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The development of the computerized version of the early speech perception test battery

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THE DEVELOPMENT OF THE COMPUTERIZED VERSION OF THE EARLY SPEECH PERCEPTION TEST BATTERY

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ABSTRACT

The Early Speech Perception Test battery - Standard Version and Low Verbal Version is an audiological tool designed to assess speech perception ability of profoundly hearing impaired children. It allows professionals to place profoundly hearing impaired children in one of the four speech perception categories identified by Geers and Moog in 1987. The categories are: Category One - No Speech Discrimination, Category Two - Pattern Perception, Category Three - Some Word Recognition, and Category Four - Consistent Word Recognition. Presently, the ESP Test is being administered using monitored live voice. This paper discusses the development of the computerized version of the ESP Test battery with reliability and validity testing results. Reliability and validity testing of both the Standard Version and the Low Verbal Version have shown the following: The Standard Version has proven to be a reliable and valid test for assessing speech perception ability of profoundly hearing impaired children. Also, the Pattern Perception and Two Syllable Word Identification subtests of the Low Verbal Version are both reliable and valid assessment tools. However, the One Syllable Word Identification subtest is not a valid test for assessing word recognition abilities of profoundly hearing impaired children.

INTRODUCTION

The most disabling effect of prelingual hearing impairment on an individual is the interference in the development of spoken language. The degree to which the development of spoken language is affected is dependent on a number of factors. According to Geers and Moog, the most important factor is the extent of the hearing impairment (Geers & Moog, 1987). The more speech an individual can perceive, the easier it is to learn to understand and produce it.

The degree of an individual's hearing impairment is predominantly classified as one of the following: mild, moderate, severe, profound, or the combination of two categories depending on the configuration of the individual's unaided audiogram. It is through the use of amplification that speech is moved into a region of audibility for the hearing impaired individual. It should be noted that amplifying speech so as to make it audible does not imply that the speech has been made discriminable.

Speech perception ability with the use of amplification in hearing impaired children is commonly assessed by the child's ability to recognize two - syllable equal stress words or one syllable words when presented with a carrier phrase. Research has shown that children score high on mono-syllabic word recognition tests if their hearing threshold averages for the frequencies 500, 1000, and 2000 Hz are better than about 70 dBHL (Erber, 1974). In 1974, Erber conducted a study to determine the ability

of hearing impaired children with hearing threshold averages worse than 72 dBHL to recognize two syllable equal stress words with amplification. He found the following: children with average threshold levels better than 85 dBHL scored from 70 to 100% correct, children with average threshold levels between 85 to 100 dBHL scored from 0 to 96% correct, and children with average threshold levels poorer than 100 dBHL scored from 0 to 30% correct (Erber, 1974). It seems that many professionals make the mistake of classifying all profoundly hearing impaired children as poor speech perceivers. However, it is clear in the above results that speech perception ability of profoundly hearing impaired children varies greatly and is not predicted by hearing threshold levels alone.

Because of the apparent problems with predicting speech perception ability of the profoundly hearing impaired with the use of pure tone thresholds alone, Geers and Moog, in 1987, proposed the use of a categorization scheme to aid in the identification of speech perception ability of profoundly hearing impaired children who are wearing appropriate amplification. The categories are as follows:

Category 1- No Speech Discrimination Ability: This category refers to the children who are unable to detect amplified speech or who can detect speech but are unable to discriminate speech patterns. Children who have the ability to detect speech are unable to discriminate between words or phrases that differ in durational patterns (for example, "ball" versus "ice cream cone").

Category 2 - Pattern Perception Ability: Category Two children are children who have minimal ability in discriminating amplified speech. The range of ability within this category is greater than the range

of ability within the other three categories. Skill within this category ranges from the ability to discriminate (with some difficulty) words or phrases that differ in durational patterns to the ability to easily differentiate durational patterns and words that differ in stress (for example, "cookie" versus "airplane"). Category Two children are not able to make use of spectral information to discriminate vowel or consonant sounds.

Category 3 - Some Word Recognition Ability: Category Three children are children who are able to make some use of spectral or intonational information. Children within this category demonstrate the ability to discriminate among words or phrases of similar stress and durational patterns when they are presented in a small closed set of up to 12 choices and when the words contain highly differential vowels (for example, "hotdog" versus "toothbrush"). Success at this task is dependent upon the degree to which the vowels differ.

Category 4 - Consistent Word Recognition Ability: Category Four children are children who demonstrate greater facility in using spectral information for discrimination. These children consistently discriminate among words and phrases containing different vowel sounds when presented in small closed sets of up to 12 words. (Geers & Moog, 1987).

In 1988, Geers and Moog identified various standardized audiologic tests which can be used to place profoundly hearing impaired children in these speech perception categories. Also included in their study are specific test scores which correspond to the four speech perception categories (Geers & Moog, 1988).

Most educators agree that the major role of aural rehabilitation is to move hearing impaired children through the hierarchy of aural ability. It has been informally documented that some children move from one category to the next after auditory training. However, factors relating to the amount of movement from one category to the next have not been documented.

Presently, Geers and Moog are in the process of developing the Early Speech Perception Test Battery - Standard Version and Low Verbal Version (ESP) which is designed to place profoundly hearing impaired children wearing amplification into the appropriate speech perception category. (The Low Verbal Version is used with children who exhibit limited vocabulary.) Each version consists of three subtests: the Pattern Perception Subtest, the Two Syllable Equal Stress Word Identification Subtest, and the One Syllable Word Identification subtest. Speech stimuli are presented individually via monitored live voice at a level of (70 - 75 dB SPL) and the child is then directed to choose a picture from a group of twelve pictures shown before him or her.

When assessing speech perception ability, audiologists generally present speech stimuli using either monitored live voice (mlv) or pre-recorded stimuli. Advantages and disadvantages of the different methods of presentation have been identified by researchers in the past. For example, according to Carhart, results obtained with mlv of different speakers cannot be compared unless the talkers have been shown to be equivalent. Carhart also identifies disadvantages in the use of pre-recordings saying

that "...each talker's unique characteristics are permanently built into the test he has recorded. There may be as much difference between one recording and another as between two live-voice talkers." (Carhart, 1965). Both arguments may indeed be true. However, it seems to be to this researcher that the advantages in using pre-recorded stimuli far outweigh the advantages of using mlv.

PURPOSE

The intent of this project was to record the stimuli for the ESP test battery on the Macintosh SE computer and acquire reliability and validity measures for the computerized version of the ESP on a select group of profoundly hearing impaired children.

The rationale for selecting the Macintosh SE is multi-fold. Control of stimuli intensity is possible. Recording life is greatly increased with the use of digital storage as opposed to analog storage. The Macintosh SE allows for quick random access and instantaneous output of stimuli, characteristics which are not available when using the more conventional analog equipment, and the Macintosh SE is relatively inexpensive and user friendly.

The remainder of this paper is devoted to a discussion of the development of the computerized version of the ESP and the presentation of reliability and validity measurements for each version of the test battery.

STEPS IN THE SELECTION & RECORDING OF THE ESP STIMULI

The following outline identifies the major steps in the process of recording the ESP stimuli. Each will be discussed in some detail.

I. Measurement of noise in the recording area (anechoic chamber).
II. Initial recording of words onto a video casette tape through a 16 bit digital audio processor.
III. Initial recording of words from the video casette tape onto the Macintosh SE computer.
IV. Identification of word patterns through the tactile mode.
V. Final setup of stimuli onto the Macintosh SE.

Measurement of noise in recording area: The room chosen for the recording of the ESP stimuli was the anechoic chamber located in the clinic and research building at Central Institute for the Deaf (CID). This area contains the least amount of ambient noise and is the least reverberant if compared to any other area located on the CID campus. The following equipment was used in the measurement of noise within the chamber:

Bruel & Kjaer (B&K) Modular Precision Sound Level Meter (SLM) type 2231 plus Integrating SLM Module BZ 7100
B&K 1/3 ti 1/1 Octave Filter Set type 1625
B&K Microphone Cartridge type 4165 (K factor of 0.00)

The equipment was placed in the anechoic chamber at the point where the recordings actually took place. The noise was measured in the following ways: SPL dB (A), SPL dB (C), overall linear dB SPL from 2 Hz to 70 KHz, overall linear dB SPL from 10 Hz to 20 KHz, and dB SPL from 20 Hz to 20 KHz in one third octave bands. Measurements taken can be viewed in Table 1a and 1b. A graph of the noise levels in one third octave bands can also be viewed in Fig. 1

Initial recording of words: The following equipment was used in the recording of the test stimuli:

B&K Microphone type 4179
B&K Microphone Preamplifier type 2660
B&K Microphone power supply type 2801
Simple passive RC HP filter (value = 0.082 uF)
Sony PCM-501ES Digital Encoder
JVC BR-7110U VCR
(Fig. 2 displays block diagram)

The stimuli were initially recorded onto the JVC BR-7110U VCR tape through the Sony PCM-501ES digital encoder for the following reasons. It was first thought that initial recording of the stimuli onto the Macintosh SE was the quickest most efficient procedure. However, at the time of the recordings, an 8 bit analog to digital Macintosh SE recorder was all that was available for our purposes. By recording the stimuli onto the JVC VCR through the Sony PCM, we were able to record the stimuli onto a 16

bit digital system, thus allowing for the greatest resolution in sound recording.

The speaker, a forty year old female audiologist on the CID clinic staff, stood in the anechoic chamber at a distance of one half meter from the microphone. It was decided that variation in level of syllables within the two and three syllable words be within 3 dB. Once the recording began, the speaker repeated each word three to nine times. The number of repetitions generally depended on the level at which the words were spoken. While producing each word, the speaker watched the peak dB SPL output levels on a General Radio sound level meter positioned near the microphone. The speaker attempted to repeat each word at a level of 70 to 75 dB SPL. This level was specified for two main reasons. First, 70 to 75 dB SPL is the accepted level for normal conversational speech. In addition, this level optimized the signal to noise ratio within the chamber without causing voice strain which could impair the quality of the utterance.

Recording of words onto the Macintosh SE COMPUTER: The following equipment was used to record the test stimuli onto the Macintosh SE Computer:

JVC BR- 7110U VCR
Rockland Brickwall Active Filter - Model 751-02
Grason - Stadler Audiometer - Model 1701
MacRecorder (Audio to Digital Recorder)
Macintosh SE Computer - Model M5010

(Refer to Fig. 3 for block diagram)

There were two major concerns in recording the stimuli onto the computer. First, it was important to have as little noise as possible on the final recording. Second, peak output levels of each word needed to be within 5 dB on the dB(A) scale.

The filter was used in the process of recording the words onto the computer to eliminate as much noise as possible which existed on the tape recording. It is believed that the noise on the recording was in fact the noise which existed in the anechoic chamber. The high and low cutoffs of the filter were set so as not to interfere with the speech signal. The speaker's fundamental frequency was measured to be 175 Hz. The high pass cutoff of the filter was set at 160 Hz and the low pass cutoff was set at 20 KHz.

Prior to recording onto the computer, it was decided that the peak sound pressure level of each word be within 5 dB on the dB(A) scale. This criterion was set to eliminate the possibility of words being identified on the basis of intensity cues. The audiometer was used in the equipment set up to accomplish this task. One word was chosen arbitrarily as the reference word. As the word was being played through the equipment set up, the vu meter on the audiometer was set at 0 dB. The samples of that word were then recorded onto the computer at that relative level. Prior to recording the remaining words onto the computer, each group of samples were played through the equipment set up and the vu meter of the

audiometer was set at the reference 0 dB level. Approximately three to five samples of each word were recorded onto the computer.

The next step in the process of choosing the final words was to pick the "best" word from each group of samples. Words were chosen on the basis of the quality of their production (eg: natural stress and duration) and overall quality of recording. Once the final words were chosen, .05 seconds of silence was inserted before each word.

Identification of word patterns through the tactile mode: To assure that the words on the Standard Pattern Perception Battery could be categorized according to their associated word patterns (ie: one syllable, two syllable - unequal stress, two syllable - equal stress, and three syllable), words were played through a bone conductor oscillator which was held in the hand of eight normal hearing listeners, who were artificially deafened with speech noise, for categorization purposes. Presentation of stimuli was at 15 dB above each individual's tactile threshold. Once a stimulus was played, each subject was asked to categorize it according to one of the stress patterns. Each stimulus was played twice.

Table 2 displays the responses of each of the eight subjects. Also included in Table 2 is the combined percent correct categorization for each of the stimuli. Subjects had the most difficulty correctly categorizing "popcorn" (56% correct categorization), and "elephant" (13% correct categorization). "Popcorn" was consistently categorized as a two - syllable unequal stress word, and "elephant" was consistently categorized as a two - syllable equal stress word. Because of these

results, the following changes were made on the Pattern Perception Subtest "hotdog" replaced "popcorn" and "hamburger" replaced "elephant".

Final setup of stimuli onto the Macintosh SE: As noted previously, one of the main reasons for selecting the Macintosh SE is that it allows for quick random access of stimuli, a characteristic which is not available with the more conventional equipment. The computer program selected to achieve this task is the "Hypercard Program" which is specifically designed to be run on the Macintosh SE.

The final recorded cleaned-up sample of each stimulus was inserted into the "Hypercard" program within the Macintosh SE. Computer screens for each subtest of the ESP Test Battery were then created (Refer to Figures 4a through 4e for printed copies of the subtest screens). A Stimulus is played by clicking on the corresponding "button". The stimuli which are displayed on the screen can be played at any time and in any sequence.

RELIABILITY AND VALIDITY STUDY

Once the process of recording the stimuli onto the Macintosh SE and setting up each computer screen for test administration was complete, it was necessary to collect reliability and validity data for the Standard and Low Verbal Versions of the ESP Test Battery.

METHOD

SUBJECTS

The subjects were 49 children (17 female and 32 male), ranging in age from 4 to 15 years, who attended classes at Central Institute for the Deaf. All of these children exhibited better ear pure tone threshold averages (at 500, 1000, and 2000 Hz) equal to or greater than 90 dBHL and displayed nonverbal intelligence quotients within the normal range. It was necessary that the children be familiar with the vocabulary presented in the test battery and the children were only tested when they were wearing appropriate amplification.

RELIABILITY TESTING CONDITIONS AND PROCEDURE

TEST - RETEST RELIABILITY FOR THE STANDARD VERSION: Twenty-three children were tested and retested by two different testers. Testing took place in an audiologic test room. Stimuli were presented at a level of 70 to 75 dBSPL. Testing procedure followed procedure outlined in the ESP Test Manual with the following exception: in most cases testing continued to one subtest beyond the recommendation of the test manual.

TEST-RETEST RELIABILITY FOR THE LOW VERBAL VERSION: Twenty-four children participated in the reliability study for the Low Verbal Version of the ESP test battery. Conditions were the same as those outlined for the Standard Version. Procedure followed that which is presented in the ESP Test Manual with the same exception as noted above.

VALIDITY TESTING CONDITIONS AND PROCEDURE

STANDARD VERSION

Thirty children were selected for testing to assess the validity of the Standard Version of the ESP Test Battery. The children chosen were those who scored within category three (some word recognition ability) or category four (consistent word recognition ability) on the Standard Version of the ESP Test Battery. Each child was administered the Word Intelligibility by Picture Identification (WIPI).

LOW VERBAL VERSION

Twenty-two children were administered both the Standard and Low Verbal Versions of the ESP Test Battery. Conditions and procedure were the same as those noted in the section discussing the reliability testing for the Standard Version of the ESP Test Battery.

RESULTS

RESULTS OF THE RELIABILITY TESTING FOR THE STANDARD VERSION

Raw scores from each subtest and associated categories for the test - retest condition are displayed in Table 3. Correlation coefficients (shown in Table 4) were computed for the following scores: test - retest raw scores from the Pattern Perception subtest, test - retest combined raw

scores from the Two Syllable and One Syllable subtests, and test - retest category placements. Accurate correlation coefficients could not computed individually for the raw scores of the Two Syllable subtest or the One Syllable subtest due to insufficient data. The correlation coefficients are as follows:

Pattern Perception:	.78
Two Syllable / One Syllable Combined	.89
Category Placement:	.94

RESULTS OF THE RELIABILITY TESTING FOR THE LOW VERBAL VERSION

Raw scores from each subtest and associated categories for the test - retest condition are displayed in Table 5. Correlation coefficients (shown in Table 6) were computed for the following scores: test - retest raw scores from the Pattern Perception subtest, test - retest combined raw scores from the Two Syllable and One Syllable subtests, and test - retest category placements. Accurate correlation coefficients could not computed individually for the raw scores of the Two Syllable subtest or the One Syllable subtest due to insufficient data. The correlation coefficients are as follows:

Pattern Perception:	.75
Two Syllable / One Syllable Combined	.77
Category Placement:	.89

RESULTS OF THE STANDARD VERSION VALIDITY TESTING

The validity of the ESP (Standard Version) was determined by correlating the combined raw scores for each subject of the Two Syllable Equal Stress Word Identification subtest and the One Syllable Word Identification subtest with the percent correct scores of the WIPI. Table 7 displays the raw scores for each subtest of the Standard Version, the combined subtest scores, the raw scores from the WIPI, and the percent correct scores from the WIPI. A validity correlation coefficient of .87 was computed (refer to Table 8).

RESULTS OF THE LOW VERBAL VERSION VALIDITY TESTING

Percent correct for each subtest and associated categories for the test to test condition are displayed in Table 9. To determine the validity of the Pattern Perception Subtest, a correlation coefficient was computed for test to test percent correct on the Pattern Perception subtest (Table 10a).

Because accurate correlation coefficients could not be computed individually for percent correct scores on the Two Syllable subtest or the One Syllable subtest, due to insufficient data, the following computations were performed to determine their validity. Combined percent correct for the Two Syllable and One Syllable subtests on the Low Verbal Version was correlated with the combined percent correct for the Two Syllable and One Syllable subtests on the Standard Version (Table 10b). Test to test categorization was correlated (Table 10c). A chi square distribution matrix was designed to display category placement with the use of the

three subtest scores (see Figure 5), and a chi square distribution matrix was designed to display category placement of subjects with the use of the Two Syllable raw scores alone (see Figure 6). The following are the correlation coefficients computed:

Pattern Perception:	.81
Two Syllable / One Syllable Combined	.65
Category Placement:	.72

DISCUSSION

The above testing and computations were completed to establish the Early Speech Perception Test Battery as a reliable and valid audiological tool for assessing speech perception ability in profoundly hearing impaired children. Correlation coefficients of .75 or better shows that a strong relationship exists between the two selected variables.

Reliability of the Standard Version: Each of the three variables correlated (Pattern Perception scores, combined Two Syllable and One Syllable scores, and Categorization scores) yielded correlation coefficients better than .75 denoting high reliability in the test - retest situation.

Reliability of the Low Verbal Version: Each of the three variables correlated (Pattern Perception subtest scores, combined Two Syllable and One Syllable subtest scores, and Categorization scores) yielded

correlation coefficients equal to or better than .75 denoting high reliability in the test - retest situation.

Validity of the Standard Version: When the combined raw scores from the Two Syllable Word Identification subtest and the One Syllable Word Identification subtest were correlated with the percent correct score from the WIPI, a high correlation coefficient of .87 was computed. This shows a strong relationship between the combined scores from the Two Syllable and One syllable subtests for category three and four children and their WIPI score.

Validity of the Low Verbal Version: A correlation coefficient greater than .75 was computed when comparing the Pattern Perception subtests of each Version of the ESP Test. Since the Standard Version has been shown to be a valid assessment tool, the implication here is that the Pattern Perception subtest of the Low Verbal Version is also a valid assessment tool.

Correlation coefficients lower than .75 were computed when comparing the combined scores from the Two Syllable and One Syllable subtests of the Two Versions of the ESP battery and when comparing the categorization scores from each version of the test battery. These measurements strongly imply that a problem exists with either the Two Syllable subtest, the One Syllable subtest, or both subtests of the Low Verbal Version.

In order to determine where the problem existed, the chi square distribution matrices were computed. The chi square distribution matrix comparing category placement from test to test shows that a large number of subjects were mis-categorized as category three and four speech percievers on the Low Verbal Version of the ESP battery. In all but one of these cases, the subjects were categorized as having greater speech perception ability when administered the Low Verbal Version. This information also implies that a problem exists on either the Two Syllable subtest, the One Syllable subtest, or both.

The chi square distribution matrix displaying category placement with the use of the raw scores from the Two Syllable subtest supports the validity of this subtest. Eighty two percent of the subjects were correctly categorized in terms of speech perception ability as either category two or better speech percievers. This information strongly suggested that the problem of poor validity was due to the One Syllable subtest. A review of the test to test raw scores and category placements show that nine of the twenty-four subjects were mis-categorized as category four speech percievers on the Low Verbal Version. In many instances, the subjects scored much better on the Single Syllable subtest than on the Two Syllable subtest. Since category four placement can only be achieved by meeting criteria for the One Syllable subtest, it is obvious that The One Syllable subtest is not an accurate tool for assessing category four speech perception ability.

CONCLUSIONS

The computer version of the Early Speech Perception Test Battery was designed not only to create a computer recorded test battery which allowed for high resolution in sound recording, random access, instantaneous output of stimuli, and prolonged recording life of stimuli due to digital storage, but to produce a test which accurately assessed speech perception ability of profoundly hearing impaired children.

The computer related goals were achieved. Stimuli on the computer version of the ESP were recorded with high resolution, they can be accessed randomly, output is near instantaneous, and recording life is greatly extended if compared to analog recordings.

It can be concluded from the results of the reliability and validity study that the Standard Version of the ESP is both a valid and reliable audiological test for assessing speech perception ability of profoundly hearing impaired children. Results from the Low Verbal Version indicate that both the Pattern Perception and Two Syllable Subtests are reliable and valid and that the One Syllable subtest is reliable. However, no validity measures computed for the Single Syllable Subtest indicate that it yields a valid score for assessing the speech perception ability of the subjects within the study.

It is believed that the problems of the One Syllable subtest are mainly due to the durational characteristics of the one syllable words included. It seems that many of the subjects were able to identify words based on

duration and not necessarily on spectral content. Because of this, modifications of the One Syllable subtest are being made. The one syllable words presently included on this subtest are being replaced with one syllable words with similiar durational characteristics. With this change, it is hoped that the Low Verbal Version of the ESP Test battery will prove to be a valid audiological tool for assessing speech perception ability of profoundly hearing impaired children who exhibit limited vocabulary.

TABLES AND FIGURES

TABLE 1a): Measurement of noise levels within the anechoic chamber with the following SLM settings: dB SPL (A), dB SPL (C), Linear from 2Hz to 70 KHz, and Linear from 10 Hz to 20 KHz.

Sound Level Meter Setting	Measurement
A Weighting	19.5 dB SPL
C Weighting	42.0 dB SPL
Linear 2 Hz to 70 KHz	58.1 dB SPL
Linear 10 Hz to 20 KHz	51.2 dB SPL

TABLE 1b): Measurement of noise levels within the anechoic chamber in 1/3 octave bands.

Center Frequency in Hz	Level in dB SPL
20	36.2
25	29.7
31.5	34.2
40	27
50	32.8
63	39.7
80	28.1
100	19.5
125	20.8
160	10.6
200	6
250	4
315	1
400	0.5
500	0
630	0.5
800	0.5
1K	0.95
1.25K	2
1.6K	3
2K	3.2
2.5K	3.5
3.15K	4.2
4K	5.4
5K	5.15
6.3K	5.5
8K	5.6
10K	5.05
12.5K	4.45
16K	2.7
20K	2.7

TABLE 2: Results of categorization of stimuli through the tactile mode. Included are percent correct catigorization for all subjects combined.

	SUBJECT	.....	SHOE	BALL	FISH	COOKIE	BABY	APPLE	AIRPLANE	TOOTHBRUSH	POPCORN	ELEPHANT	BIRTHDAY CAKE	ICE CREAM CONE
1	JM		I I	I I	I I	I I	I I	I I	I I	I I	X I	X X	I I	I I
2	LD		I I	I I	I I	I I	I I	I I	I I	I I	I I	I I	I I	I I
3	AG		I I	I I	I I	I I	I I	I I	I I	I I	I I	X X	I I	I I
4	NN		I I	I I	I I	I I	X I	I X	X I	I I	X I	X X	I I	I I
5	TW		I I	I I	I I	I I	I I	I I	I I	I I	I I	X X	I I	I I
6	DM		I I	I I	X I	X I	I I	I I	I I	I I	X X	X X	I I	I I
7	GP		I I	I X	I I	X I	I I	I I	I I	I I	X X	X X	I I	I I
8	MR		I I	I I	I I	I I	I I	X I	X I	I I	I X	X X	I I	I I
9	% CORRECT													
10	CATIGORIZATION		100...	94%	94%	88%	94%	88%	88%	100%	56%	13%	100%	100%

TABLE 3: Raw scores and categorization results for the test-retest conditions on the Standard Version of the ESP Test battery. (T1=tester 1, T2=tester 2, TST=test, RETST=retest, PP=Pattern Perception subtest, TS=Two Syllable subtest, SS=Single Syllable subtest, CAT=categorization score)

	SUBJ.	T1	TST:PP	TST:TS	TST:SS	CAT.	T2	RETST:PP	RETST:TS	RETST:SS	CAT	TST:TS+SS	RETST:TS+SS
1	TO	L	22	11	6	3	M	22	8	•	3	17	8
2	KO	L	19	7	•	2	M	17	3	•	2	7	3
3	MH	L	24	18	14	4	M	24	24	15	4	32	39
4	TC	L	23	15	•	3	M	24	17	•	3	15	17
5	SW	L	17	5	•	2	M	23	1	•	2	5	1
6	SA	L	22	0	•	2	M	21	5	•	2	0	5
7	JP	L	22	6	•	2	M	20	4	•	2	6	4
8	JJ	L	18	8	•	3	M	20	14	•	3	8	14
9	AH	L	20	5	•	2	M	20	5	•	2	5	5
10	JK	L	14	2	•	1	M	13	2	•	1	2	2
11	TC	L	23	15	8	3	T	23	19	12	3	23	31
12	JR	M	9	4	•	1	L	15	•	•	1	4	•
13	SR	L	18	9	•	3	M	21	16	7	3	9	23
14	JD	L	9	•	•	1	M	18	2	•	2	•	2
15	EL	L	24	20	18	4	M	24	24	20	4	38	44
16	JM	L	24	24	19	4	T	24	23	21	4	43	44
17	BC	L	24	23	20	4	T	23	14	11	3	43	25
18	GB	M	10	2	•	1	T	8	•	•	1	2	•
19	SC	L	22	17	17	4	M	24	20	15	4	34	35
20	LY	M	21	5	•	2	L	17	•	•	2	5	•
21	AV	M	21	2	•	2	L	21	5	•	2	2	5
22	HC	L	17	5	•	2	M	21	3	•	2	5	3
23	JS	L	13	•	•	1	M	17	6	•	2	•	6

TABLE 4: Correlation coefficients for the test-retest condition of the Standard Version of the ESP Test battery: A) Pattern Perception subtest, B) Two Syllable and One Syllable subtests combined, C) Categorization placement.

A).

Corr. Coeff. X_1: TST:PP Y_1: RETST:PP

Count:	Covariance:	Correlation:	R-squared:
23	15.545	.779	.607

B).

Corr. Coeff. X_2: TST:TS+SS Y_2: RETST:TS+SS

Count:	Covariance:	Correlation:	R-squared:
18	210.196	.894	.798

Note: 5 cases deleted with missing values.

C).

Corr. Coeff. X_3: CAT. Y_3: CAT

Count:	Covariance:	Correlation:	R-squared:
23	.964	.943	.889

TABLE 5: Raw scores and categorization results for the test-retest conditions on the Low Verbal Version of the ESP Test battery. (T1=tester 1, T2=tester 2, TST=test, RETST=retest, PP=Pattern Perception subtest, TS=Two Syllable subtest, SS=Single Syllable subtest, CAT=categorization score)

	SUBJ.	T1	TST:PP	TST:TS	TST:SS	CAT	T2	RETST:PP	RETST:TS	RETST:SS	CAT.	TST:TS+SS	RETST:TS+SS
			X_1			X_3		Y_1			Y_3	X_2	Y_2
1	TT	L	0	•	•	1	M	0	•	•	1	•	•
2	BE	L	7	•	•	1	M	8	4	2	2	•	6
3	BB	M	12	8	10	4	T	8	2	7	4	18	9
4	RH	L	11	6	7	3	M	12	6	6	3	13	12
5	AV	L	9	6	•	2	M	12	3	•	2	6	3
6	JS	L	6	•	•	1	M	8	4	•	1	•	4
7	JR	L	12	9	7	3	M	10	7	12	4	16	19
8	YR	T	8	5	9	4	M	12	2	•	2	14	2
9	TO	M	11	11	12	4	L	12	8	9	4	23	17
10	MH	M	12	11	11	4	L	12	12	10	4	22	22
11	TC	M	12	12	9	4	L	12	9	10	4	21	19
12	SW	M	11	8	10	4	L	10	8	9	4	18	17
13	SA	T	12	1	9	4	M	12	7	9	4	10	16
14	JP	M	10	10	9	4	L	10	8	9	4	19	17
15	JJ	M	12	11	9	4	L	12	12	10	4	20	22
16	JK	M	6	2	•	1	T	8	3	6	2	2	9
17	TC	M	12	10	12	4	T	12	12	12	4	22	24
18	SR	M	12	6	11	4	L	11	9	9	4	17	18
19	EL	M	12	12	12	4	L	12	12	11	4	24	23
20	JM	T	12	12	8	4	L	12	12	11	4	20	23
21	BC	T	9	11	12	4	L	12	12	12	4	23	24
22	GB	T	3	•	•	1	M	10	4	•	2	•	4
23	SC	M	12	11	12	4	L	12	11	11	4	23	22
24	HC	L	10	5	4	2	M	12	2	•	2	9	2

TABLE 6: Correlation coefficients for the test-retest condition of the Low Verbal Version of the ESP Test battery: A) Pattern Perception subtest, B) Two Syllable and One Syllable subtests combined, C) Categorization placement.

A).

Corr. Coeff. X_1: TST:PP Y_1: RETST:PP

Count:	Covariance:	Correlation:	R-squared:
24	6.574	.752	.565

B).

Corr. Coeff. X_2: TST:TS+SS Y_2: RETST:TS+SS

Count:	Covariance:	Correlation:	R-squared:
20	35.316	.771	.595

Note: 4 cases deleted with missing values.

C).

Corr. Coeff. X_3: CAT Y_3: CAT.

Count:	Covariance:	Correlation:	R-squared:
24	1.234	.887	.786

TABLE 7: Raw scores and categorization results on the Standard Version of the ESP Test battery, and raw scores and percent correct results on the WIPI. (PP=Pattern Perception subtest, TS=Two Syllable subtest, SS=Single Syllable subtest, CAT=categorization score, WIPI RS= raw score on the WIPI, and WIPI %=percent correct on the WIPI.)

	SUBJ.	PP	TS	SS	TS+SS	CAT	WIPI RS	WIPI %
1	TO	22	11	6	17	3	10	40
2	MH	24	18	14	32	4	12	48
3	TC	23	15	•	15	3	5	20
4	SA	22	9	•	9	3	6	24
5	JJ	18	8	•	8	3	7	28
6	TC	23	15	8	23	3	9	36
7	SR	18	9	•	9	3	7	28
8	EL	24	20	18	38	4	16	64
9	JM	24	24	19	43	4	21	84
10	BC	24	23	20	43	4	16	64
11	SC	22	17	17	34	4	13	52
12	TD	22	19	8	27	3	11	44
13	YR	23	11	6	17	3	7	28
14	JF	23	24	18	42	4	13	52
15	DR	24	24	24	48	4	23	92
16	JL	24	24	22	46	4	22	88
17	CW	24	16	18	34	4	13	52
18	JW	24	24	24	48	4	18	72
19	JG	24	24	21	45	4	16	64
20	JC	24	16	6	22	3	6	24
21	EF	23	14	9	23	3	16	64
22	AF	24	10	8	18	3	7	28
23	TH	20	15	16	31	4	11	44
24	SK	24	20	14	34	4	10	40
25	TM	19	24	21	45	4	18	72
26	RR	24	24	18	42	4	17	68
27	NW	22	15	•	15	3	10	40
28	KB	23	24	17	41	4	14	56
29	BR	22	17	15	32	4	11	44
30	BW	24	22	21	43	4	21	84

TABLE 8: Correlation coefficient for the comparison between the combined scores of theTwo Syllable subtest and the One Syllable subtest of the Standard Version of the ESP Test battery and the percent correct scores of the WIPI.

Corr. Coeff. X_1: TS+SS Y_1: WIPI %

Count:	Covariance:	Correlation:	R-squared:
30	231.062	.866	.75

TABLE 9: Percent correct scores and categorization results for the Standard and Low Verbal versions of the ESP Test battery. (T=tester, Stan=Standard Version, LV=Low Verbal Version, PP=Pattern Perception subtest, TS=Two Syllable subtest, SS=Single Syllable subtest, CAT=categorization score)

	SUBJ.	T	STAN:PP	STAN:TS	STAN:SS	STAN:CAT	LV:PP	LV:TS	LV:SS	LV:CAT	STAN:TS+SS	LV:TS+SS
1	TO	M	92	33	•	3	92	92	100	4	33	192
2	MH	M	100	100	63	4	100	92	92	4	163	184
3	TC	M	100	71	•	3	100	100	75	4	71	175
4	SW	M	96	4	•	2	92	67	83	4	4	150
5	SA	M	88	21	•	2	100	58	75	4	21	133
6	JP	M	83	17	•	2	83	83	75	4	17	158
7	JJ	M	83	58	•	3	100	92	75	4	58	167
8	JK	M	54	8	•	1	50	•	•	1	8	•
9	TC	M	96	83	50	3	100	83	100	4	133	183
10	SR	M	88	67	29	3	100	50	92	4	96	142
11	EL	M	100	100	83	4	100	100	100	4	183	200
12	JM	L	100	100	79	4	100	100	92	4	179	192
13	BC	L	100	96	83	4	100	100	92	4	179	192
14	GB	M	42	8	•	1	83	33	•	2	8	33
15	SC	M	100	83	63	4	100	92	100	4	146	192
16	LY	M	88	21	•	2	100	25	•	2	21	25
17	HC	M	88	13	•	2	100	17	•	2	13	17
18	JM	L	50	•	•	1	58	•	•	1	•	•
19	YR	M	96	46	25	3	100	17	•	2	71	17
20	GM	M	88	17	8	2	92	50	58	3	25	108
21	TD	T	92	79	33	3	100	92	100	4	112	192
22	AV	M	88	8	•	2	100	25	•	2	8	25

TABLE 10: Correlation coefficients for the test to test results on the Low Verbal Version and Standard Version of the ESP Test battery: A) Pattern Perception subtest, B) Two Syllable and One Syllable subtests combined, and C) Categorization placement.

A).

Corr. Coeff. X_1: STAN:PP Y_1: LV:PP

Count:	Covariance:	Correlation:	R-squared:
22	185.874	.807	.652

B).

Corr. Coeff. X_2: STAN%:TS+SS Y_2: LV%:TS+SS

Count:	Covariance:	Correlation:	R-squared:
20	2958.692	.645	.416

Note: 2 cases deleted with missing values.

C).

Corr. Coeff. X_3: STAN:CAT Y_3: LV:CAT

Count:	Covariance:	Correlation:	R-squared:
22	.801	.72	.519

FIGURE 1: Graph displaying levels of noise (in dB SPL) within anechoic chamber measured in 1/3 octave bands from 20 Hz to 20 KHz.

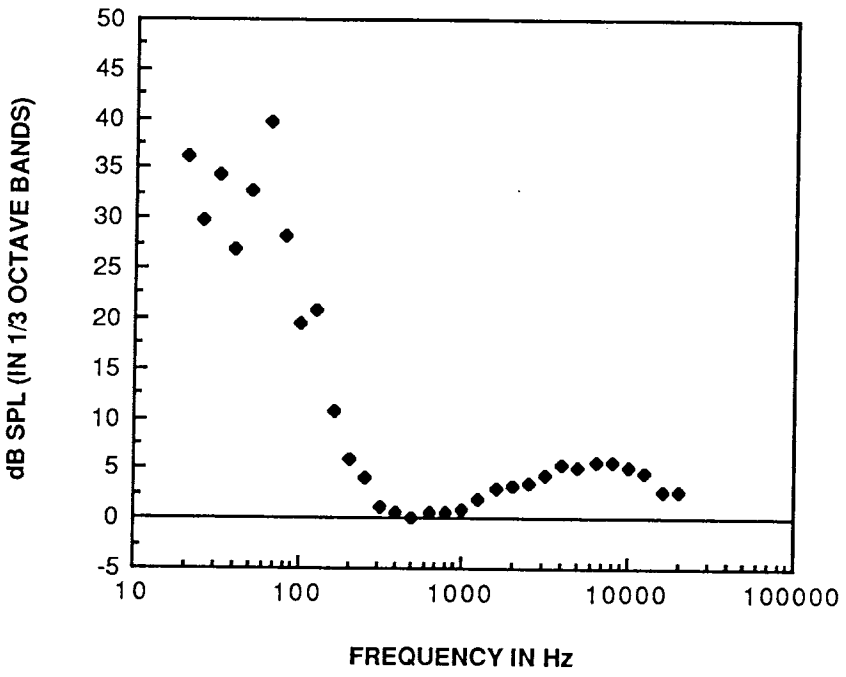


FIGURE 2: Block diagram of the equipment setup for the recording of the ESP stimuli onto the JVC BR-7110U VCR.

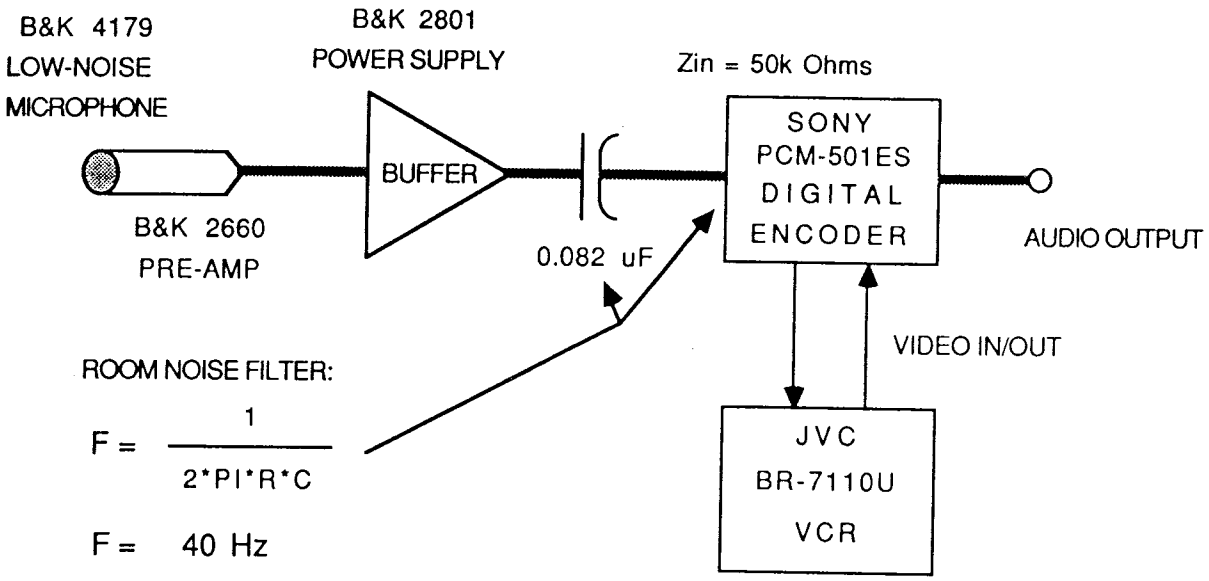


FIGURE 3: Block diagram of the equipment setup for the recording of the ESP stimuli onto the Macintosh SE from the JVC BR-7110U VCR.

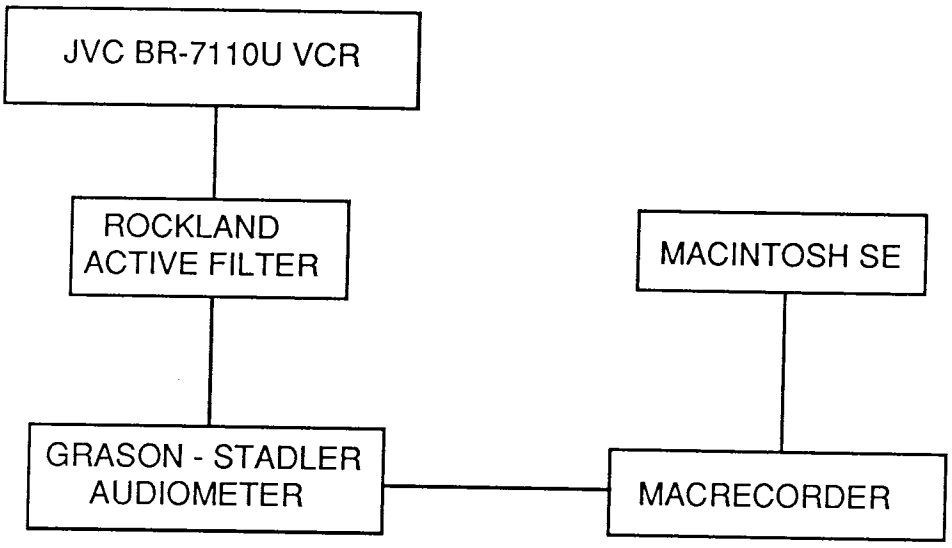
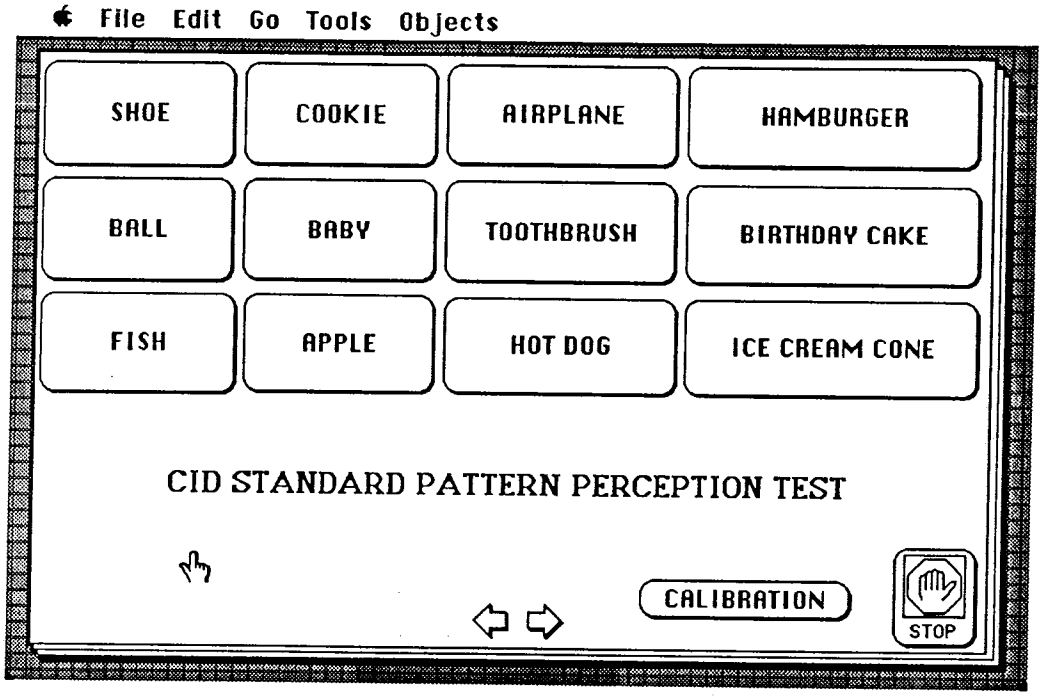
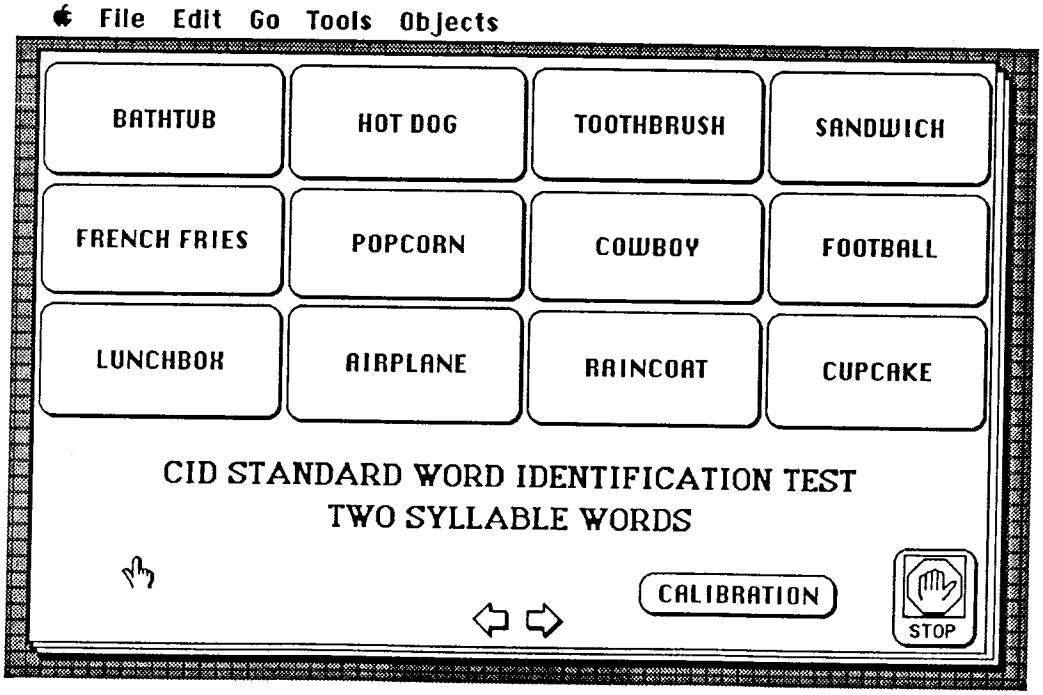


FIGURE 4a) through 4e): Copies of the computer screens of the ESP Test battery - Standard and Low Verbal versions.

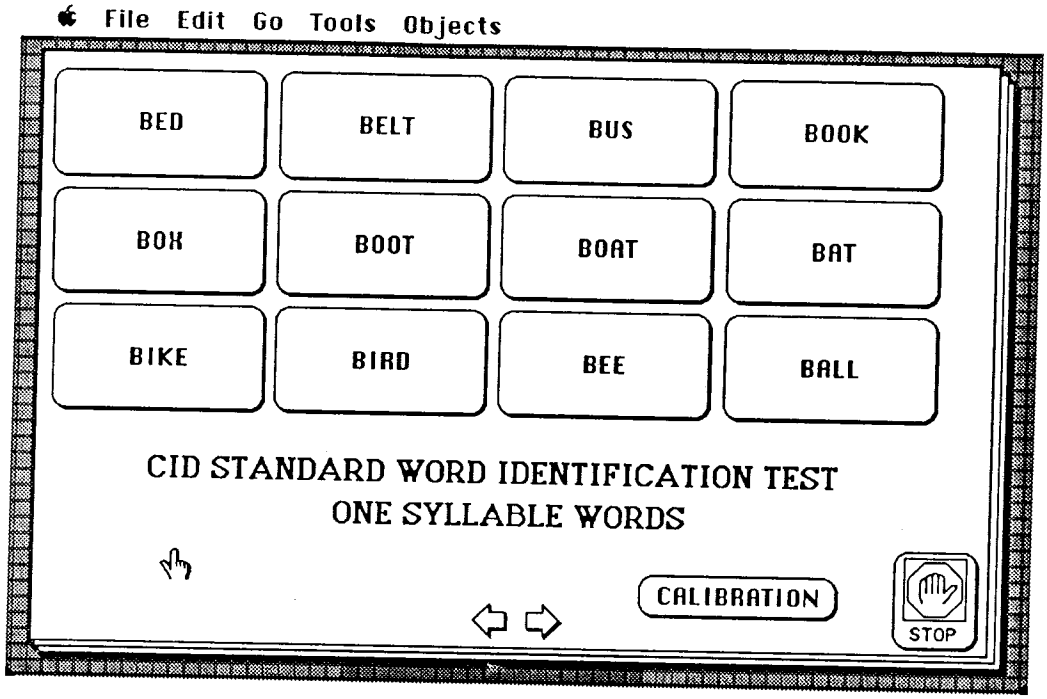
4a): Pattern Perception subtest of the Standard Version.



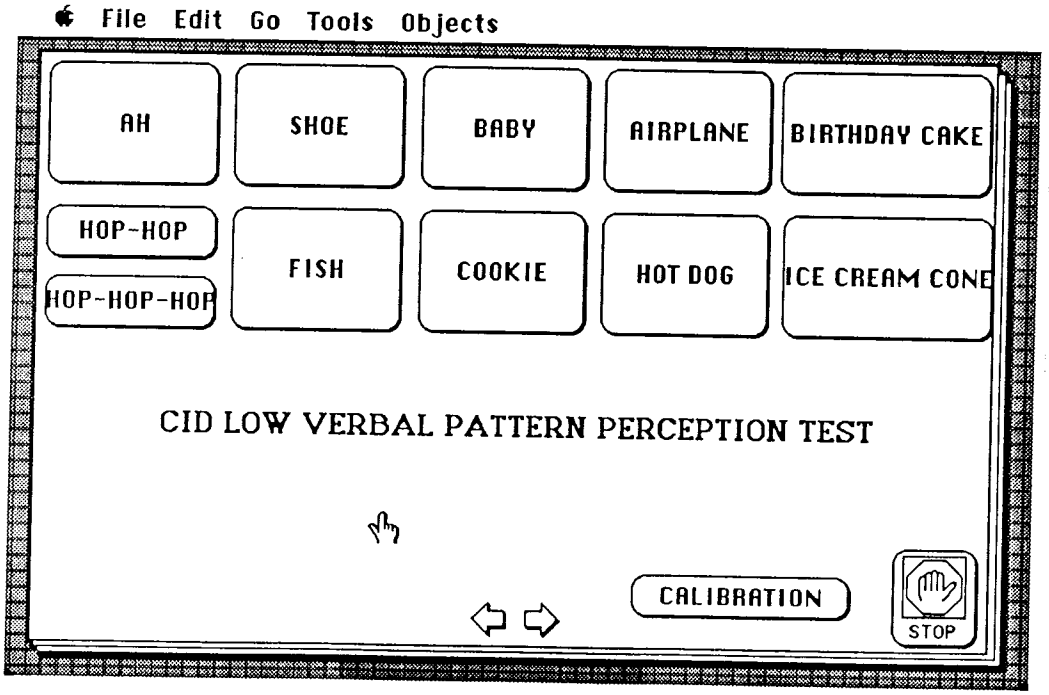
4b): Two Syllable Word Identification subtest of the Standard Version.



4c): One Syllable Word Identification subtest of the Standard Version.



4d): Pattern Perception subtest of the Low Verbal Version.



4e): Two Syllable and One Syllable Word Identification subtests of the Low Verbal Version.

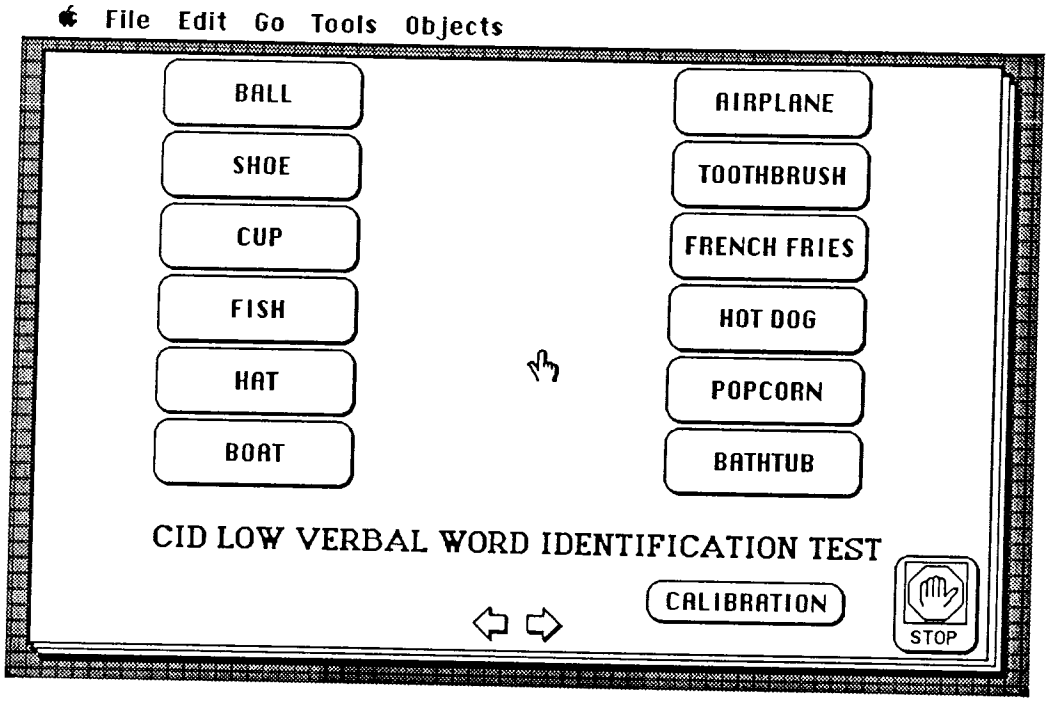


FIGURE 5: A Chi Square Distribution Matrix showing the relationship between category placement with the use of each version of the ESP Test battery.

LOW VERBAL VERSION

STANDARD VERSION

	CATEGORY 1	CATEGORY 2	CATEGORY 3	CATEGORY 4
CATEGORY 1	0.67	0.33	0.00	0.00
CATEGORY 2	0.00	0.43	0.14	0.43
CATEGORY 3	0.00	0.14	0.00	0.86
CATEGORY 4	0.00	0.00	0.00	1.00

FIGURE 6: A Chi Square Distribution Matrix showing category placement with the use of the scores from the Two Syllable Word Identification subtest from both versions of the ESP Test battery