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Auditory Processing and Perceptual Abilities of "Organic" and "Functional" Stutterers

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The present investigation was undertaken to determine whether significant differences in auditory processing and perceptual abilities exist between (1) stutterers as a supposedly homogeneous group when compared with controls, (2) two differentiated subgroups of stutterers, and (3) either of the stuttering subgroups when separately compared with controls. Dichotic listening and masking level difference (MLD) tasks were administered to the two groups of school-age stutterers and an age-matched nonstuttering control group. Stuttering subjects were differentiated into "organic" and "functional" subgroups on the basis of neuropsychological test performances. Organic stutterers performed significantly poorer than did controls on one MLD experimental condition. Functional stutterers performed more like control subjects than like organic stutterers.

INTRODUCTION

An emerging body of literature suggests that stutterers exist who exhibit some type of organic or physiological dysfunction or who have a proclivity to such organicity. Several organic etiological factors among stutterers have been described. For example, genetic inheritance (Andrews and Harris, 1964; Records, Kidd, and Kidd, 1976), unusual latent tetany (Weiss, 1967), differences in neuromuscular control (Schwartz, 1974; Starkweather, Hirschman, and Tannenbaum, 1976), atypical performance on neuropsychological tests (Daly and Smith, 1976; Daly, Kimbarrow, and Smith, 1977), lack of cerebral dominance (Curry and Gregory, 1969; Brady and Berson, 1975), and dysfunction of auditory processing and perceptual abilities (Hall and Jerger, 1978; Toscher and Rupp, 1978). The hypothesis that some type of organic dysfunction may

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lead to a proclivity for, or maintenance of, stuttering among certain persons certainly appears tenable.

A recent focus of research interest has centered on the brainstem as a possible site of central auditory system dysfunction in stutterers. Depressed performance by stuttering subjects on different central auditory batteries has been reported by several investigators (Klein, 1977; Toscher and Rupp, 1978; Hall and Jerger, 1978; and Barrett et al., 1979).

In addition to various batteries measuring central auditory function, another innovative technique for detecting central auditory brainstem pathology is a psychoacoustic phenomenon known as masking level difference (MLD). Masking level differences have been shown to demonstrate the continuing presence of auditory brainstem lesions despite normal conventional pure-tone and speech sensitivity tests (Quaranta and Cervellera, 1974; Noffsinger et al., 1975; and Olsen et al., 1976).

The pioneer work by Curry and Gregory (1969) on dichotic listening abilities of stutterers has led to increased investigation of auditory laterality at the cortical level. Research on normal speakers has consistently demonstrated that right-handed subjects are more successful at reporting words presented to the right ear than to the left, thus reflecting left hemisphere dominance for speech and language. The findings of Brady and Berson (1975) supported the results of Curry and Gregory (1969) by demonstrating a greater percentage of left-ear preferences among their stuttering subjects as compared with controls. The speculation that there is less clear-cut cerebral dominance in stutterers was confounded, however, by other researchers, who found no significant differences for ear preferences (Quinn, 1972; Cerf and Prins, 1974). The major explanation for these differing results has centered around the type of stimuli used, e.g., digits, syllables, or words. In addition, some authors have suggested that the results may be attributable, in part, to a lack of homogeneity among the stuttering subjects (St. Onge and Calvert, 1964; Van Riper, 1971; Sussman and MacNeilage, 1975).

Recently, Daly and Smith (1976, 1979) and Daly, Kimbarrow, and Smith (1977) attempted to differentiate stutterers on the basis of their performance on the Michigan Neuropsychological Test Battery (Smith, 1975). Fifty-four presumably "functional" stutterers, i.e., stutterers who exhibited no concomitant disorders, such as hearing loss, cleft palate, learning disabilities, mental retardation, and articulation problems, were studied. Surprisingly, 35% of their carefully screened stuttering subjects exhibited three or more positive neuropsychological signs of cerebral dysfunction. Classification of organic sign involved a stringent performance criterion of at least 2 yr below chronological age norms for these children with otherwise normal intelligence. Daly and Smith classified the stutterers with three or more such signs as organic and suggested the probability of cerebral and neurological dysfunction in and among certain members of the entire stuttering population.

The present study sought to investigate central auditory processing and perceptual abilities in two carefully defined subgroups of stutterers: an organic and a functional group. Two central auditory processing and perceptual tasks were used: one at the cortical level, dichotic listening, and the other at the level of the brainstem, MLD. Three experimental questions were asked for each auditory task. Do significant differences in auditory processing and perceptual abilities exist between (1) stutterers as a supposedly homogeneous group when compared with control subjects? (2) the two subgroups of stutterers themselves? and (3) either of the differentiated groups of stutterers when compared separately with the control group?

METHOD

Subjects

Three groups of school-age male subjects were studied: six organic stutterers; six functional stutterers; and six nonstutterers, who served as the control group. All 18 subjects were right-handed, matched for age within 6 mo, and were required to pass an air-conduction hearing screening at 20 dB HTL. All stutterers were campers at the University of Michigan's Shady Trails Camp. The six stutterers designated as the organic group exhibited three or more positive neuropsychological signs when tested, ranging in age 12–18 yr, with a mean of 14.8 yr. The six age-matched stutterers who showed zero or only one sign of neuropsychological deficit were arbitrarily classified as functional stutterers. This group, having no compelling evidence of organicity, ranged in age 11–18 yr with a mean of 15.0 yr. The six nonstuttering subjects were selected from a parochial school in Ann Arbor, Michigan, and ranged in age 12–18 yr with a mean age of 15.0 yr. All 18 subjects were normal school achievers, in appropriate grade levels, with ostensibly normal intelligence.

Procedure

The dichotic listening procedure was administered first to control for any possible auditory fatigue effect that masking might induce. Three CV monosyllable lists (J, K, and L) computer-generated at the Kresge Hearing Research Laboratory in New Orleans were used in this study. Following familiarization with the CV syllables, subjects were then instructed that they would hear two of the syllables, one in each ear, simultaneously. A specially designed response board (Figure 1) was placed in front of the subject, whose task was to simply point to the two CV syllables heard. Following a practice trial consisting of 30 CV pairs (list J), two additional sets of 30 random CV pairs (lists K and L) were presented to the subjects through standard phase-balanced headphones at 75 dB SPL.

After a short break, the MLD procedure was introduced. Subjects were trained to use a Békésy audiometry switch and were then instructed to keep a beeping sound at a level at which they could just barely hear it. A pulsed 500-Hz signal and a 95-dB SPL white noise masking signal were used. Both signals were fed into a MLD attenuator (Calder, Model CDA-6K) and were presented through headphones. Subjects traced their thresholds by operating a standard Békésy audiometry switch for 1 min after stabilizing the tracing under each of the test conditions ($S\pi No$, $SoN\pi$, SoNo). Each subject had previously completed Békésy tracings in quiet and was allowed to practice one of the masking conditions ($S\pi N\pi$),

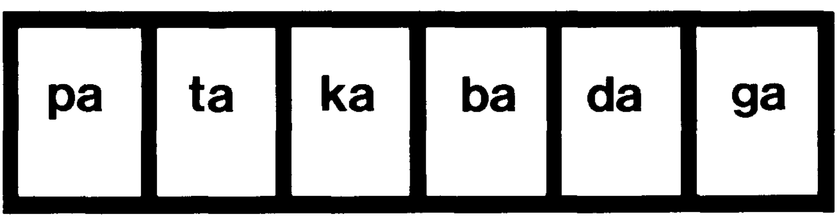

Figure 1: CV syllable response bond.

before the MLD data were gathered. Each subject's MLD was defined as the difference between the threshold obtained in the baseline condition and that obtained under the two antiphasic or experimental conditions.

RESULTS

Dichotic Listening

Table 1 presents the combined right- and left-ear scores (for lists K and L) for each subject, as well as the total correct score, regardless of ear preference. Seven of the stutterers exhibited right-ear preference, with the

TABLE 1

Right- and Left-Ear Correct Scores for Combined Dichotic Listening Subtests (K and L) and Total Correct Score, Regardless of Ear Preference

Subject	Subtest K and L[a]		Total
	Right	Left	Correct Score[b]
	Organic Stutterers		
1	38	20	58
2	30	33	63
3	42	29	71
4	42	35	77
5	20	38	58
6	35	42	77
	Functional Stutterers		
7	26	39	65
8	32	25	57
9	43	28	71
10	34	42	76
11	41	27	68
12	36	31	67
	Control Group		
13	34	34	68
14	31	31	62
15	32	33	65
16	31	28	59
17	35	37	72
18	29	27	56

[a]Out of a possible 60.
[b]Out of a possible 120.

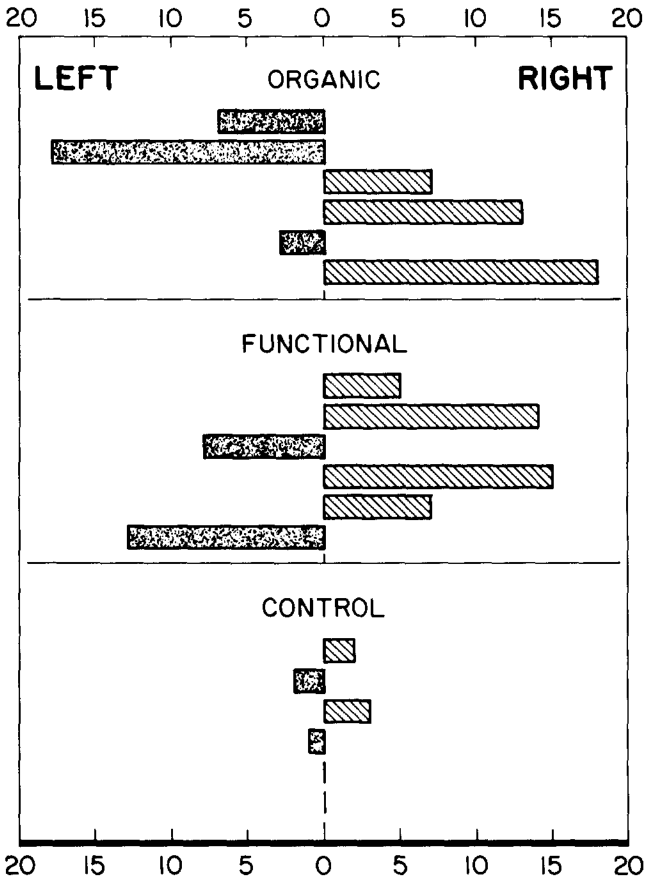

Figure 2: Individual between-ear difference scores on the combined dichotic listening subtests (K and L), regardless of direction (right or left).

remaining five showing left-ear preference. Of the six control subjects, two exhibited right-ear preferences, two showed left-ear preferences, and two had identical combined scores for each ear. The finding that control subjects' dichotic listening scores were more variable than those of the stutterers was unexpected. Differentiating the stuttering subjects into two groups demonstrated that three members of the organic stuttering group and four members of the functional stuttering group displayed right-ear

TABLE 2

Group Mean Scores for Right and Left Ears on Combined Dichotic Listening Subtests (K and L) and for Total Number Correct Responses, Regardless of Ear Preference

Group	$\bar{X}$ Correct Score (K and L)[a] Right Ear	$\bar{X}$ Correct Score (K and L)[a] Left Ear	$\bar{X}$ Total Correct Score[b]
Organic stutterers	34.5	32.8	67.3
Functional stutterers	35.3	32.0	67.3
Control	32.0	31.7	63.7

[a]Out of a possible 60.
[b]Out of a possible 120.

advantages, whereas the remaining subjects in each group had left-ear preferences. The combined between-ear difference scores for each subject are graphically displayed in Figure 2. It is noteworthy that the magnitudes of the combined-ear difference scores were greater for the stutterers, regardless of the direction of ear preference.

Group mean scores for the right and left ear on the combined dichotic subtests (lists K and L) as well as for the total number of correct responses are presented in Table 2. Although three groups of subjects exhibited a slight right-ear preference, the mean performances for each ear on the combined subtests did not produce statistically significant right-ear advantages. Inspection of the mean total correct responses for each group also showed insignificant differences among the three groups. Results of an ANOVA ($F = 0.54$; $df = 2, 15$) further confirmed that the performances of the three groups were essentially identical.

Masking Level Difference

Mean MLD scores for each group under experimental conditions are presented in Table 3. Because MLDs are obtained from Békésy tracings, scores are represented as averages. For each person tested, two baseline scores (SoNo) were recorded, one after successful tracings were established in quiet and the other following the two experimental conditions (SoNπ, SπNo). The two scores were then averaged together to obtain an average baseline score (Average SoNo). Experimental scores were then

TABLE 3

Mean Masking Level Difference Scores for Each of the Three Subgroups under Experimental Conditions[a]

Subgroups	Condition I SoNo−SoNπ Mean Average (dB)	Condition II SoNo−SπNo Mean Average (dB)
Organic stutterers	7.87	6.42
Functional stutterers	9.38	8.87
Control	9.75	10.25

[a] $n = 6$ in each subgroup.

subtracted from this baseline threshold to yield MLDs for each of the experimental conditions (Average SoNo-SoNπ, Average SoNo-SπNo). The group means for each of the experimental conditions were subjected to an analysis of variance to compare the performances of the three groups. For condition I (Average SoNo−SoNπ), no statistically significant differences among the three groups were obtained ($F = 0.81$; $df = 2, 15$). However, statistical significance at the 0.05 level was obtained for condition II (Average SoNo−SπNo) between the organic stuttering group and the control group ($t = 2.38$; $df = 10$). This large performance difference is clearly displayed in Figure 3. The performance of the functional stuttering group under both conditions also deserves special attention. Specifically, the functional stutterers performed more like the nonstuttering subjects than like their organic counterparts.

DISCUSSION

It was interesting to note that it was the brainstem level task that resulted in a significant difference, rather than the cortical dichotic listening task. This finding lends collaborative support to the results reported by Hall and Jerger (1978) and Toscher and Rupp (1978), among others. Using different procedures to evaluate central auditory abilities, these investigators suggested that stutterers might indeed exhibit subtle dysfunction of the central auditory system at the brainstem level. Data from several sources further support the contention that the neurophysiological or-

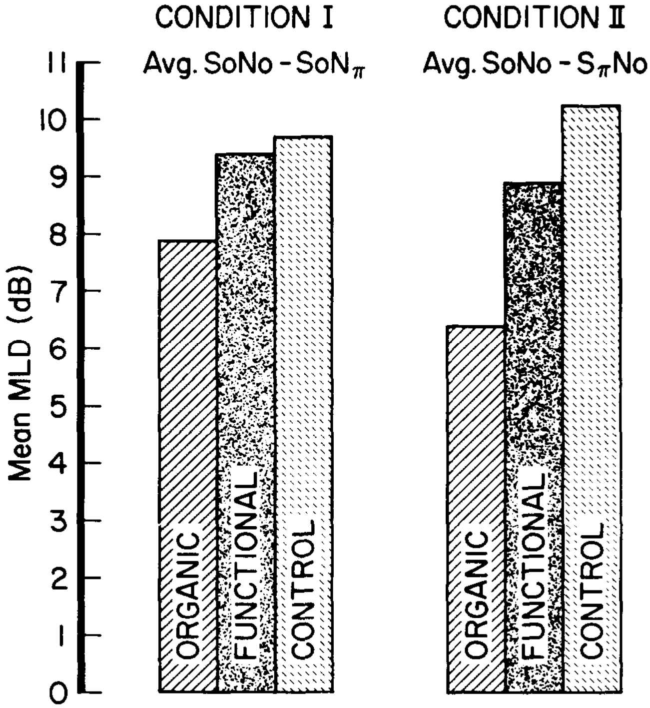

Figure 3: Average group mean masking level differences for the two experimental conditions.

ganization of some stutterers is different from that of normally fluent speakers and might not, in fact, be limited to just one specific level of brain functioning (Quinn, 1975; Zimmerman and Knott, 1974). Other levels of possible neurological dysfunction include visual perceptual laterality (Jasper, 1932), unilateral eyelid movement (Barrett and Stoeckel, 1979), oral and laryngeal reaction times (Adams and Hayden, 1976; Adler and Starkweather, 1979), attending problems (Riley and Riley, 1979), and auditory laterality (Curry and Gregory, 1969).

Whereas this study also investigated auditory laterality with dichotic listening, the findings were somewhat unexpected. Most dichotic studies tend to support significant between-ear differences and report that stutterers display more left-ear preferences than are found in the normal population. The findings of this investigation demonstrated no statistically significant group differences on the dichotic listening procedure. In fact, all three groups exhibited a slight right-ear preference.

Comparisons of the magnitude of between-ear differences (Figure 2) with Curry and Gregory's (1969) data indicated another noteworthy contrast. Their data displayed a greater magnitude of between-ear difference scores for control subjects, whereas the present study found just the opposite. The extent of between-ear differences for the nonstuttering control group children was considerably less than differences observed for either stuttering subgroup. The magnitudes of these differences, as well as the direction, are conceivably of theoretical importance for normal speakers and stutterers.

Although differences in the types of auditory stimuli used have been identified as a major reason for conflicting results in dichotic listening studies (Dermody, 1975; Berlin and McNeil, 1976; Moore, 1976), several additional variables could account for the variance between the present study and earlier investigations.

1. Response Mode. If the primary purpose of a dichotic task is to correctly identify auditory stimuli presented, factors such as short-term memory deficits, language associations, fear of stuttering on particular sounds or words, and time pressures, should be carefully controlled. The response mode employed in the present study sought to reduce the effects of such variables by having subjects merely point to the two CV syllables heard.
2. Age. Most other investigations have used adult stutterers as subjects. All subjects in this study were adolescent stutterers, ranging in age from 11 to 18 yr. Just what effect neurological maturation has on central auditory processing and perception is unknown, but it could, indeed, be a critical variable.
3. Differentiation of Stuttering Subgroups. The 12 stuttering subjects were selected from a finely screened larger pool of stutterers. Any stutterer having a concomitant disorder, such as misarticulation, cluttering, cleft palate, mental retardation, cerebral palsy, aphasia, or learning disability, was excluded from the pool of presumably functional stutterers. Only after subsequent neuropsychological testing were the 12 stuttering subjects subgrouped as organic or functional stutterers. Had

the stutterers with concomitant disorders been included, as in many other studies, the dichotic results, and perhaps th^ brainstem results, might have been quite different.

The findings of this investigation support the belief of St. Onge (1963), Gregory (1968), Sheehan (1970), Van Riper (1971), and others, who maintain that stuttering is not a unitary disorder, but rather a generic label for a wide range of related disorders. The common practice of grouping dysfluent persons into a presumably discrete group for comparison with another sample of nonstuttering subjects reflects a tacit assumption that stutterers constitute a homogeneous population. This research strategy has undoubtedly concealed or masked potentially important differences among stuttering subjects. To reconcile the inconsistent and conflicting findings in the literature on the phenomenon of stuttering, researchers must intensify their efforts to identify subpopulations of stutterers. Many contradictory theoretical and clinical issues have the potential to be resolved, at least in part, if efforts are taken to differentiate subgroups of stutterers.

This study is based on a master's thesis completed by RML at The University of Michigan. We are grateful for the help of Dr. John H. Wiley and Dr. Ralph R. Rupp, whose thoughtful and constructive comments greatly strengthened this work. Essential information contained in this article was presented at the 1979 Annual Convention of the American Speech–Language–Hearing Association, Atlanta. Requests for reprints should be directed to David A. Daly, Program in Speech and Hearing Sciences, University of Michigan, 1111 East Catherine Street, Ann Arbor, MI 48109.

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