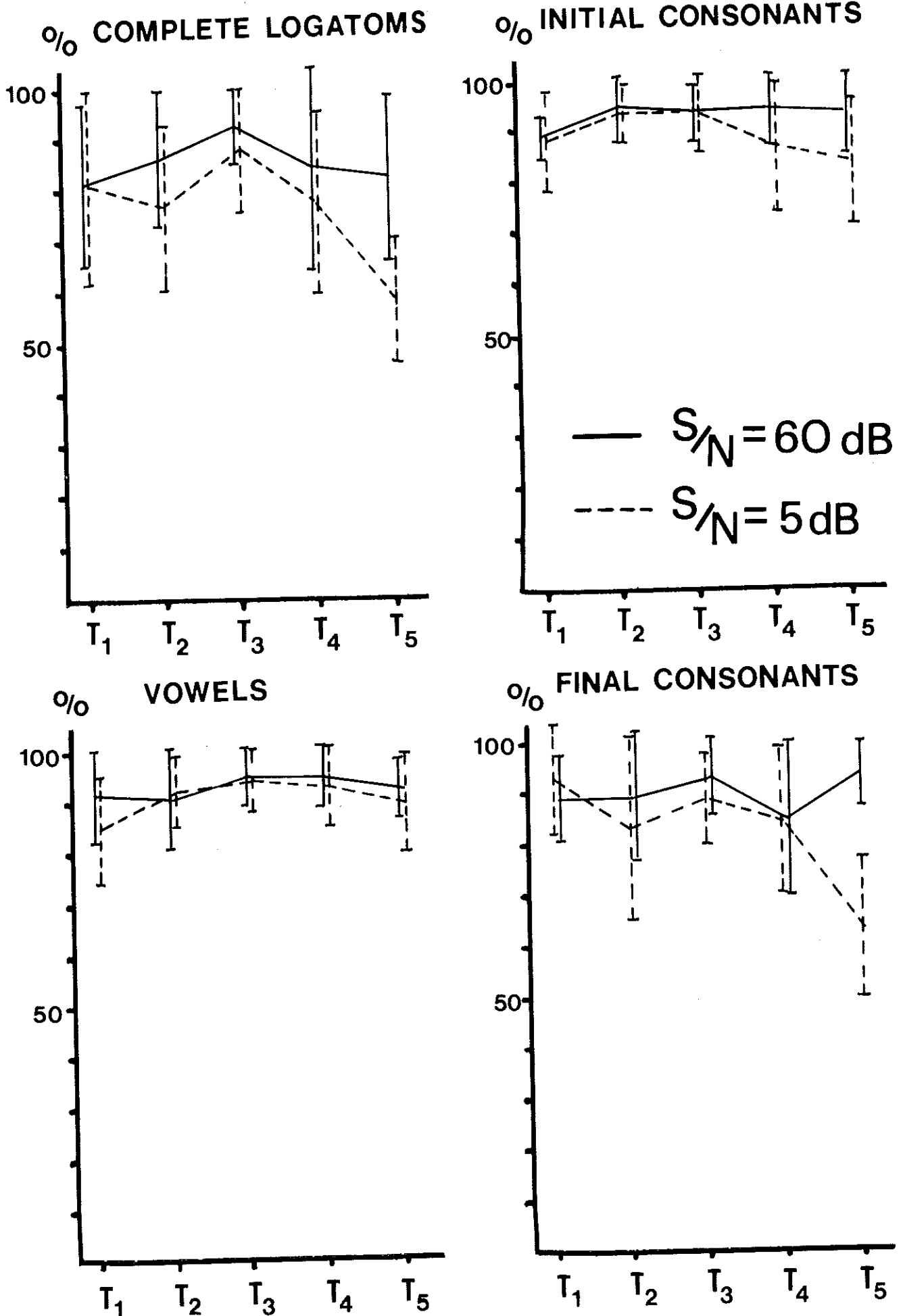


Figure D-2. Normalized discrimination of the pathological group in Experiment I. Time constants according to table I.

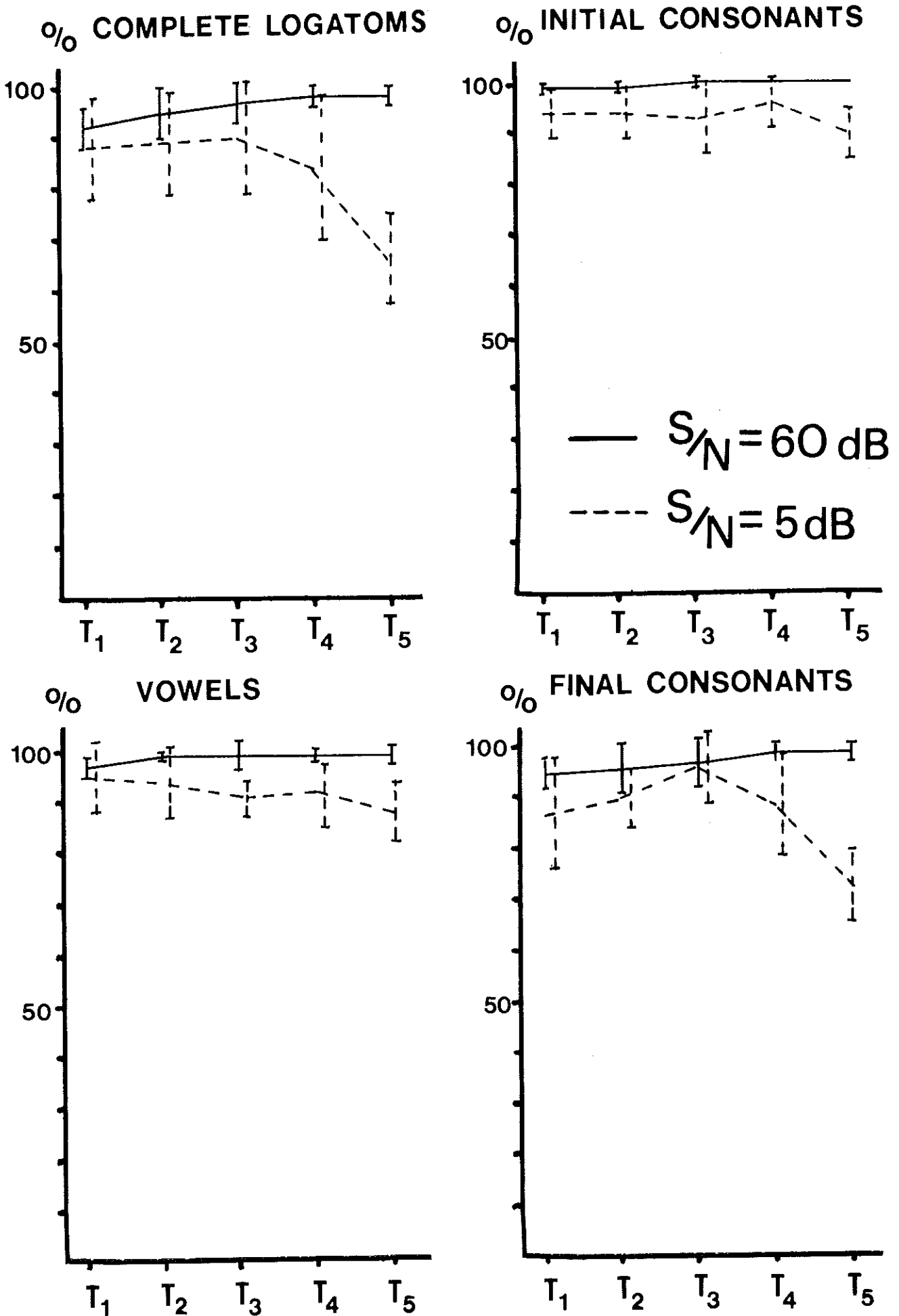


Figure D-3. Normalized discrimination of the normal hearing group in Experiment II. Time constants according to table I.

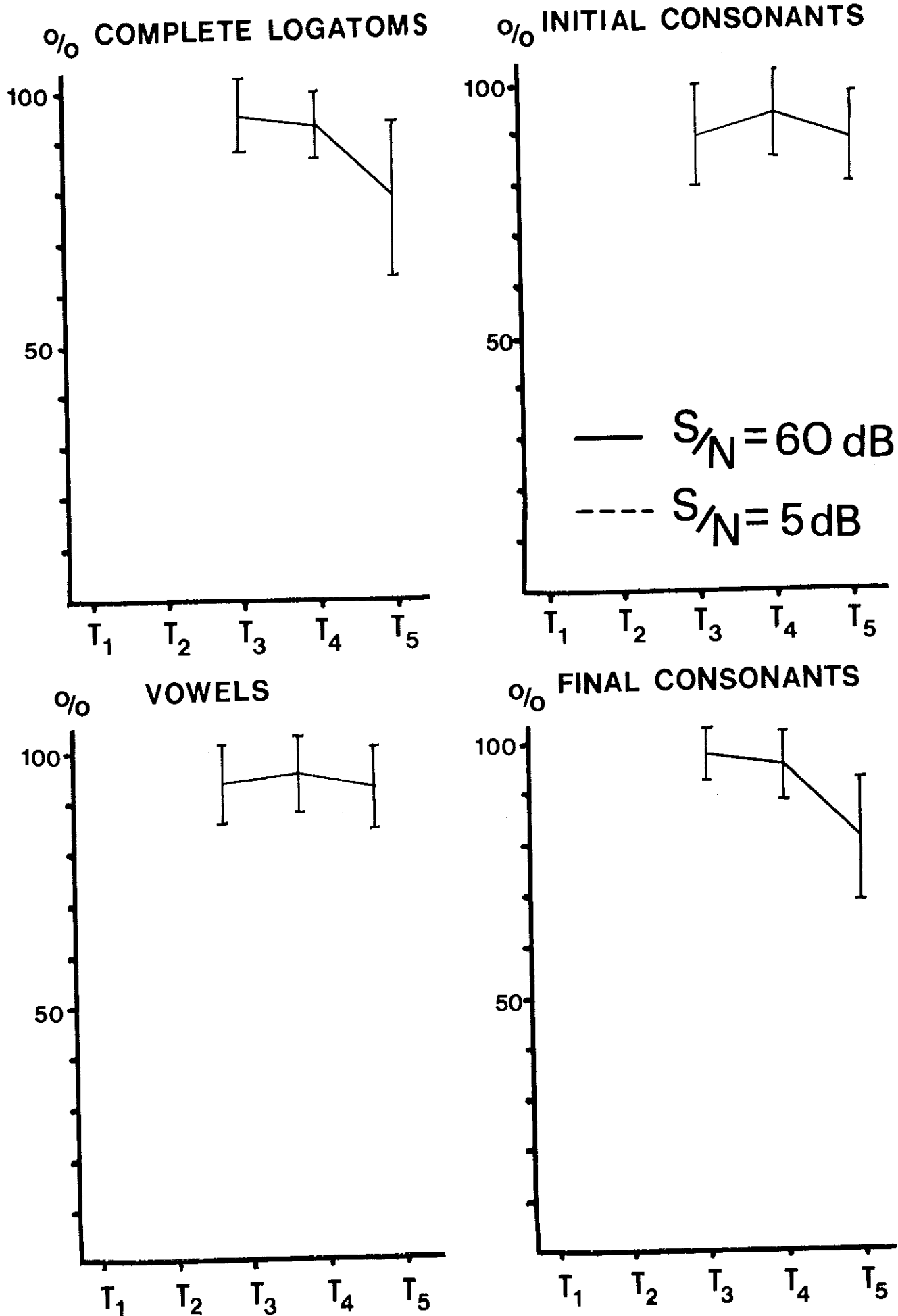


Figure D-4. Normalized discrimination of the pathological group in Experiment II. Time constants according to table I.

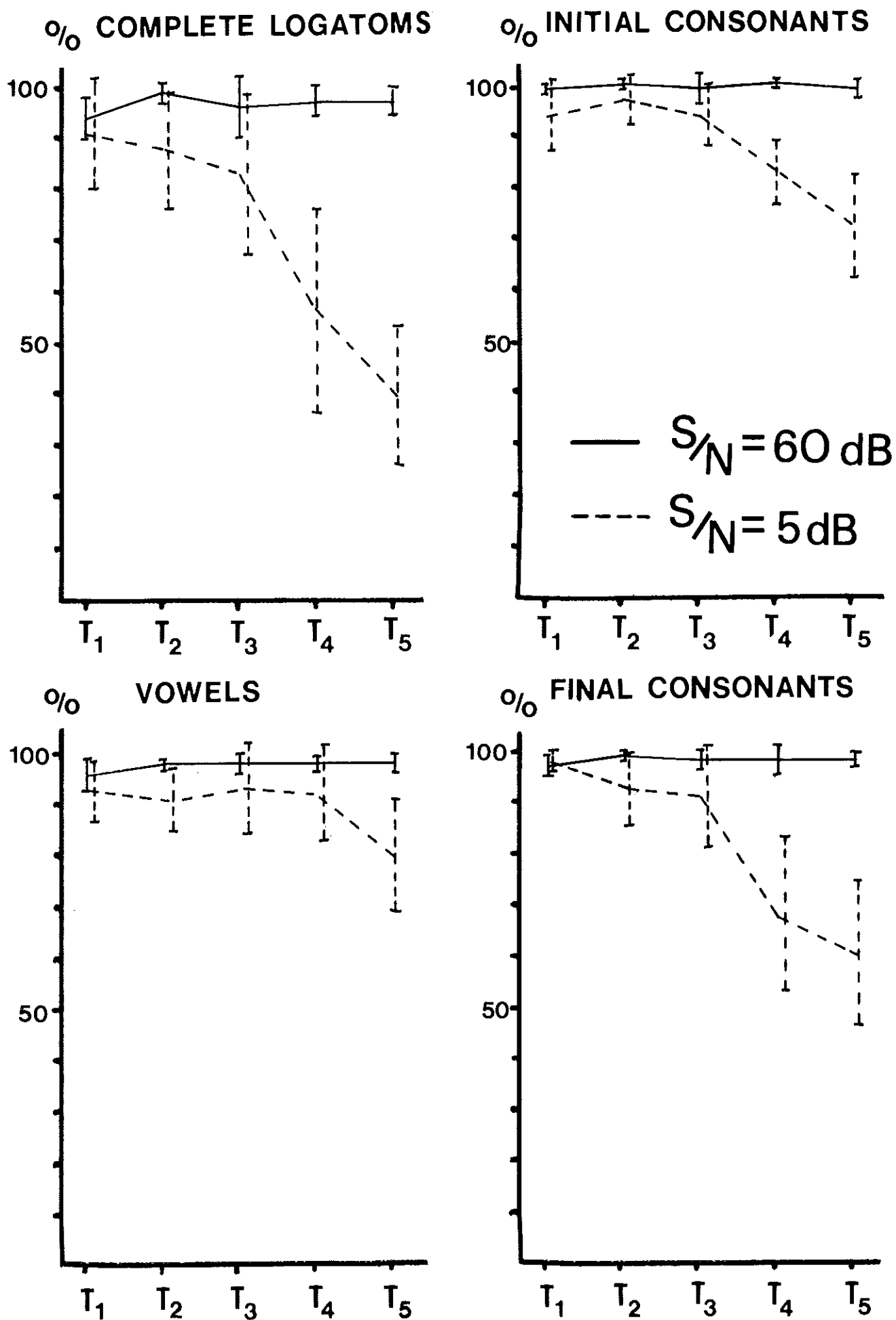


Figure D-5. Normalized discrimination of the normal hearing group in Experiment III. Time constants according to table II.

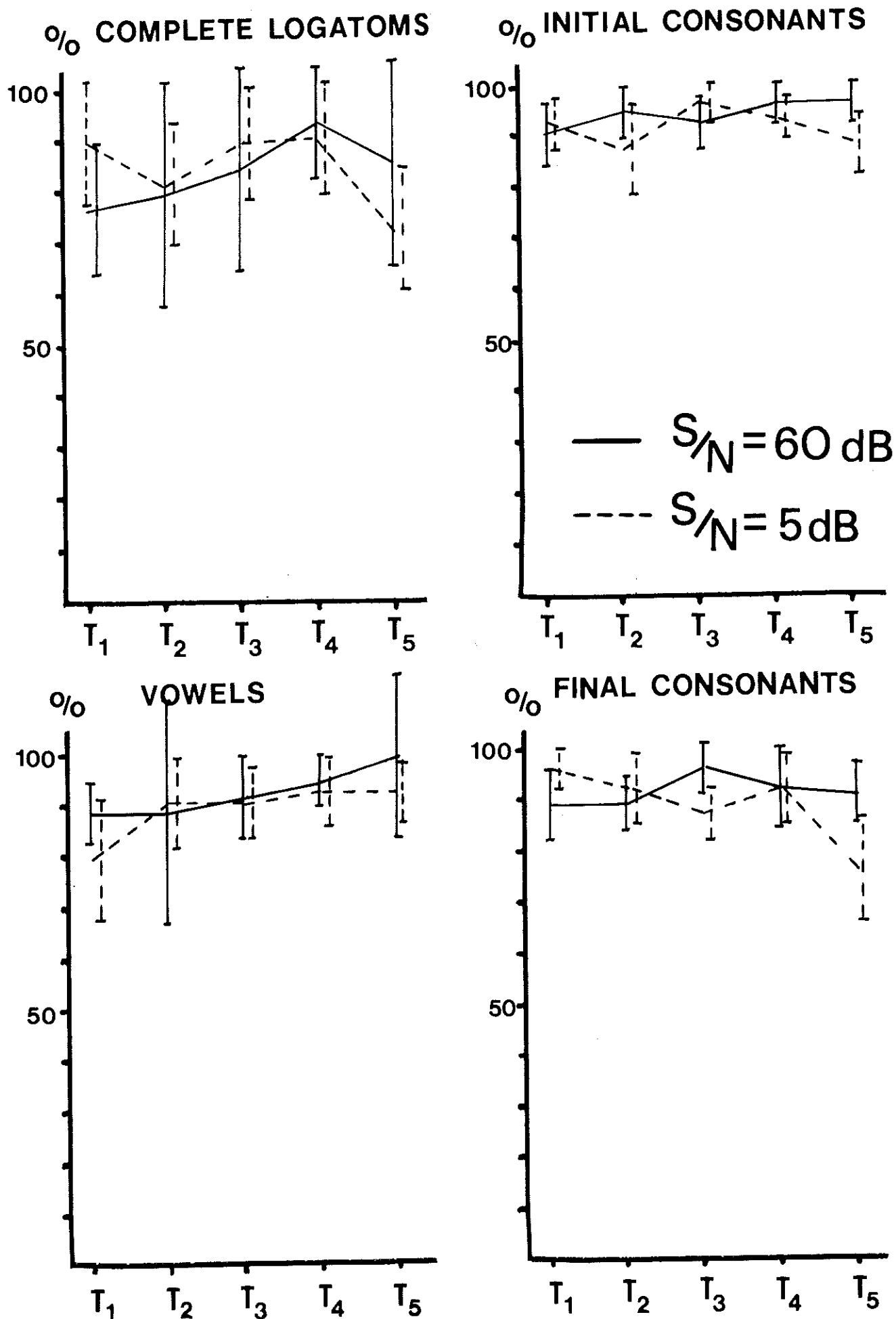


Figure D-6. Normalized discrimination of the pathological group in Experiment III. Time constants according to table II.

Table E-I. Normalized discrimination of the normal hearing group in Experiment I. Complete logatoms. Time constants according to table I.

S/N = 60 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
1	92	98	100	98	96	96
2	94	100	100	96	100	100
3	98	98	92	100	100	98
4	83	98	96	100	96	92
5	96	94	100	94	96	98
6	96	98	94	98	100	100
7	94	100	98	90	94	100
8	96	96	100	100	98	100
9	96	100	96	100	98	98
10	100	100	100	96	100	100
\bar{X}	94.50	98.20	97.60	97.20	97.80	
s	4.60	1.99	2.95	3.29	2.20	

S/N = 5 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
1	81	100	90	81	58	62
2	65	78	100	88	40	80
3	91	69	100	91	60	70
4	100	79	90	100	55	58
5	100	81	69	97	69	64
6	100	90	90	84	84	62
7	100	81	78	100	92	72
8	97	94	100	85	56	68
9	92	95	100	61	61	76
10	92	84	100	100	71	72
\bar{X}	91.80	85.10	91.70	88.70	64.60	
s	11.21	9.46	10.83	12.11	15.04	

Table E-II. Normalized discrimination of the normal hearing group in Experiment I. Initial consonants. Time constants according to table I.

S/N = 60 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
1	98	100	100	96	100	100
2	100	100	100	98	100	100
3	100	100	100	100	100	100
4	96	100	100	100	100	100
5	100	98	100	100	100	100
6	100	100	100	100	100	100
7	100	100	100	98	100	100
8	98	100	100	100	100	100
9	100	100	96	100	98	100
10	100	100	100	98	100	100
\bar{X}	99.20	99.80	99.60	99.00	99.80	
s	1.40	0.63	1.26	1.41	0.63	

S/N = 5 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
1	82	100	86	78	82	98
2	92	96	100	98	77	96
3	96	89	100	98	91	94
4	100	82	89	96	87	90
5	93	88	98	100	88	86
6	96	91	100	91	96	94
7	98	79	88	90	100	96
8	96	91	100	94	79	94
9	93	98	100	89	89	92
10	98	94	98	100	90	96
\bar{X}	94.40	90.80	95.90	93.40	87.90	
s	5.04	6.68	5.78	6.75	7.16	

Table E-III. Normalized discrimination of the normal hearing group in Experiment I. Vowels. Time constants according to table I

S/N = 60 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
1	94	100	98	100	96	98
2	96	100	100	100	100	100
3	98	98	92	100	98	100
4	94	96	98	100	98	100
5	94	94	100	96	98	100
6	96	100	94	100	100	100
7	96	100	98	98	98	100
8	100	98	100	100	98	100
9	100	100	100	100	100	98
10	100	100	100	98	100	100
\bar{X}	96.80	98.60	98.00	99.20	98.60	
s	2.53	2.12	2.83	1.40	1.35	

S/N = 5 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
1	95	89	89	100	86	88
2	75	75	100	88	67	96
3	93	90	100	98	90	82
4	90	90	100	93	78	82
5	100	79	79	98	79	86
6	98	88	98	90	100	82
7	83	93	80	100	85	92
8	100	93	98	90	81	84
9	88	88	100	70	84	86
10	93	91	100	93	91	86
\bar{X}	91.50	87.60	94.40	92.00	84.10	
s	7.91	5.93	8.54	8.88	8.85	

Table E-IV. Normalized discrimination of the normal hearing group in Experiment I. Final consonants. Time constants according to table I.

S/N = 60 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
1	98	94	100	98	98	100
2	98	100	100	98	100	100
3	98	98	96	98	100	100
4	85	100	96	98	96	94
5	100	100	98	94	96	100
6	100	98	100	98	100	100
7	98	100	100	94	94	100
8	98	98	100	100	100	100
9	96	100	100	100	100	100
10	100	100	100	100	100	100
\bar{X}	97.10	98.80	99.00	97.80	98.40	
s	4.43	1.93	1.70	2.20	2.27	

S/N = 5 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
1	90	100	100	88	68	80
2	91	98	100	100	81	86
3	96	83	100	93	65	92
4	92	85	100	90	69	78
5	96	100	84	89	78	90
6	100	93	81	88	81	84
7	94	79	100	96	85	94
8	95	100	100	95	75	88
9	90	100	94	90	75	96
10	95	100	98	98	80	88
\bar{X}	93.90	93.80	95.70	92.70	75.70	
s	3.18	8.32	7.24	4.35	6.55	

Table E-V. Normalized discrimination of the pathological group in Experiment I.. Complete logatoms. Time constants according to table I.

S/N = 60 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
2	93	84	84	100	95	86
3	93	100	83	100	72	58
4	74	87	90	100	71	62
6	78	78	100	89	100	18
11	76	100	97	87	79	76
75	97	95	95	68	100	74
77	52	64	100	48	60	50
\bar{x}	81.86	86.86	92.71	84.57	82.43	
s	15.61	13.04	7.16	19.80	15.97	

S/N = 5 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
2	76	80	88	100	48	50
3	80	56	100	68	64	50
4	100	82	76	88	53	34
6	67	56	100	78	67	18
11	50	93	100	79	54	56
75	100	96	83	87	79	48
77	100	78	72	44	44	36
\bar{x}	81.86	77.29	88.43	77.71	58.43	
s	19.41	15.99	11.94	17.90	12.20	

Table E-VI. Normalized discrimination of the pathological group in Experiment I. Initial consonants. Time constants according to table I.

S/N = 60 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
2	92	92	94	96	100	100
3	91	100	98	100	89	88
4	83	98	87	100	81	94
6	85	97	88	100	94	68
11	91	93	98	87	100	92
75	94	100	91	83	100	94
77	90	83	100	93	88	84
\bar{X}	89.43	94.71	93.71	94.14	93.14	
s	3.95	6.05	5.19	6.87	7.45	

S/N = 5 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
2	100	88	93	98	69	84
3	90	93	98	100	90	80
4	100	87	84	89	68	76
6	76	100	82	62	97	68
11	77	91	100	91	80	88
75	86	100	98	84	98	88
77	90	98	100	83	83	82
\bar{X}	88.43	93.86	93.57	86.71	83.57	
s	9.69	5.52	7.61	12.65	12.23	

Table E-VII. Normalized discrimination of the pathological group in Experiment I. Vowels
Time constants according to table I

S/N = 60 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
2	96	100	98	100	100	94
3	98	93	84	100	91	90
4	98	90	98	100	88	84
6	100	80	97	97	87	60
11	91	100	96	91	87	92
75	89	98	96	94	100	94
77	74	77	100	85	95	78
\bar{X}	92.29	91.14	95.57	95.29	92.57	
s	8.99	9.42	5.29	5.71	5.80	

S/N = 5 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
2	88	100	98	98	80	82
3	95	100	100	80	95	80
4	88	94	100	97	97	64
6	73	85	85	100	79	66
11	73	98	88	100	80	80
75	100	87	97	92	97	78
77	82	85	94	85	100	68
\bar{X}	85.57	92.71	94.57	93.14	89.71	
s	10.31	6.92	5.94	7.88	9.52	

Table E-VIII. Normalized discrimination of the pathological group in Experiment I. Final consonants. Time constants according to table I.

S/N = 60 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
2	98	83	81	100	90	96
3	100	92	97	92	100	72
4	85	100	97	92	97	78
6	90	66	86	62	100	58
11	87	98	100	98	91	94
75	93	89	100	82	91	90
77	76	100	92	68	84	74
\bar{X}	89.86	89.71	93.29	84.86	93.29	
s	8.19	12.20	7.34	14.83	5.94	

S/N = 5 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
2	100	97	88	100	59	68
3	90	65	100	90	65	80
4	93	93	93	100	50	60
6	100	53	77	70	43	60
11	71	83	100	74	79	84
75	100	100	81	92	78	74
77	100	93	86	66	69	58
\bar{X}	93.43	83.43	89.29	84.57	63.29	
s	10.71	17.83	8.90	14.32	13.57	

Table E-IX. Normalized discrimination of the normal hearing group in Experiment II. Complete logatoms. Time constants according to table I.

S/N = 60 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
1	96	96	100	100	98	94
2	92	96	98	98	100	100
3	94	98	100	100	100	100
4	85	83	87	100	96	92
5	92	96	96	100	100	100
6	96	100	100	94	100	100
7	92	90	96	96	100	98
8	90	98	100	98	94	100
9	94	98	100	98	96	100
10	86	98	92	100	98	98
\bar{X}	91.70	95.30	96.90	98.40	98.20	
s	3.77	5.08	4.38	2.07	2.20	

S/N = 5 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
1	80	90	70	100	80	60
2	100	78	84	72	56	64
3	97	85	100	79	58	66
4	100	75	80	100	60	40
5	97	100	82	88	68	68
6	83	93	100	96	60	60
7	71	100	94	74	71	62
8	76	90	100	93	69	58
9	89	78	100	58	58	72
10	88	100	88	81	78	64
\bar{X}	88.10	88.90	89.80	84.10	65.80	
s	10.40	9.63	10.64	13.77	8.68	

Table E-X. Normalized discrimination of the normal hearing group in Experiment II. Initial consonants. Time constants according to table I.

S/N = 60 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
1	98	100	100	100	100	100
2	96	98	100	100	100	100
3	100	100	100	100	100	100
4	98	100	96	100	100	100
5	98	100	100	100	100	100
6	100	100	100	100	100	100
7	100	96	100	100	100	100
8	100	100	100	100	100	100
9	98	100	100	100	100	100
10	100	100	100	100	100	100
\bar{X}	98.80	99.40	99.60	100	100	
s	1.40	1.35	1.26	0.0	0.0	

S/N = 5 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
1	90	94	90	100	88	96
2	100	96	96	98	89	90
3	96	96	91	100	91	90
4	100	83	77	94	77	94
5	91	100	94	89	89	94
6	86	88	100	98	90	96
7	100	100	96	100	91	90
8	91	93	100	93	91	90
9	89	96	100	89	89	94
10	96	98	89	100	96	94
\bar{X}	93.90	94.40	93.30	96.10	89.10	
s	5.15	5.34	7.07	4.51	4.79	

Table E-XI. Normalized discrimination of the normal hearing group in Experiment II. Vowels, Time constants according to table I.

S/N = 60 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
1	98	100	98	98	96	100
2	98	98	100	100	100	100
3	98	100	100	100	100	100
4	94	100	100	100	94	98
5	98	100	100	100	100	100
6	100	100	100	100	100	100
7	96	98	100	98	100	100
8	92	100	100	98	100	100
9	98	100	100	98	98	100
10	96	98	92	100	98	100
\bar{X}	96.80	99.40	99.00	99.20	98.60	
s	2.35	0.97	2.54	1.03	2.12	

S/N = 5 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
1	95	100	90	90	88	82
2	100	80	84	80	82	88
3	100	93	93	90	86	84
4	100	92	92	86	78	74
5	100	100	90	90	95	84
6	93	93	89	100	93	82
7	93	100	98	98	98	82
8	77	86	91	100	86	86
9	100	98	95	88	86	84
10	93	93	88	100	90	84
\bar{X}	95.10	93.50	91.00	92.20	88.20	
s	7.16	6.57	3.86	6.96	6.01	

Table E-XII. Normalized discrimination of the normal hearing group in Experiment II. Final consonants. Time constants according to table I.

S/N = 60 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
1	96	94	98	100	100	96
2	98	96	98	98	100	100
3	96	98	100	100	100	100
4	91	81	85	98	100	94
5	96	96	96	100	100	100
6	96	100	100	94	100	100
7	96	96	96	96	100	98
8	96	98	100	100	94	100
9	98	98	100	100	96	100
10	90	98	98	100	100	98
\bar{X}	95.30	95.50	97.10	98.60	99.00	
s	2.67	5.36	4.53	2.12	2.16	

S/N = 5 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
1	74	92	82	100	87	78
2	100	89	97	92	76	74
3	98	88	100	80	73	82
4	76	79	100	100	67	66
5	100	89	86	98	73	88
6	80	87	100	87	63	85
7	77	93	100	70	74	86
8	95	97	100	97	72	78
9	89	83	100	83	67	92
10	81	100	90	86	83	84
\bar{X}	87.00	89.70	95.50	89.30	73.50	
s	10.55	6.20	6.80	9.92	7.28	

Table E-XIII. Normalized discrimination of the pathological group in Experiment II. Complete logatoms. Time constants according to table I.

S/N = 60 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
11			100	83	100	46
12			100	93	73	88
13			100	94	75	64
14			100	92	58	24
15			85	100	95	40
17			88	100	75	16
\bar{X}			95.4	93.6	79.3	
s			7.1	6.4	15.5	

Table E-XIV. Normalized discrimination of the pathological group in Experiment II. Initial consonants. Time constants according to table I.

S/N = 60 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
11			100	91	84	88
12			100	94	92	98
13			96	100	91	92
14			80	100	74	70
15			80	100	93	88
17			83	79	100	76
\bar{X}			89.7	94.0	89.1	
s			9.9	8.3	8.9	

Table E-XV. Normalized discrimination of the pathological group in Experiment II. Vowels. Time constants according to table I.

S/N = 60 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
11			80	82	100	88
12			98	100	87	92
13			100	93	98	84
14			100	100	100	60
15			91	100	93	84
17			96	100	80	50
\bar{X}			94.0	95.8	92.9	
s			7.9	7.4	8.1	

Table E-XVI. Normalized discrimination of the pathological group in Experiment II. Final consonants. Time constants according to table I.

S/N = 60 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
11			100	83	86	72
12			100	98	90	100
13			100	100	70	80
14			100	93	80	60
15			100	100	96	56
17			88	100	64	50
\bar{X}			98.0	95.8	81.1	
s			4.9	6.6	12.3	

Table E-XVII. Normalized discrimination of the normal hearing group in Experiment III. Complete logatoms. Time constants according to Table II.

S/N = 60 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
1	94	100	83	96	96	94
2	100	100	100	98	100	94
3	94	100	98	92	94	96
4	98	100	100	92	98	98
5	96	98	96	98	100	100
6	88	98	96	98	100	98
7	98	96	100	100	100	98
8	96	96	90	100	94	98
9	87	100	100	100	96	94
10	92	98	100	98	94	98
\bar{X}	94.30	98.60	96.30	97.20	97.20	
s	4.27	1.65	5.66	3.01	2.70	

S/N = 5 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
1	74	100	88	71	56	68
2	76	85	100	50	32	68
3	100	88	97	91	38	64
4	100	75	81	-	38	64
5	77	92	100	50	48	67
6	93	67	100	47	10	60
7	100	100	63	-	59	58
8	93	100	66	24	28	58
9	100	96	78	52	48	46
10	100	77	61	65	39	62
\bar{X}	91.30	88.00	83.40	56.25	39.60	
s	11.17	11.79	15.95	19.72	14.38	

Table E-XVIII. Normalized discrimination of the normal hearing group in Experiment III. Initial consonants.
Time constants according to table II.

S/N = 60 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
1	98	100	92	100	98	98
2	100	100	100	98	100	100
3	100	100	100	100	94	100
4	100	100	100	98	100	100
5	100	100	100	100	100	100
6	98	100	100	100	100	100
7	100	100	100	100	100	100
8	100	98	98	100	100	100
9	98	100	98	100	100	100
10	98	100	100	100	98	100
\bar{X}	99.20	99.80	98.80	99.60	99.00	
s	1.03	0.63	2.53	0.84	1.94	

S/N = 5 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
1	84	98	100	84	87	90
2	98	98	100	80	72	92
3	93	100	98	91	73	92
4	100	87	96	-	64	94
5	95	100	100	89	86	88
6	96	91	100	71	58	90
7	98	100	92	-	81	84
8	80	100	83	76	63	92
9	100	98	90	85	66	82
10	98	100	86	89	68	88
\bar{X}	94.20	97.20	94.50	83.13	71.80	
s	6.84	4.52	6.38	7.00	9.98	

Table E-XIX. Normalized discrimination of the normal hearing group in Experiment III. Vowels. Time Constants according to table II.

S/N = 60 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
1	94	100	94	100	100	98
2	100	98	98	98	98	98
3	100	96	96	96	98	100
4	96	98	100	98	98	100
5	96	100	98	98	100	100
6	90	98	98	96	100	100
7	96	96	100	98	100	100
8	96	98	96	100	98	100
9	96	98	100	98	96	100
10	94	98	98	100	96	100
\bar{X}	95.80	98.00	97.80	98.20	98.40	
s	2.90	1.33	1.99	1.48	1.58	

S/N = 5 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
1	84	100	100	84	84	88
2	90	86	100	95	81	84
3	98	91	95	100	76	86
4	95	82	92	-	100	78
5	84	93	100	77	61	88
6	95	85	97	100	64	78
7	100	97	80	-	83	84
8	100	100	89	82	84	76
9	90	90	100	95	85	80
10	95	90	76	100	80	82
\bar{X}	93.10	91.40	92.90	91.63	79.80	
s	5.92	6.19	8.76	9.24	11.05	

Table E-XX. Normalized discrimination of the normal hearing group in Experiment III. Final consonants. Time constants according to table II.

S/N = 60 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
1	98	100	96	96	98	98
2	98	98	100	100	100	98
3	90	100	98	92	96	100
4	100	100	98	92	98	100
5	100	98	98	100	100	100
6	94	98	96	100	98	100
7	100	98	98	100	98	100
8	100	100	96	100	96	98
9	92	100	100	98	98	96
10	94	98	100	96	98	100
\bar{X}	96.60	99.00	98.00	97.60	98.00	
s	3.78	1.05	1.63	3.24	1.33	

S/N = 5 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
1	91	100	88	86	77	86
2	95	98	100	60	53	86
3	100	83	100	90	68	84
4	100	98	93	-	47	86
5	95	100	100	70	78	80
6	95	85	100	49	37	82
7	100	100	77	-	76	82
8	100	90	74	60	50	84
9	100	89	84	55	63	76
10	100	83	93	78	51	82
\bar{X}	97.60	92.60	90.90	68.50	60.00	
s	3.31	7.34	9.86	14.97	14.41	

Table E-XXI. Normalized discrimination of the pathological group in Experiment III. Complete logatoms.
Time constants according to table II.

S/N = 60 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
1	66	83	86	91	100	70
3	73	80	98	100	90	80
4	95	97	92	100	84	74
5	62	38	46	100	46	26
7	84	96	96	100	94	100
9	85	85	92	73	100	52
\bar{X}	77.5	79.8	85.0	94.0	85.7	
s	12.6	21.6	19.5	10.9	20.4	

S/N = 5 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
1	94	72	100	72	61	36
3	95	73	100	91	59	44
4	81	70	84	100	86	74
5	70	90	80	100	70	20
7	98	98	100	98	74	84
9	100	92	75	87	87	48
\bar{X}	89.7	82.5	89.8	91.3	72.8	
s	11.7	12.2	11.5	10.8	12.0	

Table E-XXII. Normalized discrimination of the pathological group in Experiment III. Initial consonants.
Time constants according to table II.

S/N = 60 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
1	81	100	88	98	96	96
3	90	92	98	100	98	96
4	91	96	93	96	100	92
5	93	90	85	100	90	80
7	90	100	98	100	98	100
9	100	90	95	90	100	84
\bar{X}	90.8	94.7	92.8	97.3	97.0	
s	6.1	4.7	5.3	3.9	3.7	

S/N = 5 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
1	100	81	100	97	86	74
3	98	93	100	90	88	80
4	89	89	91	98	100	94
5	92	76	95	100	82	76
7	89	91	100	94	89	94
9	90	100	95	93	88	84
\bar{X}	93.0	88.3	96.8	95.3	88.8	
s	4.8	8.6	3.8	3.7	6.0	

Table E-XXIII. Normalized discrimination of the pathological group in Experiment III. Vowels.
Time constants according to table II.

S/N = 60 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
1	88	92	92	88	100	96
3	83	96	91	91	100	92
4	98	100	96	98	91	94
5	85	44	78	100	59	54
7	94	100	98	100	98	100
9	85	100	98	95	90	80
\bar{X}	88.8	88.7	92.2	95.3	89.7	
s	5.9	22.1	7.5	5.0	15.9	

S/N = 5 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
1	75	100	100	89	83	72
3	84	76	89	100	89	76
4	83	89	93	98	100	92
5	58	100	83	83	92	48
7	88	94	98	100	94	98
9	90	90	86	90	100	84
\bar{X}	79.7	91.5	91.5	93.3	93.0	
s	11.8	8.9	6.7	7.0	6.6	

Table E-XXIV. Normalized discrimination of the pathological group in Experiment. III. Final consonants.
Time constants according to table II.

S/N = 60 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
1	80	85	100	100	93	80
3	86	84	100	98	86	98
4	100	87	87	91	85	94
5	88	91	100	81	91	64
7	92	96	96	100	98	100
9	94	91	97	86	100	70
\bar{X}	90.0	89.0	96.7	92.7	92.2	
s	6.9	4.5	5.0	8.0	6.1	

S/N = 5 dB

subject No	T ₁	T ₂	T ₃	T ₄	T ₅	Maximum absolute discrimination
1	100	97	87	90	74	62
3	95	100	89	89	61	76
4	91	80	80	100	80	90
5	100	91	91	97	75	64
7	96	94	94	100	79	94
9	100	94	88	82	91	68
\bar{X}	97.0	92.7	88.2	93.0	76.7	
s	3.7	6.7	4.7	7.2	9.8	

Figure F-1. Confusion matrix for the final consonant discrimination of the pathological group in Experiment I.

Time constant combination T_1 according to Table I.

S/N = 5 dB.

STIMULUS		LIST = 064										12 LISTS									
ANSWER \	?	B	D	G	P	T	K	H	F	S	SJ	TJ	J	V	R	M	N	NG	L	POS	
?	.	.	.	2	.	3	3	.	.	2	.	.	2	.	5	6	8	1	5	.	
	.	.	12	.	4	13	9	.	.	11	2	.	7	4	.	2	4	.	.	.	
B	.	.	2	3	.	.	.	.	.	.	.	.	.	2	.	1	.	.	1	.
D	.	11	1	22	5	1	.	.	.	.	.	.	.	1	2	.	2	1	1	.
G	.	.	1	2	23	.	.	.	.	.	.	.	2	.	.	1	7	3	.	.
P	.	1	.	.	.	21	1	.	1	.	.	.	.	.	.	.	.	.	.	.
T	.	6	.	.	.	5	81	8	.	3	.	.	2	.	.	2	1	.	.	.	
K	.	5	.	1	.	12	9	75	.	3	6	.	1	.	.	2	.	1	.	.	
H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
F	.	.	.	.	.	.	1	.	7	2	.	.	.	.	.	.	1	.	.	.
S	.	.	.	.	.	1	.	.	5	92	1	.	.	.	.	1	3	.	2	.
SJ	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	1	.	.	.
TJ	.	1	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.
J	.	1	.	.	.	1	.	.	.	1	.	.	13	.	.	.	1	1	1	.	
V	.	8	.	3	1	.	.	.	.	.	.	.	1	12	.	5	2	.	.	.
R	.	.	.	1	2	1	4	.	.	1	.	.	.	1	59	.	2	.	3	.	
M	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	7	6	1	1	.
N	.	2	.	1	.	.	.	.	.	.	.	.	.	.	.	2	22	3	.	.
NG	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	5	8	.	.
L	.	.	.	.	.	.	2	.	.	.	.	.	1	1	13	3	9	3	71	.
POS	.	.	.	5	.	5	8	.	.	9	1	.	2	.	.	.	1	.	.	.	

Figure F-2. Confusion matrix for the final consonant discrimination of the pathological group in Experiment I.
Time constant combination T_3 according to Table I.
 $S/N = 5$ dB.

STIMULUS		LIST = 072										12 LISTS									
ANSWER	?	B	D	G	P	T	K	H	F	S	SJ	TJ	J	V	R	M	N	NG	L	POS	
?	.	.	.	1	.	2	.	.	.	4	.	.	.	3	5	8	9	4	11	.	
	.	.	13	.	4	25	12	.	.	14	.	.	13	4	.	4	5	.	.	.	
B	.	.	1	5	1	.	.	.	.	.	.	.	1	1	1	.	2	.	1	.
D	.	7	1	16	3	.	.	.	.	.	.	.	1	.	.	.	3	.	1	.
G	.	.	1	8	19	.	.	.	.	.	.	.	3	.	2	.	1	.	2	.
P	.	1	.	1	.	10	7	5	2	5	.	.	.	.	.	1	.	.	.	.
T	.	20	.	2	.	10	57	25	2	18	.	.	4	.	.	1	1	1	.	.	
K	.	4	.	.	1	12	16	54	4	12	1	.	1	2	3	.	.	.	.	.
H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
F	.	.	1	.	.	4	3	.	4	12	.	.	.	.	.	.	.	.	.	.
S	.	1	.	1	.	1	3	2	1	49	.	.	.	.	.	.	1	.	1	.
SJ	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
TJ	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.
J	.	.	.	.	.	.	1	.	.	1	.	.	6	.	.	.	2	.	.	.
V	.	9	.	1	1	.	.	.	.	.	.	.	.	10	.	1	1	.	.	.
R	.	.	.	1	4	2	3	5	.	1	.	.	1	.	58	.	2	.	1	.	
M	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	7	11	3	.	.
N	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	9	30	3	.	.
NG	.	.	.	.	.	.	.	.	.	.	.	.	.	.	7	2	3	10	1	.
L	.	.	.	.	.	1	.	.	.	1	.	.	.	.	.	1	7	1	69	.
POS	.	.	.	4	.	2	15	9	.	3	.	.	1	.	.	.	.	.	.	.

Figure F-3. Confusion matrix for the final consonant discrimination of the normal hearing group in Experiment II. Time constant combination T_1 according to Table I. $S/N = 5$ dB.

STIMULUS		LIST = 064										10 LISTS									
ANSWER \	?	B	D	G	P	T	K	H	F	S	SJ	TJ	J	V	R	M	N	NG	L	POS	
?	
	.	.	5	.	.	2	7	.	.	4	.	.	2	4	1	4	2	.	2	.	
B	.	1	2	1	1	.	.	.	.	.	.	.	.	2	.	1	1	.	1	.
D	.	6	.	28	1	.	.	.	.	.	.	.	.	.	.	.	4	.	1	.
G	.	1	.	2	22	.	.	.	.	.	.	.	.	.	.	1	3	1	4	.
P	.	.	.	.	28	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
T	.	8	.	1	.	89	1	.	.	.	.	.	.	.	.	1	1	.	.	.
K	.	5	.	.	.	3	1	71	.	.	.	.	.	.	.	.	.	1	.	.
H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
F	.	.	.	.	1	4	.	1	.	8	1	.	.	2	.	1	1	.	.	.
S	.	1	.	.	.	.	.	.	4	92	.	.	.	.	.	1	.	.	1	.
SJ	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
TJ	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.
J	.	3	.	.	.	.	1	.	.	.	.	.	19	.	1	1	.	.	1	.
V	.	12	2	1	.	.	.	.	.	.	.	.	1	8	.	2	3	.	2	.
R	.	.	.	.	.	1	4	.	.	.	.	.	.	.	58	1	1	.	1	.
M	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	9	8	2	2	.
N	.	.	.	1	.	2	.	.	.	.	.	.	.	.	.	8	29	4	3	.
NG	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	3	9	.	.
L	.	1	.	1	.	.	.	.	.	.	.	.	2	1	7	2	4	2	53	.
POS	.	.	.	3	.	6	6	.	.	4	.	.	.	.	.	1	1	.	.	.

Figure F-4. Confusion matrix for the final consonant discrimination of the normal hearing group in Experiment II. Time constant combination T_5 according to Table I. $S/N = 5$ dB.

STIMULUS		LIST = 072										10 LISTS									
ANSWER \	?	B	D	G	P	T	K	H	F	S	SJ	TJ	J	V	R	M	N	NG	L	POS	
?	
B	.	1	.	3	4	.	.	.	.	3	.	.	5	4	.	3	3	.	1	.
D	.	9	1	26	3	1	.	.	.	.	.	.	1	3	1	.	1	.	.	.
G	.	.	1	5	14	.	.	.	.	.	.	.	1	1	.	.	1	.	1	.
P	.	.	.	.	14	.	5	.	2	.	.	.	1	.	.	1	.	.	.	.
T	.	13	.	.	5	72	8	.	.	1	.	.	.	.	1	1	1	.	.	.
K	.	4	.	.	1	12	11	60	.	2	1	.	.	.	3	.	1	1	.	.	
H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
F	.	.	.	.	2	1	4	.	7	7	1	.	.	.	.	.	.	.	.	.
S	.	3	.	.	.	1	.	.	1	85	.	.	.	.	.	.	.	.	.	.
SJ	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
TJ	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.
J	.	5	.	.	.	1	.	.	.	.	.	.	13	.	.	.	.	2	1	.
V	.	6	1	3	2	1	.	.	.	.	.	.	1	7	1	.	3	.	.	.
R	.	.	.	1	.	.	2	.	.	.	.	.	.	.	57	.	2	.	2	.
M	.	1	.	1	.	.	.	.	.	.	.	.	.	.	.	12	9	5	2	.
N	.	1	1	.	1	.	.	.	.	.	.	.	.	1	.	12	36	5	.	.
NG	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1	3	6	.	.
L	.	.	.	1	.	.	.	.	.	.	.	.	1	1	3	2	.	.	64	.
POS	.	.	.	2	.	4	3	.	.	5	.	.	.	.	.	.	1	1	.	.

Figure F-6. Confusion matrix for the final consonant discrimination of the pathological group in Experiment II. Time constant combination T_5 according to Table I.
 $S/N = 60$ dB.

STIMULUS		LIST = 064										7 LISTS									
ANSWER \	?	B	D	G	P	T	K	H	F	S	SJ	TJ	J	V	R	M	N	NG	L	POS	
?	
	.	.	4	.	2	12	8	.	.	4	.	.	4	1	1	.	6	1	1	.	
B	.	2	1	5	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.
D	.	2	1	15	3	.	.	.	.	.	.	.	.	.	1	.	.	.	2	.
G	.	.	.	2	12	.	1	.	.	.	.	.	.	1	1	.	1	.	.	.
P	.	.	.	.	.	13	8	.	1	.	.	.	.	.	.	.	.	.	.	.
T	.	.	4	.	4	36	3	.	2	8	.	.	.	.	2	.	2	.	.	.
K	.	3	.	.	4	12	47	.	3	5	.	.	1	.	.	1	.	3	.	.	
H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
F	.	.	.	.	.	.	.	.	1	6	.	.	.	.	.	.	.	.	.	.
S	.	1	.	.	.	1	.	.	.	48	.	.	.	.	.	.	.	.	.	.
SJ	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
TJ	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
J	.	1	.	.	.	.	1	.	.	.	.	.	10	1	.	.	.	.	1	.
V	.	7	.	1	.	.	.	.	.	.	.	.	.	8	1	4	4	.	.	.
R	.	.	.	1	.	.	2	.	.	.	.	.	.	1	32	.	1	.	2	.
M	.	.	1	.	.	.	.	.	.	.	.	.	.	.	2	7	6	.	.	.
N	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1	16	2	1	.
NG	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	4	7	1	.
L	.	.	.	.	.	.	.	.	.	.	.	.	1	.	4	3	5	1	42	.
POS	.	.	1	4	.	7	9	.	.	2	.	.	.	1	.	.	1	.	.	.	