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Response errors by normal hearing listeners on the Maryland CNC Test

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Response Errors by Normal Hearing Listeners on The Maryland CNC Test

by

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A carrier phrase is often used in word recognition tests to provide perceptual cues to the listener to aid in the selection of a target item. One such test of word recognition, The Maryland CNC Test (Causey, Hood, Hermanson and Bowling, 1984) employs the carrier phrase "Say the ____ again." Informal clinical observation has indicated that many clients will often commit errors on stimulus items that are not nouns and thus do not maintain syntax of the carrier phrase when tested using The Maryland CNC Test word lists.

The purpose of the study was to investigate the types of errors made by normal hearing listeners on The Maryland CNC Test. Given that the linguistic environment influences an individual's speech perception, then the errors made during word recognition testing may be, at least partially, determined by the syntactic structure of the carrier phrase. The following hypotheses were proposed: (1) the stimulus items that fall within the grammatical class of noun will be responded to with significantly fewer errors than those items that fall outside of that grammatical class; and (2) the grammatical class of the incorrect responses will not be significantly associated with the grammatical class of the stimulus item.

To test the hypotheses, thirty-two normal hearing subjects listened to word lists presented at 10, 20, and 30 dB SL (re: SRT). Their incorrect responses were categorized as nouns or non-nouns. The results indicated that stimulus items which could be recognized as nouns were identified with significantly fewer errors than those items which were not nouns. The results for the second hypothesis indicated a significant but very weak association between the grammatical class of the incorrect response and that of the stimulus item. The implication of these results on word recognition testing and future research were discussed.

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CHAPTER I: INTRODUCTION AND LITERATURE REVIEW

Word recognition testing has been an integral part of hearing assessment since the beginnings of audiology. The ability to understand speech has been recognized as a prerequisite for coping with the rigors of daily living in a "complex auditory world" (Penrod, 1985). Evaluation of word recognition has undergone a metamorphosis over the years. The development and modification of word recognition tests have brought to light factors which can affect a listener's word recognition score.

One factor affecting word recognition is the use of a carrier phrase to facilitate word recognition. The rationale for using a carrier phrase is that it provides perceptual cues to the listener to aid in the selection of the target item. The contextual environment of the carrier phrase may provide syntactic, semantic or acoustic-phonetic cues which influence selection of a target item. The present study investigated the influence of a carrier phrase on the identification of target items.

Clinical Application of Word Recognition Testing

According to Penrod (1985), establishing an individual's pure tone thresholds provides information regarding hearing sensitivity, but fails to provide sufficient information about an individual's receptive auditory communication ability. While a clearly defined relationship exists between an individual's pure tone thresholds and speech recognition threshold, the relationship between the pure tone threshold and word recognition ability tends to be highly variable. This variable relationship has led some researchers to question the clinical applicability of word recognition testing.

Word recognition testing has had wide clinical application. Examples of application include the assessment of auditory function; identification of site of lesion testing; determination of candidacy for surgery; evaluation of central auditory disorders; and determination of social adequacy of communication. Word recognition testing has also been used in the selection of hearing aids and in the development of rehabilitation and assessment of its effectiveness (Penrod, 1985).

Hayes (1984) argued that word recognition testing has had little impact on the identification of the presence of hearing impairment and localization of the site of auditory disorders. She advocated that the goal of word recognition testing lies in the improvement of techniques for the rehabilitation of patients with presbycusis; prediction of successful rehabilitation of profoundly hearing-impaired individuals; and selection of amplification devices for mildly to severely hearing-impaired individuals.

Thornton (1985) agreed with Hayes' proposition. He stated that word recognition plays a minor role in the diagnosis of disease and is ineffective for site of lesion determination. However, he thought that it plays an important role in predicting the need for the rehabilitation of a hearing impairment and in the assessment of the effects of any rehabilitation programs. According to Thornton, although the pure tone audiogram contributes more and better information for hearing aid selection, word recognition testing also provides some beneficial information for the hearing aid user. Therefore, the strength of word recognition testing lies in the assessment of a hearing handicap and in the prediction of rehabilitation benefits.

Apparently some controversy exists regarding the efficacy of word recognition testing for the diagnosis of disease and the localization of site of lesions. However, there seems to be agreement that word recognition testing has definite utility in the realm of rehabilitation. As audiologists strive to restore the ability of hearing-impaired individuals to understand speech, they should continue to develop and use methods that can predict an individual's word recognition ability.

Factors Affecting Word Recognition Scores

Miller, Heise and Lichten (1951) and Penrod (1985) have discussed the various factors which influence word recognition scores. The three broad categories discussed are physical factors, test administration factors, and linguistic factors.

Physical factors include equipment, the physical environment used for testing, and the test stimulus. The test stimulus is influenced by the level of presentation, distortion, frequency composition, duration, and signal-to-noise ratio. The second category of test administration factors includes the manner and rate of presentation, stimulus materials, and scoring method. This category also includes the personnel involved in the testing. Speaker and listener performance may be affected by variables such as age, fatigue or intelligence, for example. The third category, linguistic factors, constitutes a wide range of variables. These include articulation and dialect of the speaker and listener, and familiarity, redundancy and context of the test items.

Context is often a key factor in word recognition. Miller et al. (1951) described three means of providing context to the listener. It can be provided by the knowledge that the test item meets one or more of the following conditions: (a) it is a repetition of a preceding word; (b) it is one of a limited number of words; and (c) it is preceded by words in a phrase or sentence. The last condition is often met in word recognition testing by supplying a carrier phrase such as "Say the word _____."

Effects of the Carrier Phrase

Several researchers disagree as to the effectiveness of the carrier phrase in facilitating word recognition. Martin, Hawkins and Bailey (1962) "noted that the carrier phrase seems to confuse some patients, especially those with severe discrimination problems" (p.319). The researchers investigated the effect of a carrier phrase on phonetically balanced (PB) word recognition scores and subject preference for its exclusion. Of the 75 subjects, 30 had sensorineural hearing loss, 30 had conductive loss and the remainder had normal hearing. Each subject listened to the PB words in isolation and with the carrier phrase "Say the word _____." They were then asked if they preferred hearing the words in isolation or with the carrier phrase. Most subjects preferred exclusion of the carrier phrase. The results indicated that recognition scores were not affected by the presence or absence of a carrier phrase with the phonetically balanced (PB) words.

Kreul, Bell and Nixon (1969) studied the influence of the carrier phrase and accompanying levels of noise on the word recognition scores of normal hearing subjects. They used two carrier phrases, "You will strike through _____ now" and "You will strike _____ please." Each carrier phrase was recorded by two different speakers. The carrier phrases were presented to three groups of listeners at varying signal-to-noise ratios. The resulting confusion matrices indicated that the rank order of test item difficulty was unaffected by the carrier phrase, speaker or signal-to-noise ratio used. However, the findings revealed significant differences in the number of errors found at each signal-to-noise ratio between the carrier phrases, regardless of the speaker. This study found carrier phrases can affect the word recognition scores. However, the phrases used in the study are not commonly employed in typical clinical audiology settings (Lynn and Brotman, 1981) and may not have clinical impact.

Gladstone and Siegenthaler (1971) explored differences in word recognition scores in normal hearing subjects as a function of three commonly used carrier phrases: "Say the word _____;" "You will say _____;" and "Point to the _____;" and no carrier phrase. The interaction condition allowed for the opportunity of phonemic interaction between the carrier phrase and the test item. In the no interaction condition, carrier phrases and test items were recorded separately and then spliced together. The results indicated that recognition scores improved when a carrier phrase was used in the interaction condition. Furthermore, significant differences were found between the carrier phrases in this condition. Their results suggested that carrier phrases can affect word recognition performance and, specifically, the phonemic interaction between the carrier phrase and the test item affects the word recognition score. However, this finding is not universal. In contrast to the findings of Gladstone and Siegenthaler (1971), Martin et al. (1962) concluded that carrier phrases were not essential based on the word recognition scores of the carrier phrase "Say the word ____."

Gelfand (1975) studied the effects of a carrier phrase on subjects with sensorineural hearing loss using monitored live voice word recognition testing. Each subject listened to CID W-22 word lists with and without the carrier phrase "Say the word _____." The results revealed significantly higher word recognition scores using a carrier phrase. The subjects were questioned regarding the clarity of the test items and preference for the inclusion of a carrier phrase. Of the 22 subjects questioned, 10 reported no difference in clarity with the carrier phrase, 10 reported that it increased clarity and two reported greater clarity without the phrase. Eleven subjects expressed preference for inclusion of the carrier phrase, three preferred exclusion and eight had no preference. Gelfand found that subjective clarity and preference for a carrier phrase were not significantly related to the word recognition scores of the subjects. These findings conflict with those found by Martin et al. (1962) in subject preference and performance. In response to Martin et al. (1962), Gelfand concluded that subject preference is a poor argument for the exclusion of a carrier phrase.

A more recent study by Lynn and Brotman (1981) investigated normal hearing subjects' ability to identify the place of articulation for the initial stop consonant /p/, /t/, and /k/. They found that the carrier phrase "You will say _____," in comparison to words in isolation, provided more perceptual cues for the correct identification of target phonemes, again stressing the influence of a carrier phrase.

Although the researchers did not attempt to generalize their findings to other carrier phrases, they hypothesized that different carrier phrases would produce different scores based on the acoustic properties of the carrier phrase. Carrier phrases such as "Say the word _____" and "You will say _____" approach different vowel consonant format transitions during the last centisecond of the phrase. Thus, they may provide different perceptual cues.

Lynn and Brotman's hypothesis is supported by the results of Gladstone and Siegenthaler (1971), who reported the highest recognition scores for the carrier phrase "You will say _____" compared to "Say the word _____" or "Point to the _____." They thought that "You will say _____" had a greater potential for phonemic interaction due to the final diphthong /eĩ/. The carrier phrase "Point to the _____" provides the same syllabic nucleus for the vowel consonant transition pattern as "You will say _____," but possibly has a shorter vowel duration which may affect phonemic interaction. Lynn and Brotman stated that the vowel consonant formant transitions during the last phases of "Say the word _____" approach the alveolar place of articulation. Possibly this transition does not allow for as much phonemic interaction as those of other carrier phrases. Thus there is good evidence to suggest the acoustic-phonetic influence of a carrier phrase.

A study by Craig (1988) investigated the interactions between sentence context and word predictability on word recognition scores. Word recognition scores were obtained for normal hearing listeners under conditions of high semantic predictability sentences, low semantic predictability sentences and a semantically neutral predictability carrier phrase. The high predictability sentences were embedded with semantic cues that preceded the target words. The low predictability sentences did not provide semantic cues, although they were meaningful. The neutral predictability carrier phrase used was "I will now say the word the _____." The results indicated significant differences in word recognition scores between the high predictability sentences and the low predictability sentences or the neutral carrier phrase. The implications of syntactic effects of the carrier phrase will be discussed later.

According to Craig, other researchers have determined that sentences have high predictability when listeners can use both "acoustic-phonetic" (p.588) and "linguistic-situational" (p.588) information for speech recognition. Craig proposed that having the listener identify a target word at the end of a low predictability sentence and at the end of a carrier phrase may not be synonymous tasks. He thought that carrier phrases tend to leave the listener free to attend to the acoustic-phonetic cues of speech, whereas low predictability sentences tend to demand attention to the semantic content. However, any differences in word recognition scores between the carrier phrase and the low predictability sentences in his study were not significant.

Word recognition of a target word appears to be influenced by the semantic, syntactic and acoustic-phonetic context. The studies described above have demonstrated that the context of the carrier phrase can influence word recognition scores. Furthermore, these scores may be sensitive to the unique set of cues provided by each carrier phrase.

Finally, Craig proposed that the position of the target word is predictable in a carrier phrase and thus frees the listener to ignore semantic content and focus on acoustic-phonetic cues. However, the effects of syntax were not addressed. A carrier phrase may possibly impose syntactic constraints on a listener.

Word Recognition and Linguistic Rules

Miller and Isard (1963) conducted several experiments on the auditory perception of grammatical, anomalous and ungrammatical sentences. Given that speech perception is facilitated by linguistic rules, Miller and Isard hypothesized that sentences which violated semantic and syntactic rules would be most difficult to repeat, whereas those which obeyed the rules would be the easiest. These researchers constructed and tape recorded sentences that were grammatical, anomalous and ungrammatical. Their subjects were required to listen to the sentences and immediately repeat what was said. The results indicated that both grammatically anomalous and ungrammatical sentences were indeed more difficult to repeat than the grammatical sentences. These findings became more dramatic when the signal-to-noise ratios were reduced. That is, they found that the grammatical sentences were more resistant to noise than the ungrammatical sentences. Miller and Isard's (1963) findings demonstrated that linguistic rules can affect word recognition at least at a sentence level.

Carrier Phrases and Phrase Structure Rules

Several tests of word recognition employ a carrier phrase. The Maryland CNC Test (Causey, Hood, Hermanson and Bowling, 1984) uses the carrier phrase "Say the _____ again" in an attempt to provide a phonetically neutral context for the test word. Causey and his colleagues proposed that the vowel /   / in the word final position of "the" and the word initial position of "again" would minimize the effects of coarticulation. In the effort to minimize coarticulation, a syntactic constraint was placed on the carrier phrase. This becomes evident when syntactic theory as described by Chomsky (1965) is applied to the carrier phrase. The phrase structure rules require that a noun phrase consist either of a noun itself or a determiner and a noun. The carrier phrase "Say the _____ again" employs the determiner "the."

Therefore, the phrase structure rules demand that the test item be a noun to maintain syntactic structure and ultimately, grammaticality.

Two previously discussed studies investigated carrier phrases that also employed the determiner "the." Craig (1988) used the carrier phrase "I will now say the word the __________." The grammatical categories of the target words were not specified, however the author stated that "The list selection included consideration of the nature of the word immediately preceding each target word" (p.30), which may have maintained syntactic neutrality, but it is not clear from the discussion.

Gladstone and Siegenthaler (1971) used the carrier phrase "Point to the _____" and the first twenty-five words from the CID Test W-22, List 3B as target items. The target items included words which fall outside of the grammatical classification of nouns. The results indicated significant differences in word recognition between the above mentioned carrier phrase and the carrier phrases "Say the word ____" and "You will say ____" in the phonemic interaction condition. The phrase "Point to the ____" was the least enhancing of the carrier phrases in the interaction condition. These results may have been due to the semantic nature of the phrase (the subjects were giving verbal, not pointing responses) and/or the syntactic constraints of placing words other than nouns after the determiner "the." There is enough evidence from this study to at least question the use of a carrier phrase placing the determiner "the" before stimulus items which may not be nouns.

Informal clinical observation has indicated that many clients will commit errors on those target items that are not nouns when tested using The Maryland CNC Test word lists. In many cases, the clients appear to have processed the target item in order to fit the syntactic structure of the carrier phrase. For example, when the target word is "sung," it is often identified by clients as "sun" or "song."

The Maryland CNC Test was of particular interest because of its wide use by the Veterans Administration (VA). The Veterans Administration has mandated that The Maryland CNC Test be used for word recognition testing during all Assessments of Social Efficiency, VA examinations for determining disability of hearing loss.

Purpose of the Study

The purpose of the study was to investigate the types of errors made by normal hearing listeners on The Maryland CNC Test. Given that the linguistic environment influences an individual's speech perception (Craig, 1988; Gladstone and Siegenthaler, 1971; Miller, 1951; Miller and Isard, 1963), then the errors made during word recognition testing may be, at least partially, determined by the syntactic structure of the carrier phrase. Specifically, the following hypotheses were proposed:

1. The stimulus items that fall within the grammatical class of noun will be responded to with significantly fewer errors than those items that fall outside of the grammatical class.
2. The grammatical class of the incorrect responses will not be significantly associated with the grammatical class of the stimulus item.

CHAPTER II: METHODS

Subjects

The rationale for subject selection and test procedures was based on the normative studies of The Maryland CNC Test as described by Causey, Hood, Hermanson and Bowling (1984). Thirty-two women between the ages of 18 and 26 years participated in this study. All subjects spoke English as their primary language and had negative histories of otologic surgeries. All subjects had audiometric thresholds equal to or better than 15 dB HL (ANSI, 1969) in each ear for pure tone stimuli presented at octave intervals between 250 and 8000 Hz. Otoscopic inspection revealed relatively clear ear canals bilaterally. Each subject also had normal oto-immittance results, as defined by Jerger Type A tympanograms and a measurable acoustic reflex threshold obtained for ipsilateral stimulation at or below 100 dB nHL at 1000 Hz for each ear.

Instrumentation

Pure tone screening, speech reception threshold, and speech recognition testing were conducted in an IAC sound treated suite (model number 1400 AC7), which meet the ANSI 1977 standards for noise level. All testing was performed with a Grason-Stadler 10 two-channel audiometer with TDH-50 earphones and MX41/AR cushions. The audiometer was calibrated quarterly to ANSI 1969 and 1981 standards.

In addition, the audiometer was given a biological calibration check daily. An Amplaid 702 impedance bridge was used for acoustic immittance screening. This system was calibrated electroacoustically prior to the data collection.

The Maryland Speech Intelligibility Test (Causey and Elkins, 1981) was used in this study. Specifically, CNC tape recordings of lists 1-1, 1-3, 1-6, 1-7, 1-9, and 1-10 were obtained from Olsen Distributors and used for this study. These particular lists were found to have inter-list equivalencies (Causey et al., 1984). The tapes were presented to subjects by a Fisher cassette tape recorder fed through the Grason-Stadler 10 audiometer and TDH-50 earphones.

The stimulus items and the subjects' responses were recorded using a Pioneer Stereo Amplifier A-5 and a Nakimichi BX-100 tape recorder using an LTD wireless microphone system. The microphone was attached approximately four inches from the subject's mouth. Maxell XL II cassette tapes were used for storage of the subjects' responses.

Procedures

Subjects were informally screened for clarity of articulation using a 23-word test of articulation (Bzoch, 1989) which is presented in Appendix A. They were scored for the entire test on a subjective pass/fail basis.

Hearing was screened using pure tone stimuli presented at 15 dB HL to each ear for each subject across octave frequencies from 250 to 8000 Hz. A speech recognition threshold was established for each ear, following the Guidelines for Determining the Threshold Levels of Speech (ASHA, 1987) using monitored live voice.

After the speech recognition threshold was established and prior to the presentation of the word recognition test stimuli, each subject was familiarized with the task. A conventional set of instructions and four practice stimuli were presented (Appendix B). The practice stimuli were presented by monitored live voice at 60 dB HL and were not included among the test items.

After familiarization with the task, a different word list (Appendix C) was presented at each of three presentation levels (10, 20, 30 dB SL re: SRT). These presentation levels were chosen because they are near the subject's hearing threshold and therefore most errors would be anticipated at these levels. The results of the normative study (Causey et al., 1984) indicated that correct responses asymptote at approximately 45 dB HL. The presentation level and word lists were randomly assigned within the constraint of not repeating a list for a given subject and ear presentation was counterbalanced.

The subjects' verbal responses were recorded and scored on-line by the examiner. The responses were also recorded on audiotape for inter-rater reliability purposes. Of the 61 ears tested and recorded, six were randomly selected and scored by a second judge, who was familiar with The Maryland CNC Test and the purpose of the study. Reliability was scored using a point-by-point formula of number agreements minus number of disagreements divided by the total number squared. An inter-judge reliability of 90 percent or greater was desired.

Data Analyses

Each stimulus item used was categorized into grammatical class by three graduate students in communication sciences and disorders. Words were categorized as: 1) noun or both *(NB)* for words that are nouns in at least one usage including those nouns which could also be placed in another grammatical category (e.g., walk); or 2) other than a noun *(Other)* for those words which fall outside of the noun category (e.g., happy). For the purpose of this study, the stimulus items were then categorized as *NB* or *Other* based on the judgement of at least two of the three raters. If no consensus was reached, then a standard English dictionary classification (Urdang and Flexner, 1968) was employed to make the category judgement.

The subjects' responses were recorded and scored as correct if they matched the stimulus item and incorrect if they did not. The subjects' incorrect responses were also placed into a grammatical category as described above with one exception. Responses were placed into a third unidentified category *(UN)* if a subject's response was unintelligible, if a subject failed to respond to a stimulus item, or if the response was a nonsense word as determined by the examiner.

The presentation level was not of interest in this study, so the data obtained across the three levels was collapsed for each subject. A proportion of error was calculated for each subject for the stimulus items in each ear condition and each grammatical class. A two-way repeated analysis of variance (Bruning and Kintz, 1977) was performed (confidence level of .05). The incorrect responses were pooled by grammatical category of the stimulus item and the response. A chi-square analysis (Bruning and Kintz, 1977) was performed to determine any association between the grammatical class of the stimulus and the grammatical class of the incorrect response (confidence level of .05). If an association was found, in light of the potentially large sample size a contingency coefficient (Bruning and Kintz, 1977) was performed to determine the strength of the association.

CHAPTER III: RESULTS

Three of the 32 subjects failed the screening criteria for pure tones or acoustic immittance for one ear, so testing was performed on one ear only. All other subjects had data for both ears and consequently, data were collected for a total of 61 ears. Data were collected for all three presentation levels per ear for 30 subjects. However, two subjects were run with only two out of three presentation levels for one ear only, due to examiner error.

The number of stimulus items in each grammatical category for each Maryland CNC word list appears in Table 1. The total number of stimulus items in each grammatical category for the 61 ears appears in Table 2.

A two-way repeated analysis of variance (ANOVA)(Bruning and Kintz, 1977) was conducted on each subjects' proportion of error by ear and grammatical category of the stimulus item. This analysis was performed to test the first hypothesis that the stimulus items in the *NB* category would be answered with significantly fewer errors than those in the *Other* category. For this analysis only the 29 subjects for whom both right and left ear data were available were used. These 29 subjects included the two subjects who received only two presentation levels for one ear.

The mean proportion of error for each ear condition for the two grammatical categories of the stimulus word was calculated (Table 3). The sum of squares was calculated for: the total proportion of error; each subject; the differential effects of right ear versus left ear; the differential effects of *NB* versus *Other* grammatical

* *

Table 1

Grammatical Class of Stimulus Items on the

Maryland CNC Test Presented Per List

	--Rated Grammatical Class--		
CNC List	Noun-Both (NB)	Other	Total
1-1	39	11	50
1-3	36	14	50
1-6	32	18	50
1-7	30	20	50
1-9	41	9	50
1-10	37	13	50
TOTAL:	215	85	300

* *

* *

Table 2

Total Stimulus Items (61 Ears) on

The Maryland CNC Test Presented Per List

CNC List	Number of Times Used	---Rated Grammatical Class--- Noun-Both (NB)	Other	Total
1-1	28	1,092	308	1,400
1-3	31	1,116	434	1,550
1-6	31	992	558	1,550
1-7	28	840	560	1,400
1-9	32	1,312	288	1,600
1-10	31	1,147	403	1,550
TOTAL:	181	6,499	2,551	9,050

* *

categories; the interactive effects of the ear and grammatical category factors; and the error effects. A test of significance (F) was calculated for the ear condition, grammatical category, and the interactive effects of both. The results (Table 4) indicated no significant differences ($p<.05$) for either the right versus left ear condition or the ear conditions versus the grammatical categories. However, significantly fewer errors ($p<.05$) were committed on the stimulus items in the *NB* category compared to those in the *Other* category.

Three conclusions were drawn from the results. First, the ear condition had no significant effect on the errors committed. Second, the effects of the category of the stimulus items and the ear condition did not interact to a significant degree. Third, errors committed were significantly related to the category of the stimulus item, with fewer errors occurring in the *NB* category. Therefore, the hypothesis that the stimulus items falling within the *NB* grammatical category would be identified with fewer errors than those items in the *Other* category was supported.

The second hypothesis was the grammatical class of the incorrect responses would not be significantly associated with the grammatical class of the stimulus item. To test this hypothesis, a chi-square analysis (Bruning and Kintz, 1977) was performed on the incorrect responses for all 61 ears. Items were placed according to grammatical class of the stimulus item and grammatical class of the resulting incorrect response (Table 5). The chi-square analysis indicated a significant association ($X^2 = 6.94$; $p <.05$) between the grammatical class of the stimulus item and that of the incorrect response. A contingency coefficient was calculated to determine the strength of the relationship. The contingency coefficient ($C = 0.075$) indicated that

* *

Table 3

Incorrect Responses to Stimulus Items on the Maryland CNC Test

(N = 29 Subjects)

	---- Right Ear ----		---- Left Ear ----	
Proportion of Error	Noun-Both (NB)	Other	Noun-Both (NB)	Other
Sum	3.25	5.20	4.15	5.10
Mean	.112	.179	.143	.176

* *

* *

Table 4

Two Way Repeated Analysis of Variance of the Proportion of Error for Grammatical Category and Ear

Source	Sum of Squares	Degrees of Freedom	Mean Squares	F	Significance p<.05
TOTAL:	.8184	115	--	--	--
Individual Subjects	.3408	28	--	--	--
RIGHT VS LEFT EAR	.0055	1	.0055	.749	No
GRAMMATICAL CATEGORY	.0724	1	.0724	19.760	Yes
GRAMMATICAL CATEGORY x EAR	.0088	1	.0088	2.989	No
ERROR EFFECTS					
ERROR EAR	.2063	28	.0074	--	--
ERROR CATEGORY	.1026	28	.0037	--	--
ERROR CATEGORY x EAR	.9222	28	.0330	--	--

* *

* *

Table 5

Chi-Square Analysis of the Association Between Grammatical Category of Stimulus Items and Grammatical Category of Incorrect Responses

Stimulus Item	Incorrect Response: Noun-Both (NB)	Other	Unidentified	Total
NB	503 (520)*	158 (141)*	112 (112)*	773
Other	327 (310)*	68 (85)*	67 (67)*	462
TOTAL:	830	226	179	1,235

( )*= Expected Value

* *

approximately 7 percent of the variance could be attributed to the relationship of the grammatical classes of the stimulus and the response items. The significant chi-square value would reject the hypothesis, however, the contingency coefficient would caution the weak nature of the association.

Reliability

Approximately 10 percent of the data (6 ears) were randomly selected for inter-rater reliability. The second judge listened to the subjects' audiotaped responses and scored them as correct or incorrect. The incorrect responses were orthographically recorded and compared to the primary examiner's judgement of these items. Both judges had to agree on the correctness or incorrectness of the response. In addition, the judges were required to concur on the word given for the incorrect responses.

Inter-rater reliability ranged from 90% to 100% ($\bar{x}$=96.2%). Two of the presentation levels achieved 90% inter-rater reliability and the remainder equaled or exceeded 94% inter-rater reliability. For the purposes of data analysis, the primary examiner's judgement was accepted when disagreements of responses occurred between the two judges.

CHAPTER IV: DISCUSSION

The purpose of this study was to investigate the types of errors made on The Maryland CNC Test by normal hearing listeners who were similar to those on whom the test was originally normed. Test conditions were similar to those used in the original study (Causey et al., 1984) including some presentations at reduced sensation levels that yielded response errors from normal hearing subjects.

Two hypotheses were addressed. The first hypothesis predicted that stimulus items which could be nouns would be identified with significantly fewer errors than those items which were not nouns. This hypothesis was statistically supported. The second hypothesis predicted that the grammatical class of the incorrect responses would not be significantly associated with the grammatical class of the stimulus item. Results indicated a significant but very weak association between the grammatical class of the incorrect response and that of the stimulus item.

There are several factors which may have contributed to the results. As mentioned in the literature review, the carrier phrase "Say the ___ again" may be operating to influence the response. The syntactic constraint of the carrier phrase would require a noun response to maintain correct syntax. It is not surprising then that listeners were more likely to respond to stimulus items which were nouns and thus maintained the syntax of the phrase. These results are consistent with those of Miller and Isard (1963) who found significantly better performance on grammatical sentences than on anomalous and ungrammatical sentences, particularly under difficult listening situations. Any bias toward responding as though the stimulus item were a noun may have been strengthened by the high proportion of stimulus items on The Maryland CNC Test word lists which can be categorized as nouns. For the six word lists used (Appendix C), 71.6% of the stimulus items fell within the *NB* category.

Another possible explanation for the results is that subjects may have responded according to the perceptual salience of the stimulus items. That is, if items falling within the *NB* category tended to be more concrete than those items falling in the *Other* category, then the more concrete *NB* items may have been more perceptually salient to the listener and thus responded to with fewer errors. However, Elkins (1971) examined the CNC word lists for phonetic composition and word familiarity and found the word lists "are relatively uniform in word familiarity" (p.159). Elkins' findings suggested word familiarity should not be contributing to this study's results.

A third possible explanation may be related to the gender of the subjects. Gleason (1989) stated that some oral language skills are more advanced in females than males and that "while girls appear more fluent and automatic in their ability to perform various linguistic tasks, boys seem to be better in receptive and expressive vocabulary" (p. 253). Given the possibility of linguistic differences based on gender, then females may be more or less susceptible to the categorical differences of the stimulus items than males. If so, the findings for this female population may not be representative for the population as a whole.

If the syntax of the carrier phrase contributed to fewer noun stimuli being missed, then one would expect the second hypothesis to be borne out. The second hypothesis predicted that the incorrect responses would not be significantly associated with the grammatical class of the stimulus item. However, the chi-square analysis (Bruning and Kintz, 1977) showed a significant association between the grammatical categories of the stimulus items and the incorrect responses. For incorrect responses, stimulus items in the *NB* category were slightly more likely to yield an *NB* response than stimulus items in the *Other* grammatical category. However, only 7 percent of the total variance could be accounted for by this relationship. Thus, the second hypothesis could neither be fully accepted nor rejected. It appeared that the significance of this weak association could, at least partially, be attributed to the mathematical effects of the very large sample size (1,235 items).

A factor which may have contributed to the results is the frequency with which certain stimulus items elicited consistent incorrect responses. Table 6 lists the stimulus items that were incorrectly responded to greater than 50% of the time, their grammatical categories, and the grammatical categories of the errors.

Most of the stimulus items in Table 6 (8 out of 10) drew incorrect responses that fell within a particular grammatical category more than 70 percent of the time. Seven of the 10 most commonly missed words consistently drew *NB* responses. For some stimulus items the errored responses varied widely. For other stimulus items, the response errors tended to be one or two words, for example, "sun" for stimulus item "sung" and "with" or "width" for stimulus item "wit." Thus commonly missed words may have been influenced by characteristics of the stimulus items and by the availability of phonetically similar foils in the subjects' lexicon.

* *

Table 6

Stimulus Items that Elicited Incorrect Responses in More Than Fifty Percent of the Subjects

Stimulus Item	Rated Grammatical Category	CNC Word List	Proportion of Subjects Who Errored on Response	Proportion of Error by Grammatical Category of the Response		
				NB	Other	Unidentified
caught	O	1-7	.68	.89	.05	.05
bet	NB	1-7	.64	.78	.22	0
thine	NB	1-9	.62	.55	.45	0
fit	NB	1-1	.61	.53	.35	.12
cheer	NB	1-9	.59	.95	.05	0
wit	NB	1-7	.57	.19	.75	.06
thin	O	1-1	.54	.73	.13	.13
both	O	1-9	.53	.94	0	.06
sung	O	1-3	.52	.94	.06	0
hit	NB	1-10	.52	.75	.12	.12

* *

Clinical Implications

The results of this study clearly have clinical implications. In developing The Maryland CNC Test, Causey et al. (1984), stated that the test achieved criteria of phonetic/phonemic balance and word familiarity while providing an environment in the carrier phrase "Say the ____ again" which minimized the effects of coarticulation. They did not, however, address any possible negative effects of the carrier phrase. Results of this study indicated that stimulus items that fell within the grammatical class *NB* were answered with fewer errors which may possibly be due to the syntactic constraints of the carrier phrase.

One clinical alternative would be to examine use of the CNC word lists with a syntactically neutral carrier phrase which minimizes coarticulation such as "Say ____ again." Another more complicated adjustment would be to develop CNC word lists with only stimulus items in the *NB* category while maintaining the phonetic/ phonemic balance and uniform word familiarity of the present lists. Either option would reduce the bias seen in this study, whether that bias is due to syntactic constraints and/or saliency of the stimulus items, however, the first option is a more clinically feasible modification. The second option may require almost complete reformulation of the word lists for phonemic balance to be maintained. Also, there may be value in maintaining a full range of grammatical categories when assessing word recognition.

Limitations of the Study and Implications for Future Research

A primary limitation of the study was the judging of the grammatical categories. In order to include common slang usage which may not have been identified by a standard dictionary, judges determined grammatical categories. The following problems were noted with the judging of grammatical categories in this study. For several (approximately 15) of the stimulus items and incorrect responses, no consensus was reached by the judges and the dictionary was used to determine the categories of those items.

A second problem in the system used for assigning grammatical categories was disagreement between the judges' rating and the primary examiner's informal rating of the grammatical category of various items. For example, the consensus rating for the stimulus word "dead" was the *Other* category, whereas the primary examiner judged it to be a *NB*. These instances were too few to significantly affect the data, but occurred nonetheless.

A third problem related to homophonous words. Although the judges were instructed to consider homophones when judging grammatical categories, orthography may have influenced some of the judgements. For example, the stimulus items "sell" and "which" were judged as *Other*, however, both are homophonous with "cell" and "witch" (in the judges' dialect), which would shift the category to *NB*.

In order to avoid the above problems in future research it is suggested that any items which need to be assessed for grammatical category be presented with homophones denoted and that the standard dictionary classification be noted (e.g., sell/cell - *NB*). The judges could then determine any additional slang usage of the items in the *Other* category. It is hoped that the consensus problem would be resolved by eliminating the problems of orthography and deviations from the standard grammatical classification.

An issue not addressed in the present study was the effect of the stimulus items on the reliability between word lists. Further research could determine whether the presence or absence of particularly difficult stimulus items, as listed in Table 6, significantly affects a client's word recognition performance such that a person's score is determined in part by the presentation of a particular word list.

Other areas of potential research include pursuing why the stimulus items that could be used as nouns were identified with fewer errors than those items which were not nouns. To test the syntactic effects of the carrier phrase "Say the ___ again," a more syntactically neutral carrier phrase (e.g., "Say ___ again") could be employed using the same stimulus items. If items from both categories (i.e., *NB* and *Other*) were answered correctly with greater frequency using the more neutral carrier phrase, then the effects of the carrier phrase could be isolated. Another possibility would be to present only *Other* stimulus items with the carrier phrase, "Say the ____ again." This would eliminate the expectation of noun stimulus items by the listener and would thus investigate the effects of syntax on the correctness of the response.

Another area of potential research is to explore gender effects to determine if female listeners are more susceptible to the categorical effects of the stimulus items than male subjects would be. A normal hearing group of males matched for age and presentation conditions could be tested to determine any gender differences in the types of response errors.

Summary

The present study found that when The Maryland CNC Test (Causey et al., 1984) was analyzed in the manner in which it was originally normed and recommended for use, the stimulus items that can be recognized as nouns were identified with significantly fewer errors than those items which were not nouns. The implication of the finding is to question the content validity of The Maryland CNC Test. Results may be influenced by the grammatical class of the stimulus items and unduly influenced by some particularly difficult items. Further research is needed to investigate the effects of the carrier phrase, "Say the ____ again" on responses to stimulus items.

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APPENDIX A: ARTICULATION SCREENING TEST

/p/	aPPle
/b/	baBy
/t/	mounTain
/d/	canDy
/k/	chicKen
/g/	waGon
/f/	elePHant
/v/	shoVel
/θ/	tooTHbrush
/ð/	feaTHer
/s/	biCycle
/z/	sciSSors
/ʃ/	diSHes
/ʒ/	televiSion
/tʃ/	maTCHes
/dʒ/	briDGes
/w/	sandWich
/l/	baLLons
/j/	onIOns
/r/	aRRow
/m/	haMMer
/n/	baNana
/ŋ/	haNGer

From: Bzoch Error Pattern Diagnostic Articulation Test (1989)

APPENDIX B: SUBJECT INSTRUCTIONS AND PRACTICE STIMULI

The following instructions were given to each subject prior to test administration:

> Soon you will hear a man's voice on a tape. He will always say the same sentence, but only one word will change each time. He will say, "Say the blank again". I want you to repeat the word after "the". For example, if he says "Say the horse again", you repeat horse. Do you understand? If you are not sure of the word, please guess. Now let's try some practice sentences:
>
> 1. Say the bat again.
> 2. Say the sad again.
> 3. Say the tub again.
> 4. Say the jug again.

APPENDIX C: THE MARYLAND CNC SPEECH INTELLIGIBILITY TESTS

WORD LISTS

List 1-1

1. jar
2. boil
3. tough
4. tooth
5. goose
6. toad
7. rout
8. mess
9. kite
10. jug
11. pad
12. salve
13. van
14. home
15. cape
16. shore
17. wreck
18. shirt
19. knife
20. hull
21. yearn
22. sun
23. wheel
24. fit
25. patch
26. make
27. dime
28. bean
29. thin
30. seize
31. hate
32. wood
33. check
34. ditch
35. rose
36. merge
37. lease
38. loop
39. king
40. dead
41. chore
42. boat
43. wish
44. name

APPENDIX C (continued)

List 1-1 (continued)

45. pick
46. ripe
47. fall
48. lag
49. gale
50. sob

APPENDIX C (continued)

List 1-3

1. jail
2. rat
3. toss
4. soon
5. faith
6. sung
7. keg
8. vote
9. size
10. numb
11. dab
12. what
13. room
14. kid
15. dike
16. mate
17. well
18. rig
19. four
20. bush
21. dip
22. gap
23. perch
24. sheep
25. house
26. fade
27. lake
28. gull
29. rouge
30. bar
31. tone
32. chin
33. piece
34. purge
35. bell
36. work
37. life
38. pod
39. shine
40. toll
41. joke
42. head
43. with
44. keen
45. more
46. leave
47. hut
48. noise
49. man
50. yam

APPENDIX C (continued)

List 1-6

1. whip
2. bud
3. shone
4. rug
5. cheese
6. chain
7. look
8. dull
9. pope
10. calf
11. fire
12. turn
13. raise
14. sour
15. bed
16. lawn
17. sit
18. tube
19. veal
20. get
21. pace
22. night
23. hiss
24. shock
25. wing
26. door
27. niece
28. cat
29. move
30. cool
31. web
32. knock
33. jot
34. cage
35. mode
36. search
37. gone
38. rush
39. pole
40. dig
41. bad
42. live
43. map
44. wife
45. fan
46. birth
47. team
48. howl
49. hike
50. jam

APPENDIX C (continued)

List 1-7

1. note
2. doom
3. coke
4. hole
5. join
6. third
7. mouth
8. sure
9. vague
10. big
11. far
12. gun
13. pearl
14. loot
15. save
16. side
17. heat
18. bun
19. fish
20. have
21. mole
22. pine
23. nap
24. mine
25. was
26. reach
27. face
28. bet
29. caught
30. laugh
31. shall
32. geese
33. tape
34. sack
35. ridge
36. cheek
37. dumb
38. top
39. young
40. led
41. rib
42. pass
43. wit
44. did
45. call
46. neck
47. such
48. lose
49. gem
50. tar

APPENDIX C (continued)

List 1-9

1. lack
2. watch
3. power
4. mire
5. nail
6. thine
7. word
8. tool
9. mob
10. hen
11. got
12. sane
13. shout
14. pill
15. both
16. shade
17. jazz
18. lathe
19. catch
20. white
21. chair
22. loaf
23. pun
24. ham
25. lip
26. wrong
27. yes
28. sin
29. curve
30. haze
31. girl
32. time
33. book
34. reap
35. fudge
36. voice
37. rag
38. mud
39. ball
40. deck
41. cut
42. need
43. cheer
44. soap
45. feet
46. tick
47. roof
48. dog
49. beat
50. dish

APPENDIX C (continued)

List 1-10

1. sub
2. lot
3. din
4. death
5. chill
6. coin
7. cause
8. burn
9. loose
10. palm
11. judge
12. wash
13. rob
14. fine
15. while
16. chat
17. bit
18. nick
19. neat
20. hair
21. safe
22. hit
23. jade
24. hurt
25. pile
26. shack
27. cone
28. sell
29. your
30. term
31. mood
32. deep
33. meek
34. rope
35. witch
36. ride
37. bake
38. gore
39. fool
40. guess
41. mouse
42. lung
43. load
44. path
45. peak
46. run
47. sag
48. cave
49. thatch
50. towel