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The Effect of Impulse Presentation Order on Hearing Trauma in the Chinchilla

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September 1991

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91-16807



91 11 29 058

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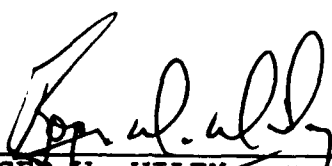
Animal use

In conducting the research described in this report, the investigators adhered to the Guide for care and use of laboratory animals, as promulgated by the Committee on Care and Use of Laboratory Animals of the Institute of Laboratory Resources Commission on Life Sciences, National Academy of Sciences-National Research Council.

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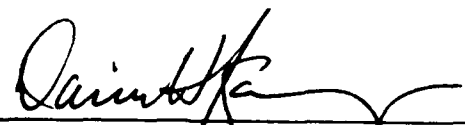


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REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED		1b. RESTRICTIVE MARKINGS			
2a. SECURITY CLASSIFICATION AUTHORITY		3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited			
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE					
4. PERFORMING ORGANIZATION REPORT NUMBER(S) USAARL Report No. 91-21		5. MONITORING ORGANIZATION REPORT NUMBER(S) U.S. Army Medical Research and Development Command			
6a. NAME OF PERFORMING ORGANIZATION Sensory Research Division U.S. Army Aeromed Rsch Lab	6b. OFFICE SYMBOL (if applicable) SGRD-UAS-AS	7a. NAME OF MONITORING ORGANIZATION			
6c. ADDRESS (City, State, and ZIP Code) P.O. Box 577 Fort Rucker, AL 36362-5292		7b. ADDRESS (City, State, and ZIP Code) Fort Detrick Frederick, MD 21701-5012			
8a. NAME OF FUNDING/SPONSORING ORGANIZATION	8b. OFFICE SYMBOL (if applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER Partial effort under contract #DAMD17-86-C-6139			
8c. ADDRESS (City, State, and ZIP Code)		10. SOURCE OF FUNDING NUMBERS			
		PROGRAM ELEMENT NO. 62777A 0601102	PROJECT NO. 3E162777A87B 3M161102BS15	TASK NO.	WORK UNIT ACCESSION NO. 157 282
11. TITLE (Include Security Classification) The effect of impulse presentation order on hearing trauma in the chinchilla					
12. PERSONAL AUTHOR(S) James H. Patterson, Jr., Dennis L. Curd, Ilija Lomba Gautier, Roger P. Hamernik, William A. Ahroon, George A. Turrentine, and C.E. Hargett, Jr.					
13a. TYPE OF REPORT		13b. TIME COVERED FROM _____ TO _____		14. DATE OF REPORT (Year, Month, Day) 1991 September	15. PAGE COUNT 58
16. SUPPLEMENTARY NOTATION					
17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)		
FIELD	GROUP	SUB-GROUP	Impulse noise, hearing, chinchilla, audiometry		
20	01				
19. ABSTRACT (Continue on reverse if necessary and identify by block number) Existing criteria for exposure to impulse noise do not provide any explicit means for evaluating exposures for which the peak SPL of the impulses varies in any given exposure day. Approaches to evaluating such exposures have included the application of a "proportional dose" method such as used with continuous noise or the use of an average level. Implicit in these approaches is the assumption that the order in which a sequence of variable intensity impulses is presented is not important. This same assumption is also implicit in any energy-based exposure criteria. This report presents the results of a pilot experiment designed to test the validity of this assumption. Two groups of chinchillas were exposed to a sequence of 100 impulses. One group received 90 exposures at 138-dB peak SPL impulses followed by 10 exposures at 146-dB peak SPL impulses; the second group received the same series of impulses but in reverse order. The results from these two groups were compared to the results of 100 exposures at 147-dB peak SPL impulses from a report by Patterson et al., (1986). CONTINUED ON BACK					
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT <input type="checkbox"/> UNCLASSIFIED/UNLIMITED <input type="checkbox"/> SAME AS RPT. <input type="checkbox"/> DTIC USERS			21. ABSTRACT SECURITY CLASSIFICATION		
22a. NAME OF RESPONSIBLE INDIVIDUAL Chief, Scientific Information Center		22b. TELEPHONE (Include Area Code) (205) 255-6907		22c. OFFICE SYMBOL SGRD-UAX-SI	

19. ABSTRACT CONTINUED

The 139-dB peak SPL exposure had the same total energy as the two variable intensity exposures. The results of the three equivalent energy exposures showed that exposures having equal energies could produce statistically different levels of hearing trauma. However, while the mean data were very suggestive in showing an effect of the presentation order, this result did not hold up to statistical analysis because of a large intersubject variability.

Acknowledgment

This research was partially completed with the Auditory Research Laboratory, State University of New York at Plattsburgh, under Contract #DAMD17-86-C-6139, dated 3 February 1986.

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DTIC Tab	<input type="checkbox"/>
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Introduction

The Committee on Hearing, Bioacoustics and Biomechanics (CHABA) of the National Academy of Sciences (1968), issued its "Proposed damage risk criterion for impulse noise (gunfire)." This criterion defines an acceptable exposure for 100 impulses per day and provides a trading rule which allows the derivation of exposure limits for exposures other than 100 impulses per day. There is an implicit assumption in this approach that the intensity of all the impulses is the same. There is no explicit procedure for estimating the hazard when a daily exposure consists of impulses whose peak sound pressure level (SPL) varies during the course of the day. The CHABA document has served as the basis for our current military exposure limits, MIL-STD-1474(C) (1979). This military document has no explicit way of treating exposures to different intensities within the same day. Analogous with the procedures used to evaluate steady state noise exposures, the U.S. Army has adopted a "proportional dose" procedure. For each intensity, an allowable number of rounds is calculated. An exposure is considered acceptable, if the sum of the fractions resulting from dividing the actual number of rounds by the allowable number of rounds is less than one.

Unpublished data collected during the developmental testing of some weapons shows a bimodal distribution of intensities in which about 10 percent of the rounds are 8 to 10 dB higher than the others. There have been suggestions made that the hazard of these weapons should be estimated by computing an average level. There is no data available from exposures to variable intensities to support such an approach. Other approaches to the evaluation of variable intensity exposures can be based upon equal energy considerations. However, if one accepts that an equal energy based measure of an impulse noise exposure can be related directly to the hazards associated with that exposure, then the order in which a series of higher and lower peak SPL impulses is presented should not be important in the final trauma to the auditory system.

The study reported here was undertaken to provide an initial set of data relevant to some of the above issues. Specifically, two groups of chinchillas were exposed to 100 impulses. One group was subjected to 90 exposures, 139-dB peak SPL impulses followed by 10 more at 146-dB SPL. The second group was given the same exposure but in the reverse order. The effect of these two equal energy exposure conditions on the auditory system was evaluated in terms of threshold shift (TS), permanent threshold shift (PTS) and sensory cell loss.

Methods and procedures

The methods and experimental paradigm were identical to those presented in Patterson et al., (1986) and thus will not be repeated in detail here. Basically, an avoidance conditioning paradigm was used to obtain pre- and postexposure threshold measurements at 10 audiometric test frequencies between 0.125 and 8 kHz. Thresholds were followed after exposure at regular intervals over a period of 30 days, at which time the animals were euthanatized for surface preparation histology. Each animal was individually exposed at a normal angle of incidence to one of the two exposure conditions identified as H/L or L/H in Table 1. The exposures consisted of the presentation of 100 impulses at the rate of one per 3 seconds. Each experimental group consisted of six animals. The impulses were presented to two different groups of animals in two different orders. The first group was exposed to 90 impulses with a 138-dB peak SPL followed by 10 impulses with a 146-dB peak SPL, the L/H group. The second group received the 10 at 146-dB peak SPL impulses first, followed by the 90 at 138-dB peak SPL, the H/L group. Comparison between these two exposures conditions will be made in terms of the amount of threshold shift, permanent threshold shift, and sensory cell loss produced. Upper and lower bounds for the expected TS, PTS, and cell loss were established using the results from Patterson et al., (1986) where animals were exposed to 100 similar impulses but at 147-dB peak SPL (Reference group I) or 139-dB peak SPL (Reference group II). A comparison of the various energies of the exposure conditions from the Patterson et al., (1986) reference conditions, as well as, the H/L and L/H exposure conditions is presented in Table 1. All the impulses were similar in the pressure-time (p-t) plane. The impulses were computer generated (Patterson et al., 1986). The p-t history and energy spectra of the type of impulse used is shown in Figure 1. From the pressure-time history of the impulsive stimulus, the integral of pressure squared over time shown in Table 1 was computed to obtain the total sound exposure level (SEL) re: 20 Pa sec for each exposure condition (Young, 1970).

Results and discussion

The mean preexposure audiogram for the 12 animals used in these experiments along with the normative data of Miller (1970) is shown in Figure 2. The group mean thresholds for the two groups are shown in Table 2. A two-way analysis of variance showed that there was no statistically significant difference in the preexposure thresholds between the two groups ($F = 0.32$, $df = 1/10$), nor was there a statistically significant interaction between the main effects of group and

frequency ($F = 1.50$, $df = 9/90$, $p < .05$) which was expected given our knowledge of the chinchilla audiogram (Fay, 1988). For each animal, threshold shifts were computed by subtracting that animal's preexposure threshold from the postexposure threshold at each audiometric test frequency. The audiometric and histological effects of each exposure were documented as follows:

(1) The mean threshold shift recovery functions over a 30-day period for each group and each test frequency (Figures 3 through 12).

(2) The maximum TS (TS_{max}) for each group and for each test frequency (Figure 13).

(3) The permanent threshold shift (PTS) for each group and for each test frequency (Figure 14).

(4) The group mean outer and inner hair cell loss (OHC and IHC) within octave band lengths of the basilar membrane at the indicated frequencies (Figure 15).

In Figures 3 through 15, bars represent the standard error of the mean. If no bar is present, the standard error was less than the size of the symbol. All the individual animal data and group mean data summaries can be found in the Appendix.

From the mean recovery curves shown in Figures 3 through 12, the general impression is that the low peak followed by the high peak sequence of impulses (L/H) produced the greater threshold shift over the entire 30-day recovery period. For the most part, the two sets of recovery functions for groups L/H and H/L are approximately parallel to each other over the 30-day course of recovery. A statistical analysis of the recovery functions was not performed to establish whether or not the apparent differences in the recovery functions are in fact statistically significant. Instead, attention will be focused on the TS_{max} variable which is a good index of the acute effect of an exposure (Hamernik et al., 1988), and on the permanent effects quantified by PTS and sensory cell loss.

The experiment was designed to probe at two issues; (1) to what extent do equal energy exposure conditions produce equivalent changes in the independent variables? and (2) to what extent does the order of impulse presentation (which does not affect the total energy of an exposure) affect the dependent variables? A graphical comparison among the experimental groups for the mean TS_{max} , PTS and sensory cell loss variables is shown in Figures 13, 14, and 15 respectively. The number of impulses and the peak levels in the L/H and H/L groups were chosen so that the mean peak level and the total

SEL would be approximately the same as the Reference II group. Thus, the Reference II group would serve as another equivalent energy exposure condition and as a lower bound to what would be expected from the L/H and H/L group. The Reference I exposure condition with 7 dB greater total energy serves as an upper bound for the expected trauma.

The data in Figures 13 to 15 was first subjected to a two-way analyses of variance with repeated measures on one factor (frequency). Each analysis included the L/H, H/L, and Ref. II groups (The 2.8 kHz test frequency was not collected in the Patterson et al., (1986) study and therefore was excluded from this analysis). The summary table for this analysis is presented in Table 3. The main effect of exposure was not statistically significant for any of the four analyses. However, the interaction of exposure and frequency was significant for both audiometric measures (TS_{max}): $F = 1.87$, $df = 16/120$, $p < .05$; PTS: $F = 2.04$, $df = 16/120$, $p < .05$), indicating there was a significant effect of the noise exposure on maximum threshold shift and PTS and that this effect was dependent upon the test frequency at which the dependent variable was measured. The same was not true for the histological variables where neither the main effect of exposure nor the interaction of exposure and frequency was statistically significant. The main effect of frequency was statistically significant for all four analyses indicating the effect of the exposure differed across the audiometric test frequency and place on the basilar membrane. Thus, although the three exposure groups had the same total energy there were frequency specific differences among the dependent variables used to quantify the results of the exposure.

A posthoc analysis of differences in audiometric variables between the L/H and H/L groups in Figures 13 to 15 was performed using the Student-t distribution. There were statistically significant differences between the two groups for both audiometric variables at the 0.125 kHz test frequency (TS_{max}): $t = -2.47$, $df = 10$, $p < .05$; PTS: $t = -2.84$, $df = 10$, $p < .05$). There was also a significant difference in TS_{max} measured at the 2.8 kHz test frequency ($t = -2.60$, $df = 10$, $p < .05$) and in PTS at the 1.4 kHz test frequency ($t = -2.24$, $df = 10$, $p < .05$). All other analyses among these groups were not statistically significant, although many approached significance at the 0.05 level.

In order to determine if the sequence in which a series of variable intensity impulses is presented is important, two-factor analyses of variance with repeated measures on one factor (frequency) were performed on TS_{max} , PTS, and inner and outer hair cell losses using only the groups L/H and H/L. The results are summarized in Table 4. The main effect of the

Table 1

A listing of the experimental and reference groups and their respective exposure parameters.

Group Identification	Peak (dB SPL)	# of Impulses	Energy (J/m ²)	Total Energy (J/m ²)	Total SEL (dB)
Upper Bound (Ref. I)*	147	100	0.095	9.50	130
Lower bound (Ref. II)*	139	100	0.015	1.50	122
High level (H)	146	10	0.075	0.75	119
Low level (L)	138	90	0.012	1.08	120
High/low level (H/L)	146/138	10/90	-	1.83	123
Low/high level (L/H)	138/146	90/10	-	1.83	123

* Ref. I and Ref. II data are taken from Patterson et al. (1986)

Table 2

Preexposure Threshold Means (dB) and Standard Deviations for all Groups Compared to Published Norms

Group	N	Test Frequency (Hz)										
		125	250	500	1000	1400	2000	2800	4000	5700	8000	
H/L	6	24.1	7.1	0.2	0.7	0.1	2.0	3.1	1.0	1.5	4.0	\bar{X}
		2.5	3.2	1.7	2.2	3.4	1.6	3.7	1.8	1.1	3.2	s
L/H	6	24.8	5.3	2.5	1.3	1.0	3.2	0.7	2.5	2.3	5.5	\bar{X}
		1.9	3.4	2.1	1.4	3.2	2.1	2.1	2.1	2.6	3.5	s
Total	12	24.5	6.2	1.4	1.0	0.5	2.6	1.9	1.8	1.9	4.8	\bar{X}
		2.2	3.3	2.2	1.8	3.2	1.9	3.1	2.0	1.9	3.3	s
Miller (1970)	36	19.9	8.8	5.1	3.0	2.2	2.7	-0.2	1.9	1.9	5.8	\bar{X}
		5.4	3.9	6.1	4.1	6.6	4.7	4.9	7.1	6.7	5.4	s
		36	36	36	36	34	36	35	36	35	36	N

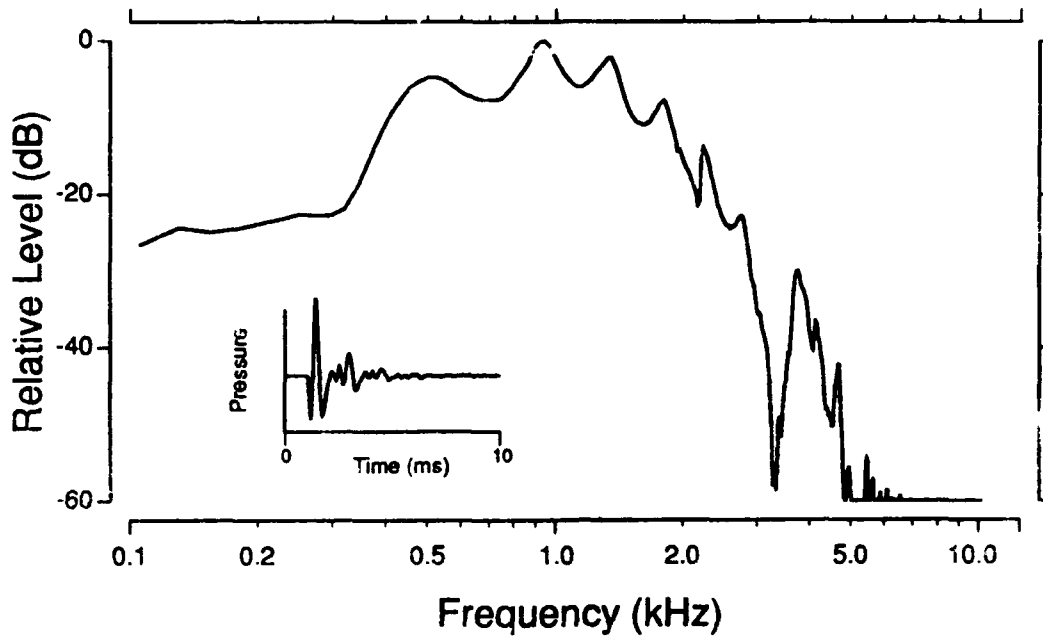


Figure 1. Amplitude spectrum and pressure-time waveform for the 146 dB peak SPL impulse.

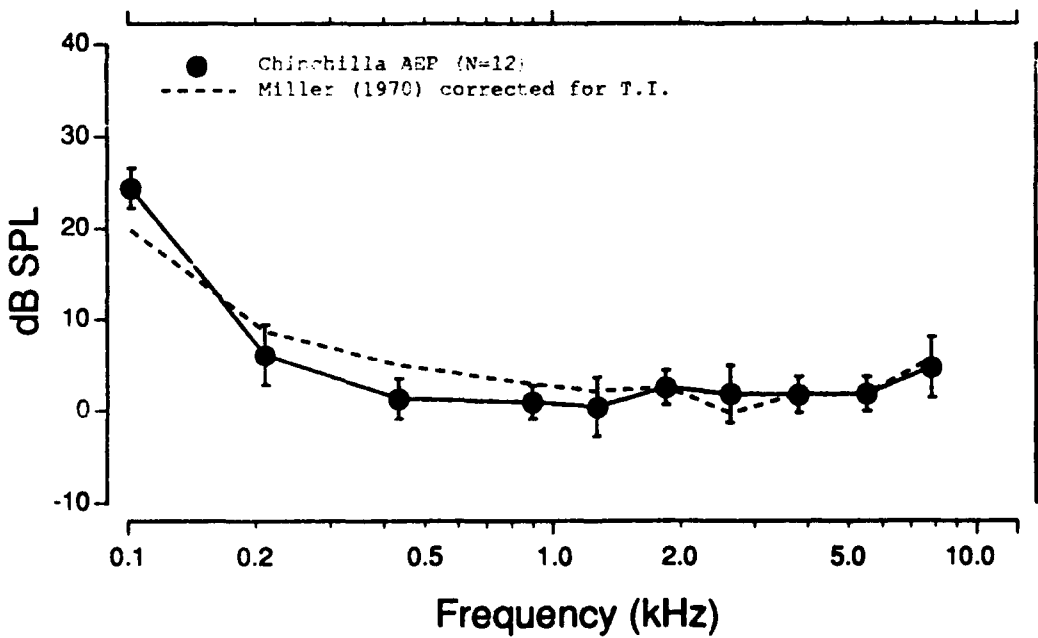


Figure 2. Mean preexposure thresholds for 12 chinchillas.

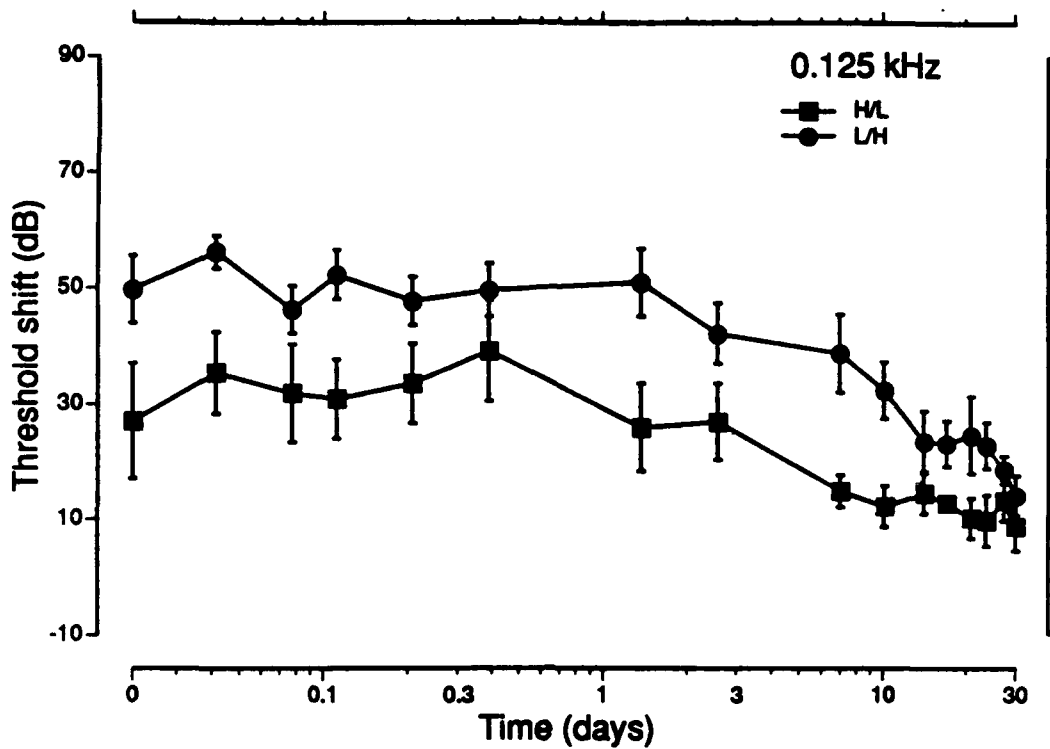


Figure 3. The group mean threshold recovery curves for each exposure condition at the 0.125 kHz test frequency

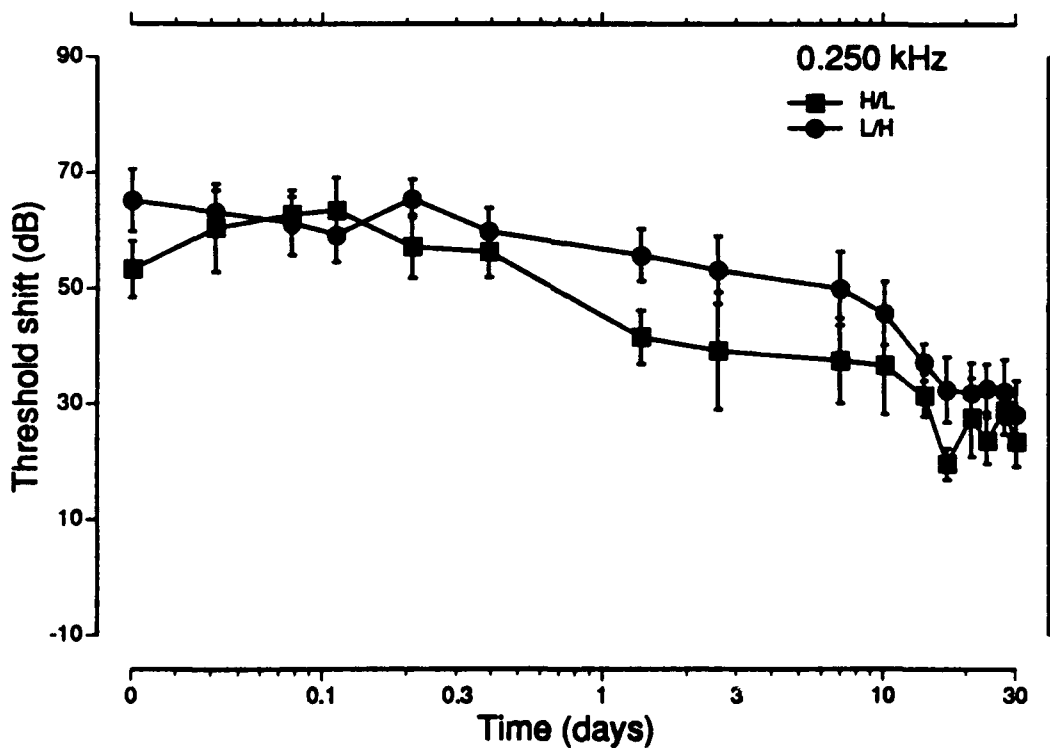


Figure 4. The group mean threshold recovery curves for each exposure condition at the 0.25 kHz test frequency

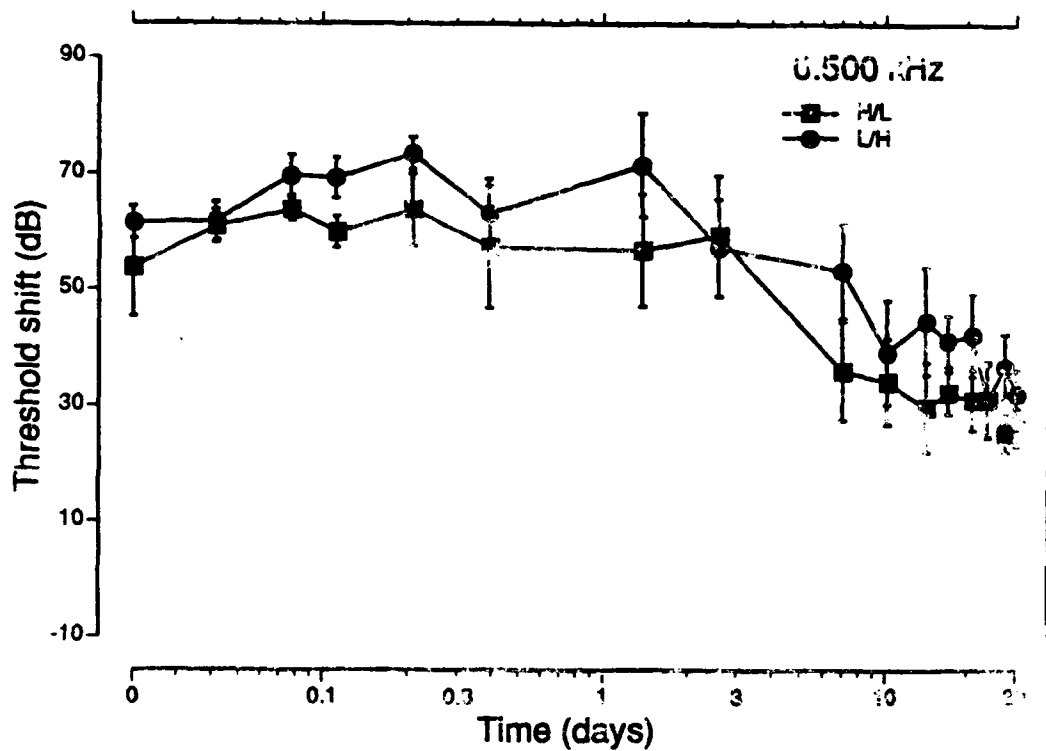


Figure 5. The group mean threshold recovery curves for each exposure condition at the 0.5 kHz test frequency

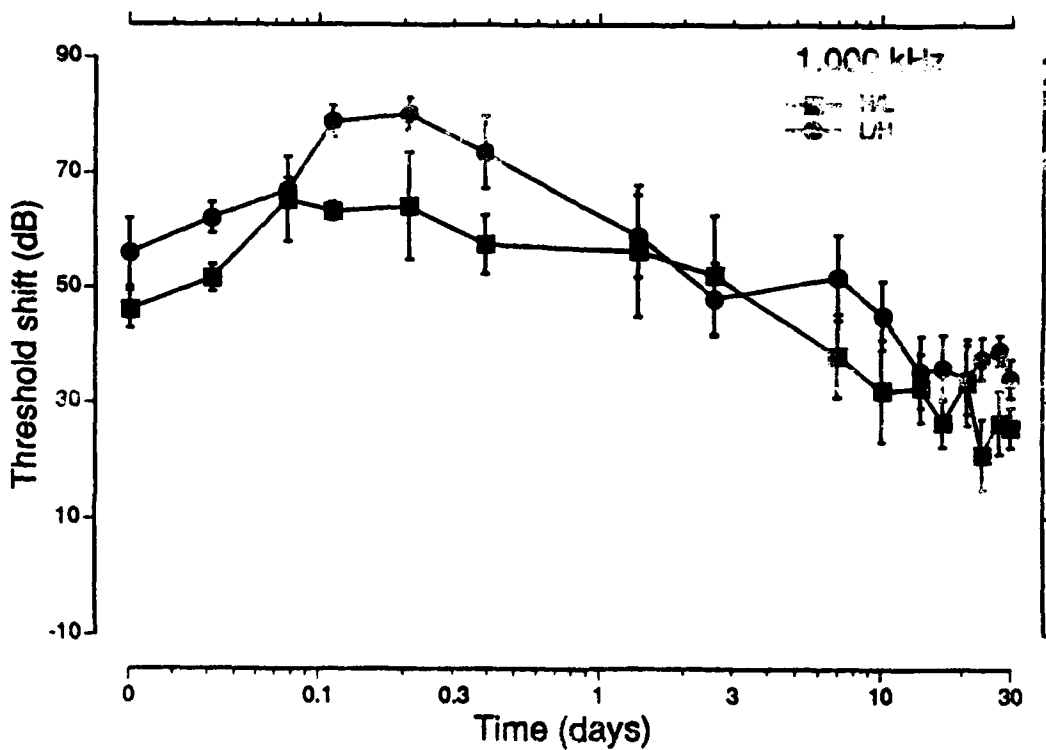


Figure 6. The group mean threshold recovery curves for each exposure condition at the 1.0 kHz test frequency

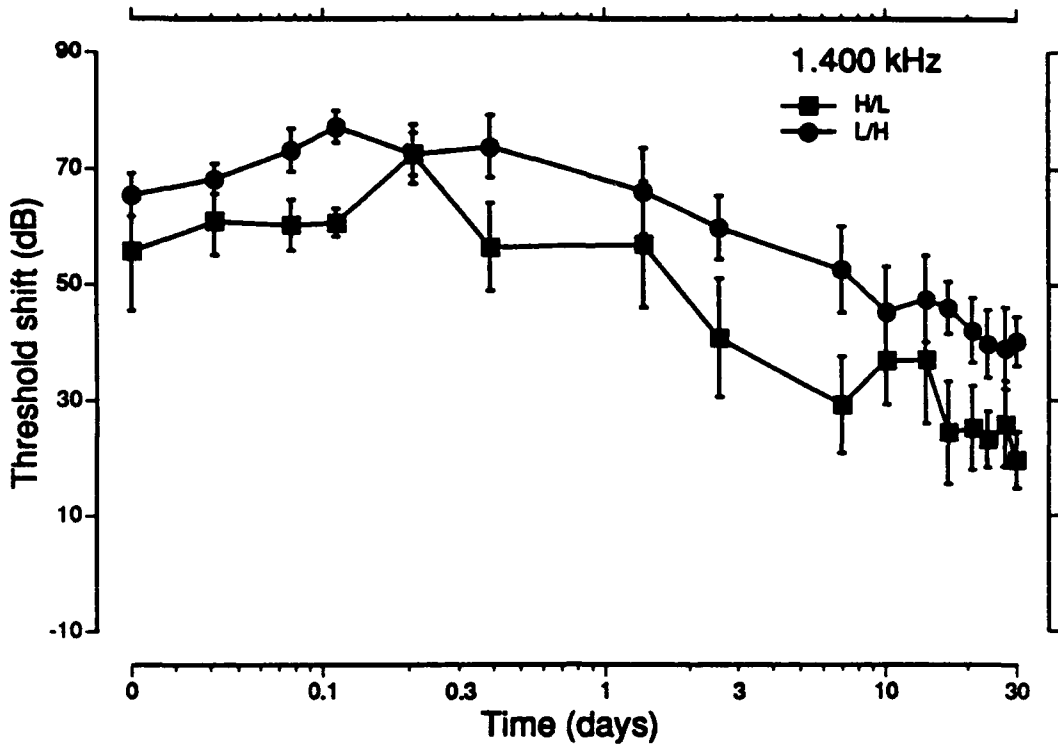


Figure 7. The group mean threshold recovery curves for each exposure condition at the 1.4 kHz test frequency

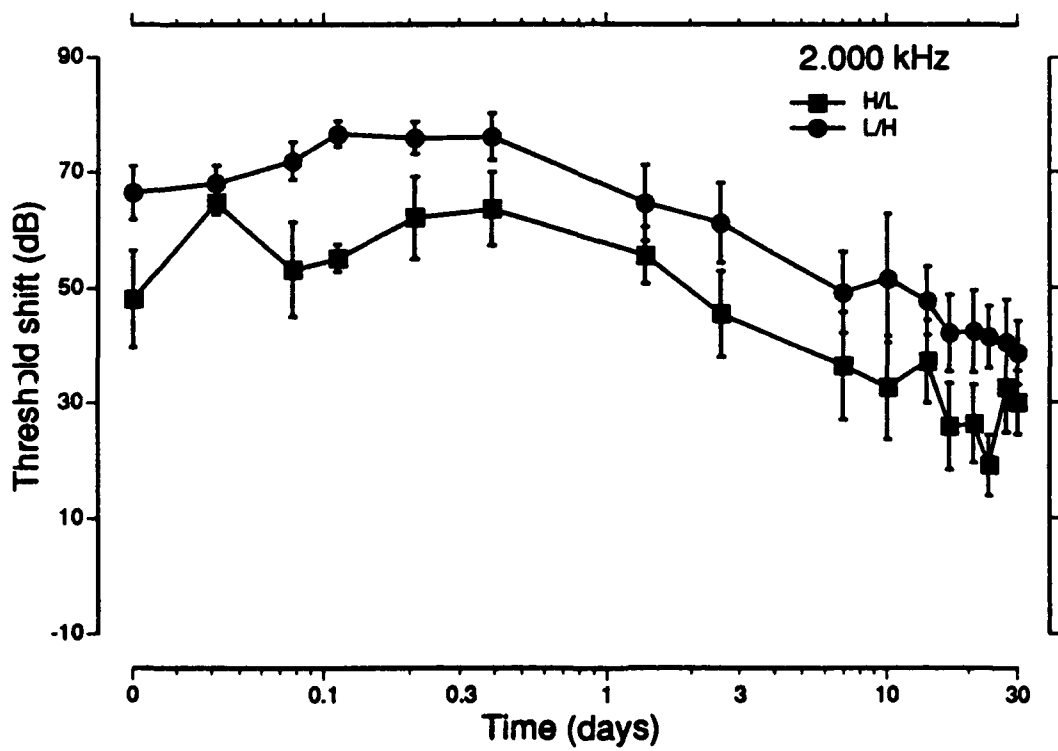


Figure 8. The group mean threshold recovery curves for each exposure condition at the 2.0 kHz test frequency

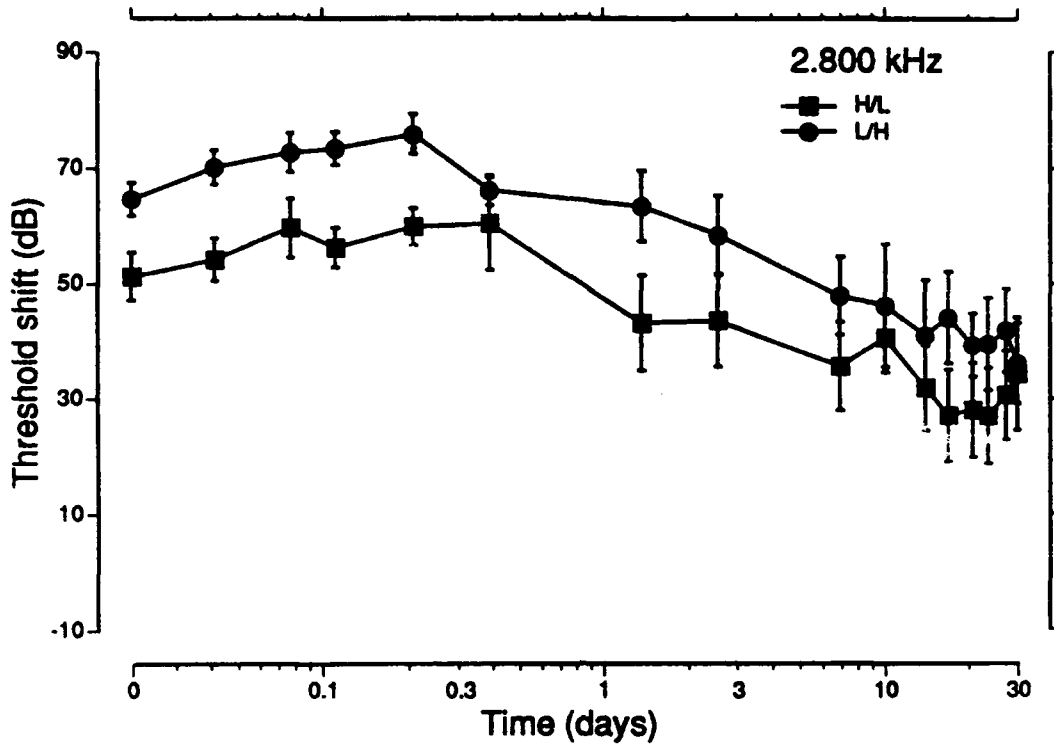


Figure 9. The group mean threshold recovery curves for each exposure condition at the 2.8 kHz test frequency

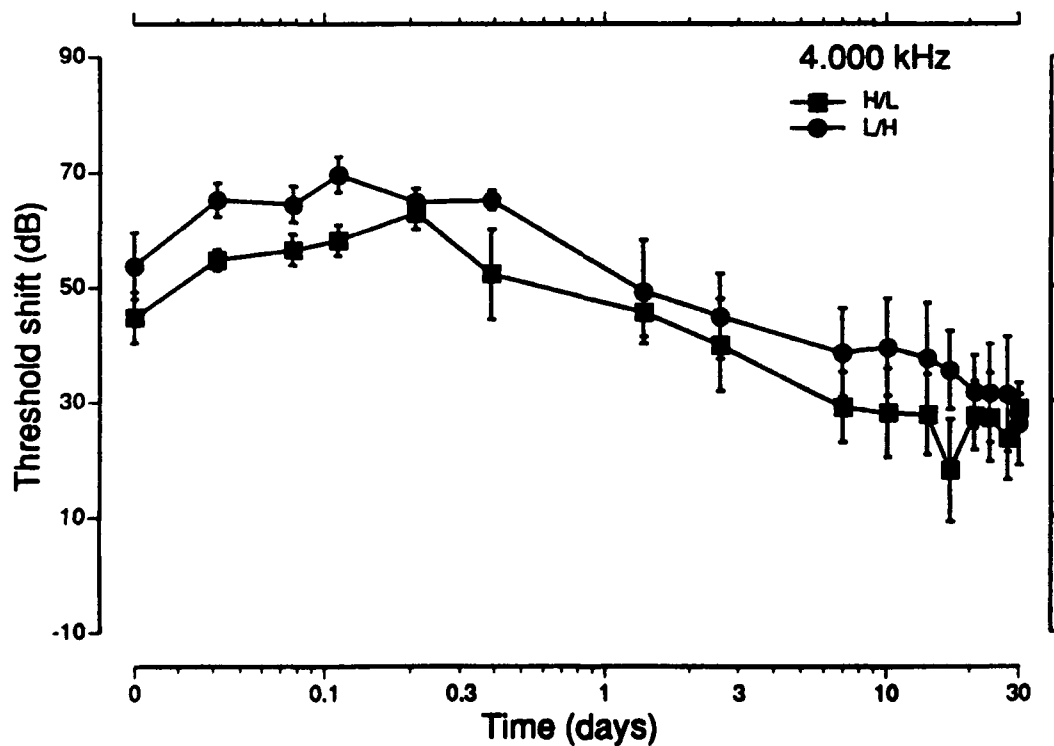


Figure 10. The group mean threshold recovery curves for each exposure condition at the 4.0 kHz test frequency

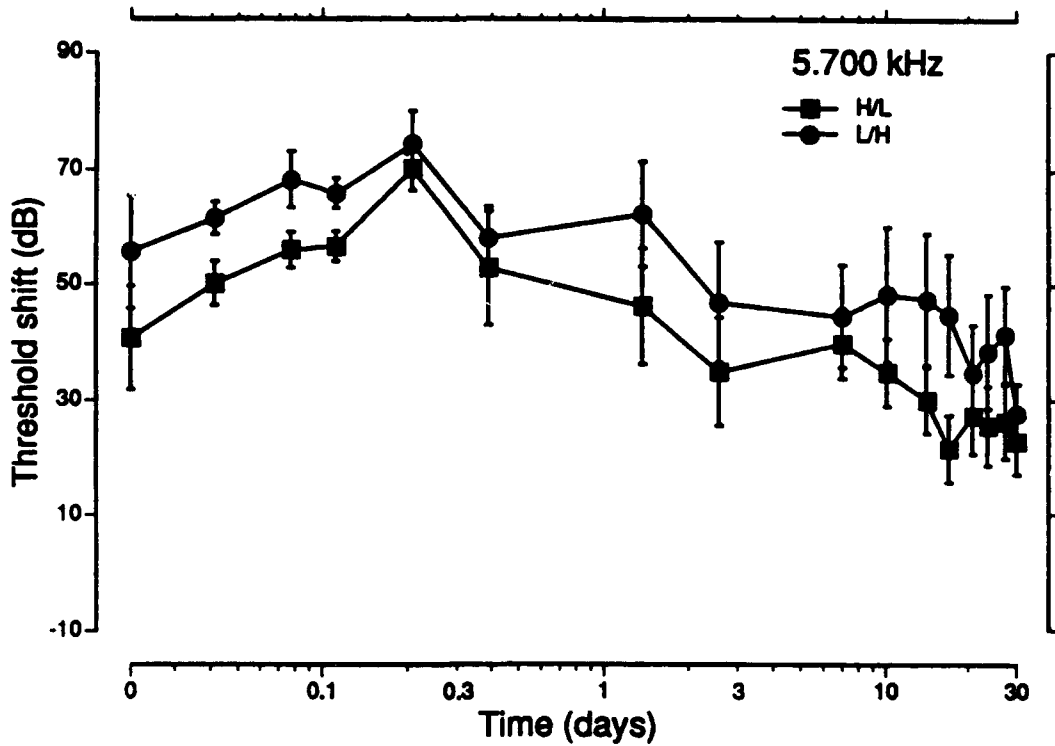


Figure 11. The group mean threshold recovery curves for each exposure condition at the 5.7 kHz test frequency

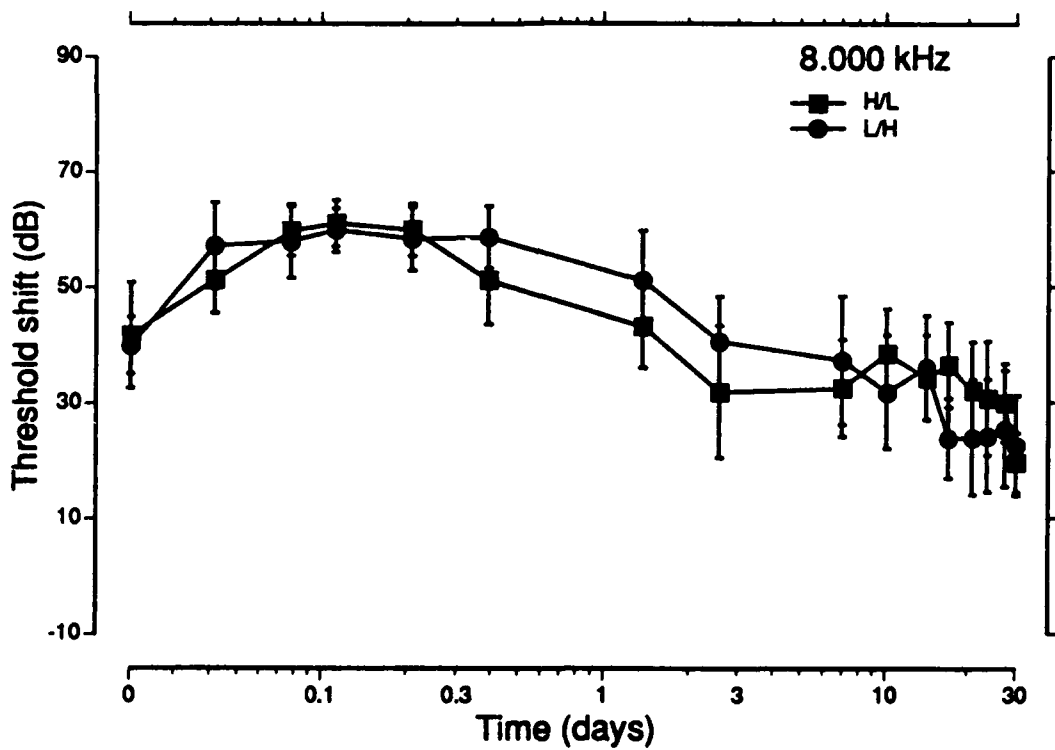


Figure 12. The group mean threshold recovery curves for each exposure condition at the 8.0 kHz test frequency

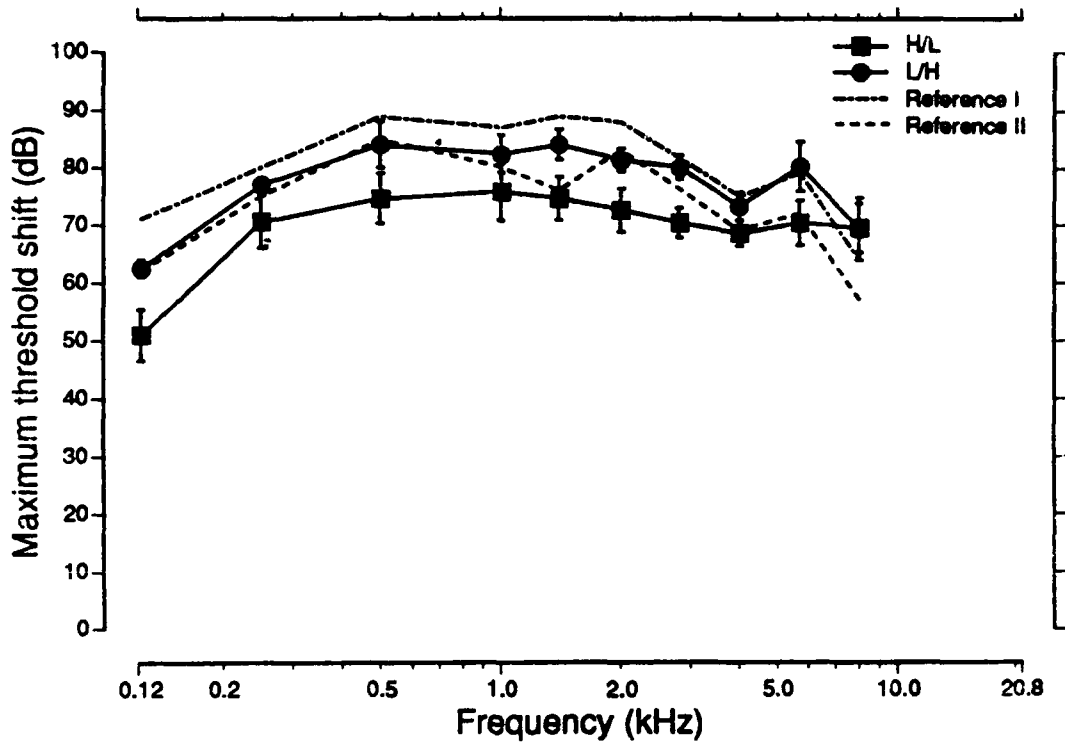


Figure 13. The postexposure group mean maximum threshold shift (TS_{max}) for each of the experimental groups at each test frequency

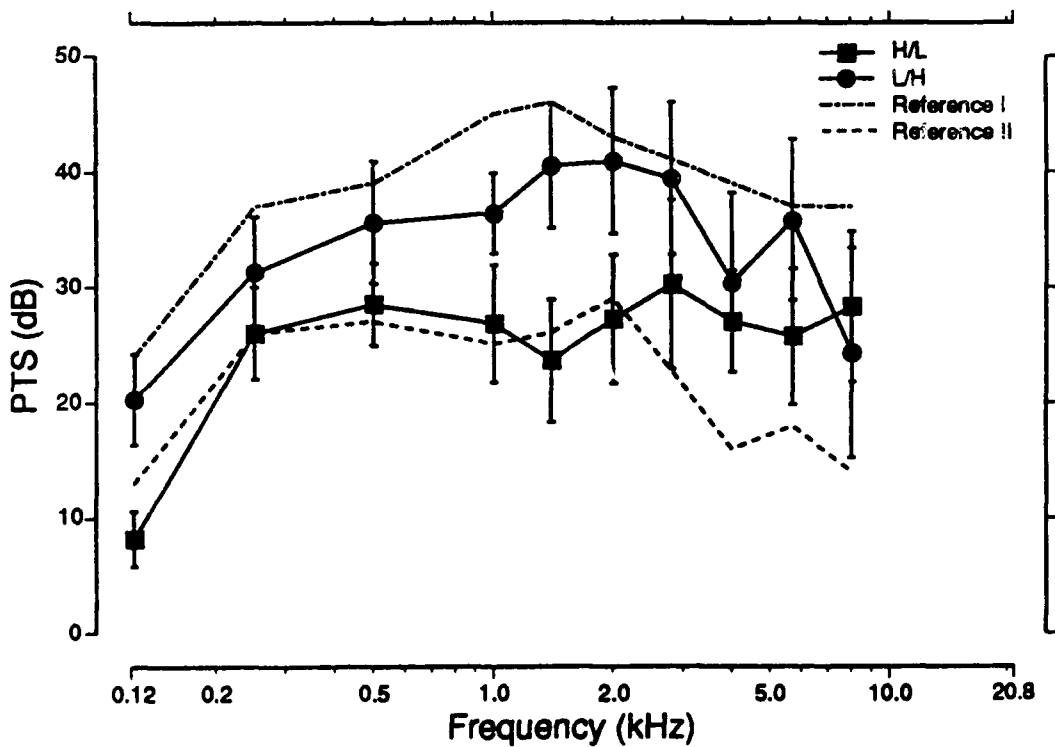


Figure 14. The group mean permanent threshold shift at each test frequency for each exposure condition

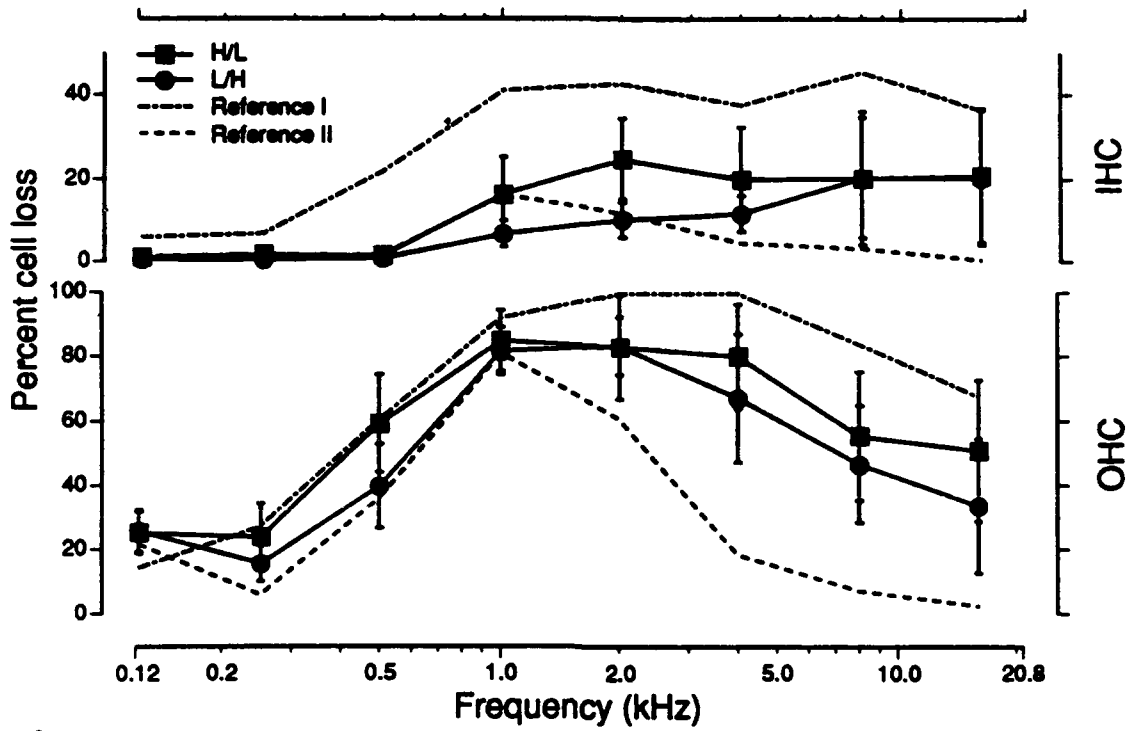


Figure 15. The group mean inner and outer hair cell losses computed over octave band lengths of the cochlea at the given frequencies for each of the experimental groups

Table 3

Analysis of Variance Summary Table for Equal Energy Groups

Maximum Threshold Shift

Source of Variation	SS	df	MS	F	F
Exposure	1489.27	2	744.64	1.56	.243
Between Subjects	7163.13	15	477.54		
Frequency	8159.01	8	1019.88	20.99	.000
Exposure x Frequency	1455.17	16	90.95	1.87	.030
Within Subjects	5830.70	120	48.59		

Permanent Threshold Shift

Source of Variation	SS	df	MS	F	p
Exposure	3745.29	2	1872.64	1.85	.192
Between Subjects	15191.06	15	1012.74		
Frequency	4492.21	8	561.53	11.64	.000
Exposure x Frequency	1573.28	16	98.33	2.04	.016
Within Subjects	5789.91	120	48.25		

Percent Inner Hair Cell Loss

Source of Variation	SS	df	MS	F	p
Exposure	1650.59	2	825.29	.77	.481
Between Subjects	16111.23	15	1074.08		
Frequency	5480.32	7	782.90	2.97	.007
Exposure x Frequency	3239.62	14	231.40	.88	.584
Within Subjects	27655.14	105	263.38		

Percent Outer Hair Cell Loss

Source of Variation	SS	df	MS	F	p
Exposure	21062.04	2	10531.02	2.67	.102
Between Subjects	59212.74	15	3947.52		
Frequency	73146.45	7	10449.49	19.12	.000
Exposure x Frequency	12712.97	14	908.07	1.66	.075
Within Subjects	57390.27	105	546.57		

order of impulse presentation was not statistically significant for any of the four dependent measures employed. Likewise, there were no statistically significant interactions between order and frequency although this interaction approached statistical significance for the PTS measure ($F = 1.95$, $df = 9/90$, $p < .055$). The main effect of frequency was statistically significant for all analyses.

Conclusions

Based upon a visual inspection of the mean data shown in Figures 14 and 15, there would appear to be clear differences between the L/H and H/L groups for the PTS measures and clear differences between the three equal energy groups for the PTS and cell loss measures. However, the standard deviations in these data are large, for example, on the order of 15 to 20 dB for the PTS data (See Appendix). Thus, while the mean data and the statistical analysis are suggestive of some potentially interesting effects, it is going to be necessary to increase the experimental sample size before clear statements can be made about the effects of the presentation order of impulses or how to evaluate exposures with variable peak intensities. The one clear conclusion from these data is that the Reference I and II exposure conditions do clearly represent upper and lower bounds to the pathology produced in the L/H and H/L groups.

Table 4

Analysis of Variance Summary Table for L/H and H/L groups

Maximum Threshold Shift

Source of Variation	SS	df	MS	F	p
Order	1755.68	1	1755.68	4.43	.062
Between Subjects	3961.02	10	396.10		
Frequency	5019.17	9	557.69	13.48	.000
Order x Frequency	312.57	9	34.73	.84	.582
Within Subjects	3723.15	90	41.37		

Permanent Threshold Shift

Source of Variation	SS	df	MS	F	p
Order	2081.25	1	2081.25	1.40	.263
Between Subjects	14819.43	10	1481.94		
Frequency	3735.04	9	415.00	7.80	.000
Order x Frequency	932.39	9	103.60	1.95	.055
Within Subjects	4787.35	90	53.19		

Percent Inner Hair Cell Loss

Source of Variation	SS	df	MS	F	p
Order	465.96	1	465.96	.30	.596
Between Subjects	15546.79	10	1554.68		
Frequency	6469.36	7	924.19	2.53	.022
Order x Frequency	668.48	7	95.50	.26	.967
Within Subjects	25587.19	70	365.53		

Percent Outer Hair Cell Loss

Source of Variation	SS	df	MS	F	p
Order	1774.47	1	1774.47	.32	.585
Between Subjects	55749.21	10	5574.92		
Frequency	50541.46	7	7220.21	10.82	.000
Order x Frequency	1210.33	7	172.90	.26	.968
Within Subjects	46732.52	70	667.61		

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Appendix

Individual data and group
summary statistics

Guide to the appendix

The individual and summary statistics for each experimental group are presented in the appendix that follows. The following paragraphs present a brief description of the contents of the data appendix. In this summary, only a single exposure group is described. All the remaining exposure groups are organized in the same manner.

Group title page

The group title page indicates the exposure that each animal in this group received [e.g., 138 dB peak SPL (90x), 146 dB peak SPL (10X)] and the subjects that comprise this group.

Preexposure and permanent threshold shift audiograms

The top panel depicts the mean preexposure thresholds for this group. The error bars on this figure and all others in the appendix represent one standard deviation plotted above and below the mean. The lower panel presents the group mean PTS.

Preexposure, postexposure and PTS measurements

This page tabulates the pre- and postexposure thresholds (in dB SPL) for each subject as well as the group mean and standard deviation. PTS is computed by subtracting the preexposure threshold from the postexposure threshold for each subject.

Recovery threshold shifts

The threshold shifts measured at frequency intervals following noise exposure are in this table.

Total cell loss summary

The total sensory cell losses for this group are presented in the top portion of this table. The lower position of the table presents the mean and standard deviation for the total number of inner and outer hair cells missing along octave band lengths of the cochlea.

Total cell losses

The total sensory cell losses in octave band lengths of the cochlea for each animal that comprises the exposure group are presented in this table. Also included at the end of the table are the group mean and standard deviation for each octave band length.

Percent sensory cell losses

This table presents the percent sensory cell losses in octave band lengths of the cochlea for each animal in this group. Also included are the means and standard deviation for each sensory cell and octave band length.

Cochleograms and PTS audiograms

These figures present cochleograms and PTS audiograms for each animal in the exposure group. The cochleograms show the percent inner and outer hair cell losses for each 0.24 mm segment of the basilar membrane. The PTS audiogram is plotted to allow easy comparison of the PTS and cell loss resulting from the noise exposure.

Index of all subjects and figures included in the present report

Subject Cochleogram	Group	Designation	Summary	PRE/PTS
G28	1	L/H		
H47	2	H/L		
H52	1	L/H		
H54	1	L/H		
H60	1	L/H		
H61	1	L/H		
H61B	2	H/L		
H65	1	L/H		
H153	2	H/L		
H225	2	H/L		
J30	2	H/L		
J36	2	H/L		

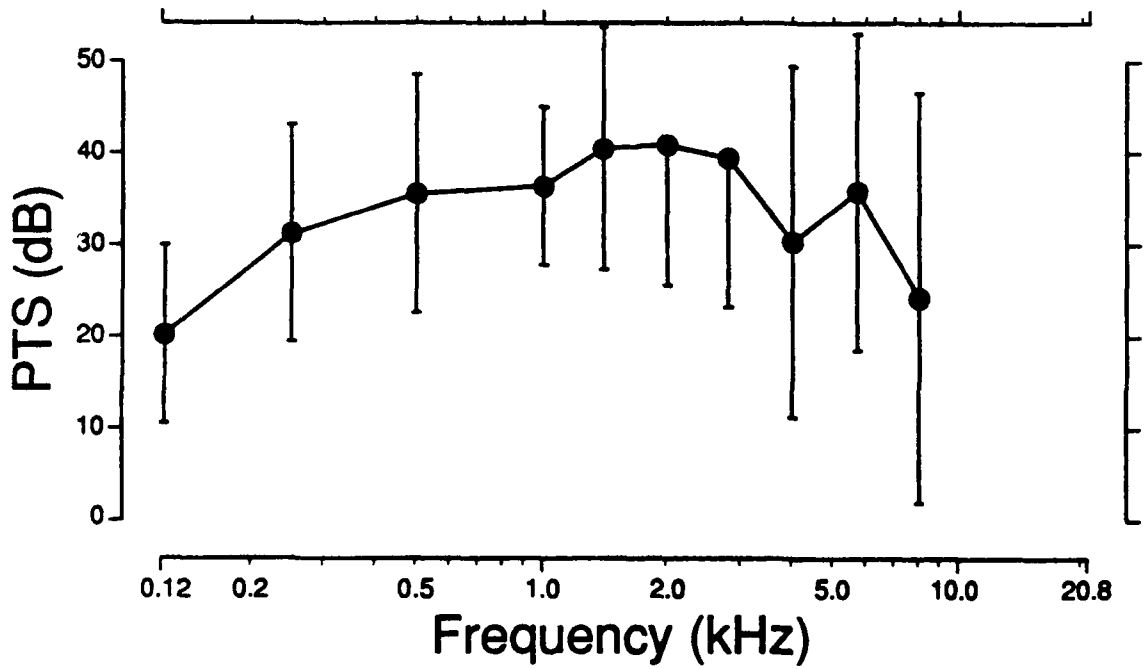
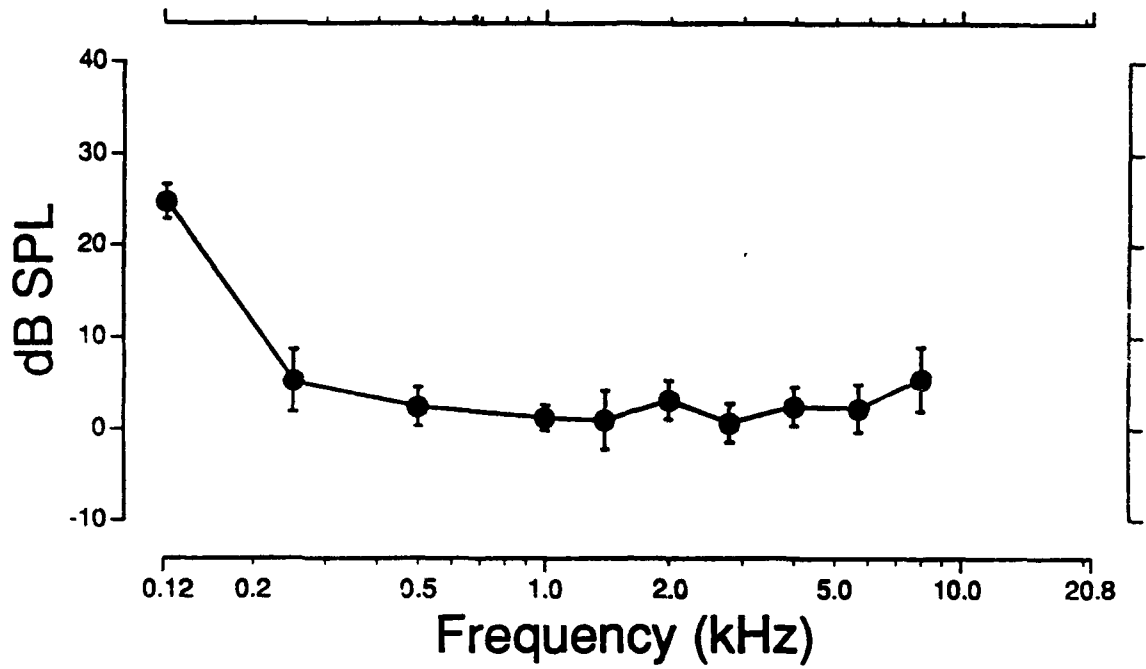
Summary data for the group exposed to:

138 dB peak SPL (90X), 146 dB peak SPL (10X)

Animal #

G28	-	Completed the entire protocol
H52	-	Completed the entire protocol
H54	-	Completed the entire protocol
H60	-	Completed the entire protocol
H61	-	Completed the entire protocol
H65	-	Completed the entire protocol

138 dB peak SPL (90X), 146 dB peak SPL (10X)



138 dB peak SPL (90X), 146 dB peak SPL (10X)

Preexposure thresholds (dB SPL)

Animal\kHz	.125	.25	0.5	1.0	1.4	2.0	2.8	4.0	5.7	8.0
G028	26.0	8.0	5.0	3.0	-1.0	1.0	-1.0	0.0	2.0	7.0
H052	28.0	7.0	3.0	2.0	-2.0	4.0	4.0	3.0	1.0	8.0
H054	23.0	1.0	0.0	1.0	-1.0	4.0	-1.0	0.0	0.0	2.0
H060	24.0	8.0	4.0	1.0	6.0	5.0	2.0	5.0	6.0	10.0
H061	23.0	1.0	0.0	-1.0	0.0	0.0	-1.0	3.0	0.0	1.0
H065	25.0	7.0	3.0	2.0	4.0	5.0	1.0	4.0	5.0	5.0
Mean	24.8	5.3	2.5	1.3	1.0	3.2	0.7	2.5	2.3	5.5
S.D.	1.9	3.4	2.1	1.4	3.2	2.1	2.1	2.1	2.6	3.5

Postexposure thresholds (dB SPL)

Animal\kHz	.125	.25	0.5	1.0	1.4	2.0	2.8	4.0	5.7	8.0
G028	38.8	23.5	25.3	28.3	42.5	42.0	34.8	19.0	23.3	26.5
H052	48.0	45.3	46.0	43.0	46.5	49.8	49.5	46.5	44.0	36.3
H054	58.3	42.3	45.8	46.5	46.3	61.5	55.3	54.0	55.5	57.5
H060	40.0	41.5	41.5	39.3	42.3	42.0	40.8	32.3	33.0	10.0
H061	50.8	42.5	48.3	41.3	51.8	50.8	49.0	41.0	53.5	43.0
H065	34.8	24.5	21.8	28.0	19.8	18.3	11.0	4.5	19.8	5.8
Mean	45.1	36.6	38.1	37.7	41.5	44.0	40.0	32.9	38.2	29.8
S.D.	8.8	9.8	11.6	7.8	11.2	14.5	16.0	18.4	15.2	19.9

Permanent threshold shift (dB)

Animal\kHz	.125	.25	0.5	1.0	1.4	2.0	2.8	4.0	5.7	8.0
G028	12.8	15.5	20.3	25.3	43.5	41.0	35.8	19.0	21.3	19.5
H052	20.0	38.3	43.0	41.0	48.5	45.8	45.5	43.5	43.0	28.3
H054	35.3	41.3	45.8	45.5	47.3	57.5	56.3	54.0	55.5	55.5
H060	16.0	33.5	37.5	38.3	36.3	37.0	38.8	27.3	27.0	0.0
H061	27.8	41.5	48.3	42.3	51.8	50.8	50.0	38.0	53.5	42.0
H065	9.8	17.5	18.8	26.0	15.8	13.3	10.0	0.5	14.8	0.5
Mean	20.3	31.3	35.6	36.4	40.5	40.9	39.4	30.4	35.8	24.3
S.D.	9.7	11.8	13.0	8.6	13.2	15.3	16.2	19.1	17.2	22.3

Temporary Threshold Shift (dB): 138 dB peak SPL (90X), 146 dB peak SPL (10X)

Frequency 0.125 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
G28	50.0	45.0	31.0	58.0	42.0	40.0	31.0	19.0	15.0	26.0	12.0	20.0	15.0	19.0	11.0	6.0	58.0
H52	63.0	66.0	37.0	62.0	34.0	38.0	53.0	49.0	37.0	33.0	16.0	19.0	20.0	25.0	23.0	12.0	66.0
H54	57.0	56.0	52.0	45.0	57.0	65.0	67.0	57.0	55.0	35.0	25.0	29.0	54.0	35.0	24.0	28.0	67.0
H60	61.0	53.0	48.0	51.0	50.0	49.0	63.0	44.0	43.0	31.0	33.0	23.0	18.0	16.0	19.0	11.0	63.0
H61	25.0	59.0	55.0	36.0	43.0	45.0	55.0	45.0	57.0	53.0	44.0	39.0	33.0	33.0	24.0	21.0	59.0
H65	43.0	58.0	55.0	62.0	61.0	61.0	37.0	39.0	26.0	17.0	12.0	10.0	9.0	10.0	12.0	8.0	62.0
Mean	49.8	56.2	46.3	52.3	47.8	49.7	51.0	42.2	38.8	32.5	23.7	23.3	24.8	23.0	18.8	14.3	62.5
S.D.	14.2	7.0	10.1	10.4	10.1	11.1	14.3	12.8	16.4	11.9	12.9	9.9	16.3	9.8	6.0	8.5	3.6

Frequency 0.250 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
G28	56.0	61.0	35.0	63.0	74.0	48.0	39.0	33.0	23.0	27.0	24.0	24.0	14.0	17.0	13.0	18.0	74.0
H52	63.0	65.0	57.0	48.0	55.0	74.0	66.0	45.0	58.0	56.0	42.0	34.0	35.0	33.0	42.0	43.0	74.0
H54	78.0	53.0	68.0	51.0	76.0	55.0	64.0	59.0	69.0	49.0	41.0	43.0	47.0	39.0	38.0	41.0	78.0
H60	78.0	55.0	70.0	62.0	62.0	65.0	59.0	60.0	49.0	47.0	41.0	29.0	33.0	38.0	35.0	28.0	78.0
H61	71.0	79.0	69.0	52.0	61.0	51.0	61.0	74.0	57.0	62.0	44.0	52.0	42.0	45.0	46.0	33.0	79.0
H65	45.0	66.0	69.0	79.0	65.0	66.0	45.0	48.0	44.0	33.0	31.0	13.0	21.0	24.0	19.0	6.0	79.0
Mean	65.2	63.2	61.3	59.2	65.5	59.8	55.7	53.2	50.0	45.7	37.2	32.5	32.0	32.7	32.2	28.2	77.0
S.D.	13.1	9.3	13.8	11.5	8.1	10.1	11.0	14.2	15.7	13.4	7.9	13.8	12.5	10.4	13.2	14.2	2.4

Frequency 0.500 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
G28	54.0	61.0	57.0	66.0	76.0	38.0	54.0	27.0	43.0	-1.0	32.0	36.0	19.0	19.0	27.0	16.0	76.0
H52	68.0	51.0	69.0	66.0	75.0	71.0	73.0	70.0	47.0	44.0	45.0	54.0	53.0	28.0	50.0	41.0	75.0
H54	60.0	67.0	77.0	55.0	64.0	65.0	98.0	70.0	72.0	56.0	87.0	48.0	64.0	41.0	40.0	38.0	98.0
H60	66.0	68.0	67.0	73.0	83.0	82.0	67.0	61.0	53.0	47.0	37.0	38.0	44.0	38.0	32.0	36.0	83.0
H61	68.0	70.0	81.0	78.0	67.0	55.0	95.0	78.0	79.0	59.0	45.0	47.0	48.0	53.0	54.0	38.0	95.0
H65	53.0	53.0	67.0	77.0	76.0	67.0	42.0	37.0	25.0	31.0	22.0	24.0	25.0	8.0	18.0	24.0	77.0
Mean	61.5	61.7	69.7	69.2	73.5	63.0	71.5	57.2	53.2	39.3	44.7	41.2	42.2	31.2	36.8	32.2	81.0
S.D.	6.9	8.1	8.5	8.7	6.9	15.1	22.2	20.5	19.8	22.1	22.5	10.7	17.1	16.2	13.8	9.9	10.1

Temporary Threshold Shift (dB): 138 dB peak SPL (90X), 146 dB peak SPL (10X)

Frequency 1.000 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
G28	70.0	51.0	75.0	78.0	75.0	53.0	44.0	37.0	42.0	31.0	25.0	34.0	13.0	29.0	37.0	22.0	78.0
H52	46.0	69.0	67.0	78.0	82.0	79.0	76.0	29.0	47.0	48.0	49.0	34.0	44.0	46.0	39.0	35.0	82.0
H54	57.0	63.0	68.0	90.0	86.0	80.0	83.0	63.0	85.0	61.0	43.0	40.0	51.0	49.0	47.0	35.0	90.0
H60	77.0	68.0	64.0	79.0	86.0	91.0	61.0	54.0	44.0	38.0	39.0	40.0	35.0	40.0	41.0	37.0	91.0
H61	41.0	63.0	69.0	80.0	84.0	82.0	52.0	67.0	60.0	64.0	47.0	56.0	42.0	37.0	43.0	47.0	84.0
H65	46.0	60.0	60.0	69.0	69.0	57.0	39.0	40.0	34.0	30.0	10.0	13.0	20.0	26.0	28.0	30.0	69.0
Mean	56.2	62.3	67.2	79.0	80.3	73.7	59.2	48.3	52.0	45.3	35.5	36.2	34.2	37.8	39.2	34.3	82.3
S.D.	14.6	6.5	5.0	6.7	6.9	15.1	17.6	15.3	18.3	14.8	15.1	13.9	14.8	9.1	6.5	8.2	8.2

Frequency 1.400 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
G28	65.0	69.0	87.0	73.0	56.0	60.0	51.0	52.0	54.0	48.0	57.0	56.0	40.0	46.0	38.0	50.0	87.0
H52	65.0	70.0	79.0	84.0	63.0	75.0	81.0	57.0	49.0	46.0	55.0	47.0	44.0	47.0	56.0	47.0	84.0
H54	67.0	56.0	69.0	82.0	89.0	94.0	85.0	77.0	77.0	62.0	65.0	52.0	53.0	44.0	47.0	45.0	94.0
H60	81.0	70.0	63.0	67.0	78.0	82.0	56.0	57.0	50.0	41.0	31.0	37.0	39.0	43.0	32.0	31.0	82.0
H61	62.0	71.0	76.0	82.0	82.0	71.0	81.0	75.0	65.0	65.0	59.0	56.0	59.0	49.0	53.0	46.0	82.0
H65	53.0	74.0	65.0	75.0	67.0	61.0	43.0	42.0	22.0	11.0	19.0	29.0	19.0	11.0	9.0	24.0	75.0
Mean	65.5	68.3	73.2	77.2	72.5	73.8	66.2	60.0	52.8	45.5	47.7	46.2	42.3	40.0	39.2	40.5	84.0
S.D.	9.1	6.3	9.2	6.6	12.5	13.0	18.2	13.6	18.5	19.3	18.3	11.0	13.8	14.4	17.3	10.4	6.3

Frequency 2.000 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
G28	80.0	76.0	80.0	83.0	83.0	60.0	68.0	58.0	50.0	56.0	49.0	49.0	40.0	36.0	51.0	37.0	83.0
H52	52.0	73.0	63.0	80.0	77.0	82.0	69.0	51.0	44.0	70.0	53.0	42.0	50.0	51.0	41.0	41.0	82.0
H54	57.0	63.0	65.0	75.0	69.0	82.0	77.0	74.0	75.0	74.0	64.0	61.0	61.0	54.0	57.0	58.0	82.0
H60	76.0	71.0	73.0	73.0	81.0	86.0	60.0	68.0	53.0	39.0	40.0	41.0	38.0	38.0	36.0	36.0	86.0
H61	62.0	70.0	83.0	81.0	80.0	79.0	79.0	82.0	53.0	69.0	58.0	48.0	55.0	51.0	52.0	45.0	83.0
H65	72.0	56.0	68.0	68.0	66.0	68.0	35.0	35.0	21.0	2.0	23.0	12.0	11.0	19.0	7.0	16.0	72.0
Mean	66.5	68.2	72.0	76.7	76.0	76.2	64.7	61.3	49.3	51.7	47.8	42.2	42.5	41.5	40.7	38.8	81.3
S.D.	11.2	7.4	8.1	5.7	6.9	10.0	16.1	17.0	17.4	27.5	14.6	16.4	17.7	13.3	18.2	13.7	4.8

Temporary Threshold Shift (dB): 136 db peak SPL (90X), 146 db peak SPL (10X)

Frequency 2.800 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
G28	71.0	75.0	75.0	78.0	74.0	55.0	48.0	48.0	25.0	43.0	53.0	57.0	27.0	43.0	45.0	28.0	74.0
H52	61.0	69.0	75.0	70.0	78.0	67.0	71.0	63.0	34.0	49.0	36.0	49.0	51.0	41.0	51.0	39.0	78.0
H54	73.0	79.0	86.0	85.0	81.0	69.0	83.0	75.0	65.0	75.0	69.0	65.0	46.0	61.0	60.0	58.0	86.0
H60	67.0	67.0	66.0	67.0	74.0	77.0	57.0	59.0	61.0	52.0	42.0	42.0	40.0	41.0	37.0	37.0	77.0
H61	62.0	73.0	73.0	67.0	87.0	65.0	75.0	75.0	61.0	61.0	48.0	45.0	53.0	49.0	50.0	48.0	87.0
H65	54.0	58.0	62.0	74.0	62.0	61.0	47.0	31.0	42.0	-2.0	-1.0	8.0	20.0	3.0	9.0	8.0	74.0
Mean	64.7	70.2	72.8	73.5	76.0	66.3	63.5	58.1	48.0	46.3	41.2	44.3	39.5	39.7	42.0	36.3	80.0
S.D.	7.1	7.3	8.3	7.1	8.4	6.4	15.0	16.1	16.7	26.2	23.5	19.7	13.4	19.5	17.8	17.2	5.3

Frequency 4.000 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
G28	70.0	70.0	50.0	74.0	74.0	60.0	45.0	34.0	27.0	40.0	58.0	58.0	23.0	19.0	20.0	14.0	74.0
H52	54.0	66.0	70.0	83.0	64.0	69.0	67.0	38.0	46.0	36.0	39.0	39.0	44.0	39.0	47.0	44.0	82.0
H54	59.0	76.0	70.0	62.0	59.0	61.0	66.0	63.0	65.0	63.0	66.0	45.0	53.0	57.0	61.0	45.0	76.0
H60	66.0	65.0	69.0	65.0	66.0	68.0	51.0	53.0	34.0	34.0	31.0	32.0	35.0	30.0	18.0	26.0	69.0
H61	40.0	56.0	67.0	66.0	68.0	69.0	59.0	64.0	49.0	59.0	33.0	32.0	27.0	47.0	48.0	30.0	69.0
H65	34.0	59.0	61.0	68.0	59.0	64.0	8.0	18.0	11.0	6.0	0.0	8.0	10.0	-2.0	-5.0	-1.0	68.0
Mean	53.8	65.3	64.5	69.7	65.0	65.2	49.3	45.0	38.7	39.7	37.8	35.7	32.0	31.7	31.5	26.3	73.2
S.D.	14.3	7.3	7.9	7.7	5.7	4.1	22.0	18.2	18.9	20.5	23.3	16.7	15.4	21.1	24.6	17.7	5.8

Frequency 5.700 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
G28	41.0	60.0	64.0	58.0	92.0	32.0	66.0	23.0	26.0	38.0	46.0	44.0	12.0	25.0	28.0	20.0	92.0
H52	65.0	68.0	61.0	73.0	82.0	61.0	82.0	60.0	67.0	56.0	54.0	67.0	50.0	33.0	47.0	42.0	82.0
H54	85.0	71.0	86.0	74.0	83.0	59.0	77.0	74.0	64.0	87.0	90.0	77.0	58.0	73.0	71.0	20.0	90.0
H60	63.0	56.0	58.0	65.0	66.0	71.0	54.0	45.0	35.0	31.0	24.0	30.0	25.0	29.0	21.0	33.0	71.0
H61	64.0	62.0	81.0	60.0	70.0	64.0	74.0	69.0	60.0	71.0	61.0	46.0	51.0	63.0	59.0	41.0	81.0
H65	16.0	52.0	60.0	65.0	54.0	61.0	21.0	11.0	16.0	8.0	11.0	6.0	14.0	9.0	24.0	12.0	65.0
Mean	55.7	61.5	68.3	65.8	74.5	58.0	62.3	47.0	44.7	48.5	47.7	45.0	35.0	38.7	41.7	28.0	80.2
S.D.	23.9	7.1	12.0	6.6	13.8	13.4	22.5	25.5	21.8	28.6	28.0	25.5	20.4	24.3	20.6	12.4	10.5

Temporary Threshold Shift (dB): 138 dB peak SPL (90X), 146 dB peak SPL (10X)

Frequency 8.000 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
G28	30.0	32.0	46.0	49.0	41.0	51.0	33.0	23.0	5.0	14.0	34.0	22.0	7.0	37.0	20.0	14.0	51.0
H52	42.0	55.0	38.0	66.0	52.0	56.0	62.0	30.0	23.0	34.0	32.0	25.0	31.0	18.0	46.0	18.0	66.0
H54	48.0	57.0	80.0	72.0	79.0	71.0	71.0	64.0	82.0	69.0	69.0	51.0	54.0	58.0	57.0	53.0	82.0
H60	34.0	49.0	51.0	49.0	64.0	38.0	46.0	37.0	24.0	11.0	16.0	7.0	2.0	-4.0	-2.0	4.0	64.0
H61	59.0	88.0	70.0	62.0	50.0	73.0	73.0	65.0	53.0	51.0	55.0	33.0	51.0	37.0	35.0	45.0	88.0
H65	27.0	63.0	63.0	62.0	65.0	64.0	22.0	25.0	38.0	13.0	12.0	6.0	0.0	1.0	-2.0	3.0	65.0
Mean	40.0	57.3	58.0	60.0	58.5	58.8	51.2	40.7	37.5	32.0	36.3	24.0	24.2	24.5	25.7	22.8	69.3
S.D.	12.1	18.4	15.8	9.3	13.5	13.3	21.0	19.1	27.1	23.9	22.1	16.9	24.6	23.8	24.7	21.2	13.4

Summary of Group Anatomical Data with
Cochleograms and PTS Audiograms
for Individual Animals

138 dB peak SPL (90X), 146 dB peak SPL (10X)

Total number of cochlear sensory cells missing

Animal number	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Total outer hair cells
G28	17	614	672	522	1808
H52	91	1267	1225	1173	3665
H54	415	1661	1596	1300	4557
H60	144	1324	1279	1044	3647
H61	230	1749	1753	1623	5125
H65	19	526	422	306	1254
Group mean	153				3343
S.D.	152				1521
S.E.	62				621

Total sensory cell losses over octave band lengths of the cochlea centered at the frequencies indicated

Octave band center frequency	Inner hair cells	Outer hair cells
Group means		
0.125 kHz	0.8	136.3
0.25 kHz	1.0	141.3
0.5 kHz	1.7	361.7
1 kHz	15.0	715.5
2 kHz	22.7	744.8
4 kHz	26.5	586.8
8 kHz	45.2	402.2
16 kHz	39.8	254.0
Standard deviations		
0.125 kHz	1.2	81.8
0.25 kHz	1.3	113.2
0.5 kHz	2.2	293.2
1 kHz	17.1	132.7
2 kHz	23.2	172.7
4 kHz	25.1	423.5
8 kHz	77.0	378.3
16 kHz	76.9	390.6

138 dB peak SPL (90X), 146 dB peak SPL (10X)

Total sensory cell losses over octave band frequencies

	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Comb. outer hair cells	Inner pillar cells	Outer pillar cells
Chinchilla G28							
0.125 kHz	3	38	99	108	245	3	2
0.25 kHz	3	9	37	150	196	5	3
0.5 kHz	0	10	14	28	52	0	0
1 kHz	2	255	228	151	634	2	9
2 kHz	2	291	258	75	624	1	18
4 kHz	4	11	35	9	55	1	1
8 kHz	3	0	0	1	1	0	0
16 kHz	0	0	1	0	1	0	0
TOTALS	17	614	672	522	1808	12	33

Chinchilla H52							
0.125 kHz	0	3	9	46	58	0	0
0.25 kHz	0	33	7	48	88	0	0
0.5 kHz	1	265	227	139	631	0	1
1 kHz	39	290	289	247	826	119	82
2 kHz	35	296	296	283	875	66	42
4 kHz	14	296	296	293	885	0	8
8 kHz	2	84	99	113	296	0	1
16 kHz	0	0	2	4	6	1	0
TOTALS	91	1267	1225	1173	3665	186	134

Chinchilla H54							
0.125 kHz	1	88	89	54	231	0	0
0.25 kHz	0	144	133	62	339	0	0
0.5 kHz	1	120	75	16	211	0	0
1 kHz	0	258	250	175	683	1	5
2 kHz	1	270	268	219	757	3	17
4 kHz	23	270	270	263	803	51	51
8 kHz	197	270	270	270	810	294	206
16 kHz	192	241	241	241	723	382	239
TOTALS	415	1661	1596	1300	4557	731	518

138 dB peak SPL (90X), 146 dB peak SPL (10X)

Total sensory cell losses over octave band frequencies

	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Comb. outer hair cells	Inner pillar cells	Outer pillar cells
Chinchilla H60							
0.125 kHz	0	45	30	32	107	0	0
0.25 kHz	1	69	48	21	138	0	2
0.5 kHz	6	192	194	71	457	1	3
1 kHz	34	289	267	219	775	82	82
2 kHz	32	303	302	270	875	6	25
4 kHz	58	301	303	300	904	67	130
8 kHz	13	125	135	131	391	10	7
16 kHz	0	0	0	0	0	0	0
TOTALS	144	1324	1279	1044	3647	166	249

Chinchilla H61							
0.125 kHz	0	27	20	18	65	0	0
0.25 kHz	2	14	27	4	45	0	0
0.5 kHz	1	267	266	212	745	1	40
1 kHz	10	289	289	287	865	2	66
2 kHz	59	296	296	288	880	92	77
4 kHz	57	296	295	254	845	11	33
8 kHz	54	296	296	296	888	2	13
16 kHz	47	264	264	264	792	1	7
TOTALS	230	1749	1753	1623	5125	109	236

Chinchilla H65							
0.125 kHz	1	16	41	55	112	0	0
0.25 kHz	0	12	6	24	42	0	0
0.5 kHz	1	35	25	14	74	0	1
1 kHz	5	232	174	104	510	1	10
2 kHz	7	208	163	87	458	0	7
4 kHz	3	11	5	13	29	1	0
8 kHz	2	10	8	9	27	0	3
16 kHz	0	2	0	0	2	0	0
TOTALS	19	526	422	306	1254	2	21

138 dB peak SPL (90X), 146 dB peak SPL (10X)

Total sensory cell losses over octave band frequencies

	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Comb. outer hair cells	Inner pillar cells	Outer pillar cells
Group means							
0.125 kHz	0.8	36.2	48.0	52.2	136.3	0.5	0.3
0.25 kHz	1.0	46.8	43.0	51.5	141.3	0.8	0.8
0.5 kHz	1.7	148.2	133.5	80.0	361.7	0.3	7.5
1 kHz	15.0	268.8	249.5	197.2	715.5	34.5	42.3
2 kHz	22.7	277.3	263.8	203.7	744.8	28.0	31.0
4 kHz	26.5	197.5	200.7	188.7	586.8	21.8	37.2
8 kHz	45.2	130.8	134.7	136.7	402.2	51.0	38.3
16 kHz	39.8	84.5	84.7	84.8	254.0	64.0	41.0
TOTALS	152.7	1190.2	1157.8	994.7	3342.7	201.0	198.5

	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Comb. outer hair cells	Inner pillar cells	Outer pillar cells
Group standard deviations							
0.125 kHz	1.2	29.5	37.3	30.8	81.8	1.2	0.8
0.25 kHz	1.3	52.6	47.1	52.5	113.2	2.0	1.3
0.5 kHz	2.2	111.7	109.0	80.2	293.2	0.5	16.0
1 kHz	17.1	24.2	43.8	66.8	132.7	52.4	38.1
2 kHz	23.2	35.8	52.4	98.2	172.7	40.4	25.4
4 kHz	25.1	144.9	140.7	138.7	423.5	29.5	49.7
8 kHz	77.0	127.0	126.3	125.3	378.3	119.1	82.3
16 kHz	76.9	130.3	130.2	130.1	390.6	155.8	97.0
TOTALS	151.6	515.9	518.2	494.0	1520.9	270.6	183.9

138 dB peak SPL (90X), 146 dB peak SPL (10X)

Percent sensory cell losses over octave band frequencies

	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Comb. outer hair cells	Inner pillar cells	Outer pillar cells
Chinchilla G28							
0.125 kHz	2.1	20.2	52.7	57.4	43.4	1.1	1.1
0.25 kHz	1.2	2.7	11.2	45.5	19.8	1.0	0.9
0.5 kHz	0.0	3.0	4.2	8.5	5.2	0.0	0.0
1 kHz	0.8	81.2	72.6	48.1	67.3	0.4	2.9
2 kHz	0.8	90.9	80.6	23.4	65.0	0.2	5.6
4 kHz	1.6	3.4	10.9	2.8	5.7	0.2	0.3
8 kHz	1.2	0.0	0.0	0.3	0.1	0.0	0.0
16 kHz	0.0	0.0	0.3	0.0	0.1	0.0	0.0

Chinchilla H52

0.125 kHz	0.0	1.7	5.2	26.4	11.1	0.0	0.0
0.25 kHz	0.0	10.8	2.3	15.7	9.6	0.0	0.0
0.5 kHz	0.4	87.2	74.7	45.7	69.2	0.0	0.3
1 kHz	17.4	100.0	99.7	85.2	95.0	25.4	28.3
2 kHz	15.8	100.0	100.0	95.6	98.5	13.8	14.2
4 kHz	6.1	100.0	100.0	99.0	99.7	0.0	2.7
8 kHz	0.8	28.4	33.4	38.2	33.3	0.0	0.3
16 kHz	0.0	0.0	0.8	1.5	0.8	0.2	0.0

Chinchilla H54

0.125 kHz	0.8	55.7	56.3	34.2	48.7	0.0	0.0
0.25 kHz	0.0	51.6	47.7	22.2	40.5	0.0	0.0
0.5 kHz	0.5	43.3	27.1	5.8	25.4	0.0	0.0
1 kHz	0.0	97.7	94.7	66.3	86.2	0.2	1.9
2 kHz	0.5	100.0	99.3	81.1	93.5	0.7	6.3
4 kHz	10.8	100.0	100.0	97.4	99.1	11.7	18.9
8 kHz	90.4	100.0	100.0	100.0	100.0	67.6	76.3
16 kHz	99.0	100.0	100.0	100.0	100.0	98.2	99.2

138 dB peak SPL (90X), 146 dB peak SPL (10X)

Percent sensory cell losses over octave band frequencies

	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Comb. outer hair cells	Inner pillar cells	Outer pillar cells
Chinchilla H60							
0.125 kHz	0.0	25.3	16.9	18.0	20.1	0.0	0.0
0.25 kHz	0.4	22.0	15.3	6.7	14.7	0.0	0.0
0.5 kHz	2.6	61.5	62.2	22.8	48.8	0.2	1.0
1 kHz	14.8	97.3	89.9	73.7	87.0	17.1	27.6
2 kHz	14.1	100.0	99.7	89.1	96.3	1.2	6.3
4 kHz	24.5	99.3	100.0	99.0	99.4	13.7	42.9
8 kHz	5.3	41.1	44.4	43.1	42.9	2.0	2.3
16 kHz	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Chinchilla H61

0.125 kHz	0.0	15.5	11.5	10.3	12.4	0.0	0.0
0.25 kHz	0.9	4.6	8.9	1.3	4.9	0.0	0.0
0.5 kHz	0.4	87.8	87.5	69.7	81.7	0.2	13.2
1 kHz	4.5	100.0	100.0	99.3	99.8	0.4	22.8
2 kHz	26.7	100.0	100.0	97.3	99.1	19.3	26.0
4 kHz	24.7	100.0	99.7	85.8	95.2	2.3	11.1
8 kHz	22.7	100.0	100.0	100.0	100.0	0.4	4.4
16 kHz	22.1	100.0	100.0	100.0	100.0	0.2	2.7

Chinchilla H65

0.125 kHz	0.7	8.3	21.2	28.5	19.3	0.0	0.0
0.25 kHz	0.0	3.6	1.8	7.1	4.2	0.0	0.0
0.5 kHz	0.4	10.4	7.4	4.1	7.3	0.0	0.3
1 kHz	2.0	72.3	54.2	32.4	53.0	0.2	3.1
2 kHz	2.8	63.4	49.7	26.5	46.5	0.0	2.1
4 kHz	1.2	3.4	1.5	4.0	3.0	0.2	0.0
8 kHz	0.8	3.0	2.4	2.7	2.7	0.0	0.9
16 kHz	0.0	0.7	0.0	0.0	0.2	0.0	0.0

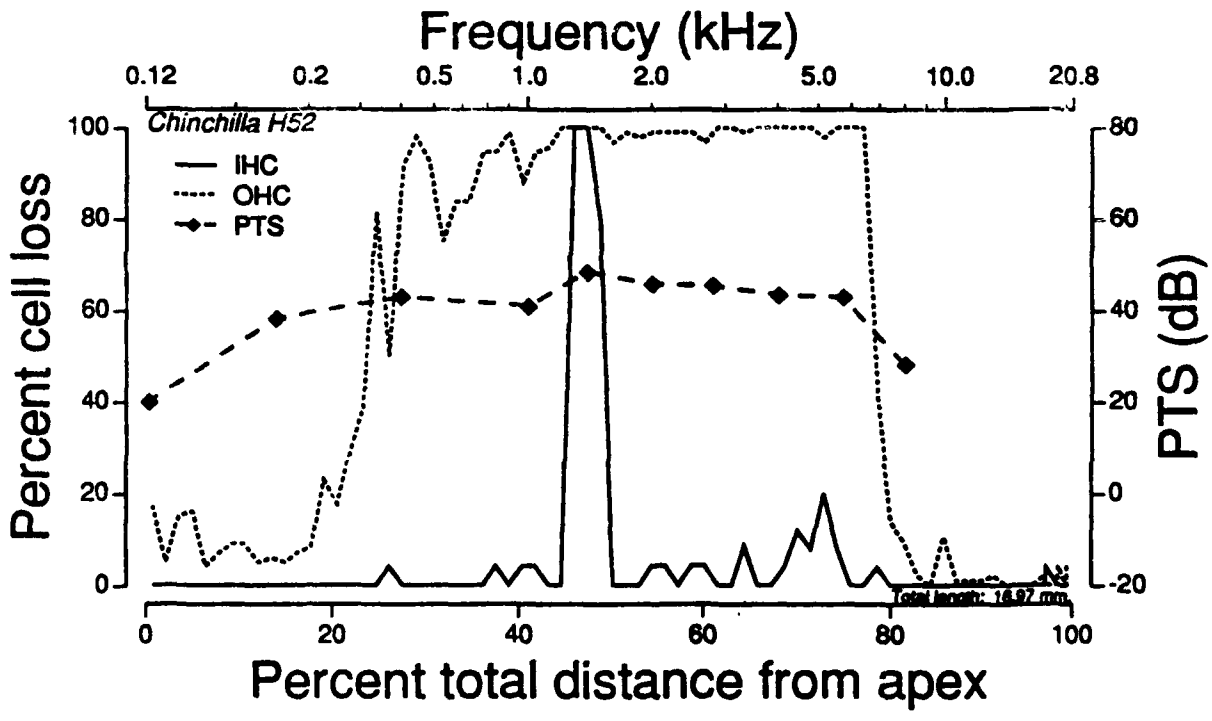
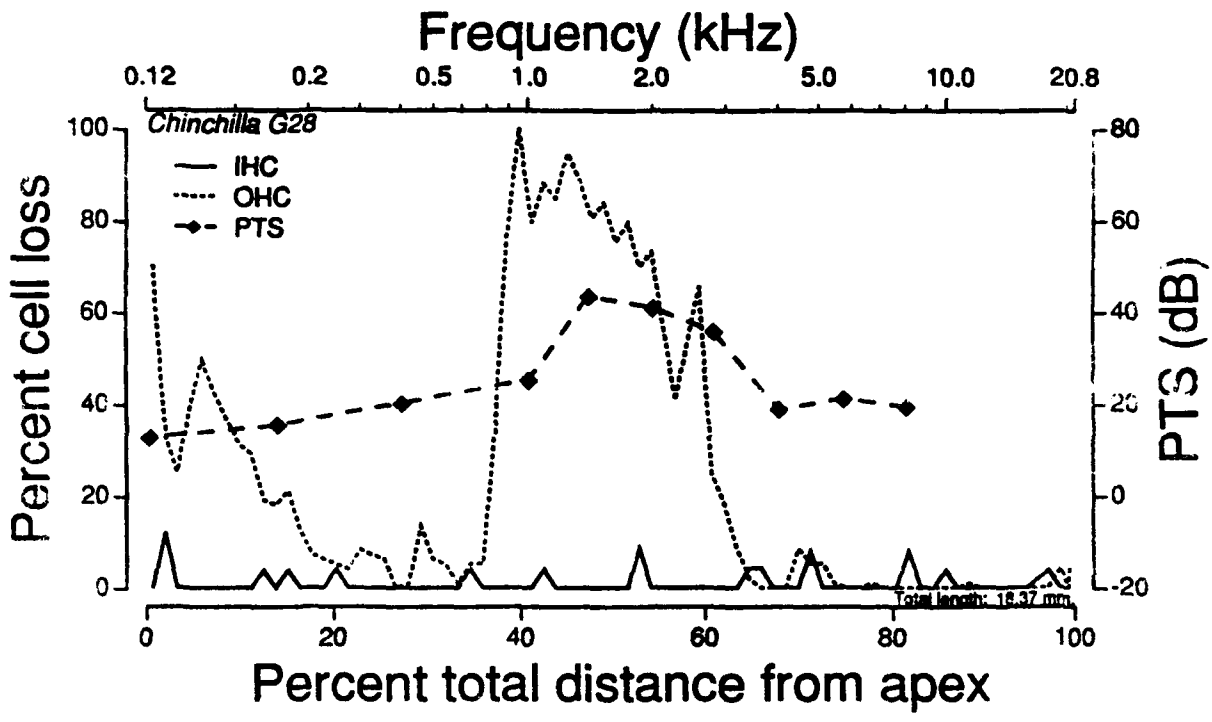
138 dB peak SPL (90X), 146 dB peak SPL (10X)

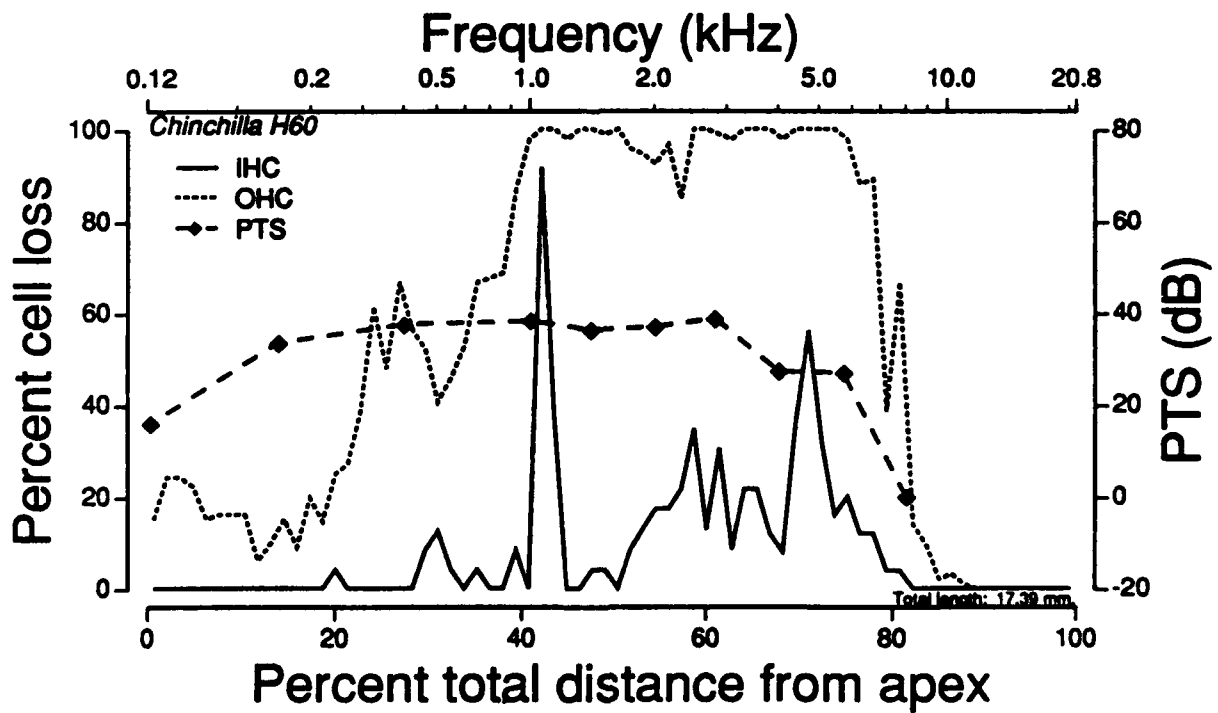
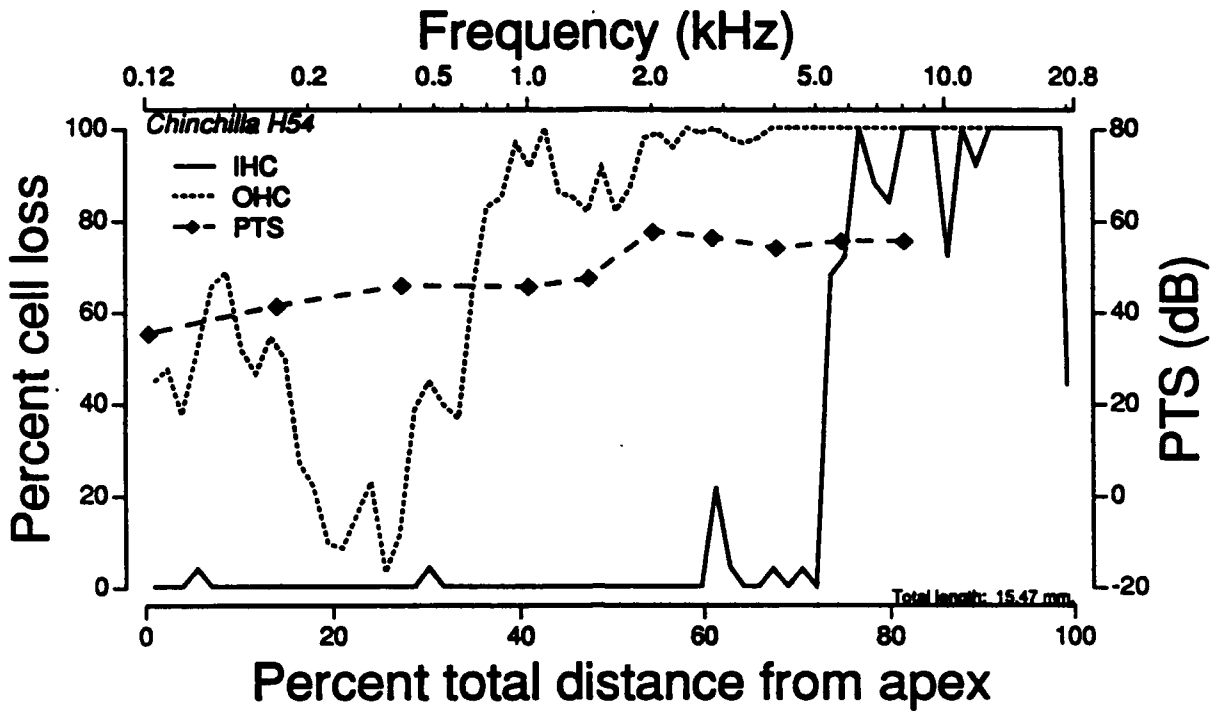
Percent sensory cell losses over octave band frequencies

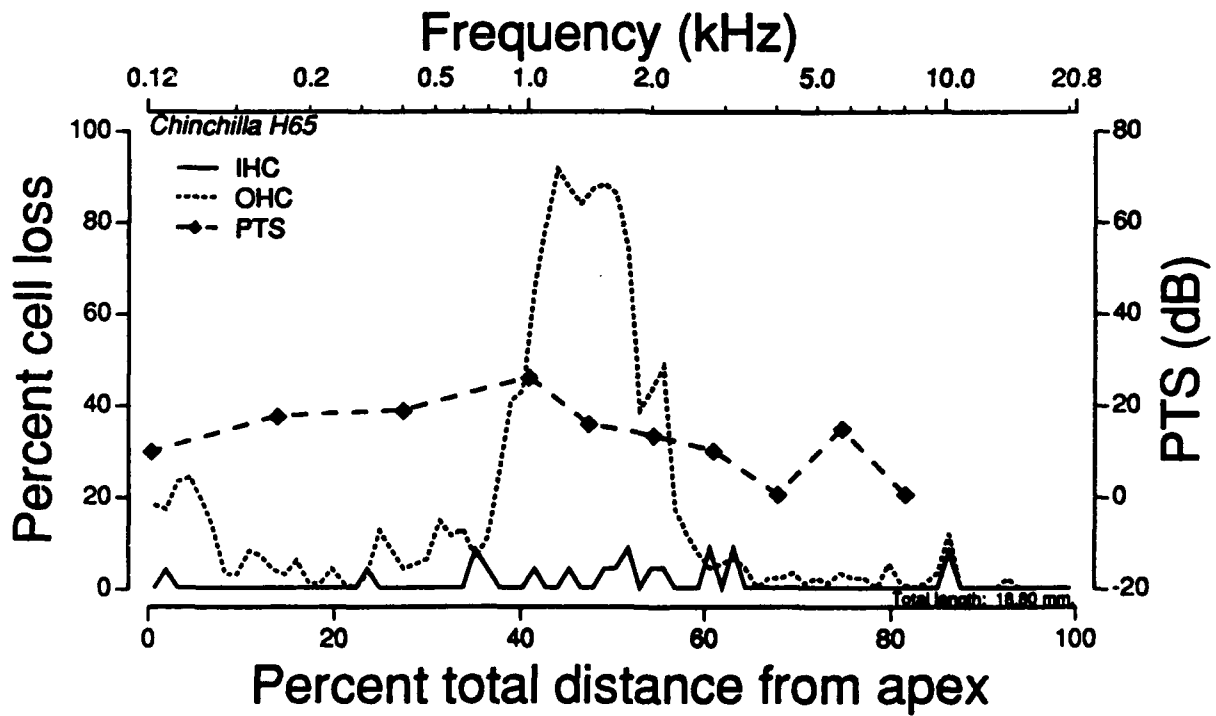
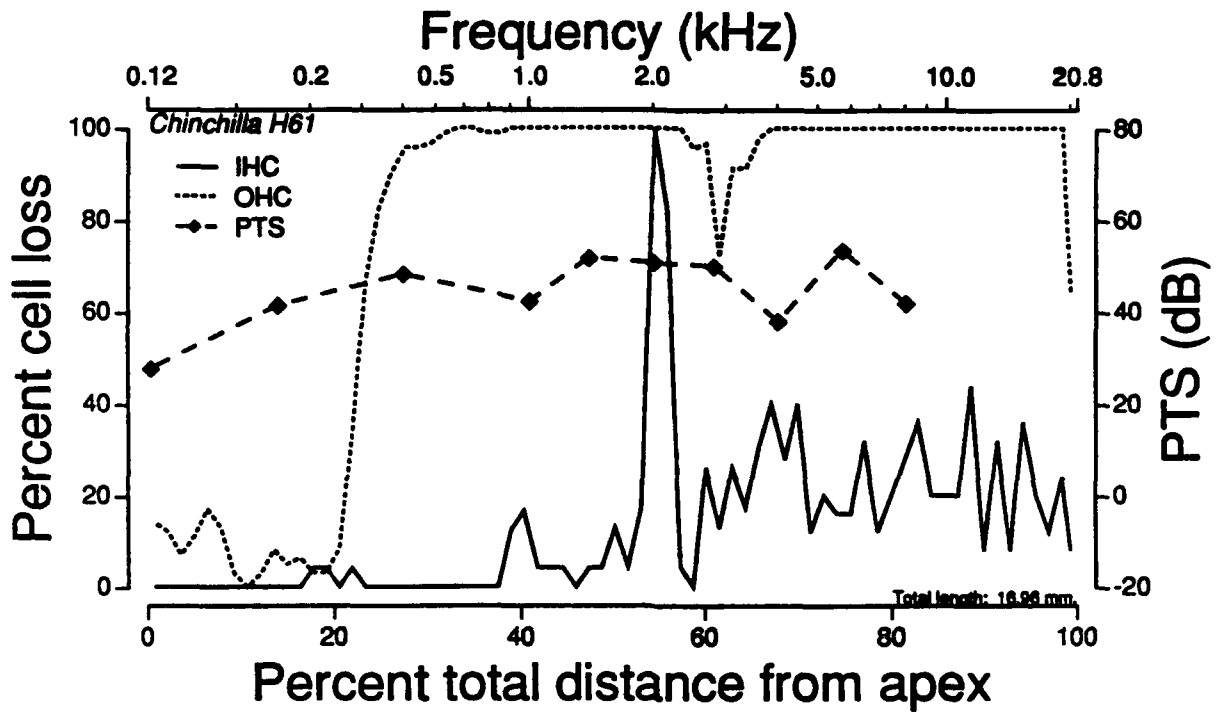
	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Comb. outer hair cells	Inner pillar cells	Outer pillar cells
Group means							
0.125 kHz	0.60	21.12	27.30	29.13	25.85	0.18	0.18
0.25 kHz	0.42	15.88	14.53	16.42	15.61	0.17	0.25
0.5 kHz	0.72	48.87	43.85	26.10	39.61	0.07	2.47
1 kHz	6.58	91.42	85.18	67.50	81.37	7.28	14.43
2 kHz	10.12	92.38	88.22	68.83	83.14	5.87	10.42
4 kHz	11.48	67.68	68.68	64.67	67.01	4.68	12.65
8 kHz	20.20	45.42	46.70	47.38	46.50	11.67	14.03
16 kHz	20.18	33.45	33.52	33.58	33.52	16.43	16.98

Group standard deviations

0.125 kHz	0.82	10.01	21.77	16.19	16.16	0.45	0.45
0.25 kHz	0.52	18.93	17.06	16.06	13.56	0.41	0.40
0.5 kHz	0.94	36.77	35.71	26.46	32.12	0.10	5.27
1 kHz	7.57	11.76	18.23	24.38	17.79	11.13	13.07
2 kHz	10.55	14.66	20.37	34.48	22.10	8.47	8.61
4 kHz	10.74	49.79	48.49	47.71	48.59	6.30	16.54
8 kHz	35.41	45.01	44.74	44.39	44.68	27.41	30.55
16 kHz	39.61	51.55	51.50	51.45	51.50	40.06	40.29







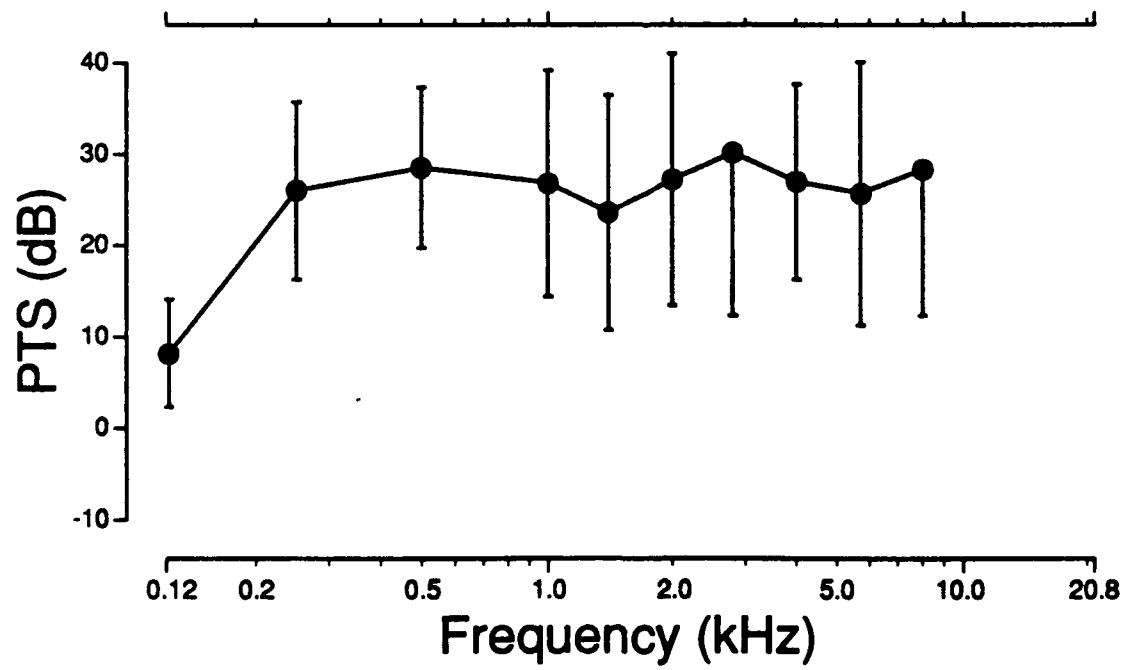
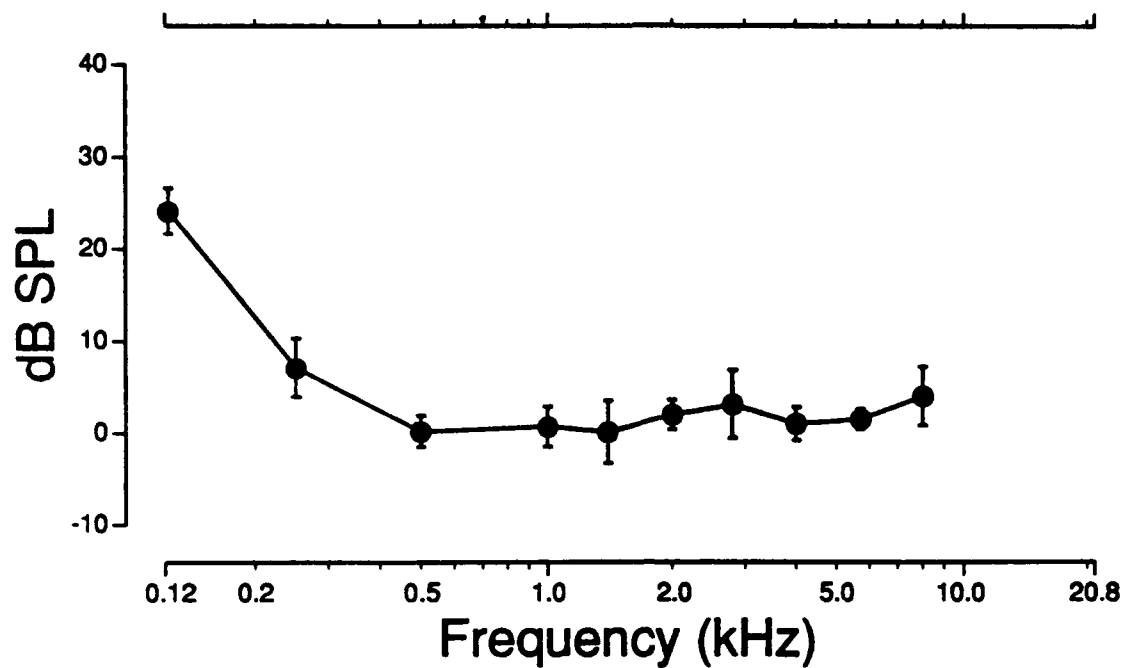
Summary data for the group exposed to:

146 dB peak SPL (10X), 138 dB peak SPL (90X)

Animal #

H47	-	Completed the entire protocol
H61R	-	Completed the entire protocol
H153	-	Completed the entire protocol
H225	-	Completed the entire protocol
J30	-	Completed the entire protocol
J36	-	Completed the entire protocol

146 dB peak SPL (10X), 138 dB peak SPL (90X)



146 dB peak SPL (10X), 138 dB peak SPL (90X)

Preexposure thresholds (dB SPL)

Animal\kHz	.125	.25	0.5	1.0	1.4	2.0	2.8	4.0	5.7	8.0
H47	26.0	8.4	-0.4	-0.6	-0.4	1.4	9.4	1.4	2.2	3.8
H61B	24.8	9.6	3.6	-2.4	3.4	1.6	4.8	-0.4	2.4	5.4
H153	25.6	9.0	-0.2	0.4	0.6	-0.4	1.0	0.4	2.6	3.8
H225	22.8	8.8	-0.4	1.2	-4.8	3.2	3.2	0.2	-0.2	2.6
J30	19.6	1.4	-1.0	1.4	-2.6	2.0	-1.0	0.2	0.6	-0.6
J36	25.8	5.4	-0.2	4.2	4.2	4.2	1.0	4.4	1.6	9.0
Mean	24.1	7.1	0.2	0.7	0.1	2.0	3.1	1.0	1.5	4.0
S.D.	2.5	3.2	1.7	2.2	3.4	1.6	3.7	1.8	1.1	3.2

Postexposure thresholds (dB SPL)

Animal\kHz	.125	.25	0.5	1.0	1.4	2.0	2.8	4.0	5.7	8.0
H47	31.8	34.9	27.1	32.4	32.9	38.4	33.2	34.7	35.0	34.8
H61B	29.1	24.6	21.1	20.6	11.9	30.6	37.8	21.1	16.4	21.9
H153	36.4	32.5	22.3	6.4	7.6	8.4	7.3	23.9	11.9	28.1
H225	29.6	25.8	26.4	23.7	19.7	14.4	21.2	10.4	15.6	8.9
J30	38.6	42.2	41.5	41.2	29.4	41.0	44.0	34.0	40.4	45.4
J36	28.6	38.4	33.8	41.0	40.7	42.2	56.0	44.4	44.1	55.0
Mean	32.3	33.1	28.7	27.5	23.7	29.2	33.2	28.1	27.2	32.3
S.D.	4.2	6.9	7.7	13.4	12.8	14.5	17.2	12.0	14.2	16.5

Permanent threshold shift (dB)

Animal\kHz	.125	.25	0.5	1.0	1.4	2.0	2.8	4.0	5.7	8.0
H47	5.8	26.5	27.5	33.0	33.3	37.0	23.8	33.3	32.8	31.0
H61B	4.3	15.0	17.5	23.0	8.5	29.0	33.0	21.5	14.0	16.5
H153	10.8	23.5	22.5	6.0	7.0	8.8	6.3	23.5	9.3	24.3
H225	6.8	17.0	26.8	22.5	24.5	11.3	18.0	10.3	15.8	6.3
J30	19.0	40.8	42.5	39.8	32.0	39.0	45.0	33.8	39.8	46.0
J36	2.8	33.0	34.0	36.8	36.5	38.0	55.0	40.0	42.5	46.0
Mean	8.2	26.0	28.5	26.8	23.6	27.2	30.2	27.0	25.7	28.3
S.D.	5.9	9.7	8.8	12.4	12.9	13.8	17.9	10.7	14.4	16.0

Temporary Threshold Shift (dB): 146 dB peak SPL (10X), 138 dB peak SPL (90X)

Frequency 0.125 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
H47	8.0	37.0	22.0	26.0	28.0	35.0	33.0	24.0	11.0	14.0	8.0	9.0	5.0	7.0	12.0	-1.0	37.0
H61B	56.0	51.0	59.0	40.0	30.0	54.0	49.0	45.0	23.0	6.0	1.0	16.0	7.0	-1.0	4.0	7.0	59.0
H153	6.0	32.0	18.0	24.0	41.0	30.0	12.0	13.0	11.0	2.0	23.0	13.0	5.0	23.0	9.0	6.0	41.0
H225	49.0	36.0	27.0	35.0	38.0	51.0	49.0	23.0	11.0	7.0	17.0	13.0	6.0	7.0	7.0	7.0	51.0
J30	53.0	41.0	48.0	53.0	46.0	66.0	25.0	39.0	22.0	27.0	26.0	10.0	25.0	15.0	24.0	12.0	66.0
J36	18.0	51.0	49.0	38.0	52.0	38.0	13.0	43.0	21.0	21.0	14.0	13.0	4.0	-5.0	11.0	1.0	52.0
Mean	27.1	35.4	31.9	30.9	33.6	39.2	26.0	27.0	15.0	12.3	14.6	12.9	10.3	9.9	13.4	8.9	51.0
S.D.	24.5	17.2	20.9	16.6	17.0	21.2	18.7	16.2	6.8	8.9	8.5	2.7	8.5	11.0	8.7	10.3	10.8

Frequency 0.250 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
H47	52.0	61.0	58.0	60.0	49.0	61.0	49.0	31.0	37.0	35.0	31.0	22.0	18.0	21.0	44.0	23.0	61.0
H61B	43.0	41.0	63.0	59.0	36.0	46.0	32.0	4.0	26.0	13.0	31.0	26.0	14.0	12.0	26.0	8.0	63.0
H153	37.0	37.0	59.0	41.0	55.0	41.0	35.0	20.0	18.0	27.0	28.0	20.0	25.0	27.0	20.0	22.0	59.0
H225	60.0	71.0	66.0	74.0	70.0	57.0	30.0	60.0	27.0	34.0	7.0	7.0	12.0	21.0	18.0	17.0	74.0
J30	60.0	67.0	55.0	80.0	71.0	68.0	59.0	67.0	51.0	75.0	49.0	22.0	48.0	41.0	39.0	35.0	80.0
J36	68.0	86.0	76.0	67.0	62.0	65.0	44.0	53.0	66.0	36.0	23.0	21.0	49.0	20.0	27.0	36.0	86.0
Mean	53.3	60.5	62.8	63.5	57.2	56.3	41.5	39.2	37.5	36.7	31.5	19.7	27.7	23.7	29.0	23.5	70.5
S.D.	11.7	18.6	7.5	13.7	13.4	10.7	11.3	24.8	19.0	20.7	9.1	6.5	16.7	9.8	10.4	10.7	11.1

Frequency 0.500 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
H47	43.0	69.0	58.0	51.0	58.0	51.0	58.0	59.0	48.0	23.0	31.0	33.0	32.0	33.0	13.0	32.0	69.0
H61B	59.0	57.0	66.0	64.0	72.0	37.0	55.0	37.0	29.0	30.0	-2.0	31.0	14.0	5.0	24.0	27.0	72.0
H153	17.0	57.0	59.0	52.0	49.0	21.0	16.0	21.0	17.0	17.0	19.0	31.0	24.0	29.0	20.0	17.0	59.0
H225	71.0	59.0	71.0	63.0	46.0	73.0	53.0	78.0	9.0	26.0	34.0	29.0	28.0	30.0	28.0	21.0	78.0
J30	69.0	70.0	64.0	66.0	71.0	70.0	70.0	78.0	61.0	67.0	48.0	21.0	52.0	44.0	35.0	39.0	78.0
J36	64.0	53.0	64.0	63.0	86.0	91.0	88.0	83.0	52.0	42.0	49.0	49.0	36.0	46.0	32.0	22.0	91.0
Mean	53.8	60.8	63.7	59.8	63.7	57.2	56.7	59.3	36.0	34.2	29.8	32.3	31.0	31.2	25.3	26.3	74.5
S.D.	20.6	7.0	4.8	6.6	15.4	25.7	23.8	25.4	20.8	18.1	19.2	9.2	12.8	14.7	8.1	8.1	10.7

Temporary Threshold Shift (dB): 146 dB peak SPL (10X), 138 dB peak SPL (90X)

		Frequency 1.000 kHz										Max					
Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
H47	50.0	58.0	65.0	63.0	23.0	58.0	65.0	60.0	49.0	32.0	43.0	38.0	35.0	29.0	34.0	34.0	65.0
H61B	44.0	52.0	68.0	65.0	80.0	72.0	70.0	59.0	45.0	14.0	28.0	34.0	19.0	19.0	24.0	30.0	80.0
H153	31.0	43.0	43.0	56.0	67.0	35.0	2.0	4.0	3.0	13.0	13.0	24.0	8.0	-1.0	6.0	11.0	67.0
H225	47.0	47.0	67.0	67.0	58.0	60.0	52.0	45.0	39.0	17.0	20.0	31.0	35.0	9.0	19.0	27.0	67.0
J30	51.0	57.0	53.0	65.0	68.0	67.0	70.0	78.0	42.0	65.0	50.0	9.0	60.0	35.0	43.0	21.0	78.0
J36	54.0	53.0	97.0	65.0	90.0	54.0	80.0	68.0	52.0	52.0	42.0	24.0	45.0	36.0	34.0	32.0	97.0
Mean	46.2	51.7	65.5	63.5	64.3	57.7	56.5	52.3	38.3	32.2	32.7	26.7	33.7	21.2	26.7	25.8	75.7
S.D.	8.2	5.8	18.2	3.9	23.1	12.8	28.2	26.1	17.9	21.9	14.6	10.3	18.4	14.9	13.2	8.6	12.2

		Frequency 1.400 kHz										Max					
Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
H47	51.0	50.0	59.0	52.0	81.0	62.0	72.0	60.0	49.0	52.0	50.0	52.0	31.0	29.0	43.0	30.0	81.0
H61B	69.0	62.0	53.0	68.0	70.0	47.0	68.0	14.0	15.0	49.0	44.0	2.0	15.0	6.0	7.0	6.0	70.0
H153	16.0	40.0	58.0	56.0	57.0	29.0	4.0	8.0	4.0	10.0	1.0	1.0	0.0	18.0	4.0	6.0	58.0
H225	83.0	74.0	72.0	63.0	78.0	82.0	57.0	54.0	14.0	25.0	5.0	21.0	22.0	25.0	19.0	32.0	83.0
J30	76.0	61.0	46.0	61.0	71.0	69.0	73.0	70.0	46.0	58.0	65.0	23.0	53.0	20.0	38.0	17.0	76.0
J36	40.0	79.0	74.0	64.0	78.0	50.0	68.0	39.0	48.0	28.0	58.0	48.0	31.0	42.0	45.0	28.0	79.0
Mean	55.8	61.0	60.3	60.7	72.5	56.5	57.0	40.8	29.3	37.0	37.2	24.5	25.3	23.3	26.0	19.8	74.5
S.D.	25.2	14.5	10.9	5.8	8.7	18.6	26.6	25.3	20.5	18.8	27.4	21.8	17.8	12.0	18.4	11.9	9.3

		Frequency 2.000 kHz										Max					
Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
H47	48.0	59.0	18.0	55.0	68.0	71.0	49.0	48.0	37.0	37.0	36.0	31.0	38.0	33.0	46.0	31.0	71.0
H61B	62.0	66.0	66.0	47.0	60.0	58.0	58.0	59.0	58.0	22.0	51.0	40.0	26.0	14.0	29.0	47.0	66.0
H153	11.0	59.0	63.0	62.0	36.0	35.0	37.0	11.0	2.0	19.0	20.0	7.0	9.0	4.0	11.0	11.0	63.0
H225	40.0	71.0	59.0	54.0	52.0	68.0	61.0	42.0	16.0	4.0	17.0	0.0	4.0	12.0	10.0	19.0	71.0
J30	64.0	66.0	41.0	62.0	70.0	77.0	56.0	62.0	54.0	62.0	63.0	32.0	38.0	37.0	50.0	31.0	77.0
J36	64.0	68.0	72.0	51.0	87.0	73.0	73.0	51.0	52.0	52.0	37.0	46.0	44.0	16.0	50.0	42.0	87.0
Mean	48.2	64.8	53.2	55.2	62.2	63.7	55.7	45.5	36.5	32.7	37.3	26.0	26.5	19.3	32.7	30.2	72.5
S.D.	20.7	4.9	20.2	6.0	17.3	15.4	12.1	18.4	22.9	21.8	17.7	18.4	16.6	12.9	18.8	13.5	8.6

Temporary Threshold Shift (dB): 146 dB peak SPL (10X), 138 dB peak SPL (90X)

Frequency 2.800 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
H47	48.0	39.0	36.0	54.0	61.0	69.0	47.0	27.0	47.0	28.0	29.0	24.0	21.0	24.0	36.0	14.0	69.0
H61B	44.0	54.0	68.0	61.0	68.0	59.0	45.0	39.0	41.0	33.0	34.0	41.0	33.0	14.0	40.0	45.0	68.0
H153	40.0	56.0	62.0	54.0	58.0	25.0	8.0	19.0	22.0	46.0	7.0	8.0	3.0	6.0	10.0	6.0	62.0
H225	49.0	67.0	58.0	43.0	51.0	56.0	68.0	48.0	10.0	23.0	21.0	1.0	11.0	15.0	6.0	40.0	68.0
J30	62.0	57.0	72.0	68.0	70.0	73.0	37.0	74.0	31.0	61.0	61.0	50.0	55.0	57.0	39.0	29.0	74.0
J36	65.0	52.0	62.0	54.0	56.0	81.0	55.0	55.0	63.0	53.0	40.0	39.0	46.0	47.0	54.0	73.0	81.0
Mean	51.3	54.2	59.7	56.3	60.0	60.5	43.3	43.7	35.7	40.7	32.0	27.2	28.2	27.2	30.8	34.5	70.3
S.D.	10.0	9.1	12.6	8.4	7.7	19.7	20.2	19.9	18.8	15.0	18.2	19.6	20.2	20.3	18.8	24.0	6.5

Frequency 4.000 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
H47	43.0	52.0	55.0	66.0	73.0	58.0	46.0	41.0	40.0	35.0	32.0	34.0	32.0	30.0	47.0	24.0	73.0
H61B	44.0	51.0	54.0	62.0	69.0	47.0	44.0	28.0	34.0	27.0	40.0	-2.0	33.0	8.0	6.0	39.0	69.0
H153	32.0	56.0	54.0	60.0	57.0	16.0	30.0	17.0	14.0	6.0	7.0	1.0	17.0	37.0	18.0	22.0	60.0
H225	44.0	52.0	67.0	54.0	57.0	62.0	54.0	36.0	8.0	7.0	6.0	-3.0	4.0	1.0	8.0	28.0	67.0
J30	41.0	55.0	61.0	60.0	57.0	64.0	59.0	75.0	46.0	52.0	43.0	44.0	45.0	42.0	20.0	28.0	75.0
J35	65.0	63.0	48.0	47.0	65.0	67.0	41.0	43.0	33.0	43.0	40.0	36.0	36.0	47.0	44.0	33.0	67.0
Mean	44.8	54.8	56.5	58.2	63.0	52.3	45.7	40.0	29.2	28.3	28.0	18.3	27.8	27.5	23.8	29.0	68.5
S.D.	10.9	4.4	6.6	6.7	7.0	19.1	10.2	19.0	14.9	18.8	17.1	21.8	14.8	18.8	17.7	6.2	5.3

Frequency 5.700 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
H47	31.0	56.0	43.0	65.0	64.0	64.0	62.0	52.0	60.0	41.0	30.0	21.0	30.0	31.0	49.0	21.0	65.0
H61B	36.0	38.0	55.0	53.0	80.0	60.0	54.0	23.0	40.0	46.0	39.0	30.0	17.0	10.0	19.0	10.0	80.0
H153	22.0	40.0	54.0	52.0	56.0	6.0	0.0	23.0	30.0	40.0	11.0	14.0	10.0	10.0	8.0	9.0	56.0
H225	20.0	56.0	60.0	50.0	72.0	69.0	69.0	1.0	19.0	6.0	17.0	-3.0	15.0	13.0	13.0	22.0	72.0
J30	65.0	61.0	65.0	64.0	68.0	68.0	41.0	61.0	53.0	39.0	49.0	37.0	52.0	48.0	31.0	28.0	68.0
J36	71.0	50.0	59.0	55.0	81.0	50.0	52.0	50.0	38.0	38.0	35.0	31.0	41.0	42.0	39.0	48.0	81.0
Mean	40.8	50.2	56.0	56.5	70.2	52.8	46.3	35.0	40.0	35.0	30.2	21.7	27.5	25.7	26.5	23.0	70.3
S.D.	21.9	9.3	7.5	6.4	9.6	24.0	24.6	23.0	14.9	14.5	14.1	14.6	16.5	17.0	15.9	14.3	9.5

Temporary Threshold Shift (dB): 146 cB peak SPL (10X), 138 dB peak SPL (90X)

Frequency: 3.000 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
H47	36.0	55.0	62.0	53.0	61.0	37.0	55.0	44.0	57.0	39.0	27.0	45.0	27.0	25.0	47.0	25.0	62.0
H61B	45.0	60.0	43.0	57.0	65.0	54.0	50.0	4.0	35.0	52.0	26.0	44.0	34.0	5.0	13.0	14.0	65.0
H153	12.0	54.0	54.0	55.0	52.0	36.0	17.0	23.0	26.0	44.0	45.0	49.0	23.0	34.0	28.0	12.0	55.0
H225	26.0	24.0	65.0	59.0	45.0	81.0	26.0	2.0	-4.0	12.0	15.0	1.0	2.0	6.0	11.0	6.0	81.0
J30	58.0	63.0	74.0	80.0	77.0	36.0	59.0	75.0	40.0	63.0	65.0	41.0	63.0	50.0	51.0	20.0	80.0
J36	74.0	52.0	61.0	63.0	60.0	64.0	53.0	44.0	42.0	22.0	29.0	40.0	45.0	66.0	31.0	42.0	74.0
Mean	41.8	51.3	59.8	61.2	60.0	51.3	43.3	32.0	32.7	38.7	34.5	36.7	32.3	31.0	30.2	19.8	69.5
S.D.	22.3	14.0	10.5	9.8	11.0	18.6	17.4	27.9	20.6	18.9	17.8	17.8	20.7	24.2	16.6	12.7	10.5

Summary of Group Anatomical Data with
Cochleograms and PTS Audiograms
for Individual Animals

146 dB peak SPL (10X), 138 dB peak SPL (90X)

Total number of cochlear sensory cells missing

Animal number	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Total outer hair cells
H47	30	1783	1855	1703	5341
H61B	110	2367	2249	2198	6814
H153	6	337	191	116	644
H225	139	1241	1155	983	3379
J30	398	2137	2009	1827	5973
J36	909	1836	1806	1716	5358
Group mean	265				4585
S.D.	345				2238
S.E.	141				914

Total sensory cell losses over octave band lengths of the cochlea centered at the frequencies indicated

Octave band center frequency	Inner hair cells	Outer hair cells
Group means		
0.125 kHz	1.5	155.0
0.25 kHz	4.7	256.2
0.5 kHz	3.5	630.7
1 kHz	40.5	856.2
2 kHz	62.2	855.5
4 kHz	51.2	824.5
8 kHz	52.8	555.2
16 kHz	49.0	451.7
Standard deviations		
0.125 kHz	3.2	105.3
0.25 kHz	5.7	268.2
0.5 kHz	3.9	403.7
1 kHz	55.7	237.0
2 kHz	58.7	410.3
4 kHz	78.0	407.4
8 kHz	102.0	483.2
16 kHz	92.3	477.5

146 dB peak SPL (10X), 138 dB peak SPL (90X)

Total sensory cell losses over octave band frequencies

	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Comb. outer hair cells	Inner pillar cells	Outer pillar cells
Chinchilla H47							
0.125 kHz	0	92	132	98	322	6	18
0.25 kHz	3	180	141	138	459	1	0
0.5 kHz	2	381	383	295	1059	1	10
1 kHz	2	363	363	353	1079	2	18
2 kHz	3	373	373	362	1108	0	14
4 kHz	8	351	371	370	1092	24	61
8 kHz	5	27	81	77	185	0	0
16 kHz	7	16	11	10	37	0	1
TOTALS	30	1783	1855	1703	5341	34	122
Chinchilla H61B							
0.125 kHz	0	79	63	75	217	0	0
0.25 kHz	3	301	206	183	690	0	1
0.5 kHz	0	347	341	318	1006	0	20
1 kHz	4	329	329	325	983	0	23
2 kHz	40	337	337	334	1008	29	79
4 kHz	44	337	337	337	1011	31	65
8 kHz	17	337	337	330	1004	26	34
16 kHz	2	300	299	296	895	0	8
TOTALS	110	2367	2249	2198	6814	86	230
Chinchilla H153							
0.125 kHz	1	9	23	27	59	0	0
0.25 kHz	3	4	6	13	23	0	0
0.5 kHz	1	14	7	3	24	0	0
1 kHz	0	271	96	42	409	2	4
2 kHz	1	7	5	12	24	0	0
4 kHz	0	2	1	4	7	0	0
8 kHz	0	27	52	15	94	0	0
16 kHz	0	3	1	0	4	0	0
TOTALS	6	337	191	116	644	2	4

146 dB peak SPL (10X), 138 dB peak SPL (90X)

Total sensory cell losses over octave band frequencies

	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Comb. outer hair cells	Inner pillar cells	Outer pillar cells
Chinchilla H225							
0.125 kHz	8	29	43	54	126	0	0
0.25 kHz	3	8	12	11	31	0	0
0.5 kHz	3	238	135	56	429	2	12
1 kHz	16	343	328	146	817	2	19
2 kHz	71	353	352	335	1040	51	66
4 kHz	32	254	275	332	861	70	102
8 kHz	6	10	9	49	68	0	0
16 kHz	0	6	1	0	7	0	0
TOTALS	139	1241	1155	983	3379	125	199

Chinchilla J30							
0.125 kHz	0	4	16	19	39	0	0
0.25 kHz	16	158	66	11	235	1	0
0.5 kHz	11	338	292	205	835	25	3
1 kHz	129	329	327	315	971	346	200
2 kHz	145	336	336	309	981	360	141
4 kHz	16	336	336	332	1004	32	26
8 kHz	29	336	336	336	1008	5	21
16 kHz	52	300	300	300	900	34	13
TOTALS	398	2137	2009	1827	5973	803	404

Chinchilla J36							
0.125 kHz	0	20	65	82	167	0	0
0.25 kHz	0	12	15	72	99	1	0
0.5 kHz	4	227	151	53	431	4	2
1 kHz	92	316	314	248	878	185	150
2 kHz	113	324	324	324	972	255	244
4 kHz	207	324	324	324	972	421	279
8 kHz	260	324	324	324	972	516	324
16 kHz	233	289	289	289	867	467	289
TOTALS	909	1836	1806	1716	5358	1849	1288

146 dB peak SPL (10X), 138 dB peak SPL (90X)

Total sensory cell losses over octave band frequencies

	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Comb. outer hair cells	Inner pillar cells	Outer pillar cells
Group means							
0.125 kHz	1.5	38.8	57.0	59.2	155.0	1.0	3.0
0.25 kHz	4.7	110.5	74.3	71.3	256.2	0.5	0.2
0.5 kHz	3.5	257.5	218.2	155.0	630.7	5.3	7.8
1 kHz	40.5	325.2	292.8	238.2	856.2	89.5	69.0
2 kHz	62.2	288.3	287.8	279.3	855.5	115.8	90.7
4 kHz	51.2	267.3	274.0	283.2	824.5	96.3	88.8
8 kHz	52.8	176.8	189.8	188.5	555.2	91.2	63.2
16 kHz	49.0	152.3	150.2	149.2	451.7	83.5	51.8
TOTALS	265.3	1616.8	1544.2	1423.8	4584.8	483.2	374.5

Group standard deviations

0.125 kHz	3.2	37.4	41.9	31.5	105.3	2.4	7.3
0.25 kHz	5.7	122.4	82.4	74.3	268.2	0.5	0.4
0.5 kHz	3.9	134.4	144.0	135.6	403.7	9.8	7.6
1 kHz	55.7	31.0	97.8	121.4	237.0	145.5	83.9
2 kHz	58.7	138.9	139.6	132.1	410.3	153.3	90.4
4 kHz	78.0	134.4	137.3	137.7	407.4	160.6	99.5
8 kHz	102.0	170.5	157.8	156.3	483.2	208.4	128.6
16 kHz	92.3	157.9	159.8	159.8	477.5	188.4	116.3
TOTALS	344.9	733.2	756.4	752.3	2238.3	733.1	466.5

146 dB peak SPL (10X), 138 dB peak SPL (90X)

Percent sensory cell losses over octave band frequencies

	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Comb. outer hair cells	Inner pillar cells	Outer pillar cells
Chinchilla H47							
0.125 kHz	0.0	42.0	60.3	44.7	49.0	1.8	8.2
0.25 kHz	1.0	46.9	36.7	35.9	39.8	0.2	0.0
0.5 kHz	0.7	99.5	100.0	77.0	92.2	0.2	2.6
1 kHz	0.7	99.7	99.7	97.0	98.8	0.3	4.9
2 kHz	1.1	100.0	100.0	97.1	99.0	0.0	3.8
4 kHz	2.7	94.4	99.7	99.5	97.9	4.0	16.4
8 kHz	1.7	7.3	21.8	20.7	16.6	0.0	0.0
16 kHz	2.6	4.8	3.3	3.0	3.7	0.0	0.3

Chinchilla H61B

0.125 kHz	0.0	39.9	31.8	37.9	36.5	0.0	0.0
0.25 kHz	1.1	86.7	59.4	52.7	66.3	0.0	0.3
0.5 kHz	0.0	100.0	98.3	91.6	96.6	0.0	5.8
1 kHz	1.6	100.0	100.0	98.8	99.6	0.0	7.0
2 kHz	15.9	100.0	100.0	99.1	99.7	5.3	23.4
4 kHz	16.7	100.0	100.0	100.0	100.0	5.7	19.3
8 kHz	6.3	100.0	100.0	97.9	99.3	4.8	10.1
16 kHz	0.8	99.7	99.3	98.3	99.1	0.0	2.7

Chinchilla H153

0.125 kHz	0.6	4.4	11.2	13.2	9.6	0.0	0.0
0.25 kHz	1.1	1.1	1.7	3.6	2.1	0.0	0.0
0.5 kHz	0.4	3.9	1.9	0.8	2.2	0.0	0.0
1 kHz	0.0	79.2	28.1	12.3	39.9	0.4	1.2
2 kHz	0.4	2.0	1.4	3.4	2.3	0.0	0.0
4 kHz	0.0	0.6	0.3	1.1	0.7	0.0	0.0
8 kHz	0.0	7.7	14.9	4.3	9.0	0.0	0.0
16 kHz	0.0	1.0	0.3	0.0	0.4	0.0	0.0

146 dB peak SPL (10X), 138 dB peak SPL (90X)

Percent sensory cell losses over octave band frequencies

	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Comb. outer hair cells	Inner pillar cells	Outer pillar cells
Chinchilla H225							
0.125 kHz	5.1	14.0	20.8	26.1	20.3	0.0	0.0
0.25 kHz	1.1	2.2	3.3	3.0	2.8	0.0	0.0
0.5 kHz	1.1	65.6	37.2	15.4	39.4	0.4	3.3
1 kHz	6.0	99.4	95.1	42.3	78.9	0.4	5.5
2 kHz	26.9	100.0	99.7	94.9	98.2	9.0	18.7
4 kHz	11.7	72.2	78.1	94.3	81.5	12.3	29.0
8 kHz	2.1	2.8	2.5	13.9	6.4	0.0	0.0
16 kHz	0.0	1.9	0.3	0.0	0.7	0.0	0.0

Chinchilla 330

0.125 kHz	0.0	2.0	8.1	9.6	6.6	0.0	0.0
0.25 kHz	6.1	45.5	19.0	3.2	22.6	0.2	0.0
0.5 kHz	4.2	98.0	84.6	59.4	80.7	4.6	0.9
1 kHz	50.6	100.0	99.4	95.7	98.4	65.2	60.8
2 kHz	57.8	100.0	100.0	92.0	97.3	66.4	42.0
4 kHz	6.1	100.0	100.0	98.8	99.6	5.9	7.7
8 kHz	10.7	100.0	100.0	100.0	100.0	0.9	6.3
16 kHz	21.5	100.0	100.0	100.0	100.0	7.0	4.3

Chinchilla J36

0.125 kHz	0.0	10.5	34.2	43.2	29.3	0.0	0.0
0.25 kHz	0.0	3.6	4.5	21.6	9.9	0.2	0.0
0.5 kHz	1.6	68.2	45.3	15.9	43.1	0.8	0.6
1 kHz	37.6	99.7	99.1	78.2	92.3	36.1	47.3
2 kHz	46.7	100.0	100.0	100.0	100.0	48.9	75.3
4 kHz	81.8	100.0	100.0	100.0	100.0	80.5	86.1
8 kHz	99.6	100.0	100.0	100.0	100.0	98.9	100.0
16 kHz	99.6	100.0	100.0	100.0	100.0	100.0	100.0

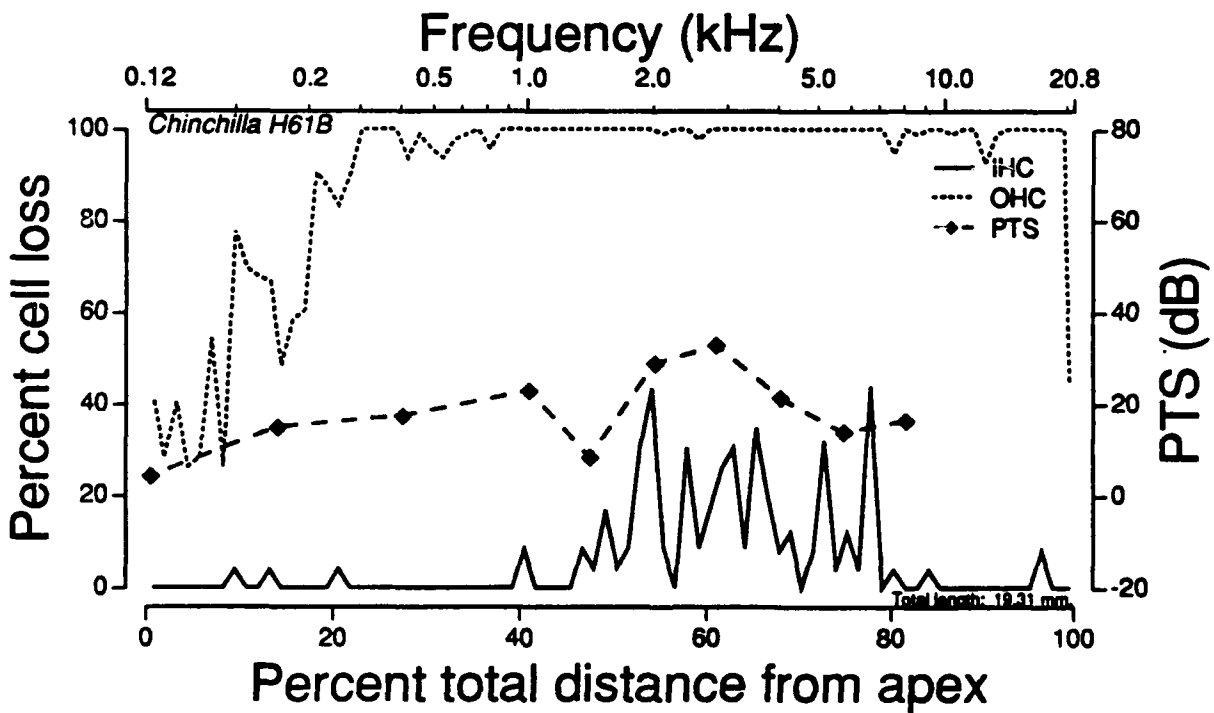
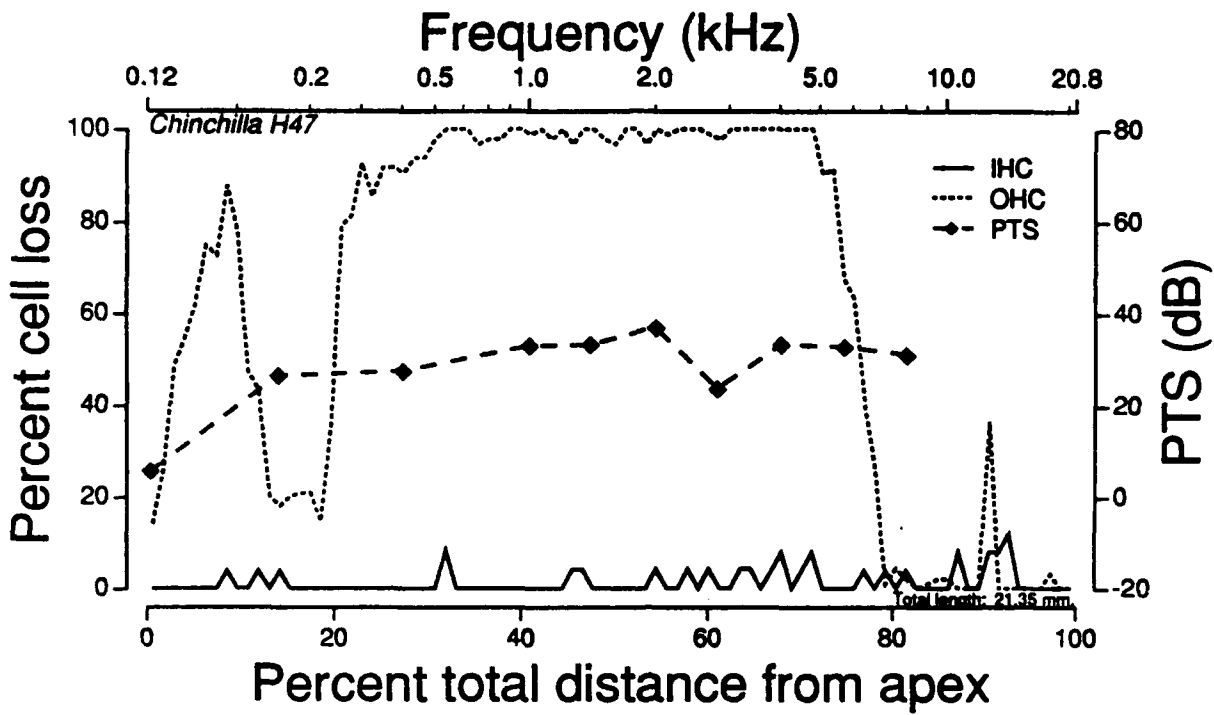
146 dB peak SPL (10X), 138 dB peak SPL (90X)

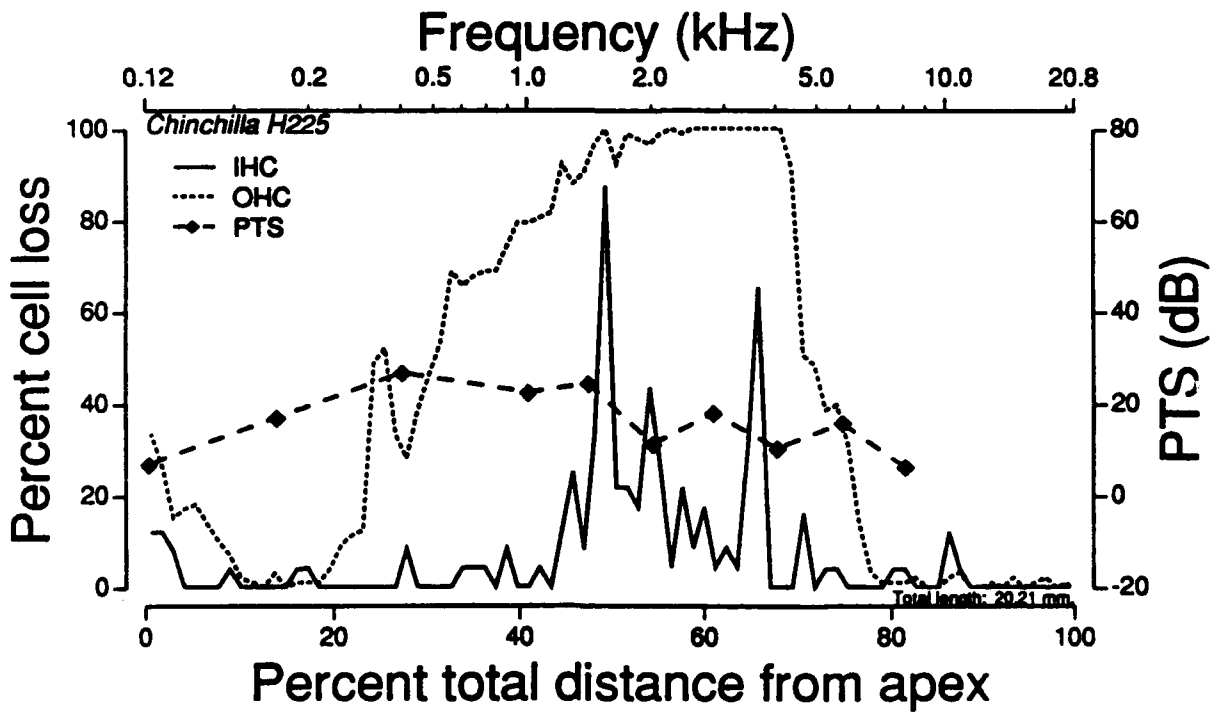
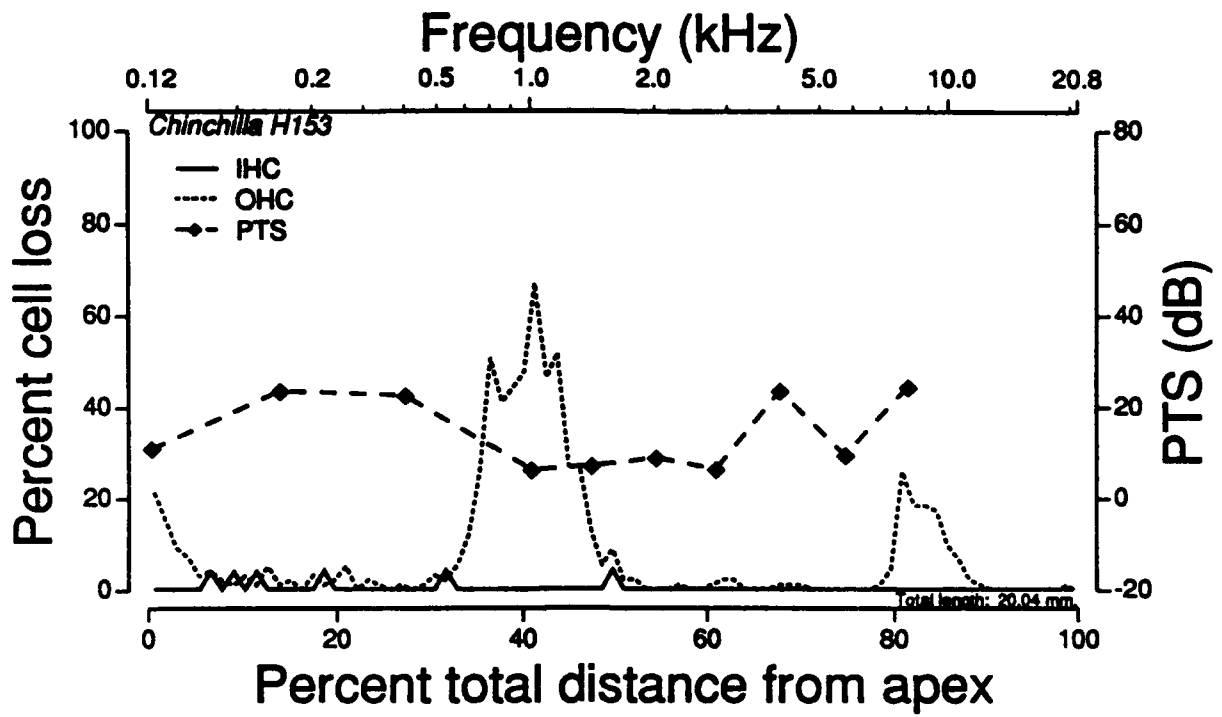
Percent sensory cell losses over octave band frequencies

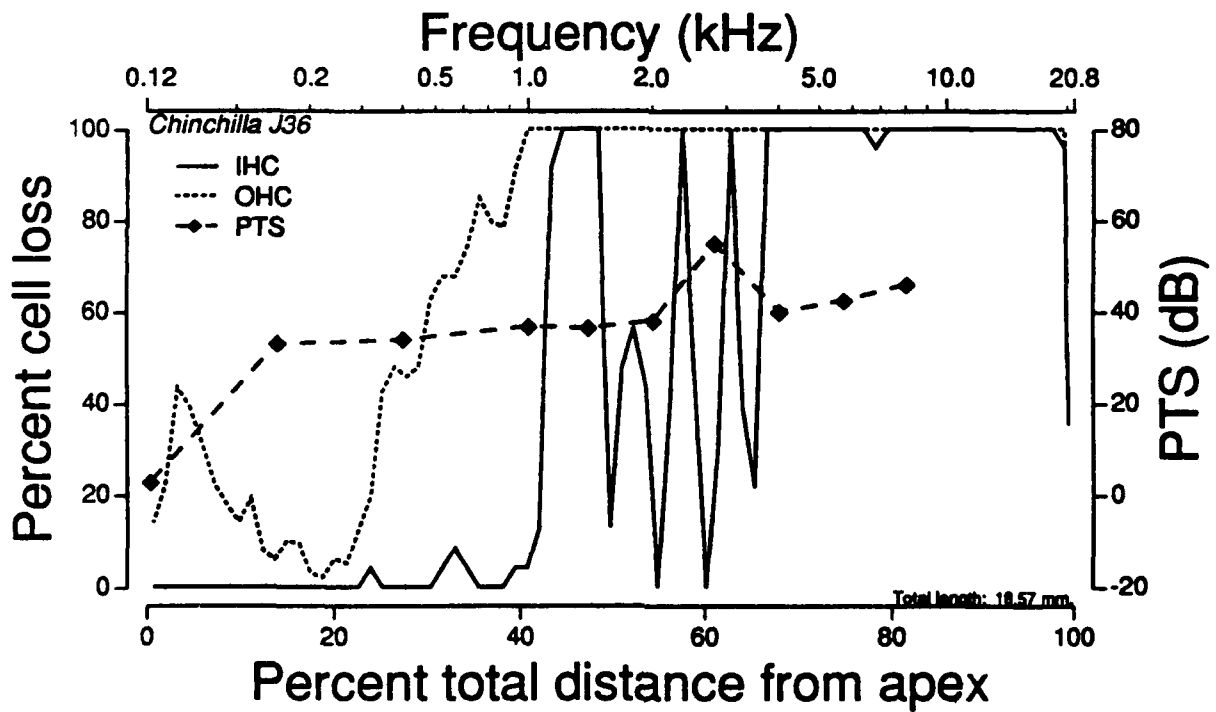
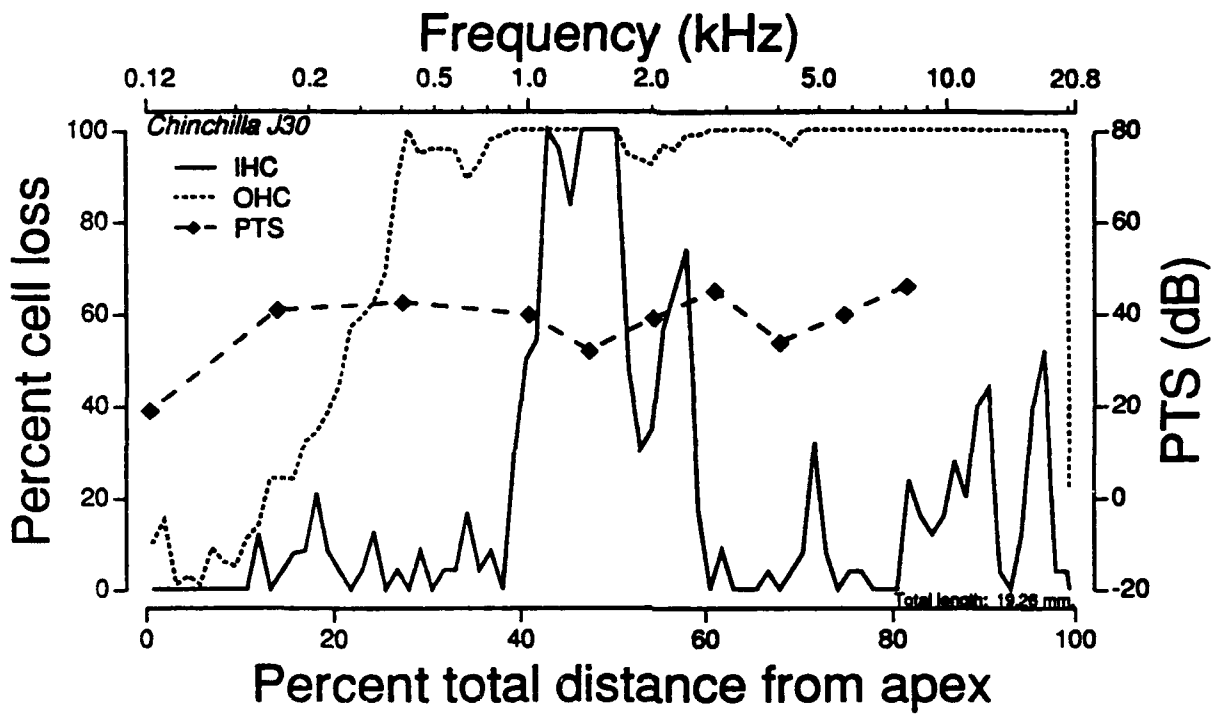
	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Comb. outer hair cells	Inner pillar cells	Outer pillar cells
Group means							
0.125 kHz	0.95	18.80	27.73	29.12	25.22	0.30	1.37
0.25 kHz	1.73	31.00	20.77	20.00	23.92	0.10	0.05
0.5 kHz	1.33	72.53	61.22	43.35	59.03	1.00	2.20
1 kHz	16.08	96.33	86.90	70.72	84.65	17.07	21.12
2 kHz	24.80	83.67	83.52	81.08	82.76	21.60	27.20
4 kHz	19.83	77.87	79.68	82.28	79.94	18.07	26.42
8 kHz	20.07	52.97	56.53	56.13	55.21	17.43	19.40
16 kHz	20.75	51.23	50.53	50.22	50.66	17.83	17.88

Group standard deviations

0.125 kHz	2.05	17.03	19.11	15.24	16.29	0.73	3.35
0.25 kHz	2.18	34.76	23.16	20.81	25.16	0.11	0.12
0.5 kHz	1.51	37.17	39.43	37.59	37.01	1.79	2.16
1 kHz	22.19	8.40	28.86	35.72	23.28	27.59	25.94
2 kHz	23.70	40.01	40.23	38.17	39.44	28.67	27.95
4 kHz	30.96	39.36	39.86	39.83	39.50	30.84	30.88
8 kHz	39.16	51.55	48.02	47.58	48.92	39.95	39.71
16 kHz	39.51	53.33	53.94	53.93	53.73	40.35	40.27







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