THE EFFECTS OF INTENSITY PRESENTATION LEVELS IN A DICHOTIC LISTENING PARADIGM

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ABSTRACT

The purpose of this study was to determine the effects of various intensity presentation levels on the right ear advantage (REA) in a dichotic listening paradigm. Thirty normal hearing subjects received a series of dichotic consonant-vowel nonsense syllables at five varying intensity presentation levels which included, 50, 60, 70, 80 dB SPL and MCL. Results of the study indicated that while non-significant differences were obtained between the five intensity presentation levels, MCL produced the largest REA and appears to have applicability for use in dichotic listening tasks.

INTRODUCTION

When consonant-vowel (CV) nonsense syllables are simultaneously presented to normal hearing subjects in a dichotic listening task, a significant hemispheric asymmetry will be reflected from reported scores. That is when speech is used as a dichotic stimuli, a right ear advantage (REA) results (Kimura, 1961a and b; Studdert-Kennedy and Shankweiler, 1970; Berlin et al, 1973). Functional hemispheric asymmetry has received supporting evidence from electrophysiological animal study (Hall and Goldstein, 1968) as well as anatomical and physiological evidence in man (Geschwind and Levitsky, 1968; Milner, Taylor and Sperry, 1968; Witelson and Pallie, 1973).

One parameter of dichotic listening tasks which have produced inconsistent differences between right and left ear scores as well as overall performance may be attributed to changes in the intensity level. To date, presentation levels have been based on sensational levels (SL) re: the subject's speech reception threshold or absolute sound pressure levels (SPL). Depending on the intensity level used, a wide variance in ear score differences have been observed. A review of literature has revealed significant REA differences which range from 2.1% (Kimura, 1961a) to 27% (Speaks and Bissonette, 1975). Thompson and Hughes (1972) presented CV's at 6 intensity levels, 30, 40, 50, 60, 70 and 80 dB SPL to twelve adult listeners. Although a REA was obtained at all intensity levels, the magnitude of the ear advantage decreased above 50 dB SPL. Right ear advantages ranged between approximately 4 and 13 percent depending upon the intensity level. These results were also reported by Cullen et al, (1974). Similarly, Roeser, Johns, and Price (1972) presented a dichotic listening task to 32 normal hearing subjects at intensity levels of 10, 30, 50 and 70 dB SL. Results indicated that while right ear scores did not differ significantly as a function of intensity, subjects scored significantly fewer

total correct responses ($\bar{X}$ difference: 14%) at 10 dB SL when compared to other intensity presentations.

It has been suggested by Cullen et al, (1974) and supported by Speaks and Bissonette (1975) that dichotic performance is directly related to the ability of the subject to correctly identify monaural stimuli. In other words, dichotic scores can be maximized as long as the presentation levels are based on an intensity which provides maximum monaural scores. It would seem therefore, that dichotic presentation levels should be determined utilizing similar methods and controls that have been established for other speech discrimination material. The consequence of which would lead to a routine plotting of an articulation curve based on monaural CV syllables. The articulation index is based on maximum discrimination as a function of intensity and provides a reference level above which maximum discrimination should be obtained. From past clinical experience, however, audiologists have established the determination of a subject's articulation curve for PB max as impractical due to time constraints. Consequently, the majority of phonetically balanced speech discrimination materials are presented at pre-established supra-threshold intensity levels re: the subject's speech reception threshold (SRT). As an alternative to relative intensity presentation levels, the use of most comfortable loudness levels (MCL) has been suggested (Martin and Pennington, 1971; Berger, 1971; Goetzinger, 1972; Ullrich and Grimm, 1976). Recently, Ventry and Johnson (1978) have provided results which indicated that MCL is clinically feasible and statistically reliable as well as providing the intensity presentation level that would produce maximum speech discrimination.

To date, incorporation of MCL as a presentation level in dichotic listening studies has not been explored. Due to the variance in ear difference scores derived under different levels of stimulus presentation, it was the purpose of this study to determine if the use of MCL as a presentation intensity could be demonstrated to be a viable alternative to absolute intensity levels in dichotic listening tasks.

METHODS

Subjects

A total of 30 right handed normal hearing adult subjects were chosen for this study. Subjects met the following criteria: (1) hearing sensitivity as measured by audiometric puretone air conduction testing had to be 15 dB HTL or better at octave frequencies 250 to 4000 Hz (re: ANSI, 1969); (2) speech reception thresholds were at least 15 dB HTL; (3) speech discrimination scores were 90% or better as measured by recorded phonetically balanced word lists (CID-W22).

Test Stimuli

The CV syllables used in this study consisted of six English stop consonants, /b,d,g,p,t,k/ paired with the vowel /a/. Dichotic presentation consisted of independently paired syllables presented simultaneously to each ear. Each presentation was followed by a six second (± 0.5) silent period. Five individual lists, consisting of thirty dichotic pairs each, were constructed in such a way that each consonant was presented equally (five) with no competition occurring between identical CV syllables. Stimulus duration for all CV syllables was exactly 270 msec., with a signal-to-noise ratio of plus 30 dB sound pressure level (SPL) or better. The stimulus tapes were constructed by using a special computer program at the Kresge Research Laboratory South by Dr. Charles Berlin.

Instrumentation

Monaural and dichotic listening tasks were performed in a sound treated test booth (IAC-1200). CV syllables were presented on an Akai-4000 stereo tape recorder operated at 7½ ips. The signal was fed via a Madsen OB-70 Clinical Audiometer coupled to Telephonic TDH-39 earphones with MX-41/AR cushions. The acoustic outputs of the earphones were calibrated using a Bruel and Kjaar (Type 2209) sound pressure level meter and an artificial ear (Type 4105) prior to the testing of each subject.

PROCEDURES

Five individual tests lists consisting of 30 CV nonsense syllables were used as stimuli in the present study. One list was dichotically presented at each intensity level of 50, 60, 70, 80 dB SPL and MCL to each of the 30 subjects. Intensity levels and list presentations were counter-balanced to assure the elimination of any possible order or learning effect. In addition, all subjects received 30 monaural CV syllables at MCL using equal loudness as the criteria. This was accomplished by requesting subjects to first find an MCL level in one ear using a modified bracketing method. This ear was considered the control ear and was determined by the best discrimination score as measured by the CID-W22 word lists. The subjects were then required to equate or match the loudness level in the opposite or variable ear with the MCL level of the control ear. The stimulus used for equating loudness levels was the same series of CV nonsense syllables used for both the monaural and dichotic presentations but reconstructed on a separate tape. The syllables were alternated between ears at one second intervals in order that memory not be considered a variable until an equal loudness level was established. All responses for CV syllables were written on an answer sheet provided and subjects were instructed to use a two-forced choice recall method of response.

RESULTS

Thirty normal hearing adult subjects received dichotic stimuli at five presentation intensity levels, 50, 60, 70, 80, dB SPL and MCL based on equal loudness levels. Mean MCL values were 76.3 and 76.7 dB SPL for the right and left ears respectively. MCL was determined by using a bracketing method described by Fausti (1971) which allowed intra-condition intensity equation within 2 dB. Further analysis revealed that the bracketing method used did not produce intensity differences within subjects which exceeded 3 dB between right and left ears. Results of a t test indicated that right and left ear presentation levels were non-significant ($t=.186$; $df=58$; $p > 0.05$).

Ear Asymmetry: Monaural

Ear asymmetry for monaural scores was determined using absolute right minus left differences for ear advantage. The scores were computed by averaging the sum obtained from the right ear scores minus the sum of the left ear scores. Mean correct raw scores were 28.9 (96.3%) for the right and 29.0 (96.6%) for the left. When raw score data were statistically analyzed, no significant ear differences were obtained for monaural CV syllables ($t=.258$; $df=58$; $p > 0.05$). The lack of statistical difference for monaural scores indicates the similar perception capability for each subject's auditory pathway under normal conditions.

Ear Asymmetry: Dichotic

In the present study, the percentage of error (POE) index was used as a measure of the relative degree of lateralization (ear error/total error). This method was chosen because it offers the predictability of measuring the degree of lateralization without variations due to accuracy, the amount of guessing, level of presentation or the method of subject

response (Harshman and Krashen, 1972). Recently, Repp (1977) has suggested that POE is independent of performance level as long as scores fall above the 50 percent criteria. Since all scores in this study did in fact fall above 50 percent, the POE measurement of laterality was felt to be an appropriate measure.

Based on POE scores, results of a two-way analysis of variance with repeated observations are summarized in Table 1. Although the analysis of overall dichotic performance as a function of intensity provided significant differences between ears ($F=43.202$; $df=1.29$; $p < .001$), intensity/subject interactions were nonsignificant ($F=1.406$; $df=4.116$; $p>0.05$). In essence, no intensity level was significantly different than any other within the present dichotic paradigm. Consequently, subsequent t scores were computed in order to analyze between ear differences for the five individual intensity presentation levels. Results produced significant individual right ear advantages for each of the 5 presentation levels (50:$t=4.37$; $df=58$; $p < 0.01$; 60:$t=6.09$, $df=58$, $p<0.01$; 70:$t=7.28$, $df=58$; $p<0.01$; 80:$t=2.80$, $df=58$; $p<0.01$; MCL:$t=7.94$, $df\ 58$, $p<0.01$). REA's ranged between 5.9% at 80 dB SPL to 12.2% at MCL. When raw score data were converted to a POE index, according to Harshman and Krashen (1972) ear advantages were consistent with previous dichotic studies (Wilson, et al., 1968; Kirstein and Shankweiler, 1969; Studdert-Kennedy and Shankweiler, 1970).

Mean POE scores at the 5 intensity presentation levels may be seen in Figure 1. The direction and degree of lateralization are represented by the POE scores contributed by the left ear. A percentage of less than 50% indicates left ear/right hemisphere dominance. A percentage of greater than 50% indicates right ear/left hemisphere dominance.

FIGURE 1:

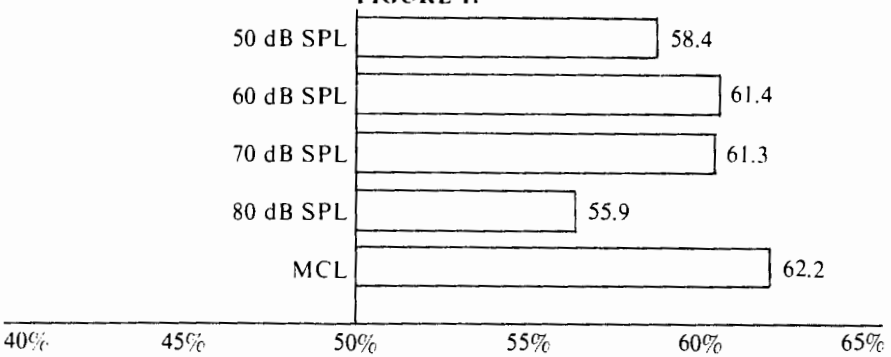

Figure 1 **Percentage of Error (POE). Scores in Percentage as contributed by the left ear. Scores above 50% indicate a right ear/left hemisphere advantage.**

DISCUSSION

Although the results of a two-way analysis of variance revealed non-significant differences between the five intensity presentation levels, subsequent t tests using the POE index produced a range of significant REA as seen in Figure 1. These results are consistent with previous studies which also show a variance in the REA based on different intensity presentation levels (Roeser, et al, 1972; Thompson, et al, 1972; Cullen, et al, 1974). A maximum REA of 12.2 percent was obtained using MCL as the presentation intensity. The other absolute intensity levels used in the present study produced REA's which ranged from a minimum of 5.9 percent obtained at 80 dB SPL to

11.4 percent at 60 dB SPL. To date, no firm conclusions can be drawn from the range in percentage differences (6.3%) in the REA's obtained from the five intensities used in the dichotic listening task. This seems particularly true in light of the work reported by Cullen et al, (1974) who have determined that the range of intensities used in this study all fall into an intensity-intelligibility asymptote. When taking into consideration however, the degree of decussation between the two auditory pathways and the multitude of neural innervation occurring in both the primary and secondary projection centers of the auditory cortex, it is little wonder that the effects of intensity can only be speculative. It is interesting therefore, to consider the role intensity plays on other facets of speech discrimination and the implications that may effect dichotic listening paradigms.

TABLE 1:

	SUM OF SQUARES	DF	MEAN SQUARE	F	
R vs L Ear	29638.098	1	29638.098	43.202	.001
	19894.958	29	685.03305		
Intensity vs Subjects	.41630119	4	.10407530	1.111	NS
	.1182912	116	.96404411		
Interaction (Intensity/ Subjects)	1737.048	4	434.26199	1.406	NS
	35812.936	116	308.7322		

Table 1 **Two-way analysis of variance for: R vs L ear; Intensity vs Subjects; and Interaction between Intensity and Subjects.**

Clinically, we are all too aware of the difficulties that arise during audiometric testing when cross-over of a stimulus is not taken into consideration. If the interaural attenuation for speech is within the 50 to 60 dB range, as Liden et al, (1959) and others suggest, what perceptual implications will higher intensity levels have on dichotic performance? We agree with Cullen et al, (1974) who also found a decrease in ear difference at 80 dB SPL and state:

> "The decrease in ear difference at the higher intensities (particularly 80 dB) may be the result of cross-over since earphones equipped with MX41/AR cushions provide approximately 50-60 dB interaural attenuation."(p. 311)

A second clinical observation which may appear to have an influencing factor on dichotic performance is that of aural overload. While a reduction in speech intelligibility due to increased intensity discrimination levels are more prevalent in a pathological ear, it is feasible that a reduction in overall performance may be due to increased intensity levels. This observation is at present under investigation in our clinic.

It is equally interesting to note that 50 dB SPL intensity produced a reduced but still significant percentage difference between ears. It is possible that at this level, under our test conditions, 50 dB may have just been sufficient to produce adequate monaural CV

discrimination scores, thus directly influencing the reduction of dichotic performance. The assumption that adequate intensity levels are necessary for maximum CV discrimination concurs with those of Speaks and Bissonette (1975) and Cullen et al, (1974) who suggest that without sufficiently high monaural scores based on a performance-intensity function, dichotic ear performance may be reduced. Consequently, in order to maximize dichotic ear performance, it is suggested that presentation levels should be based on reasonably high monaural CV performance. Although MCL was the only monaural level used, results indicate that MCL would insure maximum monaural scores.

One advantage in using MCL as a presentation level of choice may be the balancing of potential differences between the individual auditory pathways. According to Roeser et al, (1976) dichotic laterality may be affected by physiological interaural differences such as loudness. Berlin and Cullen (1975) also propose that the level of test presentation may affect dichotic results because of small asymmetries in the peripheral auditory system.

The utilization of MCL as an intensity level has also been found to have applicability for the study of pathological hearing impaired population when dichotic listening tasks were employed. Recently, Jacobson (1977) presented a series of dichotic CV syllables at equal loudness levels using MCL as the loudness criteria to a group of 30 moderate bilateral symmetrical sensorineural subjects and 10 normal hearing adults in order to determine interaural intensity differences between ears. Results of the MCL procedure produced ear differences of no greater than 4 dB between the right and left ears in 39 of the forty subjects and a maixmum ear difference of only 6 dB in the remaining individual. In every case, a significant ear advantage was observed and interaural intensity differences were proven to be a non-significant influencing factor in ear laterality. Jacobson concluded that MCL would compensate for possible physiological loudness differences in sensorineural patients who suffer from recruitment.

As stated earlier, equal loudness differences between ears were no greater than 3 dB for any of the subjects participating in this study. These data are in good agreement with the magnitude of interaural-intensity differences which affect the REA in normal subjects (Brady-Wood and Shankweiler, 1973). Recently, Speaks and Bissonette (1975) presented CV syllables to six normal hearing females with REA at four different levels: 50, 60, 70, and 80 dB SPL. They concluded that the amount of attenuation to cancel the REA was a varying factor dependent on the presentation level. The attenuation ranged from 22 dB for a reference level of 80 dB SPL to 5 dB at a 50 dB SPL reference level. Results of these differences led them to hypothesize that the REA was cancelled not by an absolute interaural intensity difference but by an absolute SPL for speech in the right ear. This level occurred at 58 dB SPL. They concluded that as long as dichotic presentation levels for both ears were within a range which produced high monotic scores, the REA was minimally altered by interaural intensity differences.

CONCLUSIONS

The intent of this study was to determine the effect different intensity levels had on REA scores in a CV dichotic listening paradigm. To accomplish this task, five different intensity levels (50, 60, 70, 80 dB SPL and MCL) were utilized in presenting a dichotic listening task to 30 normal hearing subjects. Although MCL produced the largest REA, the ANOVA data analysis revealed non-significant differences between the five presentation levels. Results of the study would suggest that the use of MCL as a presentation level in dichotic listening paradigms is a viable and acceptable procedure and may have direct applicability when investigating a population with known peripheral asymmetries.

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