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To explore the adequacy of a 50-word list, produced by item analysis of a set of 160 words in an earlier study, also by Tikofsky, tape recordings of 20 adult dysarthrics reading list were evaluated by university students who were native speakers of English and had no history of hearing loss. Results of the intelligibility study showed that the dysarthrics could be categorized according to their responses into four groups. The results also indicated that certain words presented more difficulty for some types of dysarthria than others. It was concluded that the 50 word list is an efficient and accurate means of testing dysarthrics before and after speech therapy. Tables provide biographical data on the patients, their itemized test responses, and correlations between test performance and nature of impairments; the 50-word list is also appended. (Author/JD)

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A STUDY OF INTELLIGIBILITY OF DYSARTHRIC SPEECH[1]

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A second intelligibility study using 20 additional dysarthrics was carried out. The same procedures were followed as in the original study except for the size of the word list. A scaled list of 50 words was used in the present study. The results showed that the dysarthrics could be categorized according to their responses into four groups. The results also indicated that certain words presented more difficulty for some types of dysarthria than others. It was concluded that the 50 word list is an efficient and accurate means of testing dysarthrics before and after speech therapy.

A major goal of clinical research is the development of objective and quantitative measures of speech and language production. In the case of articulatory impairments one criterion which would prove useful to the clinician is speech intelligibility. This criterion is of particular significance in articulatory impairments such as the dysarthrias. In these impairments it is often difficult if not impossible to assess adequately the relation between the acoustic event and the articulatory movements resulting in the deviant production without special instrumentation. Even when such instrumentation is available predictions made from data such as spectrograms (Lehiste, 1965) do not always agree with listener responses (Tikofsky, Glattke, & Tikofsky, 1967). Since the ultimate goal of therapy is an increase in intelligibility, it would seem reasonable to attempt to develop instruments that assess articulatory efficiency in terms of the listener's ability to understand what the speaker is trying to articulate.

Tikofsky and Tikofsky (1964) in a preliminary report described an attempt to assess the dysarthric's intelligibility based on listener responses. Their findings were based on data obtained from nine dysarthrics speaking 160 words and 30 listeners responding to each speaker. Words were arranged in three lists, CNC (consonant, syllable nucleus, consonant), spondees, and monosyllabic

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words containing initial and/or final consonant clusters. Several of their results are of interest for the present paper. They obtained high listener agreement in terms of number of correct responses to a given speaker. Further, the population of dysarthrics was clearly different from a control population of normals, and the dysarthrics maintained their rank in terms of intelligibility across lists. Intelligibility scores obtained for one word list did not differ significantly from those obtained for any of the other lists.

Correlations between lists were significant. Thus scores on one list predict with great accuracy scores for the other lists. This suggested that a shorter list could be developed. Such a list would maximize the contributions made by particular items in each of the three lists and still have the same, if not increased, power in estimating single word intelligibility of dysarthric speakers. Cursory examination of responses to single words supports the notion that some words are of greater value than others in providing estimates of intelligibility.

An item analysis (Tikofsky, R. S. in press) was carried out on the original set of 160 words to determine if a reduced list could be generated which met *a priori* criteria of difficulty and reliability. Results of the analyses yielded a 50-word list. These words ranged in difficulty from .407 (most difficult) to .841 (least difficult) with a mean difficulty of .619; a mean S.D. of .472; and a mean reliability of .676. The list included 6 CNC's, 24 clusters, and 20 spondees. All English vowels and diphthongs were represented as well as the majority of initial and final consonant combinations.

The present research was designed to explore the adequacy of this list to assess the intelligibility of a population of adult dysarthrics. It also attempts to determine if the list can discriminate among dysarthrics on the basis of listener responses. The basic design of this study was the same as that described by Tikofsky and Tikofsky (1964).

Procedure

Methods for obtaining samples of dysarthric speech will be discussed first. This will be followed by a description of the design of the listening experiment.

Dysarthric Speech Samples. Twenty-six dysarthrics from clinics in four different states provided the speech samples for the listening experiment. Of the 26 speakers all but one was male, with an age range of 16 to 65. A summary

of the available biographical and clinical data for the speakers is given in Table 1. Speakers presented no evidence of hearing loss. While several speakers

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Insert Table 1 about here

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evidenced aphasia this was not judged by the E to influence reading of the word list. Qualitative judgements of severity of dysarthria were made by the speech pathologist who made the recordings. All speakers had received some speech therapy. Data from nine dysarthrics in the original study were also included in the present analyses. Detailed descriptions of these Ss can be found in Tikofsky and Tikofsky (1964) and Lehiste (1965).

Recording Procedures. Tape recordings were made of 26 dysarthric speakers reading the 50-word list (see Table 2). The equipment varied for each S because

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Insert Table 2 about here

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of location, but a quiet room and good fidelity equipment were requested by the E. Recordings of six dysarthrics were eliminated because they lacked adequate fidelity for the preparation of listening tapes.

Listening Experiment. A listening tape was made from the original recordings of the 20 speakers for whom adequate recordings were available. This was done to allow sufficient time between the utterance of each word for the listener to record his response. Listeners were given the following instructions:

> You are about to hear a list of words. Please write down the word you think you hear on the sheets provided. If you do not understand a word, draw a line in the space along side the appropriate number. Ready, first word.

Listeners were 300 students at the University of Michigan who were native speakers of English and had no history of hearing loss. Fifteen listeners responded to each speaker in group sessions of five listeners per session. Speech samples were played on an Ampex 351-2 tape recorder in a quiet room. Listeners heard the tapes through a single TDH-39 earphone at a comfortable intensity level on one ear, with a dummy phone on the other ear.

Scoring Procedures. Listener responses were scored in terms of the total number of words correctly identified. A response was considered correct if, and only if, it was the word intended by the speaker. For words having several alternative spellings (i.e., piece, peace) either version was scored as correct. Minor spelling errors which did not affect interpretation were discounted.

For the original nine dysarthrics no new listener responses were obtained. The data obtained for these speakers were reexamined. A score comparable to that obtained for the 20 speakers in the present experiment was derived for each of the nine dysarthrics in the 1964 study. This score was based on the total number of correct responses made by the original set of listeners to the 50 words used in the present study. The groups of 30 listeners used in the 1964 study were randomly divided into subsets of 15 to correspond with the present sample. Reliability tests run to determine if there were significant differences between these groups of listeners indicated no differences. All reliability measures were in the range of .90 or greater. One set of 15 listeners was selected for each of the nine dysarthrics.

Results

Table 3 gives the raw scores (in terms of number of correct listener responses), means, and S. D.'s for the 20 Ss ordered according to listener intelligibility scores. Also included are the raw scores and means of the original

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Insert Table 3 about here

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nine dysarthrics. The S.D.'s for all 20 Ss are low. This indicates high reliability of the responses from the listeners. The scores for all 29 dysarthrics show a wide range of intelligibility. The mean scores range from a high of 47.00 to a low of .87 with the majority of mean scores in this sample falling between 30 and 45.

Test words were ranked according to their difficulty as determined by Tikofsky's (in press) Item Analysis described above. The words were then ranked on the basis of number of correct responses to each word made by all listeners across all speakers for the two groups of dysarthric speakers. The ranks based on the Item Analysis and listener responses were compared using the Spearman Rank Correlation Coefficient (Siegel, 1956). An r of .58 was obtained for the comparison using the 20 dysarthrics, and an r of .97 was obtained using the nine dysarthrics. The significance of the obtained r's was tested by reference to the t distribution (Siegel, 1956, p. 212). In both instances the obtained values of t were significant at the .01 level. Figure 1 is a plot of the mean scores of each of the 20 dysarthrics where the speakers are ordered over the abscissa from most to least intelligible. On the basis of visual inspection

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Insert Figure 1 about here
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of the curve it is possible to discern some breaking points. From such inspection the population under consideration could be divided into four groups with respect to impairment of intelligibility: minimal, mild, moderate, and severe. Except at the upper level where there is some overlap between minimal and mild, there is a distinct separation between the four categories. Also shown in this figure is the mean of the means, S.D., and the range for each sub-group. The scores for the nine dysarthrics used in the original study are also shown in this figure.

Table 4 gives the number of correct responses for each speaker to each of the 50 words. Speakers are grouped by impairment categories and the words are

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Insert Table 4 about here
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ordered from most to least intelligible based on the item analysis. Means for each sub-group and a total and mean of all groups are included. Inspection of the table reveals that while speakers falling within the same impairment sub-group have similar overall intelligibility scores, there are idiosyncratic error patterns.

Discussion

These results show that the 50-word list described by Tikofsky (in press) can be used to assess the single word intelligibility of adult dysarthrics. Thus this list can be employed by the speech therapist to evaluate one parameter of dysarthria, single word intelligibility, by means of an objective test. The cut-off points noted in the present paper could serve as a guide in classifying the dysarthric's degree of impairment of intelligibility. They provide a standard reference measure for each therapist though his experience with dysarthrics may be limited. Examination of Table 4 shows that certain individual words were more difficult for some types of dysarthrics. One dysarthric in the minimal or mild grouping obtained a score of one on the word "fused" yet all other scores were 12 to 15; another obtained a score of three on the word "crown" yet all other scores were between 10 and 15. There are other examples of this same phenomenon. The words are not the same so it is not a function of the word

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itself being difficult for dysarthrics in general. The dysarthrics overall word score is high. It seems specific words create difficulty for specific dysarthrics. Whether this is due to the types of dysarthria and relates to the etiology would bear further investigation. The reverse of this was also true to some extent. Some dysarthrics in the moderate and severe groupings would get high scores on one or two words. A dysarthric would score 11 on "platform" and 13 on "bounce" yet his overall score would be between six and zero. However, the high scores in the low groupings occurred less frequently then low scores in the minimal and mild groupings.

These results seem to indicate that the 50-word list can be employed usefully by therapists for both testing and classification of individual dysarthrics. It can also be utilized to measure progress in therapy if administered prior to and after completion of speech therapy. The additional value of this list as a test is the fact that trained listeners are not required, it is easy to administer, and it is easy to score. For these reasons it can be used in any situation by a therapist with minimal equipment and time.

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Footnote

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This is a draft of a final paper that will be submitted for publication.

Figure Caption

Figure 1. Distribution of mean number of correct listener responses to dysarthric speakers.

Table 1

Biographical and clinical data for dysarthric subjects

Patient	Age	Sex	Place of Birth	Time between onset and recording	Clinician's judgment of degree of dysarthric impairment	Etiology	Related speech finding as judged by the clinician where recording made*
O.B.	57	M	Wilburton, Okla.	7 yrs.	Moderate	CVA	Paraphrasia, motor aphasia
F.B.	65	M	San Francisco, Calif.	9 yrs.	Moderate	CVA	Residuals of motor aphasia
R.B.	54	M	Morhall, Md.	6 mos.	Mild	Thrombosis	None
J.B.	43	M	McAllister, Okla.	1 yr.	Mild	Thrombosis	Amnesic aphasia, fomulation and spelling loss, acalculia
F.C.	41	M	Mt. Harris, Colo.	6 mos.	Moderate	Cerebellar Atrophy	Ataxia
R.G.	29	M	Denver, Colo.	11 yrs.	Mild	Multiple Sclerosis	None known
O.H.	42	M	S. Dakota	13 yrs.	Moderate	CVA	None
R.H.	24	M	Baker, Ore.	5 mos.	Very mild	Auto accident	Ataxia
R. Hen	64	M	Arkansas	4 yrs.	Severe	CVA	Motor aphasia
C.K.	21	M	Detroit, Mich.	16 yrs. (?)	Mild	Huntington's Chorea	Mild choreatic speech
E. La.	50	M	El Paso, Tex.	4 yrs.	Mild	Trauma	Amnesic aphasia
E. Ly.	27	M	Toledo, O.	4 yrs.	Mild	Trauma-frontal lesion	None
H.M.	44	M	Denver, Colo.	4 yrs.	Mild	Encephalitis	Ataxia
J.M.	25	M	Longbeach, Calif.	8 yrs.	Severe	Trauma-frontal	None
D.O.	30	M	Massachusetts	9 yrs.	Severe	Trauma-frontal	None
F.P.	46	M	Montana	24 yrs.	Very mild	MS	None known
J.P.	56	M	Los Angeles, Calif.	3 yrs.	Mild	CVA	Amnesic aphasia, oral formulation loss
D.S.	40	M	Arkansas	5 yrs.	Moderate	MS-midbrain	None known
H.T.	53	M	Missouri	3 yrs.	Severe	Embolus to basilar artery system	None
G.W.	16	F	Michigan	1 yr.	Moderate-mild	Cerebellar lesion	Ataxia

*These findings in addition to dysarthria and when listened to by E, judged not to interfere with participation in experiment.

Table 2

Scaled word list

crown	inkwell
joke	cute
charge	shank
washboard	with
sketch	dwarf
eggplant	earthquake
starlight	tongue
cookbook	man
twist	blush
scarecrow	schoolboy
grove	lifeboat
chant	duckpond
spice	woodwork
shipwreck	shrug
drawbridge	bush
mushroom	platform
thread	showered
buckwheat	barb
champ	bounce
sleeps	daybreak
more	train
wildcat	fused
sledge	bind
northwest	playground
sheep	scrub

Table 3

Raw scores, means, and Standard Deviation based on correct listener responses to dysarthric speakers

Twenty Ss

S's	Raw Score*	Mean	S.D.
13	704	46.9	1.7
23	703	46.8	1.3
8	676	45.0	2.5
2	647	43.1	2.1
17	634	42.2	2.7
3	628	41.8	2.8
16	592	39.4	1.9
9	575	38.3	3.8
15	534	35.6	2.9
18	532	35.4	3.9
29	528	35.2	2.1
27	430	28.6	3.5
1	409	27.2	2.7
22	404	26.9	3.6
21	396	26.4	3.0
20	319	21.2	3.6
4	242	16.1	3.2
12	136	9.0	2.1
6	32	2.1	1.1
28	13	.87	.72

Nine Ss

S's	Raw Score**	Mean
10	1418	47.2
14	1385	46.1
5	1320	44.0
25	1251	41.7
24	1047	34.8
26	1023	34.1
7	703	23.4
30	121	4.0
11	119	3.9

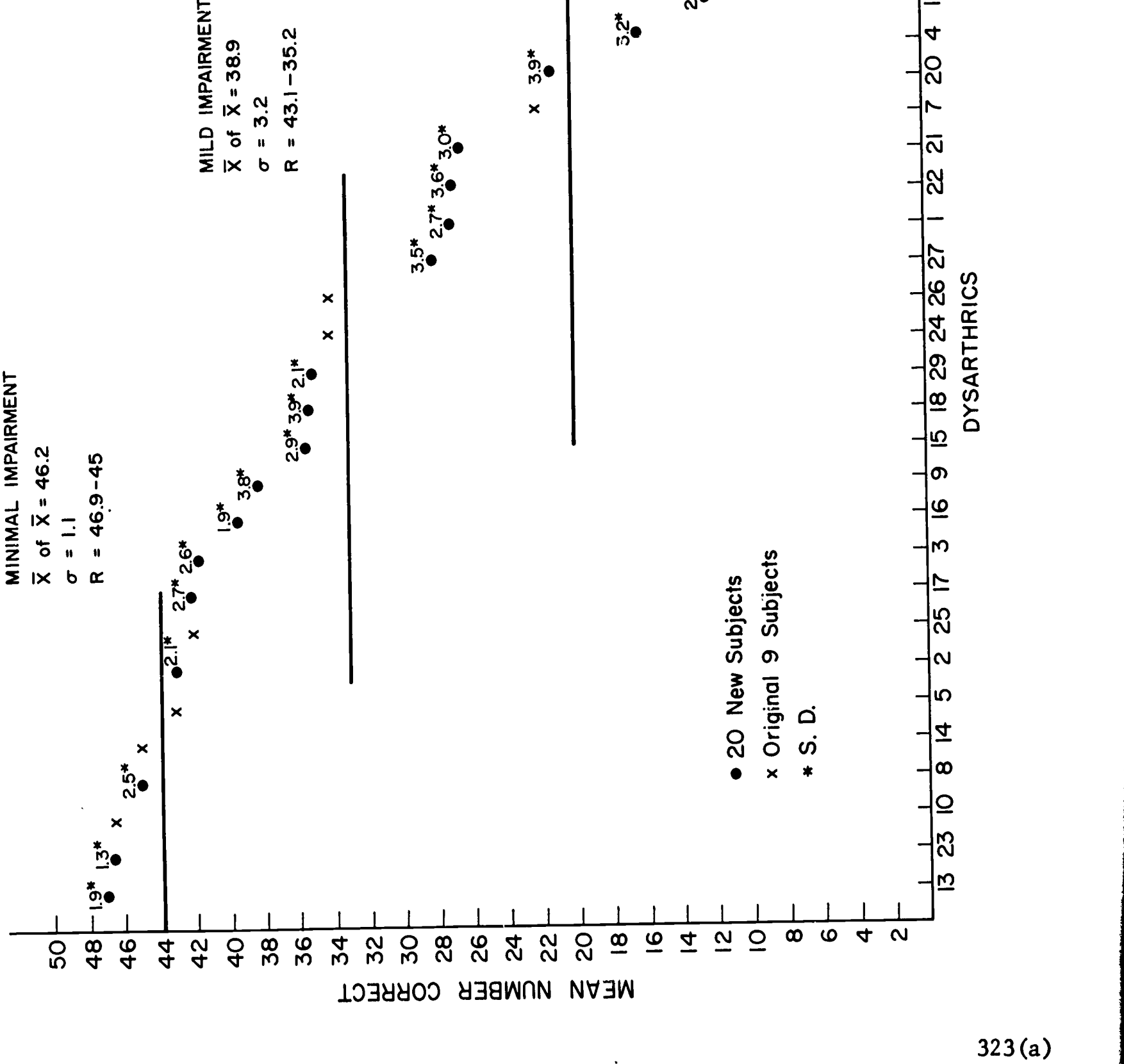
*Maximum number correct = 750 based on 15 listeners

**Maximum number correct = 1500 based on 30 listeners

Table 4

Number of correct scores for each of 20 dysarthric subjects on the 50-word list, with dysarthrics ordered according to degree of impairment, and words ordered from least to most difficult

	Minimal					Mild										Moderate							Severe					
	Subject					Subject										Subject							Subject					
	13	23	8	Σ	$\bar{X}$	2	17	3	16	9	15	18	29	Σ	$\bar{X}$	27	1	22	21	20	Σ	$\bar{X}$	4	12	6	28	Σ	$\bar{X}$
cookbook	15	15	15	45	15	15	15	14	15	15	15	15	15	119	14.8	7	3	4	10	0	24	4.8	2	5	0	0	7	1.7
lifeboat	15	15	15	45	15	15	0	15	9	15	15	6	11	86	10.7	14	13	0	4	14	45	9	8	0	0	2	10	2.5
man	15	14	15	44	14.6	14	13	13	15	15	14	15	15	114	14.2	3	15	15	8	14	55	11	4	15	10	6	35	8.7
northwest	15	15	15	45	15	15	13	15	15	15	15	13	15	116	14.5	14	15	12	13	4	58	11.6	15	0	0	0	15	3.7
washboard	15	12	15	42	14	15	15	15	15	6	14	14	14	108	13.5	14	4	6	12	0	36	7.2	7	6	1	0	14	3.5
eggplant	15	15	15	45	15	15	14	15	15	13	15	14	15	116	14.5	12	1	8	7	0	28	5.6	1	10	0	0	11	2.7
wildcat	15	15	15	45	15	10	6	14	15	1	15	11	15	87	10.8	15	15	11	12	2	55	11	8	0	0	1	9	2.2
woodwork	15	15	10	40	13.3	14	14	11	15	15	14	5	14	102	12.7	14	12	15	3	12	56	11.2	5	2	1	0	8	2
shipwreck	13	15	10	38	12.6	4	15	15	15	9	15	13	14	100	12.5	10	7	8	1	0	26	5.2	0	0	0	0	0	0
schoolboy	15	15	15	45	15	14	15	14	15	15	13	7	15	108	13.5	13	15	15	7	15	65	13	4	0	0	0	4	1
daybreak	14	15	8	37	12.3	15	15	15	15	13	14	15	13	115	14.3	2	15	2	12	6	37	7.4	3	0	2	2	7	1.7
sheep	15	14	15	44	14.6	6	14	15	11	15	5	12	2	80	10	3	13	10	10	8	44	8.8	8	0	0	0	8	2
starlight	15	15	15	45	15	15	14	15	15	1	13	10	15	98	12.2	4	7	9	4	14	38	7.6	11	0	0	0	11	2.7
inkwell	15	15	15	45	15	15	14	15	15	15	15	15	4	118	14.7	15	15	10	11	8	59	11.8	9	2	0	0	11	2.7
buckwheat	15	15	15	45	15	15	15	15	13	14	14	15	10	111	13.8	14	14	15	10	1	54	10.8	0	7	0	0	7	1.7
mushroom	15	14	15	44	14.6	15	14	15	10	14	15	15	15	113	14.1	13	0	12	10	7	42	8.4	13	1	0	0	14	3.5
platform	14	15	14	43	14.3	15	15	14	15	14	9	14	15	111	13.8	15	2	9	12	12	50	10	0	11	0	0	11	2.7
tongue	12	15	14	41	13.6	13	14	14	11	13	7	15	15	102	12.7	11	4	11	15	1	42	8.4	9	0	1	0	10	2.5
earthquake	15	15	15	45	15	15	15	15	15	15	15	15	15	120	15	15	9	15	14	12	65	13	2	0	1	0	3	.7
scarecrow	14	15	15	44	14.6	15	15	10	15	13	15	15	11	109	13.6	13	11	11	15	13	63	12.6	0	0	0	0	0	0
scrub	15	15	14	44	14.6	1	9	15	15	8	0	0	0	48	6	1	14	3	3	15	36	7.2	1	0	0	0	1	.2
dwarf	15	13	15	43	14.3	2	8	1	4	12	0	14	0	41	5.1	0	2	13	6	14	35	7	1	0	0	0	1	.2
charge	14	15	11	40	13.3	15	15	12	15	14	15	15	15	116	14.5	7	12	0	13	0	32	6.4	11	0	0	0	11	2.7
more	9	15	15	39	13	15	15	15	15	15	15	15	14	119	14.8	15	7	10	10	12	54	10.8	8	10	10	0	28	7
cute	14	15	10	39	13	14	14	13	3	0	11	15	14	84	10.5	6	14	13	8	15	56	11.2	5	0	0	0	5	1.2
playground	15	15	12	42	14	14	15	15	15	14	15	12	15	115	14.3	10	14	9	6	14	53	10.6	0	1	0	0	1	.2
drawbridge	15	15	15	45	15	15	15	15	13	14	15	14	11	112	14	13	4	15	12	12	56	11.2	0	5	0	0	5	1.2
fused	1	10	15	26	8.6	14	12	1	9	9	14	7	0	95	11.8	12	14	0	2	1	29	5.8	0	0	0	0	0	0
shrug	13	12	15	40	13.3	14	13	15	7	11	12	10	13	95	11.8	3	0	15	0	11	29	5.8	4	0	0	0	4	1
twist	15	14	11	40	13.3	15	14	11	15	7	15	3	14	94	11.7	1	11	15	13	13	53	10.6	0	0	0	0	0	0
duckpond	14	15	15	44	14.6	15	5	15	10	15	9	7	15	91	11.3	8	5	2	10	0	25	5	0	6	0	0	6	1.5
crown	12	15	3	30	10	14	7	1	3	13	2	7	0	47	5.8	3	4	0	0	0	17	3.4	14	0	0	0	14	3.5
sketch	15	15	15	45	15	15	15	15	15	6	15	14	13	108	13.5	14	1	0	15	4	34	6.8	14	0	0	0	14	3.5
spice	15	15	15	45	15	15	2	13	13	15	15	10	5	88	11	6	7	13	2	15	43	8.6	2	0	0	0	2	.5
with	14	7	10	31	10.3	9	13	7	15	12	10	5	13	84	10.5	12	0	10	13	2	37	7.4	0	8	0	0	8	2
joke	14	14	13	41	13.6	15	15	15	10	15	13	14	15	112	14	11	2	4	5	0	22	4.4	0	0	0	1	1	.2
thread	15	15	14	44	14.6	15	14	14	1	5	15	10	12	86	10.7	2	15	9	15	9	50	10	11	10	0	0	21	5.2
bush	15	15	15	45	15	15	13	15	15	14	0	1	15	88	11	2	0	14	13	2	31	6.2	13	2	0	0	15	3.7
barb	14	2	14	30	10	13	5	8	4	15	0	13	5	63	7.8	12	0	0	0	0	12	2.4	0	9	0	0	9	2.2
shank	15	14	14	43	14.3	12	14	14	14	10	14	10	0	88	11	4	14	5	5	0	28	5.6	0	0	0	0	0	0
train	15	15	8	38	12.6	11	14	12	15	9	13	15	14	103	12.8	4	0	2	15	14	35	7	11	3	1	0	15	3.7
bounce	15	14	15	44	14.6	15	7	15	13	14	1	2	13	80	10	10	15	7	2	1	35	7	10	13	0	0	23	5.7
chant	15	15	13	43	14.3	15	15	15	14	8	14	5	0	86	10.7	11	14	0	4	0	29	5.8	1	0	0	0	1	.2
showered	15	14	15	44	14.6	12	14	12	7	7	0	0	14	66	8.2	12	0	0	2	0	14	2.8	1	0	0	0	1	.2
sleeps	15	15	15	45	15	15	14	8	6	9	15	12	2	81	10.1	13	1	14	9	10	47	9.4	12	7	0	0	19	4.7
bind	15	15	15	45	15	12	13	13	3	15	0	12	0	68	8.5	0	14	3	4	0	21	4.2	7	0	4	1	12	3
grove	14	10	12	36	12	11	2	1	1	5	2	8	0	30	3.7	0	7	0	0	0	7	1.4	0	1	0	0	1	.2
sledge	15	15	15	45	15	13	15	14	14	15	12	8	15	106	13.2	0	7	15	13	7	42	8.4	0	2	0	0	2	.5
champ	12	15	12	39	13	1	15	11	8	15	5	11	13	79	9.8	10	11	1	1	1	24	4.8	4	0	0	0	4	1
blush	12	15	14	41	13.6	15	15	14	13	8	0	9	0	74	9.2	7	0	2	5	5	19	3.8	1	0	0	0	1	.2


MILD IMPAIRMENT
$\bar{X}$ of $\bar{X}$ = 38.9
σ = 3.2
R = 43.1–35.2
MODERATE IMPAIRMENT
$\bar{X}$ of $\bar{X}$ = 26.1
σ = 2.8
R = 28.6–21.2
SEVERE IMPAIRMENT
$\bar{X}$ of $\bar{X}$ = 7.0
σ = 7.0
R = 16.1 – 0.8
MINIMAL IMPAIRMENT
$\bar{X}$ of $\bar{X}$ = 46.2
σ = 1.1
R = 46.9–45
MEAN NUMBER CORRECT
DYSARTHRICS
● 20 New Subjects
x Original 9 Subjects
* S. D.

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