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Amy Marie Smith

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COMMON ERRORS MADE BY CLINIC PATIENTS RESPONDING TO THE
W-22 AND NU-6 WORD LISTS

By

Amy Marie Smith

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Dr. James D. Miller, Independent Study Supervisor

I. INTRODUCTION

Typical confusions made by clinic patients in response to the W-22 and NU-6 lists are described. Research by Thorton *et al.* (1978), Campbell (1965) and Runge *et al.* (1985) assessed the difficulty of each word in each of the four W-22 word lists as recorded at CID. Recently, Hurley *et al.* (2003) assessed the difficulty of each word in each of the four NU-6 word lists. The purpose of this study was to find out what errors are being made. These data should aid in the assessment and rehabilitation of speech perception of hearing impaired persons.

II. PROCEDURE

A. Surveys

The data was obtained through surveys of audiologists in the Missouri and Illinois areas. Contacts were obtained through the American Academy of Audiology website and professional education practicum sites from CID at Washington University. Forty-two audiologists, who were contacted, agreed to participate in the study. A total of one hundred and nineteen word lists were returned. The audiologists were asked to review word lists one through four for either the W-22 or NU-6 lists, and they were instructed to record the errors that patients make during testing. They were advised to do this from memory or from records. For the W-22 lists, twenty-five responses were received for list 1A; eighteen for list 2A, eleven-and-one-half for list 3A, and thirteen for list 4A. For the NU-6 lists, thirteen-and-one-half responses were received for list 1A, fourteen for list 2A, and twelve each for lists 3A and 4A.

B. Error Analysis

Once the surveys were returned, the data were analyzed for onset, nucleus and coda errors. The analysis of the onset and coda errors included open (crosshatch), singleton and cluster errors. Nucleus errors were analyzed by a special scheme that included monophthongs,

both rhotic and nonrhotic, and diphthongs that were nonrhotic, rhotic, or lateral (vowel + dark-el).

A few of the received items had to be disregarded due to illegibility. Occasionally, the reported errors consisted of trochaic words. These responses were not included in the analysis, however are listed as follows preceded by the stimulus word: vine-vowel(1), sell-sour(1), sure-shower(1), merge-marriage(1), lore-Laura(1), lower(6), shall-shower(2), wire-lion(1), yearn-urine(5), sour-cellar(1), tire-tired(1), near-mirror(7) for the NU-6 word list and near-mirror(3), owl-aloe(1), ease-easy(1), tear-error(1), shove-shovel(1), smooth-fluid(1) for the W-22 word list.

C. Notation

For consonants, English letters are used to represent phonemes and phoneme clusters. Their relation is transparent except for the following: TH(vl) represents the voiceless dental fricative consonant as in “thin,” TH(vo) represents the voiced dental fricative consonant as in “the,” JH represents the voiced alveolar affricate as in “jam,” Y represents the palatal glide as in “yes,” and finally, the absence of an onset or coda is represented by the crosshatch (#). Table 1 (page 8) gives the representative symbols and keywords for the nuclei.

D. Caveat

It is important to note that the nature of the word lists are open set and many of the errors may be related to lexical neighborhood effects as noted by Jusczyk *et al.* (2002), word frequency, and regional dialectical effects. Some sounds occur rarely, if at all, within the stimulus list; therefore there may be very few or no reported errors for these sounds.

III. RESULTS

A. General findings for the W-22 Lists

The total number of reported errors was 913. Most of the reported errors 456 or 50% involve codas. The next most common reported errors involve onsets with a total of 365 or 40%. The least number of reported errors, 92 or 10% involve nuclei.

B. General findings for the NU-6 Lists

The total number of reported errors was 870. Most of the reported errors, 419 or 48% involve the codas. The next most common reported errors involve onsets with a total of 261 or 30%. The least number of errors, 190 or 22% involve the nuclei.

C. Interconfusions (both lists)

1. General

An error means the sound was involved whether as stimulus or as response. Only the top two most common confusions are mentioned in the text that follows, but the reader is invited to review the attached tables for further study.

2. Coda confusions

Table 2 (page 9) displays the results of the analysis for reported coda errors for both the W-22 and NU-6 lists. Among reported coda errors: T and empty coda are by far the most common. The highest number of errors involving T is with K, followed by P and S. The highest number of errors involving empty coda is Z, followed by V and D.

3. Onset confusions

Table 3 (page 10) displays the results of the reported onset errors for both the W-22 and NU-6 lists. Among reported onset errors: N and M are the most common. The highest number

of errors involving N is with M, followed by Y and empty onset and L, P, B. The highest number of errors involving M is with N, followed by B and Y and L, K, SM.

4. Nucleus confusions

Table 4 (page 11) displays the results of the reported nuclei errors. Among nuclei errors: caret and E are the most common. The highest number of errors involving caret is with AH, followed by E and AW. The highest number of errors involving E is with AE, followed by I and Caret.

Table 5 (page 11) displays the distribution of the nucleus errors as monophthong, rhotic monophthong, diphthong, rhotic diphthong, and vowel followed by dark-el. Confusions among monophthongs are the most common. The next most common involve vowels followed by dark-el.

D. Overall frequency of errors

The frequency with which individual phonemes are involved in errors are shown in Table 6 (page 12). The coda, onset and nucleus errors were summed and ranked according to total errors. Cumulative errors were calculated and a percentage was assigned. The percentage of errors associated with each sound is based on both stimulus and response errors. [Since interconfusions were analyzed, twice the number of reported errors (noted in section III. A and B) are listed.] The data in Table 6 (page 12) show that T, N, crosshatch, K, F, M, S and P account for approximately 51% of the total reported errors. The reported errors involved with the crosshatch represent those errors which occurred as either an omission or addition of a sound. The percentage increases to 80% with the addition of D, Z, TH(vl), B, V, CH, Caret, E, ST, H, AW, TH(vo) and G. It is important to note that 3 nuclei are included in the top 21 errors.

IV. DISCUSSION

There are a large number of reported errors in all categories (coda, onset, nuclei). The most frequently reported errors are found within the coda category which involves 49% of the total reported errors. The next most frequently reported errors are found within the onset category and involves 35% of the total reported errors. The least common reported errors are found within the nuclei category and account for 16% of the total reported errors. The results for codas and onsets agree with those found by Sher *et al.* (1974) in a study of individuals with high-frequency hearing loss. Sher *et al.* (1974) report "clearly, the phonemes that were presented as stimuli in the final position were more difficult to identify correctly than were the phonemes in the initial position." Additionally, some of the common errors found by Sher *et al.* (1974) that correspond with this study include T for K, F and TH(vl) for S, S for TH(vl) in the onset category and T for K, T for P and S for F in the coda category.

There is a marked hierarchy in the number of reported errors. The top 10 or 11 phonemes account for approximately 80% of the reported errors. This holds true for codas, onsets, and nuclei.

V. SUMMARY AND CONCLUSIONS

There is a move to complete audiologic evaluations quickly. It is known that half lists are typically utilized during speech discrimination testing to decrease test time. The data provided in this study suggest that a relatively small number of syllable constituents account for most of the reported errors. Nucleus errors, while less common than onset or coda errors, comprised nearly 16% of the total and should not be ignored. Most of these errors involved monophthongs or vowels followed by dark-el. Finally it is noted that eight phonemes, T, N,

crosshatch, K, F, M, S and P account for 51% of the total reported errors. These results may be useful for the development of efficient speech tests and effective rehabilitation procedures.

Table 1. Representative symbols and keywords for the nucleus.

Caret	<u>buck</u>
E	<u>bet</u>
AW	<u>caught</u>
AH	<u>father</u>
AE	<u>hat</u>
I	<u>bin</u>
OU	<u>dough</u>
Schwar	<u>father</u>
AR	<u>far</u>
OUL	<u>hole</u>
AWL	<u>haul</u>
OO	<u>boot</u>
AI	<u>my</u>
EE	<u>bee</u>
AU	<u>cow</u>
OR	<u>more</u>
EL	<u>held</u>
AL	<u>doll</u>
AUR	<u>our</u>
UR	<u>contour</u>
UL (Caret-L)	<u>hull</u> or <u>pool</u>

Table 2. Reported coda errors found for both the W-22 and NU-6 lists. Columns 1, 2 and 3 represent the top 3 most common reported errors occurring as either a stimulus or response.¹

Codas	Sum	1	2	3
T	233	K - 70	P - 41	S - 27
#	184	Z - 72	V - 33	D - 18
N	166	M - 53	ND - 35	NG - 29
K	132	T - 70	P - 26	G - 8
Z	129	# - 72	V, N - 10	F, D - 8
F	120	S - 30	Th(vl) - 24	T - 22
S	108	F - 30	T - 27	# - 12
P	95	T - 41	K - 26	# - 7
V	82	# - 33	F, D, Z - 10	TH(vo) - 7
D	79	# - 18	B - 15	V - 10
M	76	N - 53	MZ - 9	# - 4
TH (VL)	65	F - 24	S - 10	K, Z - 7
ST	43	T - 24	S - 11	Z - 4
ND	38	N - 35	M - 2	
NG	33	N - 29		
B	27	D - 15	TH(vo) - 5	M - 3
G	20	K - 8	D - 7	# - 4
TH(VO)	17	V - 7	B - 5	#, S - 2
TS	15	T - 12		
NZ	15	N - 15		
CH	14	K, T - 3	KS, F - 2	
MZ	9	M - 9		
NT	7			
MP	6	T - 2		
SH	5			
KS	5	T - 3	CH - 2	
KST	4			
JH	3			
FT	3			
SK	3			
MB	3			
THZ (VO)	2			
NGK	1			
PTH (VL)	1			
ZD	1			
KT	1			
NK	1			
NS	1			
TZ	1			
DZ	1			
VZ	1			
ZD	1			

¹All reported coda errors were listed. Only the sounds in which the sum of the reported errors was greater than four, between the W-22 and NU-6 lists, were included.

Table 3. Reported onset errors found for both the W-22 and NU-6 lists. Columns 1, 2 and 3 represent the top 3 most common reported errors occurring as either a stimulus or response.¹

Onsets	Sum	1	2	3
N	113	M - 90	Y, # - 4	L, P, B - 3
M	107	N - 90	B, Y - 3	L, K, SM - 2
T	104	K - 32	CH, P - 14	D - 8
D	79	B - 23	G - 13	T - 8
B	75	D - 23	# - 12	TH(vl) - 6
K	73	T - 32	P - 18	CH - 5
F	72	S - 25	TH (vl) - 10	# - 9
S	70	F - 25	TH (vl) - 12	SH - 8
P	70	K - 18	T - 14	F - 8
CH	60	SH - 15	T - 14	JH - 8
#	56	B - 12	F - 9	H - 8
H	50	# - 8	P, T, S - 5	CH - 4
TH (VL)	39	S - 12	F - 10	B - 6
W	38	R - 20	B, H, L - 3	D - 2
R	32	W - 20	L - 3	Y - 2
SH	31	CH - 15	S - 8	H - 3
Y	29	# - 5	D, N - 4	M, P - 3
TH (VO)	28	D - 7	F - 4	B, V, TH(vl), H - 3
G	22	D - 13	P, K - 2	
L	18	N, W, R - 3	M, D, T, Y - 2	
TR	15	CH - 6	THR - 3	T, D - 2
JH	14	CH - 8	B, Y - 2	
V	14	B - 5	F, TH(vo) - 3	
THR	7	TR - 3		
ST	7			
SK	5	S - 2		
BR	4			
FL	3			
SM	3			
SN	2			
BL	2			
FR	2			
SP	1			
Z	1			
PL	1			
KL	1			
GL	1			
SL	1			
SV	1			
KR	1			

¹ See next page.

¹All reported onset errors were listed. Only the sounds in which the sum of the reported errors was greater than four, between the W-22 and NU-6 lists, were included. Distinction was not made between the voiced and voiceless labiovelar glide W.

Table 4. Reported onset errors found for both the W-22 and NU-6 lists. Columns 1, 2 and 3 represent the top 3 most common reported errors occurring as either a stimulus or response.¹

Nucleus	Sum	1	2	3
Caret	57	AH - 18	E - 12	AW - 6
E	56	AE - 19	I - 14	Caret - 12
AW	49	AR - 18	AU, Caret - 6	AH - 5
AH	41	Caret - 18	AE - 8	AW - 5
AE	36	E - 19	AH - 8	Caret - 3
I	28	E - 14	EI - 7	Schwar - 2
AR	26	AW - 18	Schwar - 3	
OU	23	OUL - 11	AH, EL, OO - 2	
Schwar	22	E, Caret, Schwar-L - 4	AR - 3	I - 2
AU	19	AW - 6	EL - 5	AUL - 3
AWL	18	AW, AEL - 4	EL - 3	AUL - 2
EL	17	AU - 5	AWL - 3	AEL, IL, OU x 2
OUL	16	OU - 11	OOL - 2	
OO	15	EE - 9	OU - 2	
AI	13	Caret - 5	AH - 3	
AL	13	UL (Caret-L) - 3	AW, Caret - 2	
EE	11	OO - 9	E - 2	
OR	10	AW - 3		
UL (Caret-L)	8	AL - 3		
AUR	6	AUL - 2		
UR	5	OOL - 2		

¹Errors must occur on both the W-22 and NU-6 lists. Only the sounds in which the sum of the reported errors was greater than four, between the W-22 and NU-6 lists, were included. Additionally, UL as in “pool” and Caret-L as in “hull” were combined during analysis to account for error during transcription.

Table 5. Distribution of nuclei errors.

Response → Stimulus ↓	Monophthong	Rhotic Monophthong	Diphthong	Rhotic Diphthong	Vowel followed by dark-el
Monophthong	199	21	15		4
Rhotic Monophthong	24				2
Diphthong	18			11	10
Rhotic Diphthong					2
Vowel followed by dark-el	8		18		24

Table 6. Combination of reported onset, nuclei and coda errors and associated cumulative percentage of total errors. Phonemes are listed in order of total errors.

Sound	Onset Errors	Coda Errors	Total Errors	Cum Errors	Cum %
T	104	233	337	337	10
N	113	166	279	616	18
#	56	184	240	856	25
K	73	132	205	1061	30
F	72	120	192	1253	36
M	107	76	183	1436	41
S	70	108	178	1614	46
P	70	95	165	1779	51
D	79	79	158	1937	55
Z	1	129	130	2067	59
TH(VL)	39	65	104	2171	62
B	75	27	102	2273	65
V	14	82	96	2369	68
CH	60	14	74	2443	70
Caret			57	2500	72
E			56	2556	73
ST	7	43	50	2606	75
H	50	0	50	2656	76
AW			49	2705	77
TH(VO)	28	17	45	2750	79
G	22	20	42	2792	80
AH			41	2833	81
W	38	0	38	2871	82
ND	0	38	38	2909	83
SH	31	5	36	2945	84
AE			36	2981	85
NG	0	33	33	3014	86
R	32	0	32	3046	87
Y	29	0	29	3075	88
I			28	3103	89
AR			26	3129	90
OU			23	3152	90
SCHWAR			22	3174	91
AU			19	3193	91
AWL			18	3211	92
L	18	-	18	3229	92
JH	14	3	17	3246	93
EL			17	3263	93
OUL			16	3279	94
OO			15	3294	94
TS	0	15	15	3309	95
TR	15	0	15	3324	95
NZ	0	15	15	3339	96
AI			13	3352	96
AL			13	3365	96

Table 6 (Con't)

Sound	Onset Errors	Coda Errors	Total Errors	Cum Errors	%
EE			11	3376	97
OR			10	3386	97
MZ	0	9	9	3395	97
SK	5	3	8	3403	97
UL (Caret-L)			8	3411	98
THR	7	0	7	3418	98
NT	0	7	7	3425	98
MP	0	6	6	3431	98
AUR			6	3437	98
UR			5	3442	99
KS	0	5	5	3447	99
KST	0	4	4	3451	99
BR	4	0	4	3455	99
SM	3	0	3	3458	99
MB	0	3	3	3461	99
FT	0	3	3	3464	99
FL	3	0	3	3467	99
THZ(VO)	0	2	2	3469	99
SN	2	0	2	3471	99
FR	2	0	2	3473	99
BL	2	0	2	3475	100
ZD	0	1	1	3476	100
VZ	0	1	1	3477	100
TZ	0	1	1	3478	100
SV	1	0	1	3479	100
SP	1	0	1	3480	100
SL	1	0	1	3481	100
PTH(VL)	0	1	1	3482	100
PL	1	0	1	3483	100
NS	0	1	1	3484	100
NK	0	1	1	3485	100
NGK	0	1	1	3486	100
KT	0	1	1	3487	100
KR	1	0	1	3488	100
KL	1	0	1	3489	100
GL	1	0	1	3490	100
DZ	0	1	1	3491	100
WH	0	0	0	3491	100
TW	0	0	0	3491	100
SW	0	0	0	3491	100
STR	0	0	0	3491	100
SPR	0	0	0	3491	100
SPL	0	0	0	3491	100
SKW	0	0	0	3491	100
SKR	0	0	0	3491	100
SHR	0	0	0	3491	100

Table 6 (Con't)

Sound	Onset Errors	Coda Errors	Total Errors	Cum Errors	%
SF	0	0	0	3491	100
PR	0	0	0	3491	100
KW	0	0	0	3491	100
GR	0	0	0	3491	100
DW	0	0	0	3491	100
DR	0	0	0	3491	100

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