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THE INFLUENCE OF VERB STEM FEATURES ON INFLECTED WORD PRODUCTION IN PEOPLE WITH AGRAMMATIC APHASIA

by

MARGARET A. METH

A dissertation submitted to the Graduate Faculty in Speech and Hearing Sciences in partial requirement for the degree of Doctor of Philosophy, The City University of New York

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April 22, 1998
Date

Loraine K. Obler, Ph.D.
Chair of Examining Committee

April 27, 1998
Date

Irving Hochberg, Ph. D.
Executive Officer

Katherine S. Harris, Ph. D.
Supervisory Committee

Martin Gitterman, Ph. D.
Supervisory Committee

THE CITY UNIVERSITY OF NEW YORK

Abstract

THE INFLUENCE OF VERB STEM FEATURES ON INFLECTED WORD PRODUCTION IN PEOPLE WITH AGRAMMATIC APHASIA

by

MARGARET METH

Advisors: Professor Loraine Obler

Professor Katherine Harris

The purpose of the present study was to determine what features of the verb stem, if any, influence correct production of an inflectional suffix in English when words are read, repeated, or produced in a sentence completion task. The stimuli were selected based on a number of phonological, morphological, and orthographic features of the verb stem. Eight agrammatic subjects participated based on subtest scores on a standardized aphasia battery (e.g., Boston Diagnostic Aphasia Evaluation (BDAE) (Goodglass and Kaplan, 1972) or The Western Aphasia Battery (WAB) (Kertesz, 1982). They were judged agrammatic by two speech language pathologists who rated their performance on the picture description subtest of the particular standardized test administered.

Subjects listened to a statement that included the verb in infinitive form. They next listened to a carrier phrase with the verb omitted and were asked to produce both the inflected verb using the third person and past tense forms (depending on the carrier phrase). In addition they read and repeated verbs in the infinitive, third person and past tense forms. Responses were tape recorded, edited and presented to normal listeners who rated them twice, once for stem correctness and once for affix correctness according to a forced choice paradigm.

Results indicate that there are effects of the stem on the ability to

inflect the verb, but the presence of an affix does not influence the ability to produce the stem. The aphasic speakers' ability to affix a verb is affected by whether or not a verb-stem ends in a final consonant cluster and whether it is longer than one syllable. In their unaffixed form, stems belonging to small rhyme-gangs are easier for agrammatics to produce. Results reveal an interaction between the language-grammar and speech-production systems since the longest most difficult words to produce as stems are also the most difficult to affix.

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I have been especially fortunate to be surrounded at one time or another not only by all of the above professionals for the past 10 and one half years, but by some of the what I truly believe are the most wonderful family and friends who were there before CUNY and will be with me for many years to come. Cheryl, an exemplary best friend who kept me grounded in what was really important and was always there for me. Warren, my loving husband who encouraged and supported me in every way possible, to do what I had to do "to get this done". I promise that the next 10 years will not be spent in front of the computer. Mike, you left when I started this 10 years ago, to go off to college a little boy and have returned home a professional man. It kept me out of your life and sane. Elissa, you were right, I needed something to keep me busy, and this was it. Any more ideas now that it's done??? Mom, Dad, Marlene, and Morty, don't worry, I still need winter vacations. Phil, yes, we're still young enough to celebrate and I'm very grateful that you are all here to celebrate with me.

I know there were others. I can't count the number of people who regularly asked, "Are you done yet?" And now it is. Hooorayyyyy!!!!

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Chapter 1

Introduction

Broca's aphasia is traditionally characterized by laborious articulation (Goldstein, 1948), great reduction in the flow of speech, and apparent loss of grammatical structure at least in production (Goodglass, Quadfasel, & Timberlake, 1964; Luria, 1970; Goodglass, 1968; Goodglass & Kaplan, 1973). On the face of it there is no immediate link between the motoric breakdown and the grammatical breakdown, yet the two aspects co-occur with great enough frequency to warrant exploration of their link. Despite this potential link, researchers have focused on the motoric and grammatical breakdown as two separate issues. By the term motoric, it must be noted, most researchers appear to mean phonological (Nespoulous, Joanette, Beland, Caplan, & Lecours, 1984); by the term grammatical, morphosyntax is generally meant (Miceli, Mazzucchi, Menn, & Goodglass, 1983). Since the grammatical component of agrammatism often includes deficits in production of bound morphemes, this dissertation will focus on both motor/phonological, and grammatical aspects of suffixes as they relate to their stems. Let us consider each aspect separately.

Articulatory Aspects of Broca's Aphasia

Researchers have examined the intelligibility of speech production in Broca's aphasics in an effort to explain the motor disturbance associated with Broca's aphasia.[1] Shankweiler and Harris (1960) asked subjects to repeat 200

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[1] Shankweiler and Harris (1960) refer to subjects with articulatory disturbance and included them based on lesion site "involving but not necessarily restricted to the anterior protion of the dominant left cerebral hemisphere" (p. 279). Johns and Darley (1970) refer to Broca's aphasia but state that the subjects are dysarthric and/or apraxic. Trost and Canter (1974) use the term Broca's aphasia as it is used in the Johns and Darley article to refer to those with apraxia of speech.

monosyllabic words composed of consonants (Cs) and vowel (Vs) in one of the following patterns: CVC, CVCC, CCVC and CCVCC. They found that consonants or consonant clusters in the initial position were more difficult for the subjects to produce than those in the final position. Consonant clusters were more difficult to produce than were single consonants. Vowels were the least difficult to produce. Fricatives, affricates, and consonant clusters most often resulted in misarticulations.

Because of the structural constraints on their stimulus set, Shankweiler and Harris (1960) included no words with affixes. Using more complex stimuli, Johns and Darley (1970) and Trost and Canter (1974) found the same consonants and consonant clusters to be most problematic for Broca's aphasics. Johns and Darley did not detail subject characteristics but referred to apraxics as those whose sound substitutions and repetitions were "inconsistent and unpredictable" 50% of the time. Subjects who presented with "imprecise production of consonants" or substitutions 65% of the time were considered dysarthric. In addition, dysarthric errors were consistent when patients were producing longer utterances in spontaneous speech (a picture description task). Apraxics made fewer errors in spontaneous speech than in reading or repetition.

Johns and Darley (1970) analyzed productions of nonsense syllables and words with one or more prefixes or suffixes added to nucleus words (e.g., *stands, withstand, standardize*, etc.). They also had subjects read the phonemically balanced paragraph, "My Grandfather". Responses from two groups of aphasics (dysarthrics and apraxics), were transcribed from recorded speech samples and analyzed to determine the degree to which phonemic errors fell into seven categories (e.g., substitutions, distortions, intrusive schwa, repetitions, additions, omissions, other). The authors' discussion

focuses on phonemic variability in the initial portions of words, rather than affixation. Since anterior left cerebral lesions are most typically characterized by off-target approximations of initial segments of words and because the difficulty Broca's aphasics have in initiating utterances was thought to be motor based. They further concluded that articulatory errors were the result of impaired motor function. Despite their finding that both apraxics and dysarthrics performed significantly worse as words get longer. no conclusions can be drawn from their study regarding whether the influence of lengthening words is due to phonemic as opposed to syntactic complexity because they did not consider effects of syntactic complexity on motor production.

It is also pertinent to the proposed study to note that Johns and Darley (1970) presented all stimuli in each of the three response conditions: visual (reading), auditory (tape recorded presentation for imitation), and auditory-visual (wherein the subject saw and heard the examiner speak each of the stimulus items). The auditory-visual mode of stimulus presentation brought significantly better responses than the auditory or visual modes. The difference between responses to the auditory-visual and visual modes was not statistically significant, nor was the difference between responses to the auditory and visual modes significant. The authors concluded that motorical production problems in aphasia are not perceptually based or modality specific.

In another study that looked at the effect of varied modalities, Trost and Canter (1974) further controlled the stimuli by including consonant singletons in the CVC position and consonant clusters (initial and final positions) in elicited repetition and spontaneous picture description tasks. Their findings generally agree with those of Johns and Darley (1970) and

Shankweiler and Harris (1960) as to the difficulty of phoneme production and position. Analysis of final consonant clusters showed that subjects more often omit elements of final clusters than of initial clusters.

When repetition and spontaneous speech (picture description) were compared, a greater proportion of single consonant phonemes was correctly produced in the repetition task for both initial and final positions. Poorer production in spontaneous speech was attributed to word finding difficulty. A trend for greater accuracy of production of final consonant clusters than for initial clusters was found in both repetition and spontaneous speech. When errors did occur on final consonant clusters, analysis of errors showed that subjects more often omit elements of final than initial clusters. No reference was made specifically to affixes.

Trost and Canter (1974) concluded by noting that one of the shortcomings in their research is that the speech samples elicited from picture naming and repetition may be qualitatively different from communicative language. They stated that the underlying mechanisms in the two tasks analyzed "may be different from those requisite to formulation of spontaneous communicative language" (p.77). This dissertation attempts to simulate more naturally-occurring discourse by using, in one condition, full sentences to provide context for the verbs, instead of a naming task.

These early perceptual studies (Trost and Canter, 1974; Johns and Darley, 1970; Shankweiler and Harris, 1960) agreed that the speech of Broca's aphasics was the result of a motor production problem. The next generation of research took the form of acoustic analysis to determine what exactly is being perceived as apraxia and dysarthria. Kent and Rosenbek (1982) gathered samples of speech from varied clinical settings from apraxics and dysarthrics with different neurological etiologies who were not agrammatic. They determined

that "articulatory prolongation" and "syllable segregation" are the reasons why the listener perceives slowed speech when dysarthric and apraxic aphasics who are not agrammatic speak (Kent and Rosenbek, 1982). Although the samples were not the same (i.e., analyzed utterances varied among subjects) the temporal and fundamental frequency patterns of interest (those showing syllable segmentation, slowed rate, articulatory prolongation and syllable dissociation) were observed across samples.

Collins, Rosenbek, and Wertz (1983) imposed greater controls by analyzing stimuli composed of stem words with suffixes added (e.g., *please, pleasing, pleasingly*). Their apraxic subjects retained the ability to progressively reduce the duration of the vowel in the stem portion of the word as words got longer. The fact that they did so serves as an indication that there is an underlying phonologic appreciation of the increase in length; like the previous authors, these authors did not address the syntactic aspects of the speech samples they analyzed. In particular, the effects of stem length upon inflectional and derivational endings were not considered in this work. The proposed study will consider inflectional endings.

In addition to those Broca's aphasics who present with a motor phonological problem, there are those who present without obvious motor production problems with agrammatism. In these patients, the inability to inflect words clearly cannot be attributed to difficulty producing the word final phoneme. Research since the late 1970's has focused on exploring the possibility of a syntactic-semantic integration problem with verbs. I will turn to a review of this literature next.

Grammatical Breakdown in Broca's Aphasia

The grammatical breakdown of Broca's aphasia has been described in a number of different ways. Analysis of syntactic features has shown that a number of specific grammatical difficulties are exhibited by some Broca's aphasics at the word and sentence level. In this review I consider first the reports of the classic omission of unbound functors, then the omission and substitution of bound morphemes. I then refer to the more recent studies which point to several forms of reduced syntactic complexity. I conclude with discussion of a set of studies that point to particular problems for agrammatics with verb production, as that is the focus of this project.

Let us now turn to a discussion of traditional agrammatism. Agrammatism is considered to be a problem of abbreviated or impoverished grammatical structure with utterances exhibiting simplified or telegraphic sentences, word functor omission, and loss of verb tense (Isserlin, 1922 and Pick, 1913 cited in Goodglass, 1968). In their research reviews Goodglass and Berndt and Caramazza (1981) reported the omission of articles, prepositions and personal pronouns in the speech of agrammatics. In addition Goodglass (1968) noted "interchangeability" of words within each of the aforementioned classes as well as inflectional errors. The meaning of "interchangeability" was not elaborated upon other than to note that agrammatic speakers substitute verb stems for inflected verbs.

In their work that orders the difficulty of production of the final endings, Goodglass and Berko (1960) concluded that for "aphasics" the difficulty of the 10 inflectional endings studied follows a definite order that is based on grammatical function, not phonological similarity. Although the type of aphasia the subjects presented with was not specified by the authors, one may assume that they were agrammatics since this group was the focus of

the introduction and the tasks presented. They found that aphasic patients had more difficulty with the possessive and third person singular inflection than the plural, although all three inflections have the same phonological representation (/s, z, iz/).[2]

In addition to the possibility of phonological influences on agrammatism, the influence of open and closed class words has been investigated. Bradley, Garrett and Zurif (1980) reported a series of seven studies that compared bound and unbound morphemes in 30 normals and 5 Broca's aphasics. They found that Broca's aphasics can successfully recognize both classes of words. However, they do so in a different fashion from those individuals who process language normally. The authors believe that the agrammatic's problem is not related to sentence meaning, but is related to the "integration of sentence form" (p. 276). The failure of integration of the grammatical deep structure and the phonological surface structure results in Broca's aphasia.

They further compared retrieval of closed and open class words and found that agrammatics performed differently from normals. Normal subjects recognized a greater number of high frequency open class words in a lexical decision task than low frequency open class words. There were no frequency effects for closed class words in normals. Thus, Bradley, Garrett and Zurif (1980) concluded that normal subjects access open and closed class words differently. Agrammatics showed no such discrepancy between open and closed class words. They accessed them the same.

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2 Hereafter, throughout this paper 3rd person singular present inflection will be indicated by /Z/ and present tense inflection will be indicated by /D/.

Bradley, Garrett and Zurif (1980) concluded that open and closed class words are recognized by two different routes. When the initial part of the non-word is an open-class word (e.g., toastle vs. poastle) recognition is faster than when it is a closed class word or when either (open or closed class words) appears in the final position of a non-word. They found that there are different retrieval systems for open and closed class words in normals and agrammatics and that agrammatism results from problems with phonological structure and lexical retrieval mechanisms. The authors suggested that the agrammatics' inability to access closed class elements in spontaneous speech is due to reliance upon an inefficient recognition route.

Agrammatics exhibited general morpheme accessing and syntactic agreement problems (Stemberger, 1985). Examining loss and addition errors of the three English /-s/ morphemes in sentences produced by normal and agrammatic speakers, Stemberger found that one of the problems agrammatics face is selecting among the various choices given that there are several alternative syntactic, morphological and lexical possibilities. Similarly, Tyler, Behrens, Cobb, and Marslen-Wilson (1990) reported that their agrammatic patient's problems originated in his inability "to integrate the semantic syntactic properties of morphologically complex words into the higher-level sentential representation" (p.150). In a set of six experiments their subject listened to morphologically complex words presented in an unstructured list and in different kinds of sentential contexts. Their subject participated in various experimental tasks where response time variation between hearing the onset of a specified target word that followed a contextually appropriate suffixed word (either inflected or derived) was measured. Results were compared to a control group's responses. The subject's response times were slower and unaffected by the contextual appropriateness of suffixed words

indicating that he was insensitive to the semantic and syntactic implications of the suffix but sensitive to semantic and syntactic information of the stem for derived and inflected words.

In addition to access and agreement problems, the information value of the inflection determines whether it can be produced or omitted in English speakers (Bates, Friederici, & Wulfeck, 1987). Morphology in English carries little critical information and as a result English-speaking Broca's aphasics omit inflectional endings more frequently than do speakers of other languages where the inflection serves weightier grammatical functions. Italian-speaking Broca's aphasics notoriously drop inflectional endings, using instead the citation form (Miceli, Silveri, Romani, & Caramazza, 1989), despite heavy cue validity (i.e., the amount of information encoded in the form). Wulfeck, Bates, and Capasso (1991) used a grammaticality judgment task to compare English and Italian speaking Broca's aphasics as to vulnerability of word order and morphology. Their results concur with the previous findings of Bates, Friederici, & Wulfeck (1987 and 1988) concerning the determining factor in morpheme retention after stroke (i.e., the heavier the information load, the greater the likelihood of retention).

Systematic cross-linguistic evidence exists that patients' decision to omit an item, as well as their efforts to find the correct form, appears to be a partial function of the cue validity or importance of the form in their language. The conclusions of Bates, Friederici, & Wulfeck (1987 and 1988) were based on studies of articles rather than bound suffixes. The present study will look at whether the inclusion or omission of inflectional affixes is dependent on features of the verb stem.

In looking at production of derivational and inflectional errors in a single case study of an agrammatic Italian-speaker, Miceli and Caramazza

(1988) found that inflectional verb endings were more likely to be impaired than were derivational verb endings in agrammatic speakers. They concluded that the lexicon is where morphological processes are stored. Furthermore, inflectional and derivational affixes are stored separately within the lexicon. As a result, they proposed an Inflectional Processes Component separate from Root Morpheme and Derivational Processes Components.

Badecker and Caramazza (1987) examined morphological production errors in a single agrammatic subject. They questioned whether morphological errors in reading and repetition of words and their affixed counterparts are a consequence of a deficit in morphological processing or whether they are a reflection of the lexical organization of morphological principles (i.e., a lexical-semantic or phonological output impairment). They concluded that a significant portion of morphological errors was based in a morphological processing deficit, however, they did not rule out the influence of an organizational deficit as well.

More recently in their summary of cross-linguistic studies Bates, Wulfeck, & MacWhinney (1991) observed substitution of verb stems or infinitives for inflected verb forms with frequent omission of verbs in the spontaneous speech of Broca's aphasics. In addition to noting the overuse of nominal forms substituting for content usually communicated with verb forms (e.g., "Bunny.... tears" instead of "Bunny cry") Bates, Wulfeck, and MacWhinney stated that cue validity (i.e., information value) and cue cost (i.e., the amount and type of processing required relative to frequency, salience, and pronounceability) influenced the probability of morphologic error in Broca's aphasics' productions. They further stated that grammatical morpheme production is influenced by the effects of markedness and/or frequency. Furthermore, morpheme substitution errors could be influenced

by semantic relatedness effects and the use of grammatical structures could be affected by "priming". Broca's aphasics tend to substitute simple, more frequent and/or less marked forms when they make mistakes, often avoiding contexts that require complex construction. The discussion of Bates, Wulfeck, and MacWhinney (1991) did not include mention of the cue cost of the inflected stem. Furthermore, it did not mention how affix frequency was measured in any of the studies reviewed. They discuss only the frequency of the affix. Cue validity in content words, although variable, is considered high; however, cue cost can vary greatly. The proposed study will look at effects of stem frequency on the ability to inflect the verb in an effort to clarify which features of the verb stem affect the verb inflection.

Earlier studies by De Villiers (1978) and Goodglass and Berko (1960) compared different morphological markers in their Broca's aphasic subjects. Although they would agree that third person present and past tense inflections are not used with ease in Broca's aphasics, Goodglass and Berko consider both inflections to be in the difficult to mid-frequency range when compared to other morphemes, whereas de Villiers considers them among the more difficult morphemes. De Villiers measures affix frequency from transcripts of interviews with nonfluent aphasics of varied severity. Goodglass and Berko did not concern themselves with frequency but instead order their results based on elicited responses to a sentence completion task. For the purposes of post hoc analysis in this project, affix frequency will be determined by a combination of the listings in Obler, Robinson, Kaufman, & Satake (1994) and by analysis of reported affix frequency within 20 randomly selected pages of Francis and Kucera (1982).

A number of different explanations as to why verb production breaks down in agrammatic aphasics (Bates, Wulfeck and MacWhinney, 1991; Miceli

and Caramazza, 1988) have been offered having to do with the inflectional endings (Miceli and Caramazza, 1988; Stemberger, 1985; Tyler, Behrens, Cobb, & Marslen-Wilson, 1990; Schwartz, Saffran, & Marin, 1980). A Morphological Decomposition Hypothesis, wherein morphological processes are located in the lexicon, and inflectional and derivational processes are represented independently within the lexicon, was proposed by Miceli and Caramazza. According to this theory, agrammatic aphasia is the result of a default inflectional form (the citation form) being produced when the derivational and inflectional form within the lexicon become dissociated. Their analysis of the spontaneous speech (retelling of Little Red Riding Hood) of a single agrammatic subject revealed misselection of inflectional affixes and violations of subject verb agreement. On the single word repetition task the subject was able to successfully repeat the stem but exhibited difficulty producing the affixed form. The patient's success on two additional auditory processing tasks (lexical decision and same/different judgment) suggested that the inflectional deficits noted were not the result of an inability to auditorally process complex words. The results are presented as evidence that stems and morphemes are stored separately within the lexicon.

The relationship between such grammatical constituents was looked at by Schwartz, Saffran, & Marin (1980) who have focused on impaired mapping between grammatical constituents. Although the impaired mapping cannot be overlooked when one considers breakdown of verbs, this dissertation will question whether we can go so far as to implicate the interaction between syntax and semantics in verbs as the underlying problem.

In 1994, the interaction between syntax and semantics in nouns was investigated by De Bleser and Luzzatti (1994). The authors had two Italian agrammatic subjects produce past participle suffixes on a sentence completion

task where they read sentences with the final word omitted. Responses were examined for agreement between gender and number. Errors in complex sentences resulted from difficulty in selecting the appropriate noun phrase rather than from random or inappropriate selection of inflection. The sentence completion task in this dissertation will examine the ability of English speaking Broca's aphasics to link the inflection to the noun phrase.

Most recently Friedmann and Grodzinsky (1997) present a single case study of a Hebrew-speaking agrammatic with a selectively impaired inflectional system. Tense inflection was severely impaired despite intact inflectional agreement. Morphemes within the inflectional system were considered of two different types: agreement of person, number and gender are separate from tense inflection. The level of their subject's deficit (i.e., the inflection of tense) allowed the verb to be retrieved from the lexicon but did not allow for appropriate inflection following retrieval. This dissertation will see if this finding holds true for English for a larger number of subjects than Friedmann and Grodzinsky used. Results in English could be particularly interesting since the third person present inflection marks both tense and agreement.

Past research has shown that there can be no doubt that the agrammatic aphasic's difficulty with producing inflected forms results from a complex compositional deficit with the possibility that there is more than one level of breakdown. In addition to the difficulty of producing and/or accessing the appropriate inflection in a particular syntactic environment one must consider the amount of information the inflection is encoding (Bates, Wulfeck and MacWhinney, 1991), the effect of the cost of production of the particular affix on the production of the rest of the utterance (Bates, Wulfeck and MacWhinney, 1991), the deep and surface structure of the utterance (Bradley,

Garrett and Zurif, 1980), and the choices available to communicate a specific message (Stemberger, 1985). Despite intact syntactic comprehension, errors occur which frequently result in uninflected verb production. This dissertation was designed with particular stimulus items and tasks in mind to assess whether the verb stem contributes to the difficulty of agrammatic production.

Summary of the Plan for this Study

To date, there has been no research that questions whether agrammatic deletion of inflections occurs randomly or with a pattern dependent on the verb. This researcher has observed clinically that when they are writing responses, Broca's aphasics find it is easier to inflect the verb than when they attempt to speak. Therefore, it is assumed that the inflections are accessible but unable to be produced in speech. Breakdown in the process of inflected verb production can occur at a number of points: awareness of the need to say a word, finding the targeted inflectional ending, generating some kind of motor plan, putting together the stem and the morpheme and actually speaking the word. This research will focus upon the last two levels of production (spoken production of stem and morpheme). Broca's aphasics are frequently able to produce the stem but omit the morpheme when speaking, leading me to believe that in agrammatism the level where the breakdown occurs is at the point where the stem and morpheme are combined in the speech production task. By using stimuli that are constructed based upon specific verb characteristics, interaction between the stem and the suffix target in agrammatic aphasics will be examined in this study.

A number of variables could be examined concerning how the stem affects verb production in aphasics. Some are phonological: syllable length,

phonemic length, difficulty of initial or final consonant cluster and how stress within the word influences the phonological shape of the final unstressed inflection. Others may be considered morphological: more or less frequent word stems, part of speech, prefix or suffix, whether the affix is derivational or inflectional. Others have to do with the relation between orthographic and phonological characteristics of the words (in particular gang membership) since this has an influence on how words are stored in the lexicon of literate adults (Rumelhart and McClelland, 1982). This dissertation will focus on several phonological characteristics of the stem on production. To date, these characteristics have not been evaluated with the level of control imposed upon this set of stimuli.

In this dissertation, I focused on verbs because, of forms taking inflectional affixes, these are most problematic for agrammatic speakers across languages (Bates, Wulfeck, & MacWhinney, 1991). More particularly I focused on some of the factors that have been identified that contribute to the problem agrammatics have with verb production: final consonant sound (C vs. CC), length of the verb stem (mono-, bi- and trisyllabic), and verb frequency (based on Francis and Kucera, 1982). There is also reason to believe that the size of the gang to which a verb belongs will influence its ability to be inflected. The reasons for selecting these foci will be discussed in greater detail below. Subjects were asked to produce verbs using third person singular and past tense inflections in three tasks: reading, repetition and given-new sentence completion. In what remains of this chapter I will elaborate on the topics that have not been fully dealt with to this point: gang effects, frequency and word length.

Gang Effects

The term gang effects has a number of meanings in the literature, as does the related term neighborhood effects. Definitions include similarities among sets of words based on shared phonological strings, shared orthographic strings (Rumelhart & McClelland, 1982), and shared phoneme-grapheme correspondences (Mann, Liberman, & Shankweiler, 1980). By the latter definition, for example, *pint* belongs to a small gang because the /aynt/ pronunciation for the letter string "int" is unique, while *mint, print, lint,* are members of a large gang. Researchers have studied gang effects because such similarities among words influence how they are organized in the lexicon and accessed.

Most crucial for present purposes are the third and fourth studies by Stemberger and MacWhinney (1988). Verb stimuli were selected based on their concept of gang which has to do with the number of verbs that share contiguous phonemes. The authors addressed the question of whether inflectional affixes are created on line or listed in the lexicon as forms separate from the stem forms. To investigate this question they employed verbs (e.g., chew) that sounded like irregular past tense forms (e.g., knew). Indeed, their normal college students made more errors omitting past tense inflections on verbs like *chew* than on verbs like *pass* (which does not have an irregular past tense form within the gang with which it shares the same ending). They concluded that regularly inflected forms (i.e., *chewed* in this instance) are not stored in the lexicon but rather generated on line.

To evaluate the extent to which gang status plays a role in whether or not agrammatics succeed at adding affixes, I included rhyme-gangs as one of the features to be tested via word lists in this study. Rhyme gangs according to

my definition are words that share the rhyme, whether or not they are spelled similarly.

Word Frequency

Word frequency has been implicated in a number of psycholinguistic phenomena in normals as well as in aphasics: e.g., word recognition (Cole, Beauvillian, and Segui, 1989), naming, semantic representation and word retrieval (Ellis, 1985), reading (Seidenberg, Waters, Barnes, & Janenhaus, 1984) and repetition (Monsell, 1985). In normals, evidence for hypothesizing better production of high-frequency words was presented by Seidenberg, Waters, Barnes, & Janenhaus (1984) who employed two reading tasks (reading and lexical decision) and found that there was a pool of high-frequency words that were recognized directly by a whole-word recognition route in reading. They suggested that pronunciation makes use of the lexical entry accessed by way of whole-word recognition. Low frequency words were produced as a result of synthesis of the phonemes in the word through grapheme-phoneme conversion; such a procedure suggests increased opportunity for breakdown. The extent to which this synthesis carries over to construction of words in spoken language for repetition and sentence completion tasks is not known.

Opinions vary as to the effects of root frequency on morphological composition. For example, Taft (1979) assumes that there is lexical decomposition of words into morphemes with search conducted on the root (based on results of a lexical decision task), whereas Burani and Caramazza (1987) as cited in Cole, Beauvillian, and Segui (1989) propose a whole word access model. In a series of lexical decision experiments conducted on normals, Cole, Beauvillian and Segui (1989) examine the effects of surface (count of occurrences of morphologically complex words) and cumulative root

frequencies (the count of occurrences of the root and all affixed forms that share the same root) in the recognition process of prefixed and suffixed words. They found that the most representative members of a morphological family were examined before the less representative members in a frequency-ordered fashion. They proposed that when a suffixed word begins with a root, access is provided by searching through all candidates within the morphological family. Candidates for the match in lexical decision were examined according to their respective frequency. Thus, they concluded that it takes longer to recognize a less frequent member than a more frequent member.

Kelliher and Henderson (1990) presented irregular forms of inflected and derived words (e.g., mouse-mice; sing-sang; solve-solution) to normal subjects. Word frequency was based on the frequency of the word stem and all complex forms of the stem averaged. Regardless of whether the orthographic form of the stem resembled the inflected form, the speed of lexical decision was related to the frequency of the citation form (e.g., for the inflected form *bought*, the speed of response was related to the frequency of the stem *buy*).

Kelliher and Henderson (1990) attempted to answer the question of whether frequency effects are task-specific by looking at the latency of recognition of base verb forms compared to inflected verbs. They pointed out that frequency results found in lexical decision experiments may not hold true for studies conducted in other modalities. They concluded that such effects are not easily evaluated and were unable to provide a definite answer.

Turning to research that addresses word frequency in aphasics, it is generally agreed that highly frequent words are less affected. Ellis (1985) concluded that his patient who exhibited neologistic jargon aphasia preserved function word vocabulary in spontaneous speech as a by-product of the

extremely high frequency of most function words (p. 129). Goodglass, Hyde and Blumstein's (1969) analysis of transcribed interviews with aphasics showed that Broca's aphasics overused frequent nouns (they did not address frequency of verbs, however). Indeed, Goodglass and Berko (1960) studied aphasics' use of inflectional affixes and concluded that their subjects' use or omission of inflections is based on the grammatical function of the inflection as opposed to the phonemic complexity of the inflection. No other features of the inflections were considered. It is important to note that the stimuli in their test consisted of a given-new story completion task so that the responses being elicited were controlled in order to facilitate production of the target tense. The authors did not otherwise control the target responses. Since that article, to my knowledge, no one has questioned whether the inflection problem occurs in different verbs as a result of one or more features of the verb, rather than as a result of the inflection. The present study hypothesizes that there is a pattern to the difficulty, reflecting both stem and affix frequency, (remember that according to my analysis of Francis and Kucera (1982) normals use past /D/ inflection more frequently) which should become apparent when constraints are placed on the constructed verb. This hypothesis expands on the results of frequency effects in open and closed class words on a lexical decision task (Bradley, 1978) and on inflections in a sentence completion task (Goodglass and Berko, 1960) in aphasic and non-aphasic subjects.

To date, word frequency research has not addressed whether verb stem frequency affects the ability of a speaker to add an inflectional ending. Research with normal subjects, using written (reading sentence completion task) stimuli and spoken responses, reveals some patterns that might be relevant to the ability of aphasic speakers to produce affixed verbs.

Stemberger and MacWhinney (1988) state that no-marking errors (where the base form is used when an inflected form is required) will occur in normals if high and low frequency verb forms are stored in the lexicon, as discussed earlier. The higher frequency verb form will be produced more rapidly than the lower frequency verb form. Both frequencies of inflected forms and frequency of base words were taken into account, with the frequency of the inflection relevant only when there was a need to access the inflection, of course. The frequency of the base should affect the access of the base, with high-frequency base forms showing fewer accessing errors than low-frequency base forms. Most pertinent to this dissertation, they argue that the high-frequency of a base will result in more accurate access of the following inflection. Therefore, frequency effects in inflected forms will occur only if inflected forms are stored in the lexicon in some fashion.

To my knowledge, it is not known whether Broca's aphasics have equal difficulty producing high and low frequency verbs. We do know that aphasics have difficulty producing high (as well as low) frequency functors (Bradley, 1978). I hypothesize that they will have greater difficulty producing low frequency inflected verbs, since these are not stored in the lexicon, but rather constructed on-line. I further hypothesize high-frequency inflected words should be easier for Broca's aphasics according to the model of Stemberger and MacWhinney because these are stored within the lexicon and Broca's aphasics do not have particular difficulty with lexical word retrieval. It can be seen that research on verb frequency has not focused on tasks that involve production of the inflected verb, but rather on tasks all having to do with word recognition, reading and repetition. The present study includes an effort to see if there is an effect of verb stem frequency on the ability to inflect verbs in aphasic speakers.

Word length

Another variable that may affect production of verbs is their length. Length is virtually always longer in inflected forms than in their corresponding root forms. Gibson and Guinet (1971) investigated whether verb inflections function as units to increase the length of a word read silently given tachistoscopic presentation. Third- and fifth-grade normal readers processed inflected endings occurring when the base was not a real word but readable, as well as when real words were inflected. The authors concluded that words were read as complexes of features (they considered syntax a feature that is separate from orthography and meaning). Each feature is processed independently. The authors defined syntax as the rules for forming the morphological inflections expressing plurals, possessives, and tenses. Errors increased as word length, measured by the number of letters in the word, increased. The errors in the verb inflections themselves were compared to errors in the base words of non-inflected items of the same length (e.g., *trying* vs. *listen*). Evidence favored inflected endings being read as units, leading to the conclusion that the base word and the morphological inflection are separate "features" of a word.

Reading errors took the form of substituted inflections, (e.g., ___*ing* produced instead of ____*ed*). When base words were perceived as being inflected, there was sometimes confusion as to the perception of the correct inflection. For example, when subjects produced "listening" instead of "listened", the authors suggested "that features of a word are processed, in reading, independently and sequentially" (p.188) as base "plus" inflection since both base and inflection were produced even when there was inflectional substitution. Furthermore, according to the authors, when

reading English one must pick up at least two kinds of information: orthographic and semantic features of the base word and syntactic information given by the ending. Consequently, increasing word length by adding an inflection should not interfere with a word's ability to be read appropriately, because it is not the number of letters that is significant, but rather the number of "features" it can be divided into (orthographic, syntactic, semantic).

Along with adding inflections, words can be lengthened by adding phonemes. Martin, Wasserman, Gilden, Gerstman, & West (1975) studied the interactions between phonological and morphological levels in repetition tasks. Aphasic subjects were asked to repeat CCVCC monosyllabic words. In some instances the final CC included a morpheme (e.g., *crossed*); in others the same CC ending did not include a morpheme (e.g., *breast*). Stimuli also included final CC words consisting of a combination that can never be a morphological ending in English (e.g., *plunge*). Increased errors occurred for the monosyllable that ended in inflected morphemes as compared to the other two categories. Therefore, it was concluded that morphological production is influenced by more than one component. Error type varied according to whether words consisted of one or two morphemes, with phoneme substitutions for monomorphemic words and phoneme omissions for two-morpheme words.

Length of the inflection could also alter the length of the word. This alone does not explain the relative difficulty of various syntactic constructions either, since there are widespread differences among the items that usually remain in agrammatic speech. The four most difficult constructions (Goodglass and Berko, 1960; Gleason, Goodglass, Green, Ackerman, & Hyde, 1975), (possessive -Iz, present -Iz, possessive -s, -z and past -t, -d) are no longer

than those in the middle range (past -Id, present -s, -z). However, as mentioned in the previous section, frequency of usage of the required form of the verb, as well as the structure of the stimulus cue, affect the elicited response.

It is not known whether word length affects the agrammatic's ability to read aloud. To date, to my knowledge, no research has controlled the stimuli as thoroughly as my study did, or by the same criteria. This research varied length by requiring subjects to add inflectional endings to minimally paired words with C as opposed to CC final sounds (e.g., *booted, boosted*). It was hypothesized that words ending in a consonant cluster will be more difficult to produce than words ending in a single consonant. Furthermore, it is hypothesized that monosyllabic words will be easier to produce than are bi- or trisyllabic words as was the case in the early perceptual and acoustic studies by Johns and Darley (1970), and Collins, Wertz, and Rosenbek (1983).

Overview For This Study

Eight word lists were constructed. Each word list consisted of ten words that were controlled for the following criteria: word frequency, final consonant, and whether a syllabic or a morphemic affix was required (see following section for details regarding each list and selection criteria). Two questions were asked about each word list:

1. What is the effect of group (word list) on the correctness of affix production?

    1a: What is the effect of group (word list) on the correctness of the stem?

2: What is the effect of task on the correctness of the affix?

2a: What is the effect of task on the correctness of the stem?

I sought to determine whether different patterns emerged with different tasks.

With respect to the first question, stem-features influencing suffix production, more specifically I asked:

1a. Does stem participation in large vs. small rhyme-gangs make a difference?

1b. Does high vs. low frequency of the stem make a difference?

1c. Does production efficacy vary depending upon phonological properties of the stem ending, namely, final consonant or cluster (C vs. CC)?

1d. Does verb-stem length influence ability to inflect?

The same characteristics of word lists were then compared to determine if word list characteristics affect the ability to produce the stem.

Reading, repetition, and sentence completion tasks were employed to examine whether difficulties are limited to a particular language task or extend across other performance modalities and task demands.

In summary, there was a period when focus of Broca's aphasia research was on phonology (Trost and Canter, 1974; Johns and Darley, 1970; Shankweiler and Harris, 1960). Since the late 1970's research has shifted to the syntactic deficits associated with agrammatism that is present in most Broca's aphasics (Caramazza & Zurif, 1976; Bradley, 1978; Garrett, 1984; Miceli, Silveri, Romani, & Caramazza, 1989; DeBleser & Luzzatti, 1994; Friedmann, & Grodzinsky, 1997). In this dissertation, I return to looking at phonology with controlled stimuli because even in the simplest of syntactic conditions (repeating inflected

words), it had been clinically suspected that productions could be influenced by something other than syntax.

Chapter 2

Method

Selection of Stimulus Lists

In order to compile the stimulus lists, the author first looked through materials used during Speech Therapy sessions conducted by Speech Language Pathologists with aphasia patients to remediate verb usage. To compile lists that were controlled for the factors being considered in this dissertation four main sources were used to determine which verbs from that initial list should be included: Verbs, verbs, verbs, (Beyer, et al., 1977), Frequency analysis of word usage, (Francis & Kucera, 1982), Words to rhyme with (Espey, 1986), and 30,000 selected words (Blockcolsky, Frazer, and Frazer, 1979)(listed according to initial and final consonant sounds and clusters). Any words with irregular past tense form were omitted. Ten words were selected for each of eight groups of words. All of the words can be nouns as well as verbs; about one half take syllabic inflectional endings (see Tables 1-4).

Eight word lists with 10 words from each of the following categories were selected: large and small gangs, high and low frequency, bisyllabic and trisyllabic words, final consonant and final consonant cluster for a total of 80 words. The reading and repetition tasks consisted of the 80 words in each of three forms (stem, past tense, 3rd person) for a total of 240 words for each task. The sentence completion task consisted of 80 words in 2 conditions, for a total of 160 words; there are no stem responses in this condition. As a result each subject was expected to give 640 responses. The following guidelines were used to select the words for each category.

Rhyme-Gang Membership

Starting at the midpoint of the Frances and Kucera list (3500th word) and working forwards and backwards from the mid point, verbs were sought that were monosyllabic thereby establishing a list that was considered mid-frequency. Using a rhyming dictionary (Espey, 1989), the author next established large and small rhyme-gang groups from the verbs selected (Table 1). You will recall that according to Stemberger and MacWhinney (1988) to be considered members of the same gang, words not only needed to share pronunciation, but spelling as well. For purposes of this study, rhymed pronunciation of stem forms that were regular when inflected in the past tense and third person present forms was the only criterion for selection. Verbs were considered members of a "large rhyme-gang" when the gang consisted of five or more verbs with endings that rhymed; "small rhyme-gangs" had 5 or fewer members. Mean frequency for large gang verbs is 37.4 with a range of 22 to 62 occurrences per million. Mean frequency of the small gang list is 38.3 with a range from 22 to 71 occurrences per million (Francis and Kucera, 1982). On average the large rhyme-gang members belonged to a group of 7.9 and had a range of 16 to 5. The small rhyme gang members belonged to a group with an average of 2.8 and had a range of 1 to 5. Once gang size membership was established, word pairs were selected or omitted based on final consonant match whenever possible. All but two pairs (four words) were matched for final consonant. These were selected based on the similar place of production for the final consonant of one pair (kiss, sign) and the similar manner of production for the final consonant of the second pair (blame, ruin). Words ending in final /r/ were not included as stimulus items to avoid issues of speakers of "r"-less dialects.

Pairs of words were chosen based on the number of rhyme forms listed in Espey (1989). For the large rhyme-gang word member of the pair number of existing members to the rhyme group was greater than the number of existing rhyme group members for the small member of the pair. The criterion for distinguishing each large gang group from its matching small gang group is that there is a ratio of at least 5:3 (see Appendix A).

Frequency

To establish lists of high and low frequency verbs, the evaluator started at each end of the Francis and Kucera's (1982) rank list of frequency and listed the first and last monosyllabic verbs that met the general criteria for selection (i.e., verbs were not irregular and 9 out of 10 word pairs had the same final consonant). The words on the rank list are based on "lemma frequency" (i.e., the total frequency for all forms). Table 2 shows the range of high frequency stimuli falls between 1016 and 89 with low frequency falling between 2 and 20. *Use* with a frequency of 1016 is the highest frequency monosyllabic regular verb in the language. It was matched with the lowest frequency word ending in the same consonant (i.e., *sneeze*).

Word Length

Low frequency monosyllabic words were compared to low frequency bi- and trisyllabic words (Table 3) in order to determine the effects of a word's length on the subject's ability to inflect the verb. The frequency of occurrence for bi-syllabic words selected for this study falls between 30 and 44 occurrences per million and for trisyllabic words the frequency per million falls between 9 and 19 occurrences. I wanted three comparable lists of mono-, bi- and trisyllabic words. The aim was to balance the three lists for frequency,

final consonant or consonant cluster, and whether a stem took the syllabic inflectional morpheme (*sneeze, sneezes*) or a single phoneme (*drown, drowns*). Due to the structure of multisyllabic words (they frequently end in one of a limited number of derivational word endings) final consonants are matched for only 50 per cent of the words in this list. As a result bi- and trisyllabic words were compared with low frequency words (frequency ranged between 2 and 20).

Final Consonant Contrasts

The final list compiled consisted of minimally paired verbs that were matched for final consonant or consonant cluster (Table 4). Frequency of occurrence on this list is matched within each pair of words for final consonant and final consonant cluster (all are low frequency words the highest being *grab* at 37 and the lowest being *raft* with a frequency of one). For example, *clap* with a frequency of 7 is matched with *clasp* a frequency of 9. Both *shell* and *shelve* have a frequency of one.

Subjects

Eight subjects were selected who had an original diagnosis of Broca's aphasia. At the time of their inclusion for this study their subtest scores on either the (BDAE) or (WAB) placed them within the mild to moderate range of agrammatism (see Table 5). Five subjects were referred by Speech Language Pathologists with whom they had been involved in speech therapy prior to the time of the study. Three subjects were recruited from a stroke support group. No subject was involved in speech therapy at the time of testing. All subjects had single lesions from a first time stroke, with no indication of dementia or

other neurological disease based on history and/or reported CT scan or MRI results. Length of time post onset varied from 6 months to 7 years. While subjects with neuro-imaging results were preferred, non-availability of such information did not exclude subjects from participating. Background information furnished by the referring Speech Language Pathologists indicated that all subjects had left CVAs. The actual CT scan report was available for only one subject. This was available because she had been followed as an acute care inpatient by this author. All subjects were treated according to ethical standards of the American Speech Language and Hearing Association (which is based on standards of The National Institute of Health). All subjects were native speakers of American English, were not bilingual and had no history of alcohol or substance abuse. Subjects who had learned a second language in high school or college, but did not speak it as a primary language at any time, were included in the study.

Subjects were considered agrammatic following judgment by two speech language pathologists (the author and an independent listener who was a certified Speech Language Pathologist) who rated their performance on the Picture Description Subtest on the particular standardized test administered. Subjects who omitted two or more functors or bound morphemes from their picture description were included. In addition, all subjects were scored for melodic line, phrase length, articulatory agility, and grammatical form profiles in accordance with BDAE standard scoring procedures based on speech sampled during their picture description. Subjects who had the battery administered within the last six months and had achieved results as described above were accepted based on the existing score; others were retested.

Subjects were screened to rule out hearing loss using pure tone audiometry. Hearing of at least 25 dB at 500 and 1000 Hertz, and 40 dB at 2000,

and 3000 Hertz in the better ear was considered adequate for inclusion in this study. This is consistent with ability to hear in a quiet setting when the listener is able to see the speaker for conversational speech (D. Lynn CCC-A; personal communication).

Experimental Protocol

During the first session, subjects who were identified as appropriate and who had signed informed consent forms were administered an intelligibility screen (Table 6) and an auditory comprehension screen (Appendix B). The auditory comprehension task was administered to insure subjects' comprehension of target inflections (3rd person /z/ and past tense inflection). Subjects were asked to point to the picture that demonstrated the sentence that was auditorily presented. Pictures were selected from the Sentence Structure subtest of the Clinical Evaluation of Language Fundamentals-Revised (Semel and Wiig, 1987) and the Patterned Elicitation Syntax Test (Young and Perachio, 1983).

On the intelligibility screen, subjects were asked to repeat 20 non-inflected one and two syllable words. All subjects included in the study scored between 80 and 100% phonemes correct on this probe. Errors took the form of sound substitutions as judged by this investigator. No subject made more than one sound substitution in any word. Five additional subjects were administered the screening protocol and eliminated from completing the entire protocol secondary to various problems: hearing impairment, dysarthria, inappropriately diagnosed as moderately agrammatic, other health problems.

During presentation of the word lists the subjects were seated across from the evaluator. One half the subjects were presented with the reading

task first; one half began with the repetition task. All subjects were presented with the sentence completion task last since piloting revealed this to be the most difficult task. Words were presented in pseudo-random order (Appendix C). No more than two contiguous words on the reading or repetition tasks had the same stem or inflected ending. No more than two words from the same word list were contiguous. Order of presentation of words varied for each subject. Prior to administration of the reading task the subjects were told: "I am going to show you some words. Please read them as clearly as possible." Words were presented one at a time from flash cards with print size of one inch. Prior to administration of the repetition task they were told: "I am going to say a word. Please repeat exactly what I say as clearly as possible". Specific instructions for the sentence completion task included an example of the task with trial items to insure understanding (see Appendix D). Order of presentation of target tense alternated for each sentence completion item between third person and past tense being presented first and second. For example, if item 10 targeted third person first, then item eleven targeted past tense first.

Clinical judgment was used to switch tasks as appropriate for each subject. For example, when the subject was struggling to read words (as evidenced by 3 or more cues for each word) the task was switched. Reading was then completed after success had been achieved at a different task (e.g., sentence completion). The examiner gave a phonemic prompt when there was no spontaneous response produced. Following 3 attempts, the evaluator modeled the correct response. Even if the subject then repeated it, the response was counted as a *no response*.

Subjects were reassured that they could stop whenever they felt fatigued. They were told that it was important to give the best answer they could and that if they needed to self-correct they could do so.

Generally between two and three sessions of no longer than two hours each were necessary to administer all of the material. Two subjects insisted on continuing to complete all the testing in one day. They were given breaks throughout the administration of the tasks. The first session usually consisted of a standardized aphasia battery (if one had not already been administered), as well as the hearing screen. The second session included administration of the screening tests and the reading or repetition tasks. The third session included the sentence completion task.

Procedures

Construction of Listening Tape

All responses were audio taped using a SONY Digital Audio Tape-corder Model TCD-D7 at a digitization rate of 48K Hz sampling rate. The subjects spoke into a microphone that was attached to a headset (Shure Professional Head-Worn Dynamic Microphone Model # SM10A).

Audio tapes were edited using digital wave formatting analysis program Q Display.EXE (Weiss, 1990) which had been modified by Eddie Yueng for the purposes of a prior analysis (Modified QDisp1) by this author. Such editing was necessary to allow for presentation of only target utterances without the influence of spontaneous conversation or carrier phrases that may have occurred throughout the taping session. In addition, agrammatic aphasics frequently utter false starts before producing their target utterance. False starts were edited out; the final response (from a possible string of responses)

was considered the target response. For the most part, subjects indicated their dissatisfaction with a response by continuing to revise it. They were allowed to continue revising until they indicated satisfaction by no longer speaking. Occasionally, clinical judgment was used to determine if subjects needed a prompt to move on to the next item.

Subjects' edited utterances were made into a file for each target utterance. Words were then randomized by the program and retaped with 5 seconds between each word at a digitization sampling rate of 22.05 Hz, resulting in listening tapes of about 20 minutes (based on 5 seconds per word and 640 words). Responses were re-edited into listening tapes using a Marantz Model PMD 430 tape recorder. A separate tape was made for each subject.

Rating of Listening Tapes

Four raters who were enrolled in a Master of Science program in Speech Language Pathology were asked to serve as response judges. Each rater listened to each tape of 640 words two times. Separate tapes were made for each subject so that each rater listened to eight tapes. Control lists were randomized for presentation and order of presentation was randomized on the listening tape so that words were not rated in the order in which they were presented and responded to by the subjects.

A sample tape, made up of utterances of 5 words from each task, was used to train raters for uniformity of rating. Within each listening session, order of presentation of lists for stem and affix judgments was alternated. Following the presentation of each list there was a pause of 10 minutes to give the raters a rest.

In the stem-rating task, listeners were asked to listen to the tape concentrating on the stem part of the word. Raters were told to judge whether the word is produced 1) correctly, 2) as a different word, 3) with distortion, or 4) no response (see Appendix E for response sheet). If the correct response was *hooks* and the subject said *hooked,* the rater was to judge the answer as correct. If the subject said *book* the word was judged incorrect (either as distorted or as a different stem, but in either case incorrect). Raters were given the following categorization rules for stems:

1. Correct Production of Stem- Production of all sounds are the same as the target word. Stress "errors" are included in this category.
2. Distorted Production of Correct Stem- Productions that include omission, addition, substitution and/or distortion of one or more vowels, consonants or syllables. The word is still identifiable as the target.
3. Production of Different Word- Response is identifiable as a different word in English.
4. Other- Response does not bear any resemblance to the target and is not a word in English. When subjects gave a response that indicated that they could not complete the task (e.g., "no" or "I can't") these verbalizations were counted under this category.

In the affix-rating task, listeners were asked to listen to the final part of the word. They were asked to judge whether the final part of the word

represented 3rd person, past tense or had no suffix (see Appendix F for response sheet). Response sheets included the target verbs in order to rule out a word effect resulting from repeated presentations of each word. (Since I was interested in only the affixes, it was important that if the subjects perseverated on one of the roots, that the raters concentrated on the affix production only and rated it despite what the stem was.) I stressed to the listeners that they were not to make any judgments as to the stem during this task. If the correct answer was *hooked* and the subject said *baked*, that was to be judged a correct response.

For both the affix and stem rating tasks, the scores were reduced to correct or incorrect. Percentage of correct responses for each subject was calculated and compared for past tense, 3rd person form and infinitive (stem) form for affix and stem for the reading, repetition and sentence completion tasks. Items upon which the subject did not respond were not counted. Items were scored as *no response* when a subject was unable to respond to an item after a cue was presented three times or when a subject said "no" after presentation of a stimulus. Including the *no-response* as errors would have resulted in inaccurate percentages correct since there would have been an exaggeration in the number of errors made by each subject. Furthermore, only one subject (Subject 7) had a large amount of *no response* and this occurred only on one task (reading). This subject had 45 *no response* of the 240 words read compared to an average of 4.42 *no response* for the other seven subjects (range 0-15) on this task.

Statistical Analysis

A Kappa statistic was computed to measure degree of consensus among raters. Kappa takes into consideration both occurrence and non-occurrence of behavior corrected for chance agreement among observers. It does not tell whether the observations are valid, but is the preferred procedure to be used for multiple observers and multiple categories (Statler, 1990). Results of the Kappa analysis for the affix rating are shown in Table 7. Average Kappa scores are consistent with conventional measures of reliability.

Rater results were tabulated on a two point scale (zero for different word, no response, or distorted production; 1 for correct response for stem analysis and 3rd person, past tense, had no suffix or other for the affix response analysis). The correct responses were totaled and a percent correct score was tabulated across raters. ANOVA repeated measures analyses were performed with three independent variables (task, target affix presence and word lists). The levels of the task variable were reading, repetition and sentence completion. The affix independent variable included three levels: past tense, third person singular and stem only. The word list independent variable included eight levels: high and low frequency, large and small gang, bisyllable and trisyllable, final consonant, final consonant cluster. Since the sentence completion level of task did not have data for the stem-only condition, two separate analyses were run. The first analysis was a 2 X 3 X 8 analysis that excluded the sentence completion task and the second was a 3 X 2 X 8 analysis that included the sentence completion task but excluded the stem-only level of the affix variable (null condition). Separate ANOVAs were performed for each dependent variable (stem score and affix score) (See Appendix G). Stem and affix scores were computed by calculating the percentage of correct responses for each group of words in each task and affix

condition (See Table 8). For listings of the mean percent correct for each word list and subject see Appendices H and I respectively,

Chapter 3

Results

Four ANOVA analyses are presented in Table 9. These will be discussed in detail in what follows.

Affixation Analyses

Word List Effects

There is a significant effect of word list for the Affix 2 X 3 analysis in Table 9 (p <.001). Figure 1 shows five word lists with relatively higher correct responses and three word lists with relatively lower correct responses. Five of the monosyllabic word lists (high and low frequency, large and small gang and single consonant) are easier to produce with the appropriate final affix than the other three.

Pairwise comparisons were made of contrasting word groups (Table 10). Apparently the word characteristic that matters is the length of the stem. There is a significant contrast between C and CC and Lo vs. Bi- and Lo vs. Tri- (p <.006, <.001, and <.012 respectively; see Table 9). These results indicate that aspects of the length of the stem affect the affix and that longer verb stems (consonant cluster, bisyllable, and trisyllable lists) are less likely to be affixed correctly. However, results of comparisons between bi- vs. tri- syllable verbs do not significantly differ from each other (see Table 10), but rather only when monosyllabic (low frequency verbs) are compared to either tri- or bisyllabic verb stems does ability to affix become significantly affected.

Word list effects are marginally significant for the Affix 3 X 2 analysis Table 9 (p < .071). This analysis excludes the stem-only condition but includes

all three tasks thereby including only results of affixed responses. It also includes results of the sentence completion task. Figure 2 indicates that the pattern is very similar to the Affix 2 X 3 analysis seen in Fig. 1, with shorter words being easier to affix although the overall percentage correct is much lower. Only one contrast, single consonant vs. consonant cluster shows a significant contrast for planned comparisons (p <.05, Table 10, Affix 3 X 2).

Affix Effects

ANOVA of Affix 2 (tasks) X 3 (affixes) (Table 9) indicates significant effects of affix p <.005. Figure 3 shows that the unaffixed verb (/Ø/) condition is the easiest to produce, followed by the 3rd person /Z/ with the 3rd person /D/ being the most difficult affix to produce. There is a significant difference between stem-only and affix past tense (see Table 11; p <.008) and between past tense and third person (see Table 11; p <015).

The Affix 3 X 2 analysis excluding the /Ø/ condition is likewise significant p <.013 (Table 9). The pattern is the same when all three tasks are considered with only the two affixed conditions (Fig. 4). There is a significant difference between past tense and third person (see Table 11; p <013).

These findings, that third person /D/ is more difficult to produce than 3rd person /Z/, expand upon Goodglass and Berko's (1960) results regarding order of difficulty of morphemes over a greater range of tasks and with greater control of stimulus words. The discussion section will elaborate upon this expansion.

Task Effects

Significant task effects for Affix production were found in both the 2 X 3 analysis and the 3 X 2 analysis (p<.015 and p<.003 respectively, Table 9). When

the sentence completion task is removed and the stem-only condition included (see Fig. 5), there is a smaller but still significant effect seen. There is no comparison of the sentence completion condition with reading or repetition in the 2 X 3 analyses because sentence completion is not included in the 2 task analysis. Figure 6 represents the mean per cent correct for production of all 3 tasks and 2 affixes (/D/ and /Z/). It can be seen that affixes are significantly easier to produce for the repetition task than for reading and sentence completion tasks.

Pairwise comparisons are significant for reading vs. repetition in both Affix 2 X 3 and 3 X 2 analyses (p <.0.5 and .017 respectively). Furthermore, when there are three tasks without the stem-only condition, there is a significant difference between repetition and sentence completion tasks (p <.005; see Table 11).

Task ease has same effect regardless of word list (repetition always easiest) (see Fig. 7). For all three tasks there are significant effects of producing affixes. There are differences in difficulty of the task, but they have the same effect on the affixes (stem-only the easiest followed by /Z/ and /D/ the most difficult).

Stem Production Analyses

Word List Effects

Of the three main effects measured, the only one that significantly affects the ability to produce the stem is word list (p <.001 for both stem analyses, see Table 9). Just as in the affix analysis, the word lists can be divided into two groups based upon length effects or a general complexity

effect. Number of syllables is also important for the stems. It can be generally observed (see Figs. 8 and 9) that as stems get longer (bisyllable, and trisyllable lists) they are less likely to be produced correctly than are shorter stems. Stems that are monosyllabic are more likely to have the affix correct than are stems that are bi- or trisyllabic. There is not a significant difference between bisyllabic and trisyllabic stems as to correctness of affixation (see Table 10).

When reviewing pairwise comparisons for stem effects there is an additional effect of gang ($p < .005$ and .013 for Stem 2 X 3 and 3 X 2 respectively; see Table 10) in the direction that is expected (i.e., small gang stems are easier to produce than are large gang stems). The phonemic complexity of the stem has less effect on the ability to produce the stem, than on the ability to add an affix to the stem.

Affix Effects

There are no significant effects of affix on the speakers' ability to produce the stem ($p < .311$ and .263 for Stem 2 X 3 and Stem 3 X 2 analyses respectively; see Table 9). The greatest number of correct stem productions occurred when there was no affix (Fig. 10).

Task Effects

The speakers' ability to produce the stem is not significantly affected by the task ($p < .330$ and .165 respectively; see Table 9, Figs. 11 and 12). Despite the nonsignificant difference for stem production the stem is easiest to produce correctly in the repetition task, just as it was for affix production. Similarly, reading is easier than is sentence completion, but not significantly easier.

When repetition is compared to sentence completion for two affix conditions, there is a significant effect on the stem ($p < .037$, Table 11).

Interaction Effects

Of the eight potential 2-way interactions on Table 9, only three are significant, two for affixation and one for stem. Plots of the three significant interactions are shown as Figures 13-15. There is no discernible pattern to the two significant interactions for affixation. For the stem condition, the only significant interaction (Table 9, 3 T X 2 Af), can be interpreted to show that task performances are more diverse for syllable and trisyllable conditions.

Summary

Results indicate that there are effects of the nature of the stem on the ability of a speaker to add an affix. In addition, affixation is easier for some tasks than others and for an affix to be added has a significant effect.

The situation is rather different when we turn to the ability of the speaker to produce the stem. Longer words (bi- and trisyllable words) are harder to produce than are shorter words. However, there is an effect of the gang size of the word on the ability to produce it. Overall there are no significant effects of affix on stem production. For planned comparisons, there is a significant difference between the repetition and sentence completion tasks. Given the large standard deviations (see Table 8), these significant results are all the more impressive.

Chapter 4

Discussion

Although previous research had determined that agrammatics omit affixes differentially (e.g., De Villiers, 1978; Goodglass & Berko, 1960), whether it mattered what stem they are added to had not been determined. I sought to predict if certain stems could be more easily accessed than others and when these stems had affixes appended, whether certain affixes were more easily added than others. I questioned whether certain aspects of morphophonology are differentially preserved among different subject groups by looking at the difference in effects on stems of different length and rhyme-gang status in three different tasks. Since word frequency is often clinically referred to as a factor influencing production of verbs, I took that into consideration as well. Conclusions are often reached based on research done with one task and generalized to other tasks. Therefore, I used three different tasks with the same stimulus words.

Early perceptual studies (Shankweiler & Harris, 1960; Johns & Darley, 1970; Trost & Canter, 1974) and acoustic studies (Collins, Rosenbek, & Wertz, 1983; Kent & Rosenbek, 1982) investigated the difficulty of phoneme production in different word positions in Broca's aphasics. They agreed that there was a motor production problem, however, the question remained as to whether the grammatical difficulties that often accompanied motor disturbance in Broca's aphasics were motorically based or linguistically based. In recent decades research focus has been on deeper morphosyntactic structures. The influence of more surface phenomena of word length

(number of syllables and final consonant status) and rhyme-gang membership on one or another aspect of word production has been refocused on here.

The present results suggest that phonology cannot be discounted even in patients who are not dysarthric. Significant differences were found for all three phonological factors looked at (word length, final consonant status and rhyme-gang membership). Phonology makes a difference for these subjects, despite the fact that they were selected to have no frank motor production speech problems.

Word List

Recall that this study was built around comparisons across pairs (and one triad) of word lists. Although word list did affect the ability of aphasics to inflect and produce stems, the effects were not always as hypothesized. Word list effects will be individually discussed in what follows.

Word Length

The first manipulation of word length in this dissertation was to contrast monosyllables that ended in a consonant and monosyllables that ended in a final consonant cluster. The present data are consistent with the finding of Martin, Wasserman, Gilden, Gerstman, & West (1975) whose subjects had difficulty producing words that ended in consonant clusters. Item analysis of the current data would determine if their finding that morphologically marked consonant clusters (e.g., crossed) are easier to produce than are unmarked consonant clusters (e.g., breast). Increased errors occurred in both studies for the monosyllables that had inflected morphemes

added to stems with final consonant clusters, in reading, repetition and sentence completion tasks.

Word length was also investigated in the current study by looking at mono-, bi-, and trisyllabic words. Traditionally bisyllabic words are considered easier than trisyllabic ones to produce. Recall that in a series of experiments that looked at the acoustic effects of word length, Kent and Rosenbek (1983) and Collins, Rosenbek and Wertz (1983) found that aphasics were sensitive to length effects as evidenced by their ability to reduce vowel length as words lengthened. Those authors did not address whether morpho-syntactic difficulty added to the articulatory or phonemic deficits present, but rather attributed the entire problem to motor deficits. The present data suggest that stem length affects morphosyntax as well, since it was easier to inflect stems that were monosyllabic rather than multisyllabic and stems that ended in a single consonant rather than a consonant cluster.

The current data also suggest that production does not necessarily become more difficult as the number of syllables increases, but rather that it is harder to inflect words that are multisyllabic as compared to monosyllabic words. The differences were not significant when bi- and trisyllable words were compared. However, when monosyllabic words were compared to either bisyllabic or trisyllabic words, significant differences were found. Furthermore, this dissertation shows that the difficulty that aphasics exhibit when producing inflections is not just a result of the act of initiating the production of the morpheme, but that it is indeed secondary to phonemic lengthening of any type (i.e., number of syllables or number of phonemes either of which may or may not be inflectional).

As for efficacy of word stem production in this study, stems were significantly more difficult to produce when they were greater than one

syllable in length as well as when they were affixed. The latter finding is consistent with that of Gibson and Guinet (1971) who found that increasing word length by adding an inflection interferes with the likelihood of a word's being read correctly since the number of features being read changes. The data from my study that show stems to be less distorted without an affix are consistent with Gibson and Guinet's claim that when reading an affixed word the person must pick up two kinds of information, orthographic and semantic features of the base plus the syntactic information of the affix. The number of features alone does not account for production correctness since affixed words in this study were harder to produce correctly than unaffixed words of the same length, when a single phoneme or syllable was added. Gibson and Guinet concluded that morphosyntactic information load plays a role in the ability to produce a word. On the other hand, since in this study production deteriorates in the stem-only condition when words are lengthened by adding phonemes or syllables (neither of which are additional features), we may assume that phonology plays a role as well.

Once again the reason for affixed words being more difficult to produce than unaffixed words is not simply the result of one feature (i.e., adding an affix) as is claimed by Gibson and Guinet (1971). The finding that past /D/ affix is significantly more difficult than third person /Z/ affix to produce tells us that there is something about the particular affix other than its mere presence that influences a speaker's ability to produce it. Perhaps it is less costly to omit /D/ since it marks for tense, whereas /Z/ marks for tense and agreement.

The number of syllables affected the subjects' ability to produce the stem appropriately. As long as the stem contained more than one syllable its production was less efficient than was that of other matched single syllable

words. The lack of an effect between two and three syllable words may be linked to the fact that many of the three syllable words were three syllables as a result of the third syllable being a derivational suffix.

Adding a consonant to the final phoneme (making it a consonant cluster) did not affect the ability to produce the stem but it did affect the ability to affix it. The effect does not seem to be a result of the number of syllables but rather just a simple syllable effect (any stem that is longer than one syllable is difficult for agrammatics to produce). Recall that Goodglass and Berko (1960) concluded that the phonological complexity of the inflection is not a factor in determining the difficulty of producing affixed verbs; the current data indicate that the phonological complexity of the stem influences the ability to inflect it since it was significantly harder to inflect verbs that ended in a CC.

Earlier studies that lengthened words by adding prefixes, suffixes and phonemes (Johns & Darley, 1970; Shankweiler & Harris, 1960; Trost & Canter, 1974; Martin, Wasserman, Gilden, Gerstman, & West, 1975) were not wrong when they concluded that longer words are more difficult for Broca's aphasics to produce. However, in view of the present findings, it is necessary to qualify the conditions that contribute to the difficulty, especially since there were no significant differences between production efficiency of two and three syllable words.

Another important implication of the results of this dissertation is that apparently there is an interplay which exists between surface and deep structure that had not been suspected in either the research which focused on motor deficits or syntactic deficits. Research on specific language impaired (SLI) children (Montgomery, 1995) found that increased demands of phonological working memory were suspected of causing a decrease in

sentence comprehension in the presence of intact syntactic semantic knowledge at the sentence-level. Children with SLI had difficulty repeating nonsense syllables of more than two syllables. They also had difficulty repeating longer redundant sentences than shorter non-redundant sentences. The authors argued that this finding is evidence that phonological working memory impacts on sentence comprehension (i.e., surface structure impacts on deeper structure of semantic-syntactic integration). Given these results, is it unreasonable to suspect the same effects on the speech production system? It seems that the results of word length analysis in this dissertation are evidence of this.

Rhyme-Gang

This dissertation sought to determine whether one could predict where the breakdown of words occurs in production for reading and two additional tasks based on the number of words in a rhyme-gang. There were no significant effects of affixation based on the size of the rhyme-gang, even when the reading task (where phoneme-grapheme gang effects have been reported) was considered separately. However, where significant effects of this variable did arise was with the stems themselves. Whether or not an affix is added to the stem, there are more correct stems produced from the small gang list than from the large gang list (see Table 8).

The present findings with agrammatic subjects are consistent with Stemberger and MacWhinney's (1988) findings for base forms that closely resemble inflected forms (e.g., *drank/spank*) in normal subjects' ability to produce inflected verbs in a fill-in task. The lack of a gang effect for their regularly inflected forms is consistent with no significant effect for the large rhyme-gang words in the present study. Their regular verbs were limited in

phonological shape, however; they all ended in /t/ or /d/. The present results expand this for verb stems belonging to gangs ending in varied phonemes.

On the other hand, this study found that membership in a small gang significantly facilitates production of the stem, even though there is no effect on the agrammatics' ability to inflect it. For the stems alone, this could be a result of there being fewer members to confuse with the target and fewer members for these mild agrammatics to search through before coming up with the target response. According to Rumelhart and McClelland (1982) pronunciation of pseudowords results from partial activation of all the words in their neighborhood. It is reasonable to assume that the same holds true for the pronunciation of real words and that in aphasics the wrong selection is often made resulting in a rhyme-gang effect. This suggests that errors and fluency problems observed in agrammatics' speech are not random, but influenced by the similarity of verbs close to the target. Although normal speakers are able to select the appropriate target when a number of similar-looking or sounding words are activated, apparently aphasics are not able to select as accurately. In fact, given the significant findings for small gangs, aphasics (or at least agrammatics) do better when there are fewer choices.

Frequency

There were no significant effects of word frequency on stem or affix production in this study. You will recall that previous research that addresses word frequency in aphasics generally agreed that highly frequent words are better spared. It was therefore hypothesized in this study that it would be easier for agrammatics to inflect high frequency words. Further review of the literature reveals that the generalization upon which the hypothesis is based was established as a result of lexical decision tasks comparing content

and function words (Bradley, Garrett & Zurif, 1980), high frequency words that are functors (Ellis, 1985), high frequency roots being accessed faster than low frequency roots for irregularly inflected verbs in a lexical decision task (Cole, Beauvillian, & Segui, 1989), and nouns (Goodglass, Hyde & Blumstein, 1969). In the study by Cole, Beauvillian, and Segui (1989) it was determined via lexical decision tasks that it takes longer to recognize a less frequent than a more frequent word, implying that longer recognition results in reduced ability to produce less frequent words as well. In the current study such results were not obtained for speech production tasks in what is presumably a population similar to theirs.

As pointed out by Kelliher and Henderson (1990), it may not be possible to generalize findings across word types, as has been the practice in the past. Stemberger (1995), agrees that different classes of words are differentially affected by frequency. Furthermore he states that frequency effects on regular words may be so small that they are undetectable. Results of the present study show that high frequency verbs are not significantly easier to produce. Past studies that have shown that frequency is a factor in content word recognition have focused on nouns (Bradley, Garret and Zuriff, 1980). Work which shows frequency effects for nouns in lexical decisions has also been done with normal subjects in the past (Monsell, Doyle, & Haggard, 1989).

Rapp and Caramazza (1997) investigated word frequency effects using different modalities in a single study. They concluded that it is not possible to determine whether frequency of grammatical class (verbs or nouns) affects spoken and written sentence production in agrammatics. Since their data set confounded word frequency and grammatical category, they determined that either can be responsible for differential production of spoken output. Further recent evidence indicates that when words within the same

grammatical class are matched for frequency, there is no evidence that frequency impacts "on the message-driven lemma retrieval" (Berndt, Haendiges, Mitchim, & Sandson, 1997b).

This dissertation controlled for both factors (frequency and grammatical class) with varied tasks other than lexical decision. Since verbs take different syntactic roles from those of nouns or functors[3] (they tend to have more complex interactions than nouns do), it was appropriate to use verbs as stimuli in this study, so that frequency effects of verbs could be determined. It is entirely plausible they are not as sensitive to frequency effects as are other parts of speech. In fact the present data suggest that verbs are indeed different from nouns since, as in Stemberger and MacWhinney (1988), there were no frequency effects in this study. In both studies subjects had more errors on low frequency verbs that were inflected, but differences were not significant. Stemberger and MacWhinney suggest that the production of regular forms is so easy that low frequency forms are not at a disadvantage. Item analysis of the present data could determine whether this is the case by looking at the type of errors made by the subjects. If for example, errors for high frequency inflected words were found to be inflectional distortions or substitutions, as opposed to omissions (i.e., stem only productions indicating stem bias) for low frequency inflected targets, then we could assume that there is indeed a high frequency advantage. If error analysis found similar types of errors for words from both lists, then indeed we could assume no advantage for high frequency inflected words.

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[3] The relationship of the verb to its clause is the basis for assigning thematic roles and the object of a sentence, whereas, thematic role of nouns is assigned based on the predicate (Caplan, 1987). Furthermore, verbs determine the basis of the argument structure and therefore the organization of the sentence revolves around the verb (S. Eisenberg, personal communication).

The lack of frequency effects in both the present study and in Stemberger and MacWhinney (1988) is evidence that inflected forms are not stored in the lexicon. The findings that inflected forms are not stored in the lexicon, that they lack frequency effects, and that subjects exhibited the ability to retrieve the verb without the ability to inflect it is consistent with Friedmann and Grodzinsky (1997). They claim that the agrammatic's deficit is at the level of the tense node. The verb is uninflected at this level having been retrieved from the lexicon and is inflected at a later syntactic level. The worst performance on the sentence completion task of this dissertation in fact shows this level of breakdown. Past research upon which my hypothesis was based (that high frequency words would be easier to inflect) did not focus on production as my sentence completion task did, but rather on reading aloud, repetition and word recognition (lexical decision). Furthermore, as stated a number of times already, in previous studies verbs were not used as stimulus items nor were words controlled for other features to the level that they were in this dissertation.

Stem frequency did not affect the ability of these aphasics to inflect the verbs just as it did not affect the ability to produce regular past tense forms in the study by Stemberger and MacWhinney (1988). Perhaps Stemberger (1995) is correct when he suggests that irregular forms show frequency effects because they are stored as individual entries in the lexicon, whereas the production of regular forms by way of rules has them stored as separate units (stem + affix) diluting the effects of frequency since there is no systematic way to store inflected forms.

In the course of using Francis & Kucera (1982) to determine the frequency for stem stimuli, I observed that in general, third person forms are less frequent that past tense. Given that the less frequently used inflection

(third person) was easier to produce in the present study, and that the order of ease of production is not the same for different affixes with more than one phonemic representation (Goodglass and Berko, 1960) it is apparent that many features of the target must be accounted for when considering the ease of production of an affix.

Task

Three different tasks were evaluated in this study. Past studies of varied modalities (Shankweiler and Harris, 1960; Johns and Darley, 1970; Trost and Canter, 1974) used different tasks, but stimuli within each task varied as well. In the current study, the reading and/or repetition tasks were used to establish that for the most part the words could be produced in what was expected to be the easiest of conditions (repetition and reading). The same stimuli (inflected forms only) were presented in the sentence completion task to determine whether agrammatics could select the right alternative from a set of legal syntactic, morphological and lexical forms within their lexicon and then produce the words in speech. With this task I sought to determine whether the problems originated as a result of an inability to integrate the semantic syntactic properties of morphologically complex words into the higher-level sentential representation. The current results are consistent with those of Friedmann and Grodzinsky (1997) suggesting a syntactic deficit for agrammatics. Schwartz, Saffran, & Marin, (1980) and Tyler, Behrens, Cobb, & Marslen-Wilson (1990) also suspected such a syntactic deficit. At this point in time, I believe that the general feeling among researchers in the field is that a syntactic deficit would be considered the underlying problem in agrammatic aphasia.

A primarily morphological deficit is unlikely since the participants were able to produce the morphological forms in the reading and repetition tasks indicating that the inflections are accessible at some level. The problem cannot be at the lexical-semantic level because the verb stem is able to be retrieved in the sentence completion task, indicating that the words within the sentence were being connected with referents in a verbal context. Given the significantly reduced overall scores for the sentence completion task, one can conclude that morphosyntax is not preserved in agrammatic aphasia. This is consistent with Tyler, Behrens, Cobb, & Marslen-Wilson, (1990) who found that an agrammatic's deficit resulted from an insensitivity to the semantic-syntactic implications of suffix as well as tense violations in discourse.

Affix production is easiest across all word lists for repetition of inflected verbs. Comparison of the percentage correct scores on the sentence completion and repetition tasks with similar data from Friedmann and Grodzinsky (1997), yields similar results. Their subject repeated inflected verbs with 75% accuracy and filled-in inflected verbs with 45% accuracy. The agrammatic subjects in this dissertation achieved 63% correct on the repetition task and 41% correct on the sentence completion task.

It was hypothesized that the difficulty of the task (the sentence completion is the most difficult) would affect the ability to inflect the stem and to produce the inflected verb. The affix data in the present study support better use of the third person affix as compared to past tense affix for all three tasks. In addition, when a subject is required to inflect the verb on the sentence completion task, it is significantly more difficult to do than when the subject must repeat it. These data support findings of De Bleser & Luzzatti (1994) who pointed out that inflectional errors are a result of the difficulty level of "syntactic processing of content words" (p. 21). There is little

syntactic processing necessary for the reading and repetition tasks in this study. Although their study looks at past participle agreement, there is no reason to believe that their finding does not hold true for third person and past tense agreement as well. On the other hand, work by Rumelhart and McClelland (1982) suggests that words in context (as in the sentence completion task) are perceived as "primed" words and would undergo some sort of priming that should enhance production.

One could claim that repetition, due to the nature of the task, might also be considered priming. In this study, repetition is significantly easier and sentence completion is significantly more difficult when compared to reading of affixed words. Given the significant difficulty the subjects experienced with the sentence completion task for stems as well, although syntax is the most likely contributor to the difficulty experienced by these Broca's aphasics when they omitted inflections, the memory load with the sentence completion task should not be overlooked as a contributor as well. Of course, since the subjects had to only produce the target word as opposed to the complete sentence or even a phrase, the effects of memory load were less than they would be in spontaneous production.

Upon looking at the effect of task on the correctness of the stem we see that the resulting data supports Taft's hypothesis (1979) wherein he assumes that there is a lexical decomposition of words into morphemes with search conducted on the root regardless of the task. In addition, the data agree with Burani and Caramazza (1987) as cited in Cole, Beauvillian, and Segui (1989) who argue that the root and stem are represented independently of their affixes even in orthographic representations. Regardless of the task, it is easier to produce stems than to affix them.

Previously information about the way Broca's aphasics inflect verbs was gathered as a result of verbs produced in a variety of ways: Given-new sentence completion (Goodglass and Berko, 1960), single word repetition (Shankweiler & Harris, 1960; Martin, Wasserman, Gilden, Gerstman, & West, 1975), single word reading (Gibson & Guinet, 1971), lexical decision (Cole, Beauvillian, & Segui, 1989), and a combination of one or more of the above tasks (Badecker & Caramazza, 1987). The current data show that data gathered from verb production can differ across tasks. It is significantly harder to inflect a word in a sentence completion task than when it is being read or repeated. We can therefore infer that it is at least as difficult to do so when constructing the entire sentence. This finding must be taken into account when constructing tasks for future research.

Affixation

It is important to remember that agrammatics are thought to use infinitive or stem forms for reasons that vary from compensatory ease (Heeschen, 1985) and/or economy, to an inability to inflect due to impaired tense and agreement nodes (Friedmann and Grodzinsky, 1997). The latter researchers further note that milder aphasics will use the infinitive form of the verb when they are unable to inflect since it is the only way they can construct a sentence in the presence of impaired inflectional nodes.

The possibility that ease of stem production is the result of bias for stem form (i.e., increased correct production of the stem) cannot be overlooked. As a result, ease of stem production as a conscious strategy by agrammatics should not be used as an explanation without caution. Bastiaanse, Jonkers, Quak, & Varela Put (1996) show that producing infinitive forms in a verb phrase is not more difficult than producing them in isolation. Although all three of the

tasks in the present study require verbs to be produced in isolation, the sentence completion task called for verb retrieval in a verb phrase whereas the other two tasks did not. One could look at the errors in the stem-only condition in the sentence completion task and see if the number of times the stem alone occurred is greater than chance to determine whether there is a stem bias effect. Further research might include the stem-only condition in the sentence completion task and perform an error analysis of incorrect verbs to see when and how often the appropriate verb was retrieved without the appropriate inflection.

Stem production was not affected by the presence or absence of the affix. This supports the evidence that inflected forms are composed on-line and stored separately. Furthermore, third person affixes were significantly easier to produce than were past tense affixes, however, this did not affect the production of the stem either.

Summary

Having established a motor production problem in Broca's aphasia, previous research investigating the grammatical breakdown looked at four different areas to determine why the breakdown occurs: Unbound functor omission (Goodglass, 1968; Berndt & Caramazza, 1981), substitution of bound morphemes (Bradley, Garrett, & Zurif, 1980; Goodglass & Berko, 1960), inability to deal with syntactic complexities (Stemberger, 1985; Tyler, Behrens, Cobb & Marslen-Wilson, 1990; Bates, Wulfeck, & MacWhinney, 1991; Badecker & Caramazza, 1987; Miceli & Caramazza, 1988) and a problem with verb production (Schwartz, Saffran, & Marin, 1980; Friedmann & Grodzinsky, 1997; De Bleser & Luzzatti, 1994; Bates, Wulfeck, & MacWhinney, 1991).

Although this study does not address the issue of unbound functor omission except as it relates to the definition of agrammatism, the inability of Broca's aphasics to produce bound functors is a major focus of the study. The results are in agreement with Stemberger (1985) that there is greater difficulty accessing affixes only (the subjects were able to access the stems with greater ease). The relative ability of these subjects to produce stems in the absence of affixes is further evidence that the morphology is not integrated with syntax but rather that the subjects' sensitivity to semantic and syntactic information allows them to produce only the stem.

It was significantly easier for these subjects to produce the third person /Z/ than the past tense /D/. Calculating the percentage of obligatory contexts filled for a subset of eight morphemes, de Villiers (1978) found that past tense morphemes occurred more frequently than did third person morphemes in 8 nonfluent aphasics when "nonstructured" interviews were transcribed. The difference in order of difficulty may reflect the different tasks that were performed by the subjects. However, since I observed in the Frances and Kucera (1960) frequency list that past tense occurs more frequently in spontaneous speech than does third person, the wide range of ability seen in de Villiers's subjects could account for the discrepancy. De Villiers notes that "contexts for third person regular...are down by almost 50% from normal frequency" (p. 135). This raises the question of whether there is something about the task of constructing sentences that compromises third person inflections that does not occur when producing single words.

Comparison of either of these sets of results to findings of Goodglass and Berko (1960) is not possible since the latter analyzed their data separately for syllabic and phonemic inflectional endings. They found no significant differences. Goodglass and Berko's results indicated that syllabic 3rd person

/-ez/ is the most difficult of the affixes they tested, followed by phonemic past tense /-t, -d/. Syllabic past /-ed/ is easier than phonemic 3rd person /-s, -z/. De Villiers' (1978) results are consistent with Goodglass and Berko's results but inconsistent with the current findings over an increased variety of tasks and with greater control of the stimulus words.

The fact that both tense and agreement are marked by the third person inflection is also relevant to the present results. Bates, Wulfeck, and MacWhinney, (1991) found that the information load of the inflection (cue validity) plays a role in whether or not it will be produced. That could account for why these subjects found it easier to produce third person than past tense inflections. Furthermore, according to Friedmann and Grodzinsky (1997) tense is a higher node than agreement. If this is so then these agrammatics are really marking for agreement, not tense, when they mark third person since the third person inflection marks for both. If their impairment were lower down (at the agreement node), then they would be able to mark at least as well for past tense.

Schwartz, Saffran, and Marin, (1980) pointed out that impaired mapping between grammatical constituents is responsible for the inability to inflect verbs in agrammatic aphasia. The present study questioned the interaction between syntax and semantics. Results are consistent with Schwartz, Saffran, and Marin. Given the ability of these subjects to retrieve the verb and the inability to mark the morphosyntax we can conclude that there is a problem with the understanding of the role of the verb. Another way to look at the problem is as stated by De Bleser and Luzzatti (1994), that there is an inability to link inflection to the noun phrase.

General Observations

Clinical impressions that participants were aware of error responses were reinforced during the testing. The agrammatics more often than not commented "no" following the incorrect responses, even when they were unable to produce the correct responses. The results of Linebarger, Schwartz, & Saffran (1983) indicating that agrammatic aphasics are often able to make correct grammaticality judgments in the presence of agrammatism is further indication of this, however, the ability to determine correctness does not imply that expressive syntax is intact.

Results of this dissertation agree with Miceli and Caramazza (1988) that agrammatics exhibit morphological decomposition given these subjects' ability to produce stems without affixes. The difference in ability to produce the same stem with different affixes and in different tasks indicates that there is separate storage of the morpheme and stem.

In the absence of item analysis it is not possible to determine if Stemberger's (1985) hypothesis that agrammatics cannot correctly select from a set of possible alternatives is correct. Although subjects were able to produce the stem-words more efficiently than the affixed verbs, the analysis so far did not determine what they produced instead. Therefore, it is not possible to know whether they were unable to select or whether they were unable to access any appropriate morphemes.

Results of this dissertation are consistent with errors occurring between the functional and the positional levels of Garrett's model (1984). The positional level, according to this writer's interpretation, is where the syntactic form of the word gets inserted into the appropriate position. At this level the lexical phonological form is retrieved, and the assignment in the phrasal planning frame for phonological content and for morphological

elements occurs. The functional level is responsible for bound and free morphemes. Phonetic motor stages follow and result in the spoken utterance. Furthermore, it would seem that the problem for agrammatics occurs at the lexeme level (where phonologic form is specified) since the lemma level (semantic specification) is able to be specified, as indicated by these subjects' ability to produce the stem more appropriately than the affix.

Clinical Implications

Having noticed when working with agrammatic patients in rehabilitation that there were times when patients were able to produce verb phrases and other times that they became very disfluent when attempting to do so, I attempted to find some order to the apparently random errors by designing this dissertation. In particular, if we think of agrammatic speech as the result of a limitation of resources, as in the early notion of telegrammatic speech, then we would predict that more difficult stems would be less likely to have inflections added to them. When working with patients we are interested in how we can facilitate responses so that they can achieve the most success.

Results of this study show that affixes are significantly easier to produce for the repetition task than for reading and fill-in tasks. When there are three tasks, there is a significant difference between reading and repetition tasks, and between repetition and fill-in tasks.

Task ease has the same effect regardless of word list (i.e., repetition was always easiest). For all three tasks there are significant effects of producing affixes, therefore we should encourage patients to use stems in order to increase the functional level of communication. There are differences in difficulty across the three tasks, but they have the same effect on the affixes

(namely, stem only was the easiest task followed by /Z/ and /D/ the most difficult).

Clinically, results indicate that therapists should use reading and repetition tasks in order to facilitate responses when working on syntax with Broca's aphasics before going on to spontaneous production. In addition, selection of stimuli for therapy sessions should take into account the phonological complexity of the verb as well as the number of syllables in the verb.

Future research

In addition to the item analyses already mentioned, it would be interesting to perform item analysis of the individual responses to determine any patterns in affix and stem responses. If errors are phonemic as opposed to morphological (for affixes) we could infer that motor/phonology problems are not entirely ruled out in agrammatics. If results indicate morphological substitutions or bias towards the stem form, inferences about the organization of the syntax and the lexicon could be made. In the former case we could conclude that agrammatics know that an inflection is needed but are selecting the wrong one. If stem form bias is observed, we could conclude that the inflected forms are inaccessible or that choosing the zero affix is the default case in English as Grodzinsky (1984) argued and Menn and Obler (1990) confirmed. It is also possible that the agrammatic is not aware that an inflection is necessary. The latter finding has implications for speech therapy with agrammatic patients. Analyses of the stem responses for semantic and phonemic paraphasias could yield similar information.

An item analysis comparing stem-only responses with affixed responses could tell if there is stem bias or if in fact stems are easier to produce when

they are being produced as unaffixed words. Such an analysis could give insight into the strategies being used by agrammatics in view of the abundance of telegraphic utterances they produce spontaneously.

Further research could look at gang stimuli to see if verbs from large rhyme-gangs with characteristics looked at by Stemberger and MacWhinney (1988) are easier or more difficult to produce based on their similarity to regular third person words. For example, words such as *gaze*, *raise* and *haze* rhyme with *plays*. Gang theory predicts that words that are similar to regularly inflected forms (as in *gaze* sounding like the inflected *plays*) should be more difficult to inflect. Stemberger and MacWhinney found this not to be the case, but they did not consider the size of the gangs, only similarity of forms.

Future research is needed to determine whether length effects hold true for other inflections as well. The results of the present study indicate that word length affects the ability to add two affixes to a verb. Whether or not this effect holds true for other inflections and nouns is a question for future research. By the same token, it is important to know if these results hold true for more severely impaired agrammatics as well.

Finally, given the established order of difficulty of inflections for English as a second language (ESL) learners (Dulay and Burt, 1974), future research could look at the ability of ESL learners to use verb inflection in verbs that are shorter and less phonemically complex as compared to verbs that are longer and more phonemically complex. One could also look at (ESL) learners' ability to produce members of small gangs and shorter verbs.

Conclusions

In the past, researchers had looked at the affix as the culprit in agrammatism (Saffran, Berndt, and Schwartz, 1989). We knew that the verb was one locus where the breakdown occurred in agrammatism (Berndt, Haendiges, Mitchim, & Sandson, 1997a). The question of whether this is a result of morphology and morphosyntax was explored in this study. Verb tense inflection was found to indeed be problematic even for mild agrammatics. Results indicate that stem length is a factor in the ability to inflect verbs. As stems get longer, as in multisyllabic words or in words ending in final consonant cluster, the likelihood of the affix being produced is reduced. Finally this study presents evidence that research in morphology has overlooked phonological effects for too long and that agrammatic speakers' deficits are not as simple as merely omitting functors and morphemes from their speech.

Table 1

LARGE AND SMALL RHYME GANGS

	Verb	Frequency	Final C or CC	Syllabic Affix /Z/ - /D/	
				-	+
1.	a. guide	51	d		
	b. load	30	d	-	+
2.	a. drag	40	g	-	-
	b. beg	32	g	-	-
3.	a. scream	40	m	-	-
	b. climb	65	m	-	-
4.	a. blame	32	m	-	-
	b. ruin	22	n	-	-
5.	a. sign	62	n	-	-
	b. kiss	31	s	+	-
6.	a. brush	38	sh	+	-
	b. push	37	sh	+	-
7.	a. scratch	22	tsh	+	-
	b. touch	32	tsh	+	-
8.	a. snap	38	p	-	-
	b. step	71	p	-	-
9.	a. ease	25	z	+	-
	b. pause	40	z	+	-
10.	a. wave	26	v	-	-
	b. carve	23	v	-	-

Key:

Entries on line a are *large* rhyme-gang words; entries on line b are *small* rhyme-gang words.

+ syllabic affix indicates that the affix is a separate syllable in this word in English; - syllabic affix indicates that when the word is affixed the number of syllables does not change .

Large Gang: mean frequency = 37.4; frequency range = 22-62
Small Gang: mean frequency = 38.3; frequency range = 22-71

Table 2

HIGH FREQUENCY-LOW FREQUENCY STIMULI

Verb	Frequency	Final C	Syllabic Affix /Z/ - /D/	
1. a. use	1016	z	+	-
b. sneeze	3	z	+	-
2. a. stop	240	p	-	-
b. type	12	p	-	-
3. a. laugh	89	f	-	-
b. stuff	10	f	-	-
4. a. live	472	v	-	-
b. pave	9	v	-	-
5. a. train	130	n	-	-
b. drown	16	n	-	-
6. a. need	413	d	-	+
b. weed	2	d	-	+
7. a. reach	324	tsh	+	-
b. pitch	20	tsh	+	-
8. a. pass	298	s	+	-
b. pace	19	s	+	-
9. a. like	294	k	-	-
b. hook	11	k	-	-
10. a. move	447	v	-	-
b. knot	5	t	-	+

High Frequency list: mean frequency = 372.3; frequency range = 89-1016
Low Frequency list: mean frequency = 10.7; frequency range = 2-20

Entries on line a are high frequency words; entries on line b are low frequency words.

+syllabic affix indicates that the affix is a separate syllable in this word in English; - syllabic affix indicates that when the word is affixed the number of syllables does not change .

Table 3

BI- TRISYLLABIC STIMULI

Verb	Frequency	Final C	Syllabic Affix /Z/	- /D/
1. a. decline	37	n	-	-
b. discipline	14	n	-	-
2. a. equip	37	p	-	-
b. overlap	11	p	-	-
3. a. transform	37	m	-	-
b. imitate	13	t	-	+
4. a. behave	32	v	-	-
b. autograph	9	f	-	-
5. a. arouse	30	z	+	-
b. summarize	16	z	+	-
6. a. release	30	s	+	-
b. reproduce	19	s	+	-
7. a. exceed	39	d	-	+
b. circulate	11	t	-	+
8. a. attach	44	tsh	+	-
b. tolerate	14	t	-	+
9. a. address	40	s	+	-
b. disable	14	l	-	-
10. a. compute	41	t	-	+
b. nominate	12	t	-	+

Frequency range: bisyllabic words = 30 - 44; mean = 36.
Frequency range: Trisyllabic words = 9 - 14; mean = 13.3

Key: + syllabic affix indicates that the affix is a separate syllable in this word English; - syllabic affix indicates that when the word is affixed the number of syllables does not change .

Table 4

FINAL CONSONANT CONTROLLED STIMULI

	Verb	Frequency	Final C or CC	Syllabic Affix /Z/ - /D/	
1. a.	boot	4	t	-	+
b.	boost	11	st	-	+
2. a.	rate	4	t	-	+
b.	raft	1	ft	-	+
3. a.	bake	15	k	-	-
b.	bask	3	sk	-	-
4. a.	lick	14	k	-	-
b.	link	25	nk	-	-
5. a.	grasp	23	sp	-	-
b.	grab	37	b	-	-
6. a.	shell	1	l	-	-
b.	shelve	1	lv	-	-
7. a.	clap	7	p	-	-
b.	clasp	9	sp	-	-
8. a.	pat	12	t	-	+
b.	pant	10	nt	-	+
9. a.	chat	6	t	-	+
b.	chant	9	nt	-	+
10. a.	braid	2	d	-	+
b.	brand	3	nd	-	+

Key: + syllabic affix indicates that the affix is a separate syllable in this word English; - syllabic affix indicates that when the word is affixed the number of syllables does not change .

Note: These words were selected to see if there is a word final consonant cluster effect. Each pair of words are similar with respect to frequency. One of each pair ends in a final single consonant with the other ending in an additional consonant preceding it.

Table 5

Subjects

	Age	Sex	Yrs. Post	Test	Std. Score	Education	Melodic Line	*MLU Length	Artic. Agility	Grammatic Form
JE	74	F	5	BDAE	60%	MA	5	2	4	4
ES	68	M	4	BDAE	83%	HS	7	6	5	5
EN	62	F	6 mos	BDAE	87%	HS	5	5	4	6
HW	60	M	3	BDAE	70%	HS	3	3.25	4	4
BM	36	F	7	WAB AQ	54.6	HS	6	4	5	4
BN	43	F	6	BDAE	57%	MBA	6	5	5	4
JN	72	F	5	WAB AQ	60.5	BA	3	1.25	5	3
HO	67	F	2	WAB AQ	89	HS	4	3.25	5	3

* MLU was calculated based on sample utterances from Cookie Theft Picture Description.

Table 6

Intelligibility Screen

1. home
2. hop
3. mud
4. bake
5. fudge
6. much
7. relax
8. hot dog
9. buzz
10. rabbit
11. house
12. resume
13. doorknob
14. pencil
15. cheese
16. bagel
17. pipe
18. flashlight
19. case
20. window

Table 7

Kappa Analysis

Subject	Kappa
JE	.80
ES	.71
EN	.77
HW	.46
BM	.90
BN	.88
JN	.81
HO	.76

Average = .76

Table 8
Mean Percent Correct/Standard Deviation Affix

	Read			Repeat			Sent. Comp.	
Word List	/D/	/Z/	Ø	/D/	/Z/	Ø	/D/	/Z/
High Frequency	28.37	39.62	81.37	43.62	68.25	82.25	28.75	53.5
S.D.	27.4	23.83	22.46	24.51	18.52	15.24	20.11	27.1
Low Frequency	32.75	38.87	71.62	51.25	71	76.37	31.63	49
S.D.	26.43	31,93	22.99	23.61	22.81	17.47	22.81	24.08
Large Gang	27.25	44.87	69.12	50	71.5	80.12	29.25	45.62
S.D.	26.81	26.61	25.40	31.98	33.90	10.49	26.90	24.6
Small Gang	34	52.75	67.12	40.37	70.5	79.5	27.7	51.8
S.D.	23.5	28.66	31.21	25.61	24.92	14.89	24.71	25.85
Single Consonant	46	50.62	67.5	61.62	64.12	78.5	32.63	51.87
S.D.	26.05	25.09	23.79	28.42	22.42	18.41	31.95	27.32
Consonant Cluster	26.5	42.12	56	54.87	48.5	67	24	27
S.D.	17.13	17.07	26.52	12.96	18.98	11.67	13.08	17.29
Bisyllable	25.75	37.62	63.75	47.75	66.25	69.75	32.25	33.5
S.D.	28.06	26.39	26.20	16.19	27.68	17.25	15.81	23.92
Trisyllable	30.12	25.87	50.87	61.37	59.37	65.75	29.38	46.37
S.D.	13.63	26.23	26.78	23.62	23.32	17.58	12.88	32.11
Grand Mean	31.34	41.54	65.92	51.35	64.93	74.90	29.45	43.67

Mean Percent Correct/Standard Deviation Stem

	Read			Repeat			Sent. Comp.	
Word List	/D/	/Z/	Ø	/D/	/Z/	Ø	/D/	/Z/
High Frequency	77.38	70.62	87.62	79.5	72.5	73.5	73	63.12
S.D.	21.35	30.70	11.99	13.44	34.52	16.27	10.84	22.90
Low Frequency	69.5	66.87	81	74.12	64.88	83	73.5	64.6
S.D.	22.07	24.99	8.66	18.09	28.37	11.0	21.09	22.31
Large Gang	65.13	65	66.12	70.87	63.38	78.62	61.5	66.75
S.D.	22.89	21.47	18.23	20.64	20.86	12.19	17.99	19.55
Small Gang	73.88	72.87	78	79.12	72.5	88.25	72.37	61.5
S.D.	15.03	23.02	17.11	19.46	28.15	14.60	20.07	32.87
Single Consonant	62.5	64.62	76.87	73.5	67.25	78	61.62	67.37
S.D.	24.13	27.52	12.27	20.12	29.93	17.52	16.54	15.90
Consonant Cluster	55.25	52	57	65.62	60	73.87	63.87	45.87
S.D.	27.24	17.05	28.49	23.42	19.40	12.81	21.54	24.09
Bisyllable	55.13	44.25	64	64.5	66.25	67.12	46.25	31.37
S.D.	23.24	22.76	25.92	14.86	19.50	16.92	28.94	13.28
Trisyllable	54.25	61.75	53.37	65.37	63.5	64	38.37	43.25
S.D.	33.26	25.93	23.05	18.84	21.29	19.39	15.48	22.9
Grand Mean	64.13	62.25	70.5	71.57	66.28	75.79	61.31	55.46

Table 9

Overall ANOVA

Variable	Affixation 2 Tasks X 3 Af	Affixation 3 Tasks X 2 Af	Stem 2 Tasks X 3 Af	Stem 3 Tasks X 2Af
Word List (L)	.001**	Marginal .071	.000**	.000**
Affix (A)	.005**	.013**	.311	.263
Task (T)	.015*	.003**	.330	.165
TXA	.238	.822	.390	.363
TXL	.110	.010*	Marginal .064	.030*
AXL	.009**	.081	.346	Marginal .068
TXAXL	.122	.019*	.231	.578

Key:
Af=affix

Table 10

Word List Pairwise Comparisons

Variable	Affixation 2 Tasks X 3 Af	Affixation 3 Tasks X 2 Af	Stem 2 Tasks X 3 Af	Stem 3 Tasks X 2Af
Hi vs. Lo	.97	.56	.316	.46
Large vs. Small	.96	.97	.005**	.013*
C vs. CC	.006**	.05*	.11	.13
Bi- vs. Tri-	.14	.61	.97	.403
Lo vs. Bi-	.001**	.15	.04*	.02*
Lo vs. Tri-	.012*	.33	.02*	.01*

Key:
Af=affix
C=final consonant
CC=final consonant cluster
Bi-=bisyllabic
Tri-=trisyllabic

Table 11

Other Planned Comparisons

Variable	Affixation 2 Tasks X 3 Af	Affixation 3 Tasks X 2 Af	Stem 2 Tasks X 3 Af	Stem 3 Tasks X 2Af
Read vs. Rpt.	.015**	.017**	.330	.308
Read vs. Fill	NA	.927	NA	.458
Repeat vs. Fill	NA	.005**	NA	.037*
Past vs. 3rd	.015*	.013*	.326	.263
Past vs. Stem	.008**	NA	.312	NA
3rd vs. Stem	.10	NA	.286	NA

Key:
Af=affix
3rd= third person
fill=fill-in
Rpt.=repeat

Appendix A

Rhyme Gangs

Large	Small
guide	load
chide	code
glide	bode
pride	
side	
drag	beg
bag	peg
brag	dreg
flag	
gag	
sag	
swag	
tag	
scream	climb
beam	prime
deem	rhyme
dream	time
cream	chime
seem	
steam	
teem	
scheme	
team	
blame	ruin
aim	spoon
flame	prune
frame	tune
maim	
name	
shame	
tame	
claim	

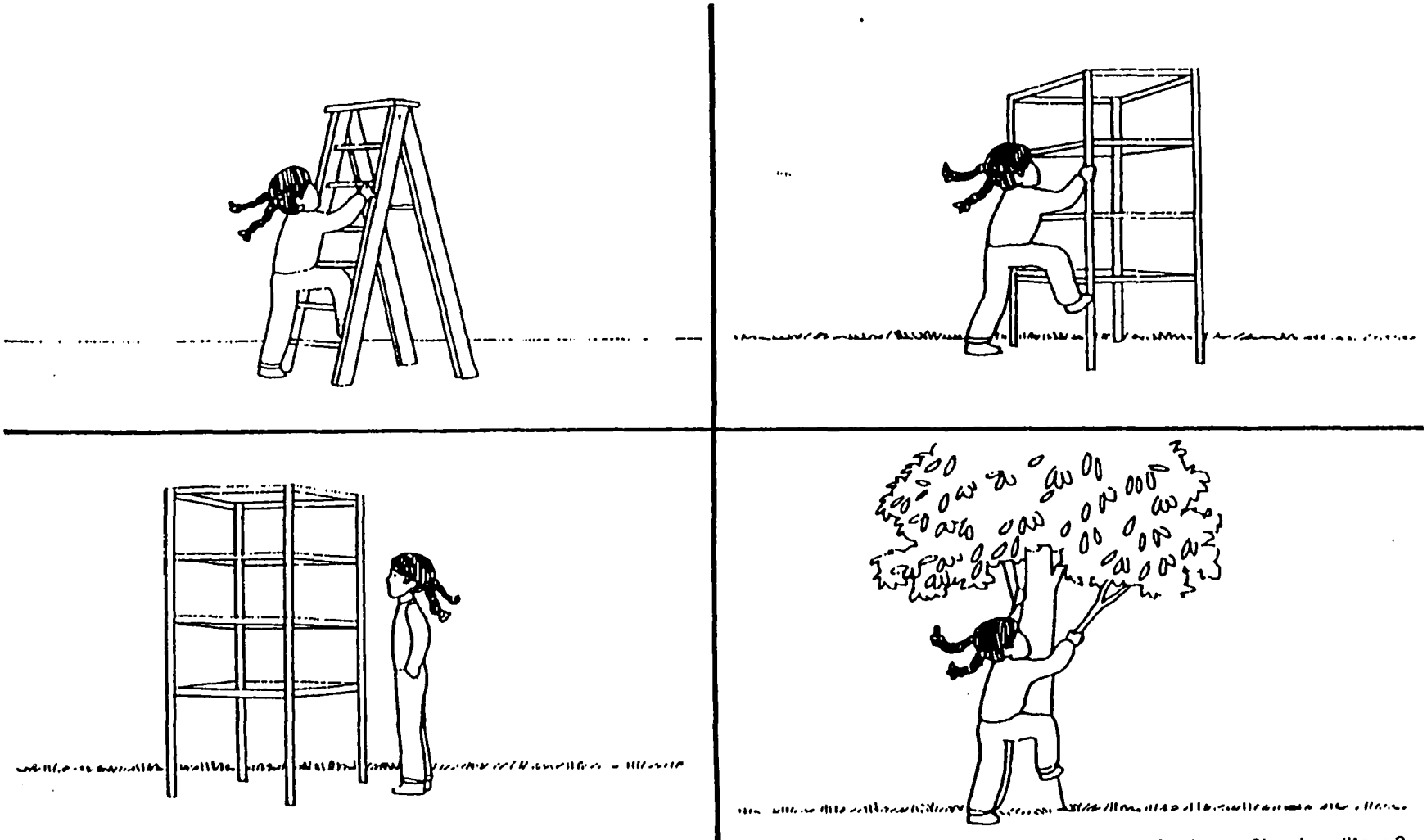
sign		kiss
whine		miss
dine		hiss
fine		
line		
pine		
shine		
mine		
brush		push
blush		
flush		
crush		
hush		
gush		
scratch		touch
batch		such
hatch		
catch		
match		
latch		
snatch		
patch		
thatch		
snap		step
chap		prep
cap	map	
strap	lap	
tap	nap	
wrap	rap	
clap	scrap	
flap	slap	
gap		
zap		

ease	pause
freeze	cause
wheeze	
please	
seize	
squeeze	
sneeze	
tweeze	
tease	
wave	carve
brave	starve
crave	
pave	
save	
rave	
waive	

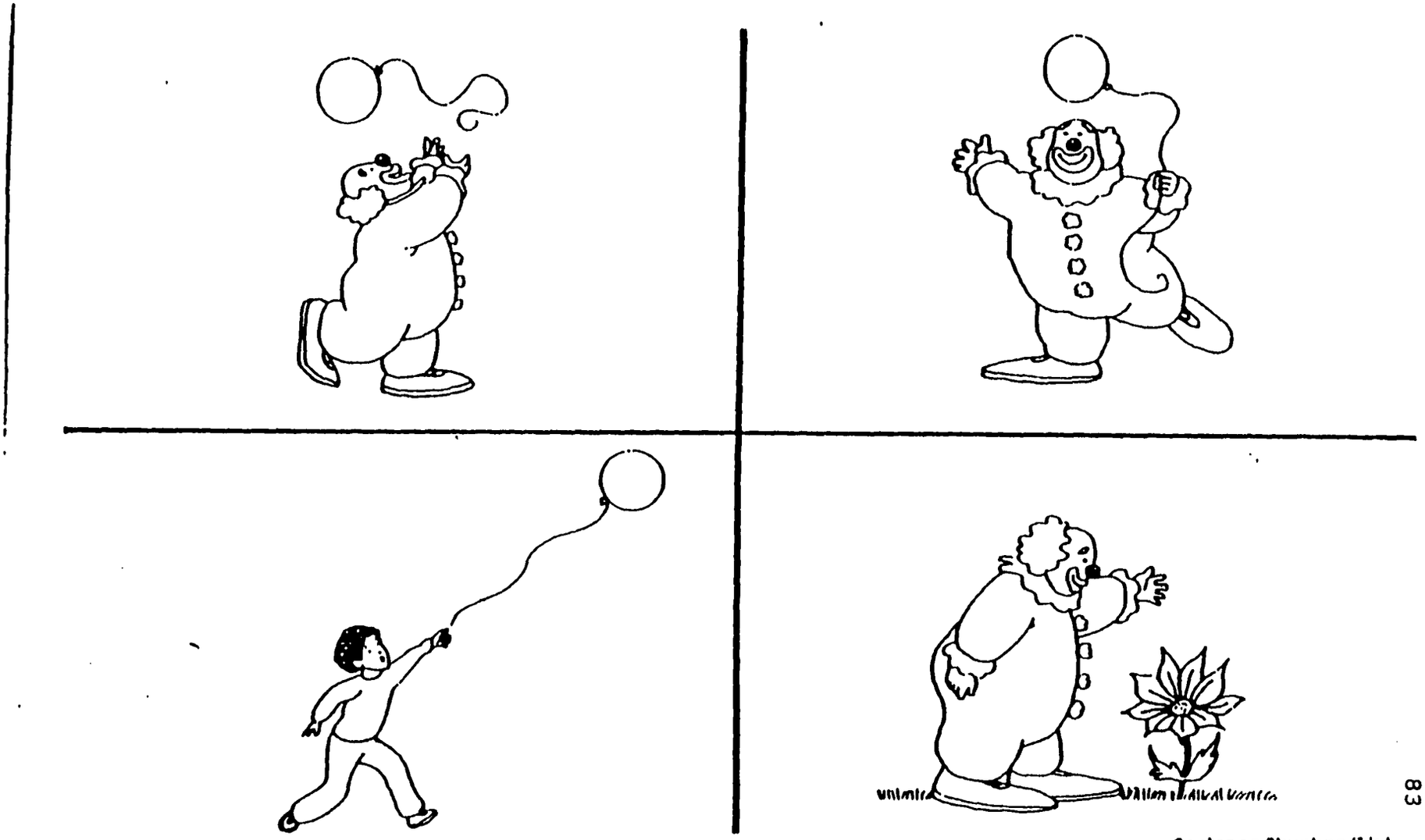
Appendix B

Auditory Comprehension Task

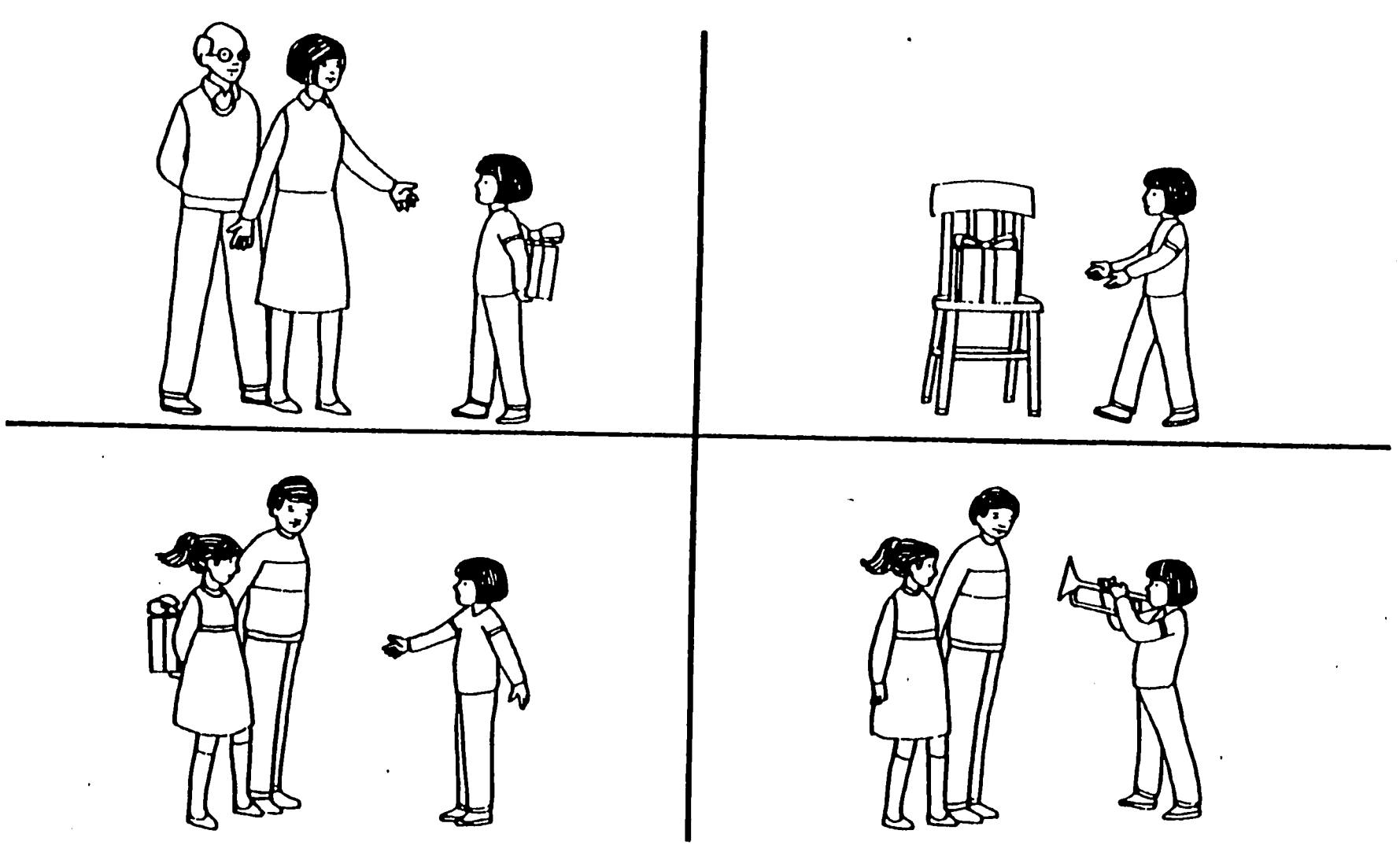
Subjects were told to point to the picture that corresponds with the sentence.



SHE CLIMBS THE LADDER. A



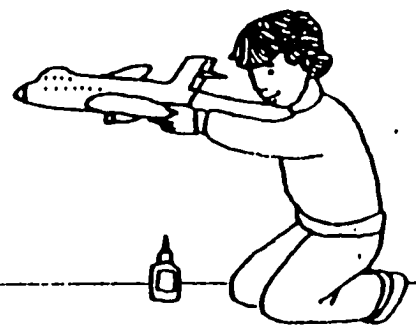
THE CLOWN HOLDS THE BALLOON. B



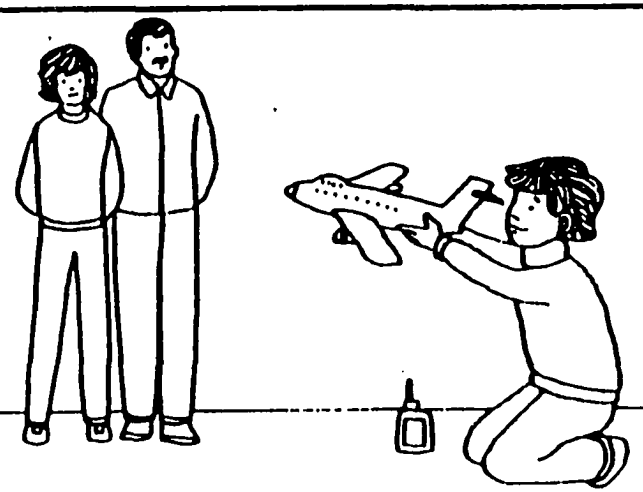
SHE FINDS THE PRESENT. B

Sentence Structure/Item 26

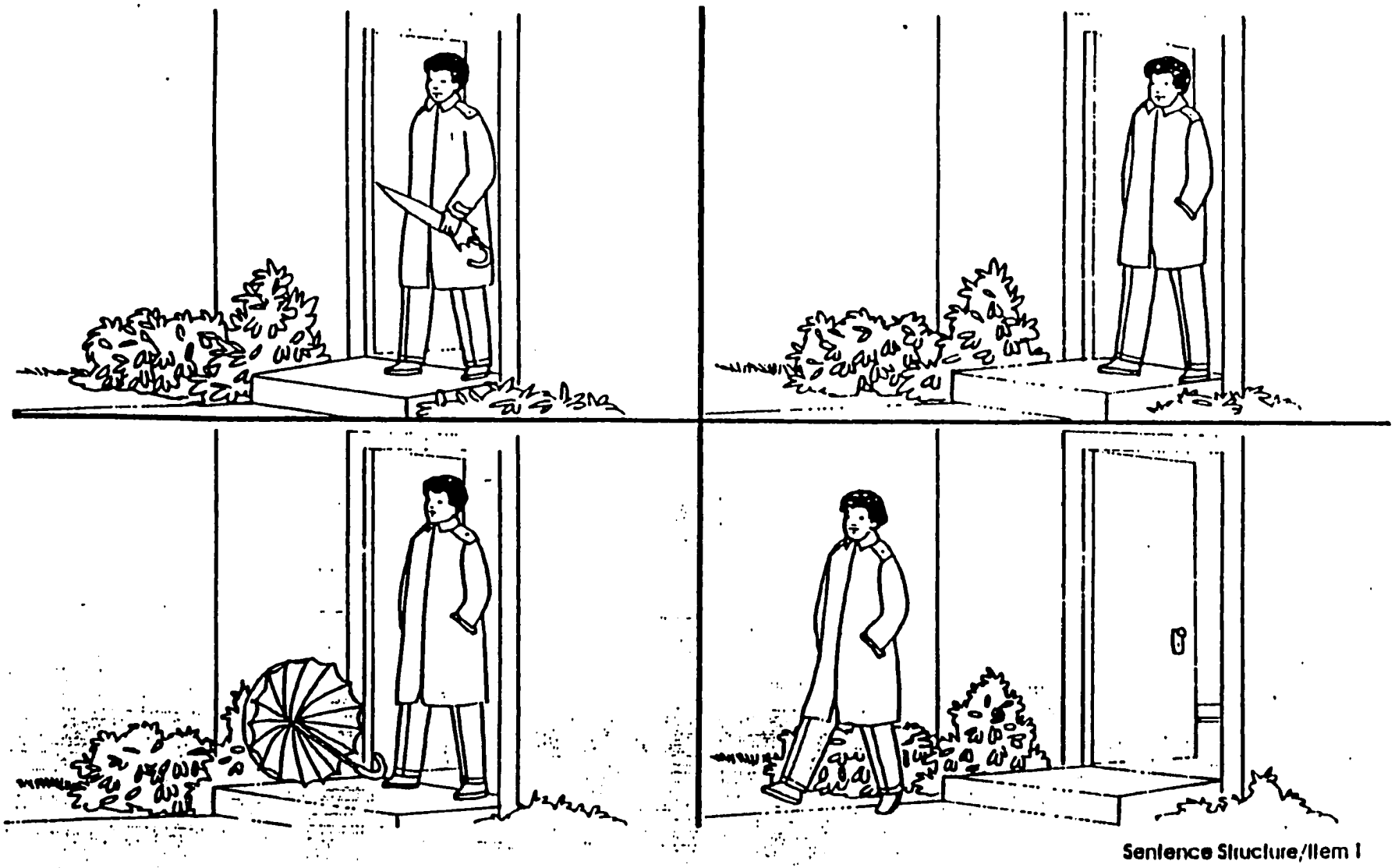
HE FIXES THE AIRPLANE. B



HE FIXED THE AIRPLANE. D

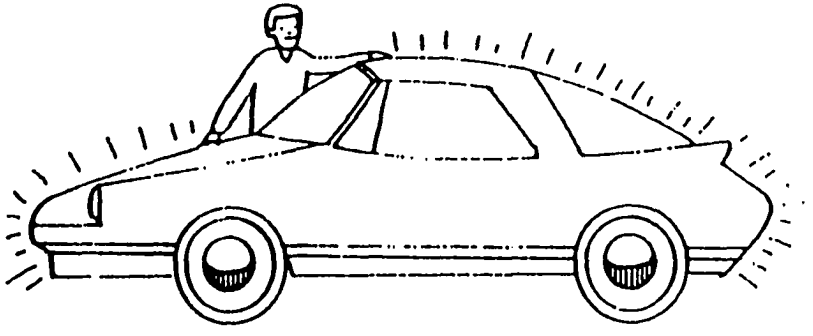


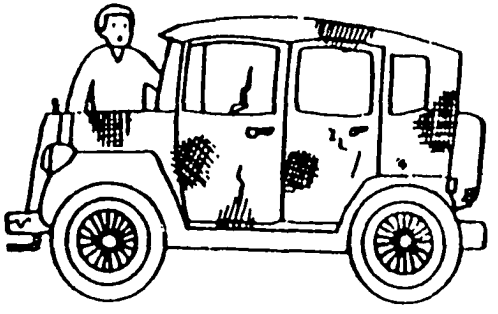
Sentence Structure/Item 24

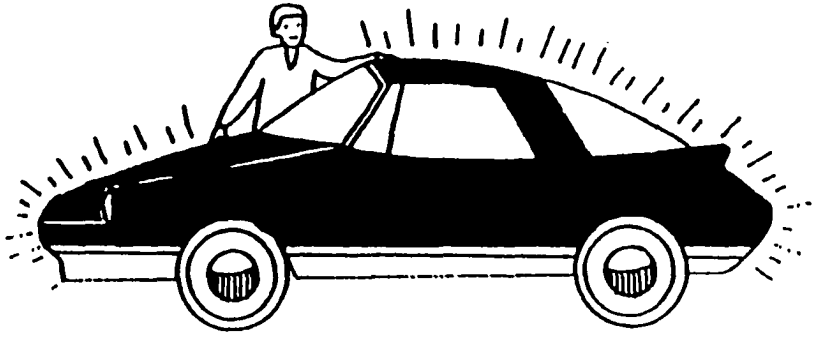


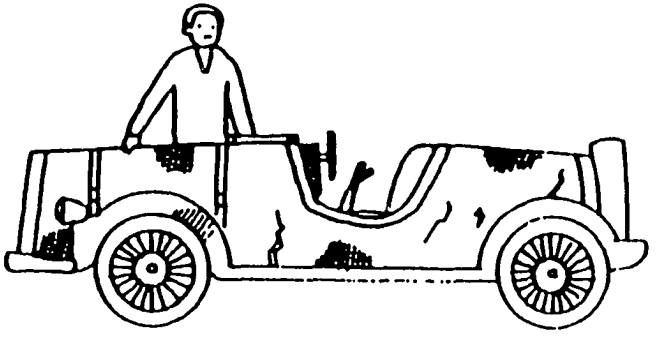
THE MAN WALKS TO THE UMBRELLA. C

THE MAN WALKED OUT THE DOOR. D

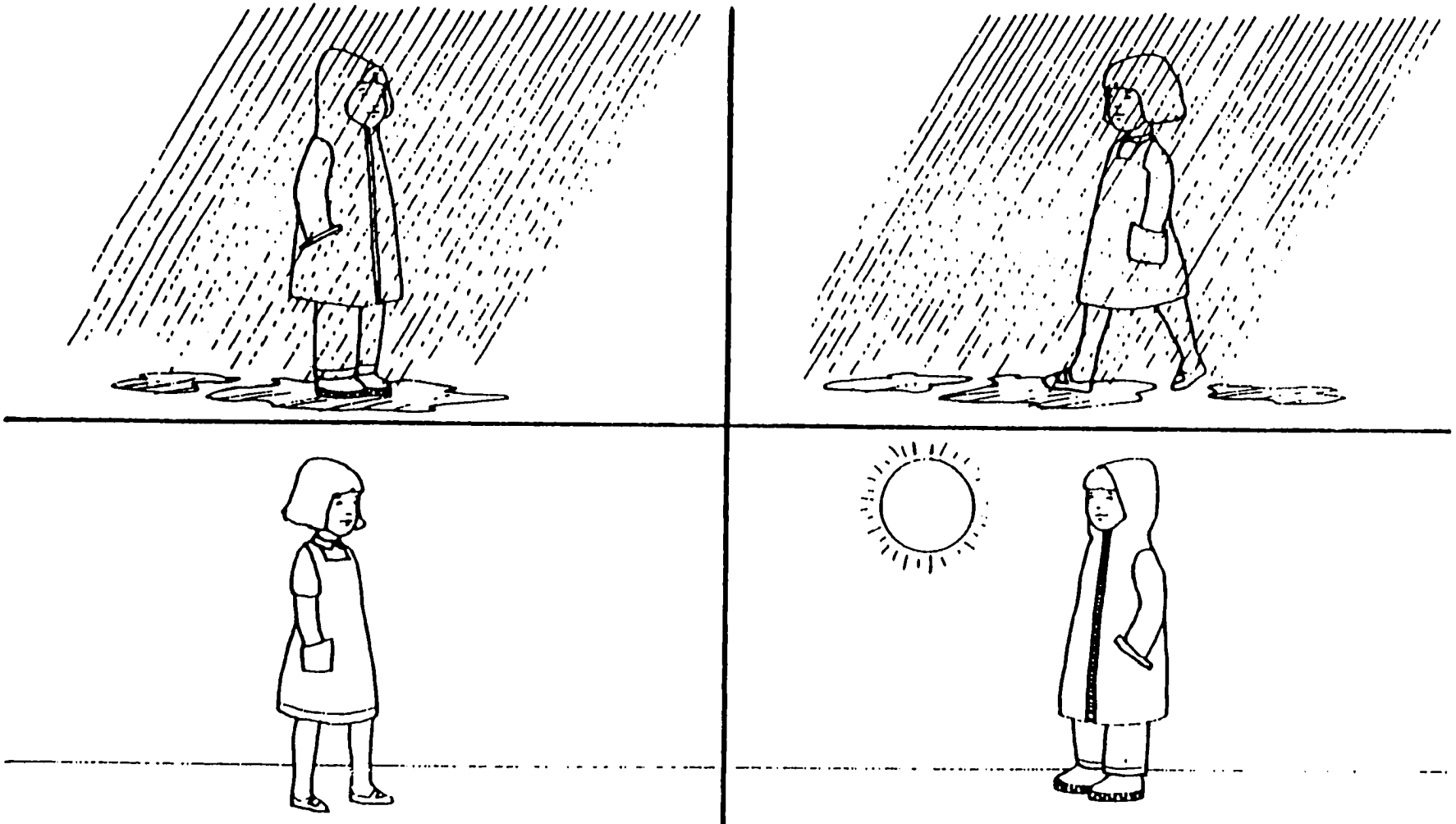




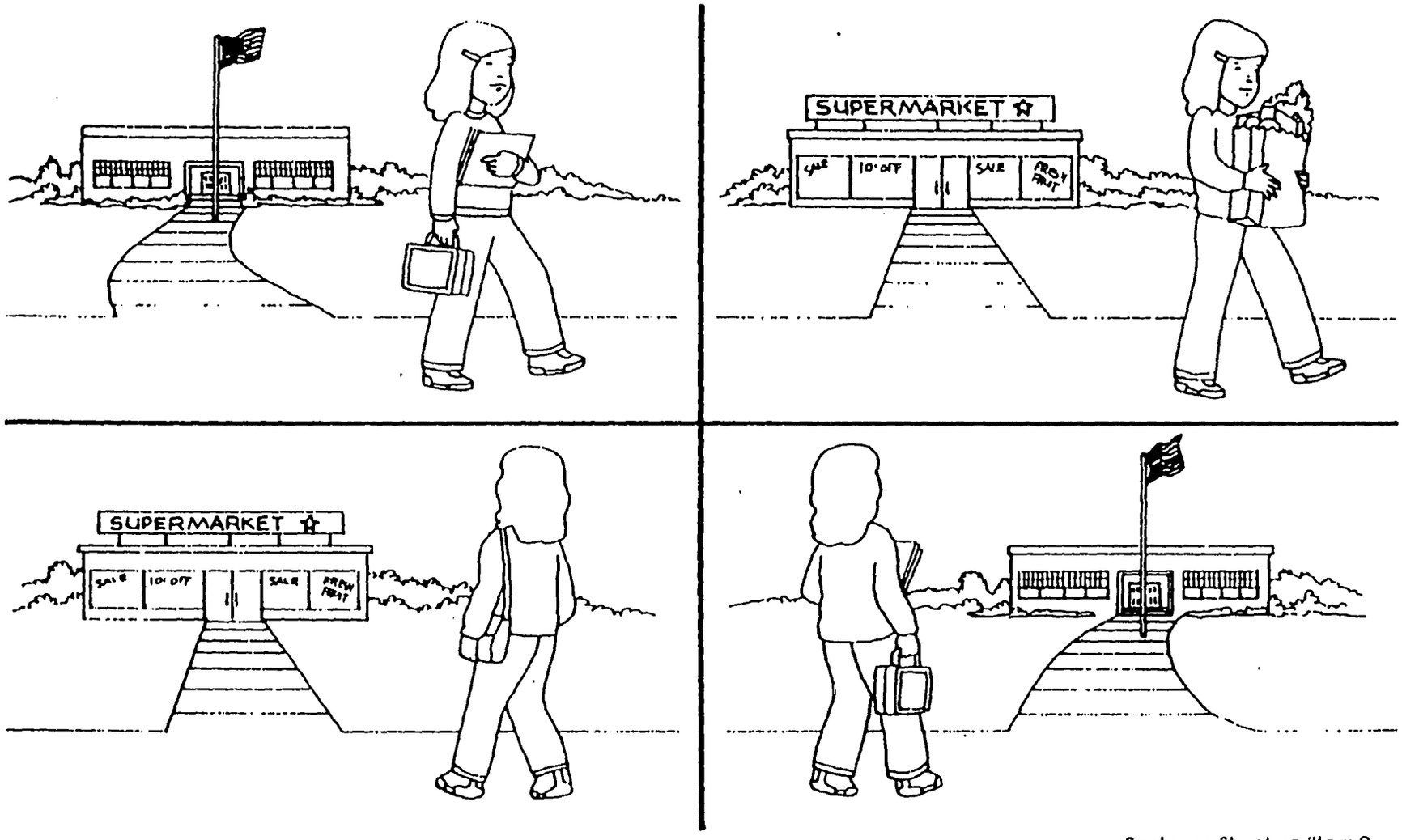




HE POLISHED THE CAR. A

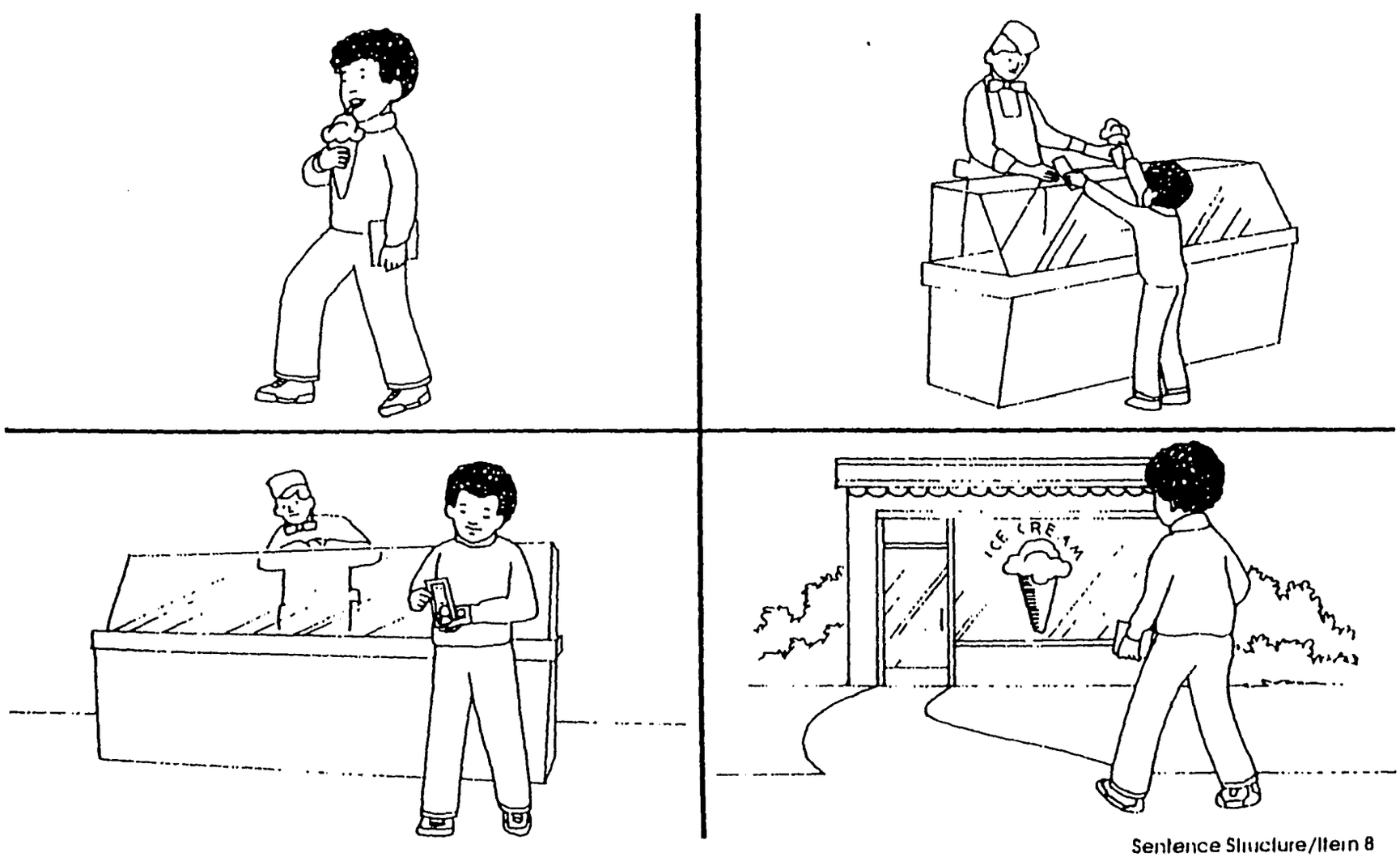


IT RAINED THIS MORNING. D

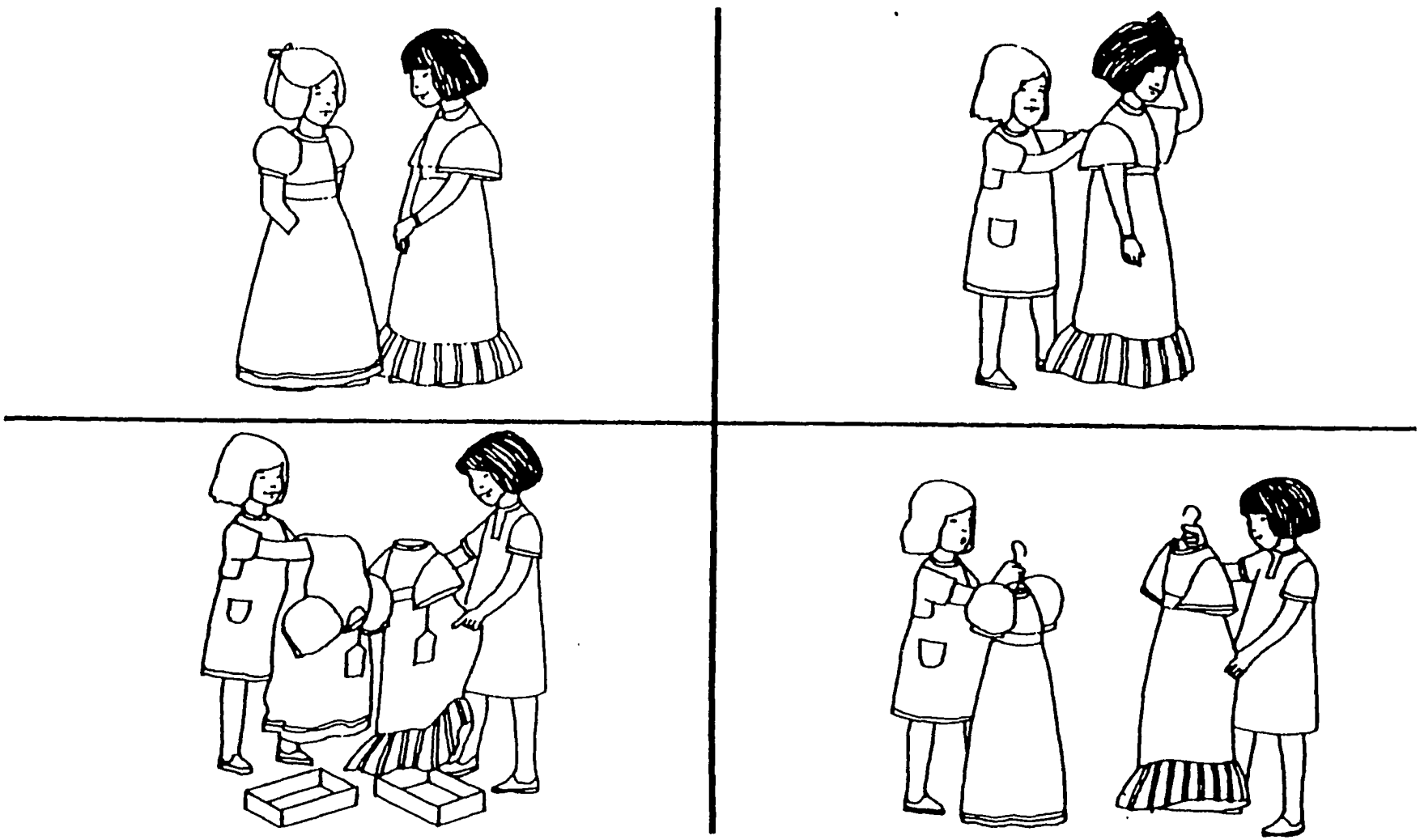


Sentence Structure/Item 9

SHE FINISHED SHOPPING. B

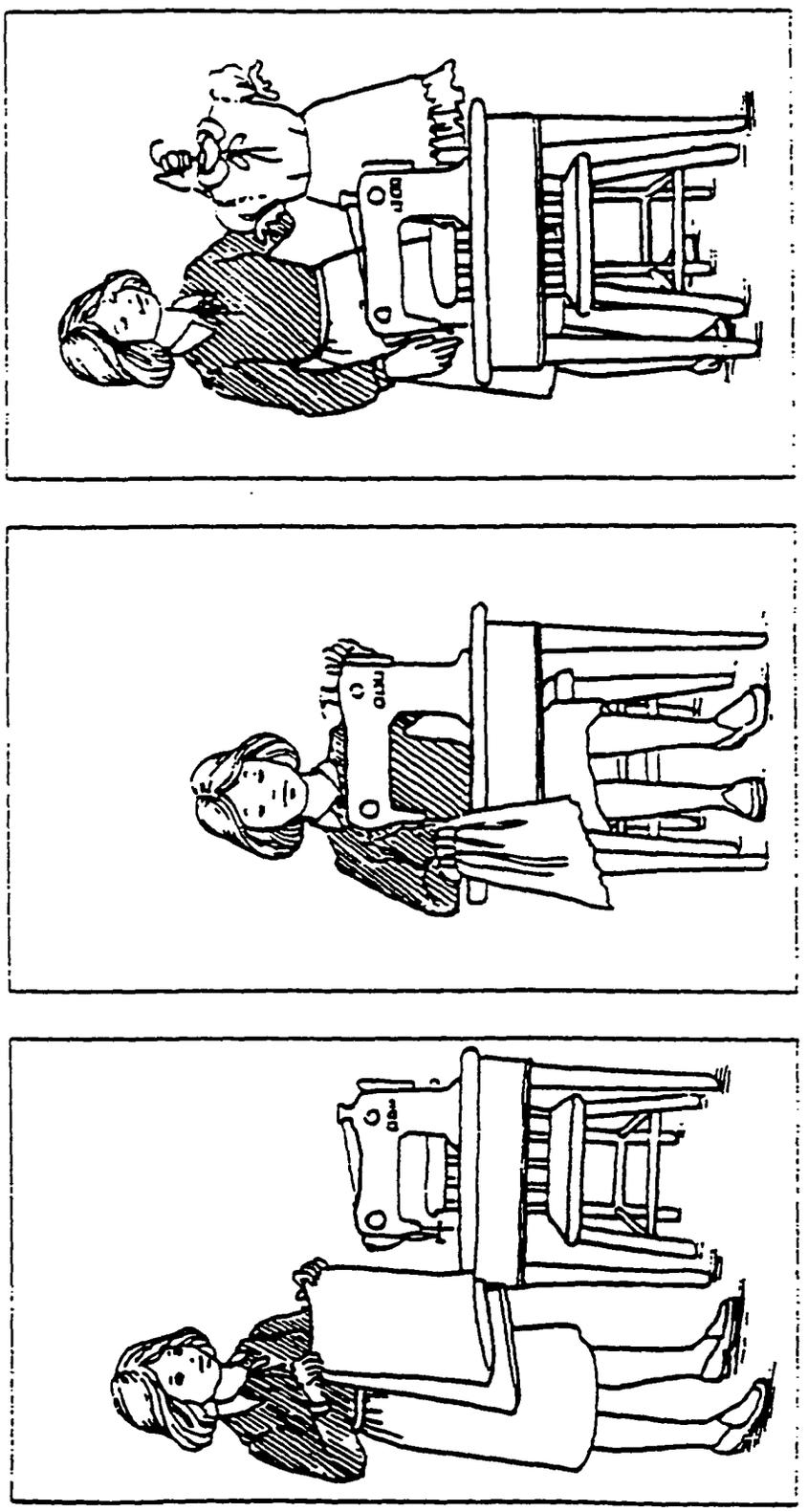


THE BOY EATS THE ICE CREAM CONE. A



THEY ARE DRESSED. B

THE DEER DRINKS. 1



SHE SEWED THE DRESS. 3

APPENDIX C
READING AND REPETITION TASKS
PSEUDO RANDOMIZATION

1. step
2. clasps
3. move
4. summarizes
5. imitate
6. grasp
7. basks
8. knots
9. pave
10. bake
11. drown
12. reproduce
13. compute
14. kissed
15. clasped
16. reproduces
17. brushes
18. transformed
19. types
20. links
21. computed
22. braid
23. typed
24. linked
25. stuffs
26. bask
27. brands
28. addresses
29. pass
30. scratched
31. autograph
32. baked
33. lick
34. ruined
35. passed
36. raft
37. basked
38. weeds
39. shells
40. pace
41. climbed
42. snapped
43. type
44. eased
45. paves
46. bakes
47. drowns
48. link
49. waves
50. overlaps
51. behaved
52. rates
53. chants
54. use
55. shelve
56. arouses
57. paces
58. behaves
59. grasps
60. reached
61. blames
62. shelled
63. overlapped
64. reach
65. attach
66. knotted
67. touched
68. transform
69. disabled
70. chanted
71. waved
72. autographed
73. clap
74. paused
75. nominates
76. touches
77. paced
78. moved
79. wave
80. loads
81. circulates
82. clapped
83. signs
84. sneeze
85. attached
86. pushes
87. weeded
88. reproduced
89. booted
90. braids
91. drowned
92. claps
93. sneezes
94. stuffed
95. rafts
96. liked
97. begs
98. grasped
99. load
100. licked
101. carved
102. kiss
103. grabs
104. pitches
105. needs
106. decline
107. used
108. nominate
109. sneezed
110. need
111. pitch
112. reaches
113. arouse
114. grabbed
115. boot
116. imitates
117. pushed
118. shelves
119. equipped
120. moves

121. disciplines
122. guided
123. train
124. carves
125. licks
126. overlap
127. shelved
128. pauses
129. needed
130. ruins
131. carve
132. declined
133. stops
134. trained
135. eases
136. screams
137. nominated
138. blamed
139. touch
140. hook
141. attaches
142. ease
143. ruin
144. equips
145. chant
146. rated
147. summarized
148. scratches
149. shell
150. aroused
151. snap
152. tolerated
153. sign
154. exceeds
155. steps
156. uses
157. like
158. declines
159. rafted
160. pause
161. scratch
162. tolerates
163. stopped
164. disables
165. circulated
166. push
167. exceed
168. transforms
169. laugh
170. address
171. patted
172. disable
173. pitched
174. scream
175. tolerate
176. drag
177. hooked
178. discipline
179. loaded
180. climbs
181. guide
182. chatted
183. behave
184. boosts
185. stepped
186. exceeded
187. live
188. clasp
189. passes
190. imitated
191. chats
192. rate
193. disciplined
194. lived
195. brush
196. chat
197. lives
198. braided
199. brand
200. boost
201. releases
202. pants
203. hooks
204. equip
205. laughs
206. panted
207. guides
208. snaps
209. pat
210. dragged

211. beg
212. boosted
213. blame
214. kisses
215. drags
216. release
217. likes
218. trains
219. weed
220. pats
221. signed
222. brushed
223. summarize
224. pant
225. addressed
226. grab
227. boots
228. circulate
229. screamed
230. released
231. laughed
232. stuff
233. climb
234. paved
235. branded
236. autographs
237. computes
238. knot
239. begged
240. stop

Appendix D

Directions

Subjects were be told: This may be hard for you. I want to see the way people use verbs. I will say some sentences and then say a variation of the sentence with the end missing. Some of the sentences will be harder than others. I want you to finish the sentence for me using a form of one of the verbs in the original sentence.

Testing was discontinued after five incorrect responses per word list.

EXAMPLES:

1. Tim tried to kick the ball.

   Every time the ball comes to Tim he _____.

   Yesterday he _____.

2. Bob has to answer the phone.

   When Bob hears the phone ring he _____.

   Yesterday he _____.

The Subject was told: You might have said "Says hello" for the second example. That is a good answer, but does not use one of the words in the original sentence as does "answers it".

3. John likes to watch TV.

   After school John sits in front of the TV and _____.

   Yesterday John _____.

"Watches " is okay, but "does his homework" is not because it does not use a word from the original sentence.

Sentence Completion Stimuli

Large Gang

1. Guide

   I asked my brother to **guide** us along the trail.

   Whenever we go on vacation my brother _____.

   Yesterday he _____ .

2. Drag

   Little children like to **drag** their blankets wherever they go.

   The baby took his blanket and _____.

   Each time he goes to his grandmother he _____ .

3. Scream

   When I saw the ghost I tried not to **scream.**

   He scared me so that I _____ .

   Each time she sees a ghost she _____.

4. Blame

   He tried to **blame** me for the accident.

   Whenever he's in a fight he _____.

   Yesterday I _____.

5. Sign

   I need to **sign** the check.

   Whenever he writes a check he _____.

   Yesterday the banker _____.

6. Brush

   I have to **brush** my teeth.

   Whenever she wakes up she _____.

   When I woke up I _____.

7. Scratch

My cat likes to scratch.

Every time I leave my cat alone he _____ .

When I saw the chair I knew he had _____.

8. Snap

The rainstorm caused the tree limb to snap.

During the last storm the antenna _____ .

Each time it rains part of the big old tree _____ .

9. Ease

The driver tried to ease the big truck into the small parking spot.

Each time he parks he _____.

Yesterday he _____.

10. Wave

As the bus pulled away everyone started to wave good-bye.

Whenever he sees his mother at the bus stop he _____.

Yesterday he _____.

Small Gang

1. Load

The man had to load the truck.

When he goes to work he _____.

Last night he _____.

2. Beg

The poor person had to beg.

Whenever he wants food he _____.

Yesterday he _____.

3. Climb

I told him not to **climb** the tree.

Every October he goes apple picking and _____.

Yesterday he _____.

4. Ruin

I tried not to **ruin** the joke.

Whenever he tells a joke he _____.

Last night he _____.

5. Kiss

He tried to **kiss** the baby.

As soon as she sees the baby she _____.

Yesterday he _____.

6. Push

The girl had to **push** the swing.

Whenever we go to the park she _____.

Last week the boy _____.

7. Touch

I asked him not to **touch** anything.

Whenever he goes into a store he _____.

Yesterday he _____.

8. Step

Be careful not to **step** on my toes.

Whenever he dances with me he _____.

Last week he _____.

9. Pause

It is nice to take a **pause.**

When she runs out of breath she _____.

The first time she _____.

10. Carve

It was time to **carve** the turkey.

Every Thanksgiving, when it's time to eat, my father _____.

Last year my brother _____.

High Frequency

1. Use

John wants to **use** the car.

He asks he father before he _____ .

Yesterday he _____.

2. Stop

He didn't want to **stop** for the light.

Whenever he sees a red light he _____.

Yesterday he _____.

3. Laugh

It feels good to **laugh.**

Whenever he hears a joke he _____.

Last night we _____.

4. Live

He wanted to **live** in Manhattan.

According to the address he _____.

Until last year we _____.

5. Move

It was time to move the car.

She goes out every morning and _____.

Yesterday he _____.

6. Need

It's healthy to need other people.

Now that she's a mother she knows how much attention a baby _____.

Yesterday I _____.

7. Train

The manager's job was to train new employees.

Whenever he hires new employees he _____.

Yesterday the manager _____.

8. Reach

It's hard for me to reach the top shelf.

She stretches and _____.

Last night I _____.

9. Pass

Charley wanted to pass the other car.

Whenever he's on the highway he _____.

Yesterday he _____.

10. Like

I taught my son to like all kind of food.

When he eats breakfast he _____.

He ate something at the party that he _____.

Low Frequency

1. Pave

   The autumn is a good time to **pave** the driveway.

   Every September he _____.

   Last year he _____.

2. Knot

   The sailor learned to **knot** the rope.

   Whenever he pulls down the sail he _____.

   Last week I _____.

3. Stuff

   It was time to **stuff** the turkey.

   Every Thanksgiving my mother cooks dinner and _____.

   This year I _____.

4. Type

   The secretary's job was to type the letters.

   I dictate them and she _____.

   Last week she _____.

5. Drown

   It is possible for a person to **drown.**

   It is sad when someone _____.

   Last summer three people _____.

6. Pitch

   He tried to **pitch** a strike.

   They win every time he _____.

   Yesterday someone else _____.

7. Weed

I like to weed the garden.

My daughter usually plants and _____.

Last week she _____.

8. Pace

Lions like to pace in their cages.

Until the caretaker brings the food the lion _____.

Yesterday he _____.

9. Sneeze

Sometimes it's hard not to sneeze.

When there is dust in the air she always _____.

I almost _____.

10. Hook

They tired to hook the fish.

He buys the bait and then _____.

Last week I _____.

Bisyllabic Words

1. Decline

He didn't want to decline the nomination.

Yesterday he _____.

Each time he is nominated he _____.

2. Equip

The cook had to equip the kitchen.

After he uses the materials he _____.

Yesterday he _____.

3. Transform

   The designer tried to transform the room.

   An artist takes materials and _____.

   Yesterday he _____.

4. Behave

   I told the children to behave.

   When he is with his grandmother he usually _____.

   Yesterday he _____.

5. Arouse

   They tried to arouse the drunkard.

   Each time she passes she _____.

   Yesterday she _____.

6. Release

   The warden wanted to release the prisoner.

   Whenever that lawyer sits on the parole board he _____.

   Yesterday the warden _____.

7. Exceed

   We didn't want to exceed the speed limit.

   Whenever he drives he _____.

   Yesterday he _____.

8. Attach

   The salesman had to attach the tag.

   Before he puts it up for sale he _____.

   Yesterday he _____.

9. Address

He had to address the envelopes.

Each day he stamps and _____.

Yesterday he _____.

10. Compute

The cashier tried to compute the difference.

Everyday the cashier counts the money and _____.

Yesterday he _____.

Three Syllable

1. Autograph

The actor stopped to autograph the program.

Whenever his fans see him in public he _____.

I gave him the program and he _____.

2. Reproduce

They tried to reproduce the drawing.

Whenever he copies great works of art he _____.

Last time they _____.

3. Summarize

The newscaster had to summarize the story.

The audience doesn't like it when that newscaster _____.

Yesterday he _____.

4. Discipline

Part of a parents job is to discipline their children.

The children don't like it when their father _____.

Yesterday he _____.

5. Imitate

The mother told the children not to imitate anyone.

John doesn't like it when his sister _____.

Last night he _____.

6. Overlap

They tried not to overlap the schedule _____.

I like it when my husband's schedule _____.

Last week it _____.

7. Circulate

It's fun to circulate at a party.

She always meets someone when she _____.

Last week he _____.

8. Disable

My opponent tried to disable my car.

Each time he tries he _____.

Last week my car was _____.

9. Tolerate

We tried to tolerate the noise.

Everyone thinks he's easy because he _____.

Yesterday we _____.

10. Nominate

I wanted to nominate my friend Bill.

Each time Bill agrees to run for office Jane _____.

Last year he _____.

Final Consonant Controlled

1. Boot

   The soccer player tried to boot the ball.

   As he gets closer to the goal he _____.

   Yesterday he _____.

2. Boost

   When the battery died he had to boost it.

   The AAA serviceman always _____.

   Yesterday he _____.

3. Rate

   It was his job to rate the movie.

   Disney films are always _____.

   When the film is violent he _____.

4. Raft

   He liked to raft on the river.

   Whenever he went on vacation he _____.

   Each time he goes to Colorado he _____.

5. Bake

   My mother loves to bake.

   As Christmas gets closer my mother _____.

   Last night I _____.

6. Bask

   It's unhealthy to bask in the sun.

   She relaxes when she _____.

   Last summer I _____.

7. Lick

The baby tried to l i c k the ice cream cone.

She always tastes and _____.

Last night I _____.

8. Link

The new highway will l i n k the two towns.

The new highway winds around the mountain and _____.

Last year two roads _____.

9. Grasp

He tried to g r a s p the ring.

She always wins the prize when she _____.

Last night I_____.

10. Grab

Someone tried to g r a b my purse.

A mugger usually runs fast after he _____.

Last week he _____.

11. Shell

It was fun to s h e l l the peas.

I usually help him when the _____.

I never _____.

12. Shelve

The librarian has many books to s h e l v e.

Each night the librarian stacks the books and _____.

Last night she _____.

13. Clap

It's easy to teach babies to clap their hands.

When his daddy comes in the room he _____.

He saw the clown and he _____.

14. Clasp

The skier forgot to clasp his boots.

First he puts on his gloves then he _____.

Yesterday I _____.

15. Pat

It's better to pat your skin dry.

First she puts on lotion then she _____.

Yesterday I _____.

16. Pant

The dog started to pant loudly.

The dog smells the food and _____.

After she ran she _____.

17. Chat

We stopped to chat.

Whenever she sees us she stops and _____.

Over lunch they _____.

18. Chant

Many people find it relaxing to chant.

When she wants to relax she _____.

Last night I_____.

19. Braid

My mother loved to **braid** my hair.

Before I went to school she _____.

Whenever she combs my hair she _____.

20. Brand

The cowboy had to **brand** all the calves.

First he ropes them then he _____.

Yesterday he _____.

Appendix E

LISTENING SHEET FOR STEM

Stimulus	Different Word	Distorted Stem Production	Correct Stem Production	No Response
1. clasps				
2. hooks				
3. bakes				
4. declined				
5. guides				
6.				
7.				
8.				
9.				
10.				
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26.				
27.				
28.				
29.				
30-640				

Appendix F

LISTENING SHEET FOR AFFIXES

INFINITIVE	ONLY STEM	PAST TENSE	3RD PERSON
1. clasp			
2. hook			
3. bake			
4. decline			
5. guide			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
13.			
14.			
15.			
16.			
17.			
18.			
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21.			
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25.			
26.			
27.			
28.			
29.			
30-640			

Appendix G

ANOVA Tables

Affix 3 X 2

Summary of ANOVAs for three tasks (reading, repetition, and fill-in) in 3rd person and past affixed conditions.

Source	Sum of Squares	dF Effect	Mean Square	F	p
Task (T)	40817.312	2	20408.656	9.336	0.003*
Affix (A)	16016.667	1	16016.667	11.057	0.013*
Word List(L)	5008.240	7	715.463	2.023	0.071
T X A	198.521	2	99.260	0.198	0.822
T X L	3645.479	14	260.391	2.282	0.010*
A X L	3967.750	7	566.821	1.951	0.081
T X A X L	4524.938	14	323.210	2.082	0.019*
Total	74178.907	47			

Stem 2 X 3

Summary of ANOVAs for two tasks (reading and repetition) in 3rd person, past and zero affix conditions.

Source	Sum of Squares	dF Effect	Mean Square	F	p
Task (T)	3015.042	1	3015.042	1.098	0.330
Affix (A)	5131.255	2	2565.628	1.272	0.311
Word List(L)	17923.542	7	2560.506	5.254	0.000*
T X A	191.005	2	95.503	1.007	0.390
T X L	2087.208	7	298.173	2.078	0.064
A X L	2052.536	14	146.610	1.126	0.346
T X A X L	2553.120	14	182.366	1.284	0.231
Total	32953.708	47			

Stem 3 X 2

Summary of ANOVAs for three tasks (reading, repetition, and fill-in) in 3rd person and past affixed conditions.

Source	Sum of Squares	dF Effect	Mean Square	F	p
Task (T)	7127.661	2	3563.831	2.052	0.165
Affix (A)	1807.003	1	1807.003	1.483	0.263
Word List(L)	22545.435	7	3220.776	5.682	0.000
T X A	296.099	2	148.049	1.091	0.363
T X L	5890.339	14	420.738	1.953	0.030
A X L	1863.602	7	266.229	2.045	0.068
T X A X L	1959.234	14	139.945	0.884	0.578
Total	41489.373	47			

Stem 3 X 2

Summary of word list planned comparisons

Source	Sum of Squares	dF Effect	Mean Square	F	p
High vs. Low Freq.	4140.500	1	4140.500	0.610	0.460
Large vs. Small	12561.125	1	12561.125	10.956	0.013*
C vs. CC	23544.500	1	23544.500	2.983	0.128
Bi- vs. Trisyllable	2812.500	1	2812.500	0.793	0.403
Low vs. Bisyllable	89253.125	1	89253.125	8.644	0.022
Low vs. Trisyllable	60378.125	1	60378.125	12.417	0.010*

Affix 2 X 3

Planned Comparisons

Source	Sum of Squares	dF Effect	Mean Square	F	p
C vs. CC	36720.500	1	36720.5	15.029	0.006
Bi- vs. Tri-	2450.000	1	2450.000	2.794	0.139
Low vs. Bi-	3415191.125	1	3415191.125	156.99	0.000
Low vs. Tri-	19306.125	1	19306.125	11.144	0.012

Affix 3 X 2

Summary of affix planned comparisons

Source	Sum of Squares	dF Effect	Mean Square	F	p
Past vs. 3 rd	768800.000	1	768800.00	11.057	0.013

Stem 3 X 2

Summary of task planned comparisons

Source	Sum of Squares	dF Effect	Mean Square	F	p
Read vs. Repeat	67528.125	1	67528.125	1.206	0.308*
Read vs. Sent. Comp.	47124.500	1	47124.500	0.616	0.458
Repeat. vs. Sent. Comp.	227475.125	1	227475.125	6.632	0.037*

Affix 2 X 3

Summary of ANOVAs for two tasks (reading and repetition) in 3 rd person, past and zero affix conditions.

Source	Sum of Squares	dF Effect	Mean Square	F	p
Task (T)	30033.375	1	30033.375	10.257	0.015*
Affix (A)	55843.083	2	27921.542	8.114	0.005*
Word List(L)	6273.292	7	896.185	4.932	0.000
T X A	3848.688	2	1924.344	1.595	0.238
T X L	1650.583	7	235.798	1.795	0.110
A X L	8023.083	14	573.077	2.286	0.009*
T X A X L	3318.729	14	237.052	1.509	0.122
Total	108990.833	47			

Affix 3 X 2

Summary of word list planned comparisons

Source	Sum of Squares	dF Effect	Mean Square	F	p
High vs. low freq.	1404.500	1	1404.500	0.372	0.561
Large vs. small	3.125	1	3.125	0.001	0.971
C vs. CC	48984.5	1	48984.5	5.649	0.049*
Bi- vs. Trisyllable	703.125	1	703.125	0.281	0.613
Low vs. Bisyllable	8192.000	1	8192.000	2.647	0.1488
Low vs. Trisyllable	4095.125	1	4095.125	1.091	0.331

Affix 3 X 2

Summary of task planned comparisons

Source	Sum of Squares	dF Effect	Mean Square	F	p
Read vs. Repeat.	999698.000	1	999698.000	9.632	0.017*
Read vs. Fill-in	420.500	1	420.500	0.009	0.927
Repeat. vs. Fill-in	959112.500	1	959112.500	16.118	0.005*

Appendix H

Mean Percent Correct By Word List

Affix Rating

	Subj.	rd ed af	rd 3 af	rd Ø af	rp ed af	rp 3 af	rp Ø af	sc ed st	sc 3 st
High Freq	JE	22	42	97	45	75	80	2	67
	ES	17	58	65	7	63	87	10	70
	EN	35	53	93	63	70	85	50	58
	HW	15	23	98	8	30	100	18	13
	BM	10	0	43	37	60	81	12	15
	BN	10	30	100	58	75	78	43	67
	JN	25	33	97	63	80	97	45	90
	HO	93	78	58	68	93	50	50	48
Mean		28	40	81	44	68	82	29	54
Low Freq	JE	17	11	82	47	77	65	7	67
	ES	10	60	45	20	53	70	15	75
	EN	45	63	87	53	100	90	50	63
	HW	10	20	80	18	25	98	8	15
	BM	40	12	27	57	80	90	27	22
	BN	27	57	90	60	70	75	43	67
	JN	23	0	87	65	85	80	30	25
	HO	90	88	75	90	78	43	73	58
Mean		33	39	72	51	71	76	32	49

Key: Rd = read; rp = repetition; sc = sentence completion; ed = past tense; 3 = third person; Ø = stem only

Large Gang	JE	12	80	77	25	100	80	22	47
	ES	0	63	45	13	23	73	3	53
	EN	43	50	95	68	98	85	68	83
	HW	23	15	78	28	13	80	13	15
	BM	10	20	20	60	80	90	0	7
	BN	30	20	88	98	80	88	40	60
	JN	15	33	87	23	88	87	20	40
	HO	85	78	63	85	90	58	68	60
Mean		27	45	69	50	72	80	29	46
Small Gang	JE	20	55	80	12	90	65	10	30
	ES	13	77	43	20	50	73	23	60
	EN	58	68	85	70	78	90	60	73
	HW	10	15	98	5	18	100	3	15
	BM	32	40	57	37	70	83	5	7
	BN	38	47	98	58	87	95	18	75
	JN	23	20	70	53	83	72	35	30
	HO	78	100	6	68	88	58	68	50
Mean		34	53	67	40	71	80	28	43
Single Cons.	JE	22	52	65	62	70	77	0	50
	ES	48	53	20	40	38	60	48	43
	EN	80	75	70	100	85	90	90	90
	HW	18	25	88	10	25	88	3	10
	BM	32	20	54	50	90	100	20	27
	BN	30	70	100	88	77	85	20	85
	JN	50	25	70	68	63	85	15	65
	HO	88	85	73	75	65	43	65	45
Mean		46	51	68	62	64	79	33	52

Cons. Cluster	JE	32	35	50	45	57	57	25	27
	ES	30	45	47	45	38	55	23	33
	EN	40	50	85	80	80	73	50	50
	HW	25	38	35	38	23	78	23	18
	BM	10	17	50	60	45	85	30	15
	BN	0	40	90	60	27	73	5	5
	JN	20	35	13	53	58	60	23	15
	HO	55	77	78	58	60	55	13	53
Mean		27	42	56	55	49	67	24	27
Bisyllable	JE	20	25	77	45	77	55	35	20
	ES	0	58	30	33	40	73	18	43
	EN	35	80	90	78	90	75	65	78
	HW	23	15	90	30	18	80	23	3
	BM	20	20	40	40	80	95	37	13
	BN	8	30	90	63	47	80	20	50
	JN	10	8	35	53	83	60	20	23
	HO	90	65	58	40	95	40	40	38
Mean		26	38	64	48	66	70	32	34
Trisyllable	JE	37	17	45	55	75	80	20	35
	ES	8	50	18	28	58	43	23	50
	EN	35	38	83	85	80	70	48	70
	HW	43	2	43	33	15	75	33	8
	BM	30	12	67	47	55	80	13	2
	BN	25	0	63	78	57	85	18	0
	JN	15	13	10	80	45	50	45	3
	HO	48	75	78	85	90	43	35	78
Mean		30	26	51	61	59	66	29	31
Grand Means		31	42	66	51	65	75	29	42

Stem Rating

	Subj.	rd ed st	rd 3 st	rd Ø st	rp ed st	rp 3 st	rp Ø st	sc ed st	sc 3 st
High Freq	JE	83	85	95	100	83	85	83	65
	ES	90	67	83	65	45	55	67	67
	EN	78	73	88	65	70	68	60	40
	HW	33	10	90	70	0	98	70	23
	BM	60	43	60	73	100	87	67	70
	BN	100	100	95	80	87	50	80	60
	JN	90	90	95	93	98	70	65	88
	HO	85	97	95	90	97	75	92	92
Mean		77	71	88	80	73	74	73	63
Low Freq	JE	83	72	80	80	70	83	88	75
	ES	65	78	75	40	43	68	55	50
	EN	85	80	80	63	70	78	45	55
	HW	38	25	83	68	13	100	78	38
	BM	43	43	65	77	83	73	77	65
	BN	84	90	95	90	90	80	100	90
	JN	58	50	85	75	50	85	50	43
	HO	100	97	85	100	100	97	95	100
Mean		70	67	81	74	65	83	74	65

Key: Rd = read; rp = repetition; sc = sentence completion; ed = past tense; 3 = third person; Ø = stem only

Large Gang	JE	98	85	58	78	68	80	78	73
	ES	55	65	50	53	53	70	33	73
	EN	63	60	53	55	48	60	48	43
	HW	38	28	85	38	23	100	45	50
	BM	37	50	40	75	70	73	80	90
	BN	90	90	90	100	80	78	58	43
	JN	58	55	78	78	83	78	73	70
	HO	82	87	75	90	82	90	77	92
Mean		65	65	66	71	63	79	62	67
Small Gang	JE	80	85	78	90	83	100	100	98
	ES	55	80	78	45	60	63	40	48
	EN	68	63	73	58	63	73	53	33
	HW	63	33	100	70	13	100	63	3
	BM	70	67	60	95	83	100	90	87
	BN	100	100	95	90	100	80	80	60
	JN	65	55	50	85	78	90	68	68
	HO	90	100	90	100	100	100	85	95
Mean		74	73	78	79	73	88	72	62
Single Cons.	JE	80	78	88	85	85	80	65	80
	ES	60	47	63	53	40	45	45	43
	EN	55	75	80	73	75	60	55	63
	HW	15	20	75	50	8	88	48	50
	BM	60	67	61	85	100	93	60	70
	BN	90	100	95	100	80	98	70	80
	JN	53	38	68	50	63	80	53	63
	HO	87	92	85	92	87	80	97	90
Mean		63	65	77	74	67	78	62	67

Cons. Cluster	JE	48	43	48	70	60	73	78	75
	ES	33	40	30	30	33	55	40	20
	EN	73	70	68	60	68	68	63	50
	HW	30	35	78	38	48	85	75	6
	BM	20	35	17	60	75	57	87	60
	BN	100	80	85	90	36	88	23	33
	JN	63	50	35	95	73	83	73	68
	HO	75	63	95	82	87	82	72	55
Mean		55	52	57	66	60	74	64	46
Bisyllable	JE	68	35	50	45	90	73	70	43
	ES	35	48	70	58	35	45	20	13
	EN	63	75	75	75	68	48	53	45
	HW	70	50	100	58	40	90	85	40
	BM	30	20	27	50	77	70	37	17
	BN	90	78	93	90	80	88	0	23
	JN	23	23	35	75	63	68	33	25
	HO	62	25	62	65	77	55	72	45
Mean		55	44	64	65	66	67	46	31
Trisyllable	JE	48	60	65	53	45	53	38	63
	ES	13	55	52	35	28	27	33	40
	EN	88	68	73	68	85	55	38	40
	HW	85	28	63	45	50	73	45	8
	BM	20	95	15	80	73	87	13	13
	BN	80	85	69	80	90	85	30	55
	JN	18	23	20	75	75	65	68	55
	HO	82	80	70	87	62	67	42	72
Mean		54	62	53	65	64	64	38	43
Grand means		64	62	71	72	66	76	61	55

Appendix I

Mean Percent Correct by Subject

Affix Rating

Subj. 1 (JE)	rd ed af	rd 3 af	rd Ø af	Rd Mean	rp ed af	rp 3 af	rp Ø af	Rp Mean	sc ed af	sc 3 af	SC Mean
High Freq	22	42	97	54	45	75	80	67	2	67	35
Low Freq	17	11	82	37	47	77	65	63	7	67	37
Large Gang	12	80	77	56	25	100	80	68	22	47	35
Small Gang	20	55	80	52	12	90	65	56	10	30	20
Single Cons.	22	52	65	46	62	70	77	70	0	50	25
Cons. Cl.	32	35	50	39	45	57	57	53	25	27	26
Bisyllable	20	25	77	41	45	77	55	59	35	20	28
Trisyllable	37	17	45	33	55	75	80	70	20	35	28
Mean	23	40	72	45	42	78	70	63	15	43	29
Subj. 2 (ES)											
High Freq	17	58	65	47	7	63	87	52	10	70	40
Low Freq	10	60	45	38	20	53	70	48	15	75	45
Large Gang	0	63	45	36	13	23	73	36	3	53	28
Small Gang	13	77	43	44	20	50	73	48	23	60	42
Single Cons.	48	53	20	40	40	38	60	46	48	43	46
Cons. Cluster	30	45	47	41	45	38	55	46	23	33	28
Bisyllable	0	58	30	29	33	40	73	49	18	43	31
Trisyllable	8	50	18	25	28	58	43	43	23	50	37
Mean	16	58	39	38	26	45	67	46	20	53	37

Key: Rd = read; pr = repetition; sc = sentence completion; ed = past tense; 3 = third person; ø = stem only

Subj. 3 (EN)											
High Freq	35	53	93	60	63	70	85	73	50	58	54
Low Freq	45	63	87	65	53	100	90	81	50	63	57
Large Gang	43	50	95	63	68	98	85	84	68	83	76
Small Gang	58	68	85	70	70	78	90	79	60	73	67
Single Cons.	80	75	70	75	100	85	90	92	90	90	90
Cons. Cluster	40	50	85	58	80	80	73	78	50	50	50
Bisyllable	35	80	90	68	78	90	75	81	65	78	72
Trisyllable	35	38	83	52	85	80	70	78	48	70	59
Mean	46	60	86	64	75	85	82	81	60	71	65
Subj. 4 (HW)											
High Freq	15	23	98	45	8	30	100	46	18	13	16
Low Freq	10	20	80	37	18	25	98	47	8	15	12
Large Gang	23	15	78	39	28	13	80	40	13	15	14
Small Gang	10	15	98	41	5	18	100	41	3	15	9
Single Cons.	18	25	88	44	10	25	88	41	3	10	7
Cons. Cluster	25	38	35	33	38	23	78	46	23	18	21
Bisyllable	23	15	90	43	30	18	80	43	23	3	13
Trisyllable	43	2	43	29	33	15	75	41	33	8	21
Mean	21	19	76	39	21	21	87	43	16	12	14
Subj. 5 (BM)											
High Freq	10	0	43	18	37	60	81	59	12	15	14
Low Freq	40	12	27	26	57	80	90	76	27	22	25
Large Gang	10	20	20	17	60	80	90	77	0	7	4
Small Gang	32	40	57	43	37	70	83	63	5	7	6
Single Cons.	32	20	54	35	50	90	100	80	20	27	24
Cons. Cluster	10	17	50	26	60	45	85	63	30	15	23
Bisyllable	20	20	40	27	40	80	95	72	37	13	25
Trisyllable	30	12	67	36	47	55	80	61	13	2	8
Mean	23	18	45	28	49	70	88	69	18	14	16

Subj. 6 (BN)											
High Freq	10	30	100	47	58	75	78	70	43	67	55
Low Freq	27	57	90	58	60	70	75	68	43	67	55
Large Gang	30	20	88	46	98	80	88	89	40	60	50
Small Gang	38	47	98	61	58	87	95	80	18	75	47
Single Cons.	30	70	100	67	88	77	85	83	20	85	53
Cons. Cluster	0	40	90	43	60	27	73	53	5	5	5
Bisyllable	8	30	90	43	63	47	80	63	20	50	35
Trisyllable	25	0	63	29	78	57	85	73	18	0	9
Mean	21	37	90	49	70	65	82	73	26	51	39
Subj. 7 (JN)											
High Freq	25	33	97	52	63	80	97	80	45	90	68
Low Freq	23	0	87	37	65	85	80	77	30	25	28
Large Gang	15	33	87	45	23	88	87	66	20	40	30
Small Gang	23	20	70	38	53	83	72	69	35	30	33
Single Cons.	50	25	70	48	68	63	85	72	15	65	40
Cons. Cluster	20	35	13	23	53	58	60	57	23	15	19
Bisyllable	10	8	35	18	53	83	60	65	20	23	22
Trisyllable	15	13	10	13	80	45	50	58	45	3	24
Mean	23	21	59	34	57	73	74	68	29	36	33
Subj. 8 (HO)											
High Freq	93	78	58	76	68	93	50	70	50	48	49
Low Freq	90	88	75	84	90	78	43	70	73	58	66
Large Gang	85	78	63	75	85	90	58	78	68	60	64
Small Gang	78	100	6	61	68	88	58	71	68	50	59
Single Cons.	88	85	73	82	75	65	43	61	65	45	55
Cons. Cluster	55	77	78	70	58	60	55	58	13	53	33
Bisyllable	90	65	58	71	40	95	40	58	40	38	39
Trisyllable	48	75	78	67	85	90	43	73	35	78	57
Mean	78	81	61	73	71	82	49	67	52	54	53

Stem Rating

	rd ed st	rd 3 st	rd Ø st	Rd Mean	rp ed st	rp 3 st	rp Ø st	Rp Mean	sc ed al	sc 3 af	S C Mean
Subj. 1 (JE)											
High Freq	83	85	95	88	100	83	85	89	83	65	74
Low Freq	83	72	80	78	80	70	83	78	88	75	82
Large Gang	98	85	58	80	78	68	80	75	78	73	76
Small Gang	80	85	78	81	90	83	100	91	100	98	99
Single Cons.	80	78	88	82	85	85	80	83	65	80	73
Cons. Cluster	48	43	48	46	70	60	73	68	78	75	77
Bisyllable	68	35	50	51	45	90	73	69	70	43	57
Trisyllable	48	60	65	58	53	45	53	50	38	63	51
Mean	74	68	70	71	75	73	78	76	75	72	73
Subj. 2 (ES)											
High Freq	90	67	83	80	65	45	55	55	67	67	67
Low Freq	65	78	75	73	40	43	68	50	55	50	53
Large Gang	55	65	50	57	53	53	70	59	33	73	53
Small Gang	55	80	78	71	45	60	63	56	40	48	44
Single Cons.	60	47	63	57	53	40	45	46	45	43	44
Cons. Cluster	33	40	30	34	30	33	55	39	40	20	30
Bisyllable	35	48	70	51	58	35	45	46	20	13	17
Trisyllable	13	55	52	40	35	28	27	30	33	40	37
Mean	51	60	63	58	47	42	54	48	42	44	43

Subj. 3 (EN)											
High Freq	78	73	88	80	65	70	68	68	60	40	50
Low Freq	85	80	80	82	63	70	78	70	45	55	50
Large Gang	63	60	53	59	55	48	60	54	48	43	46
Small Gang	68	63	73	68	58	63	73	65	53	33	43
Single Cons.	55	75	80	70	73	75	60	69	55	63	59
Cons. Cluster	73	70	68	70	60	68	68	65	63	50	57
Bisyllable	63	75	75	71	75	68	48	64	53	45	49
Trisyllable	88	68	73	76	68	85	55	69	38	40	39
Mean	72	71	74	72	65	68	64	66	52	46	49
Subj. 4 (HW)											
High Freq	33	10	90	44	70	0	98	56	70	23	47
Low Freq	38	25	83	49	68	13	100	60	78	38	58
Large Gang	38	28	85	50	38	23	100	54	45	50	48
Small Gang	63	33	100	65	70	13	100	61	63	3	33
Single Cons.	15	20	75	37	50	8	88	49	48	50	49
Cons. Cluster	30	35	78	48	38	48	85	57	75	6	41
Bisyllable	70	50	100	73	58	40	90	63	85	40	63
Trisyllable	85	28	63	59	45	50	73	56	45	8	27
Mean	47	29	84	53	55	24	92	57	64	27	45
Subj. 5 (BM)											
High Freq	60	43	60	54	73	100	87	87	67	70	69
Low Freq	43	43	65	50	77	83	73	78	77	65	71
Large Gang	37	50	40	42	75	70	73	73	80	90	85
Small Gang	70	67	60	66	95	83	100	93	90	87	89
Single Cons.	60	67	61	63	85	100	93	93	60	70	65
Cons. Cluster	20	35	17	24	60	75	57	64	87	60	74
Bisyllable	30	20	27	26	50	77	70	66	37	17	27
Trisyllable	20	95	15	43	80	73	87	80	13	13	13
Mean	43	53	43	46	74	83	80	79	64	59	61

Subj. 6 (BN)											
High Freq	100	100	95	98	80	87	50	72	80	60	70
Low Freq	84	90	95	90	90	90	80	87	100	90	95
Large Gang	90	90	90	90	100	80	78	86	58	43	51
Small Gang	100	100	95	98	90	100	80	90	80	60	70
Single Cons.	90	100	95	95	100	80	98	93	70	80	75
Cons. Cluster	100	80	85	88	90	36	88	71	23	33	28
Bisyllable	90	78	93	87	90	80	88	86	0	23	12
Trisyllable	80	85	69	78	80	90	85	85	30	55	43
Mean	92	90	90	91	90	80	81	84	55	56	55
Subj. 7 (JN)											
High Freq	90	90	95	92	93	98	70	87	65	88	77
Low Freq	58	50	85	64	75	50	85	70	50	43	47
Large Gang	58	55	78	64	78	83	78	80	73	70	72
Small Gang	65	55	50	57	85	78	90	84	68	68	68
Single Cons.	53	38	68	53	50	63	80	64	53	63	58
Cons. Cluster	63	50	35	49	95	73	83	84	73	68	71
Bisyllable	23	23	35	27	75	63	68	69	33	25	29
Trisyllable	18	23	20	20	75	75	65	72	68	55	62
Mean	54	48	58	53	78	73	77	76	60	60	60
Subj. 8 (HO)											
High Freq	85	97	95	92	90	97	75	87	92	92	92
Low Freq	100	97	85	94	100	100	97	99	95	100	98
Large Gang	82	87	75	81	90	82	90	87	77	92	85
Small Gang	90	100	90	93	100	100	100	100	85	95	90
Single Cons.	87	92	85	88	92	87	80	86	97	90	94
Cons. Cluster	75	63	95	78	82	87	82	84	72	55	64
Bisyllable	62	25	62	50	65	77	55	66	72	45	59
Trisyllable	82	80	70	77	87	62	67	72	42	72	57
Mean	83	80	82	82	88	87	81	85	79	80	80

Figure 1 Percent Correct for Affixation Across Word Lists for 2 Tasks X 3 Affixes

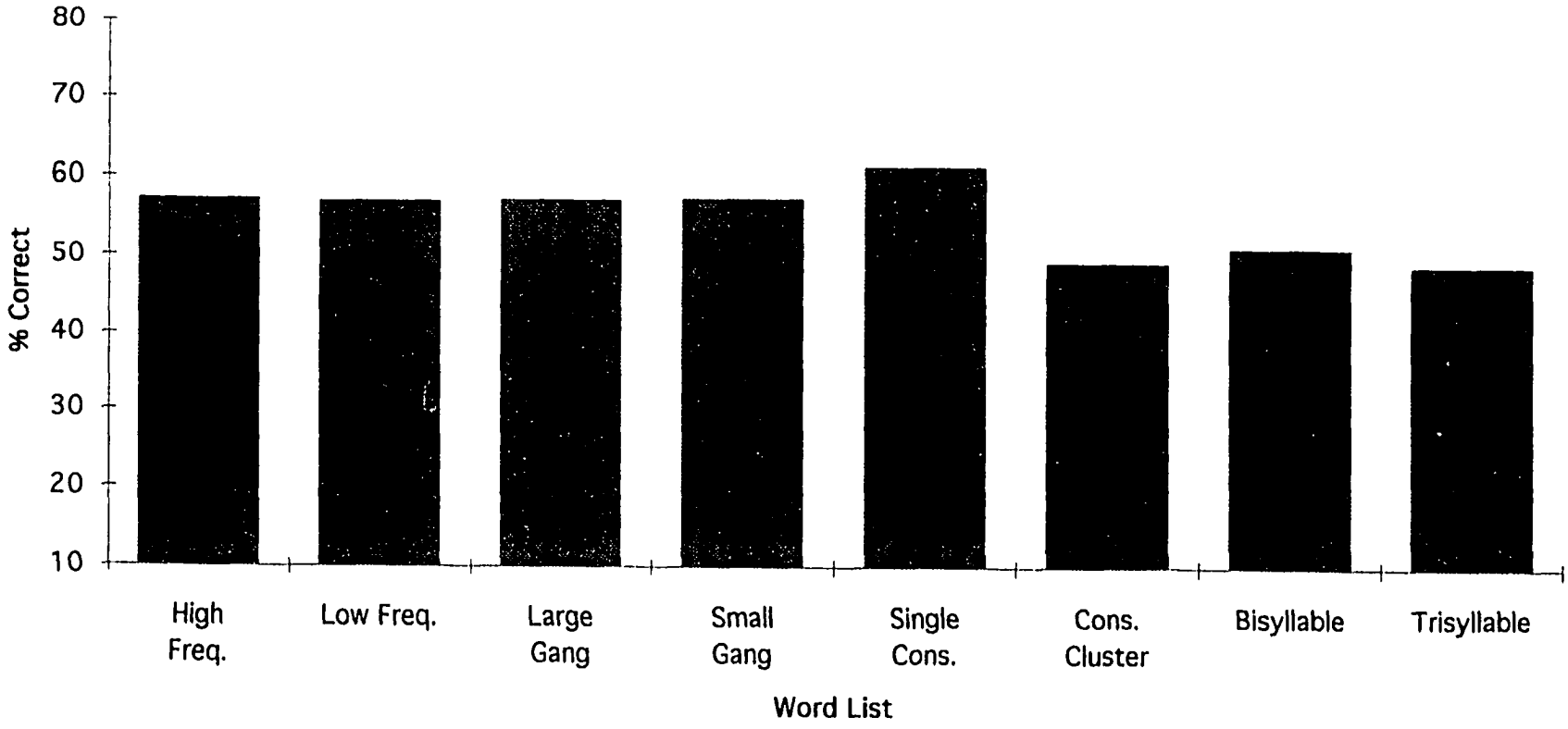


Figure 2 Percent Correct for Affixation Across Word Lists for 3 Tasks x 2 Affixes

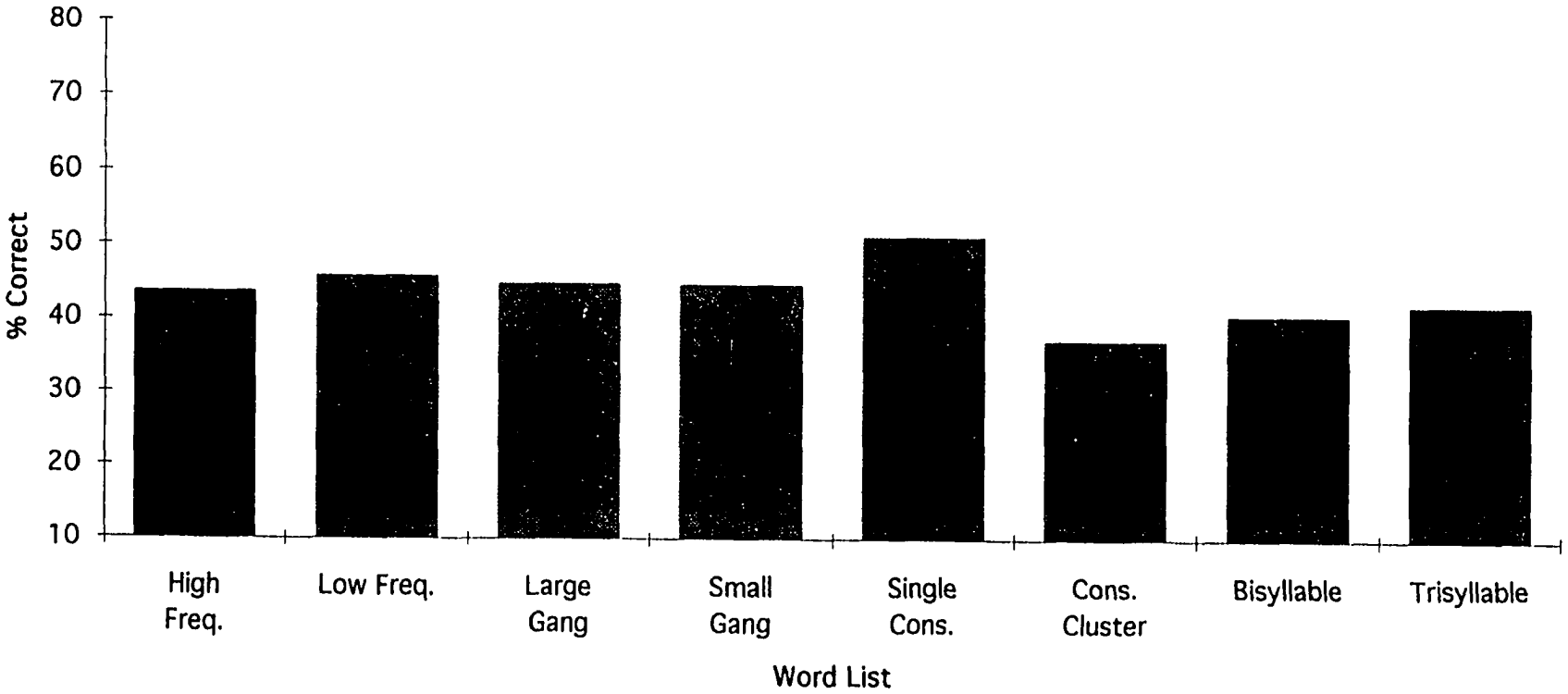


Figure 3 Percent Correct for Affixation Across 2 Tasks for 3 Affixes

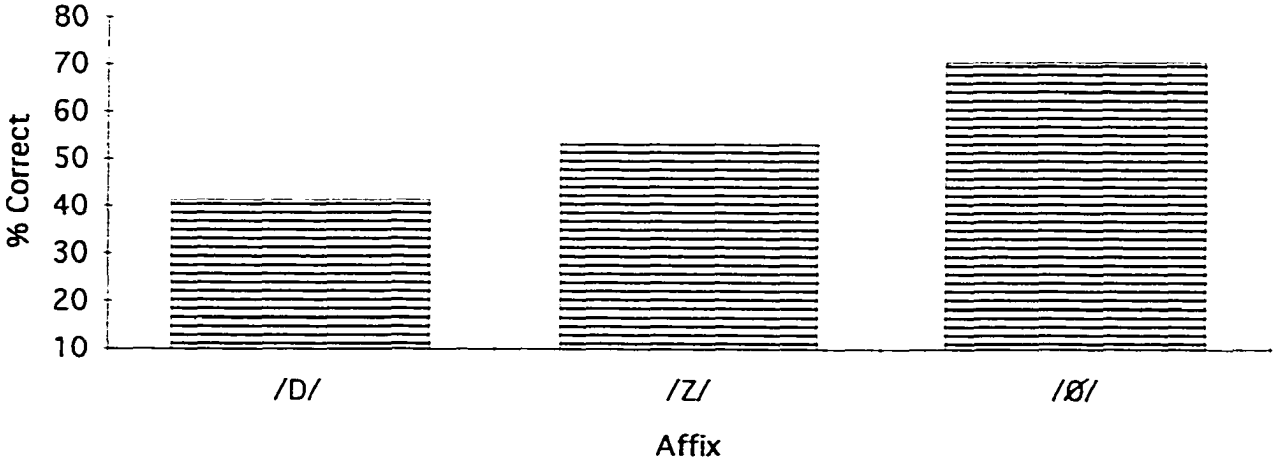


Figure 4 Percent Correct for Affixation Across 3 Tasks X 2 Affixes

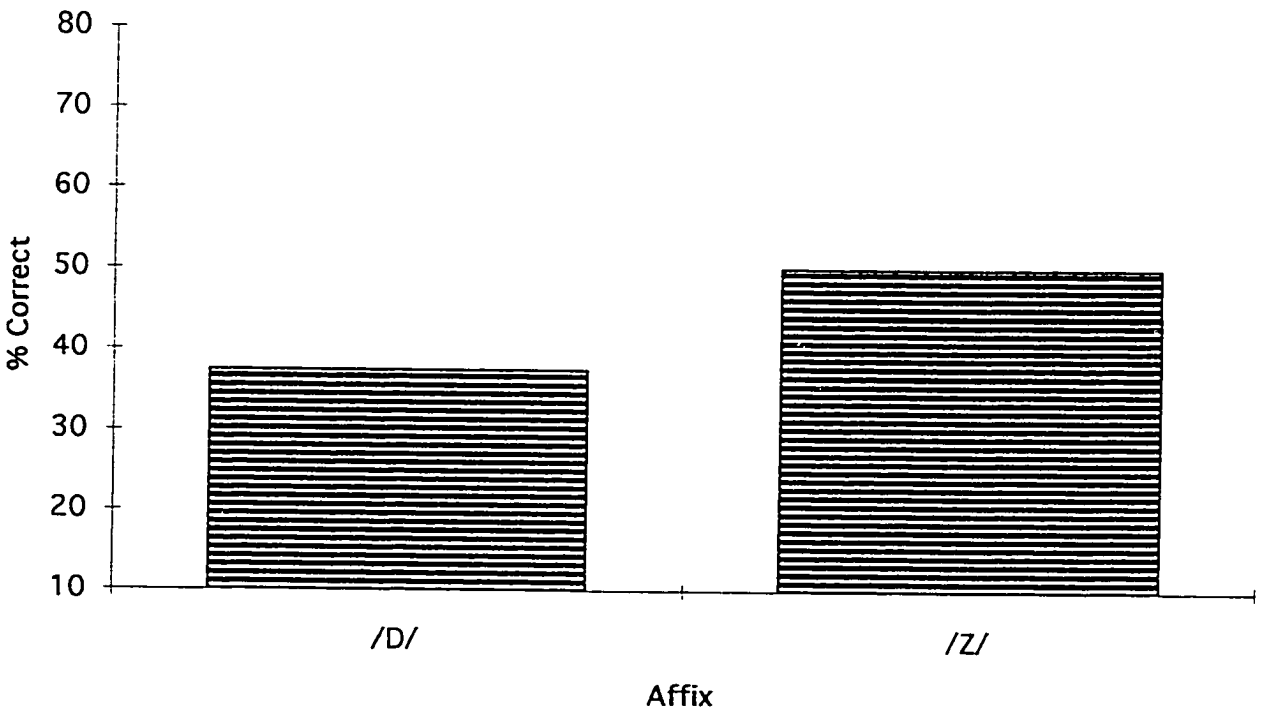


Figure 5 Percent Correct for Affixation Produced Across Tasks for 2 Tasks X 3 Affixes

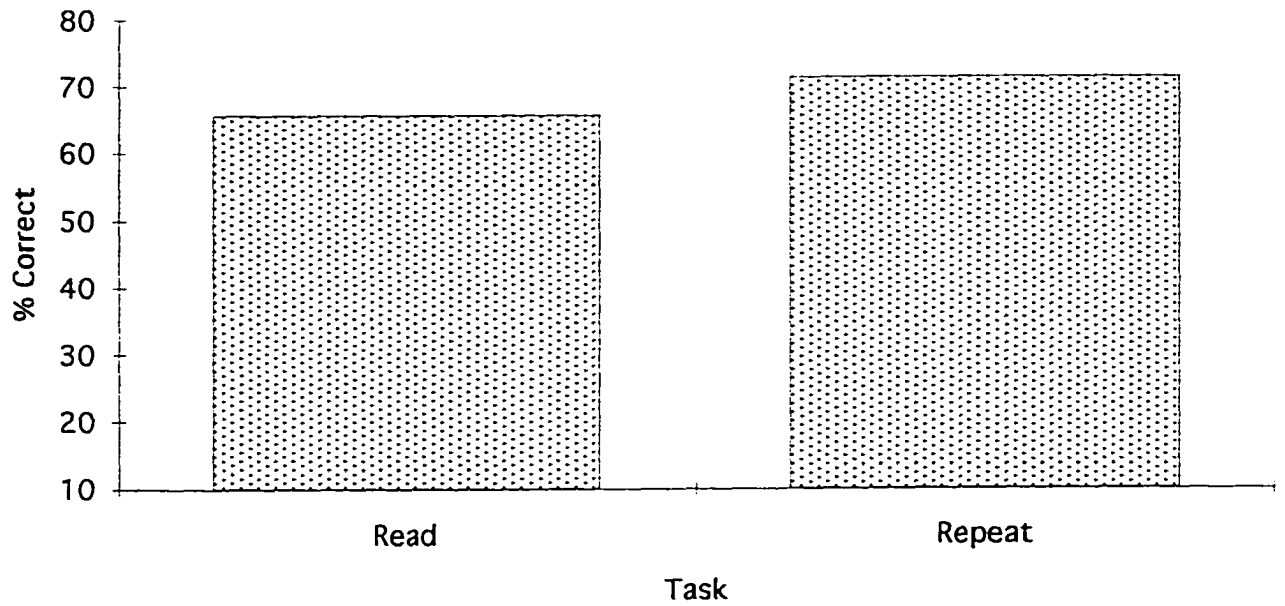


Figure 6 Percent Correct Affixation 3 Tasks for 2 Affixes

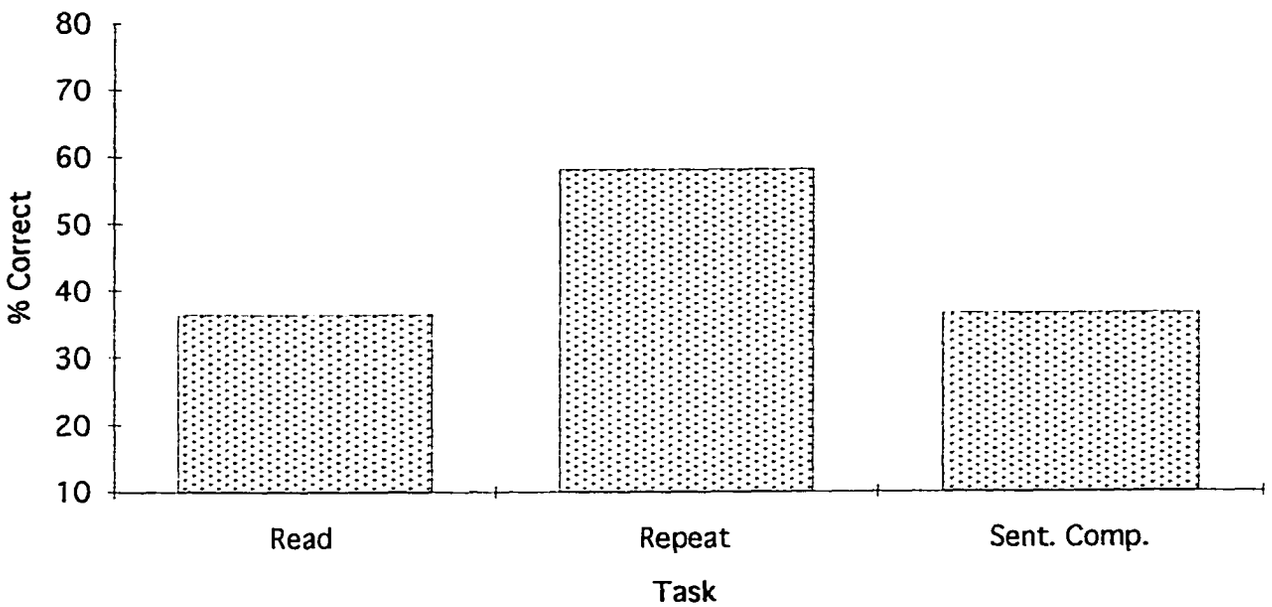


Figure 7 Percent Correct for Affixation Across Tasks for 3 Tasks and 2 Affixes

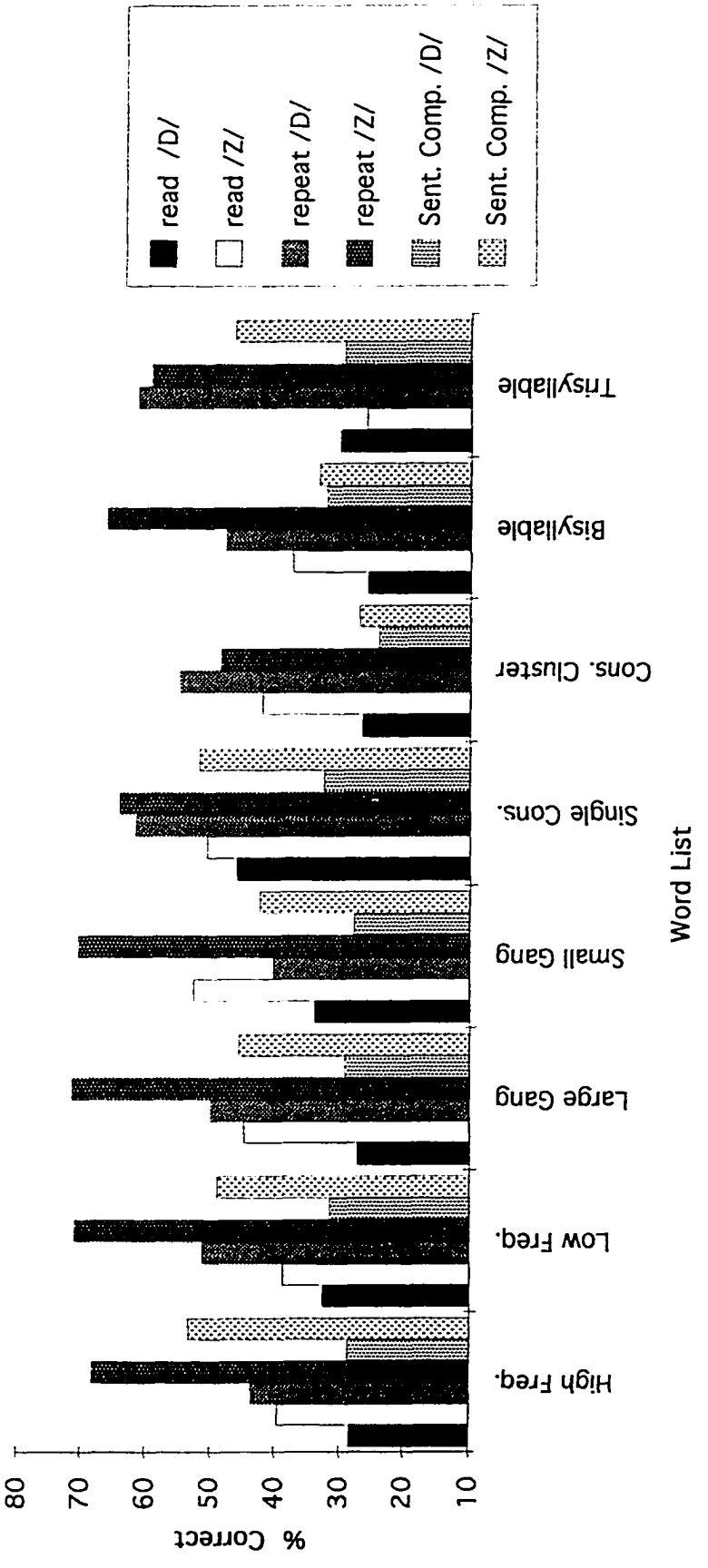


Figure 8 Percent Correct for Stem Production Across Word Lists for 2 Tasks and 3 Affixes

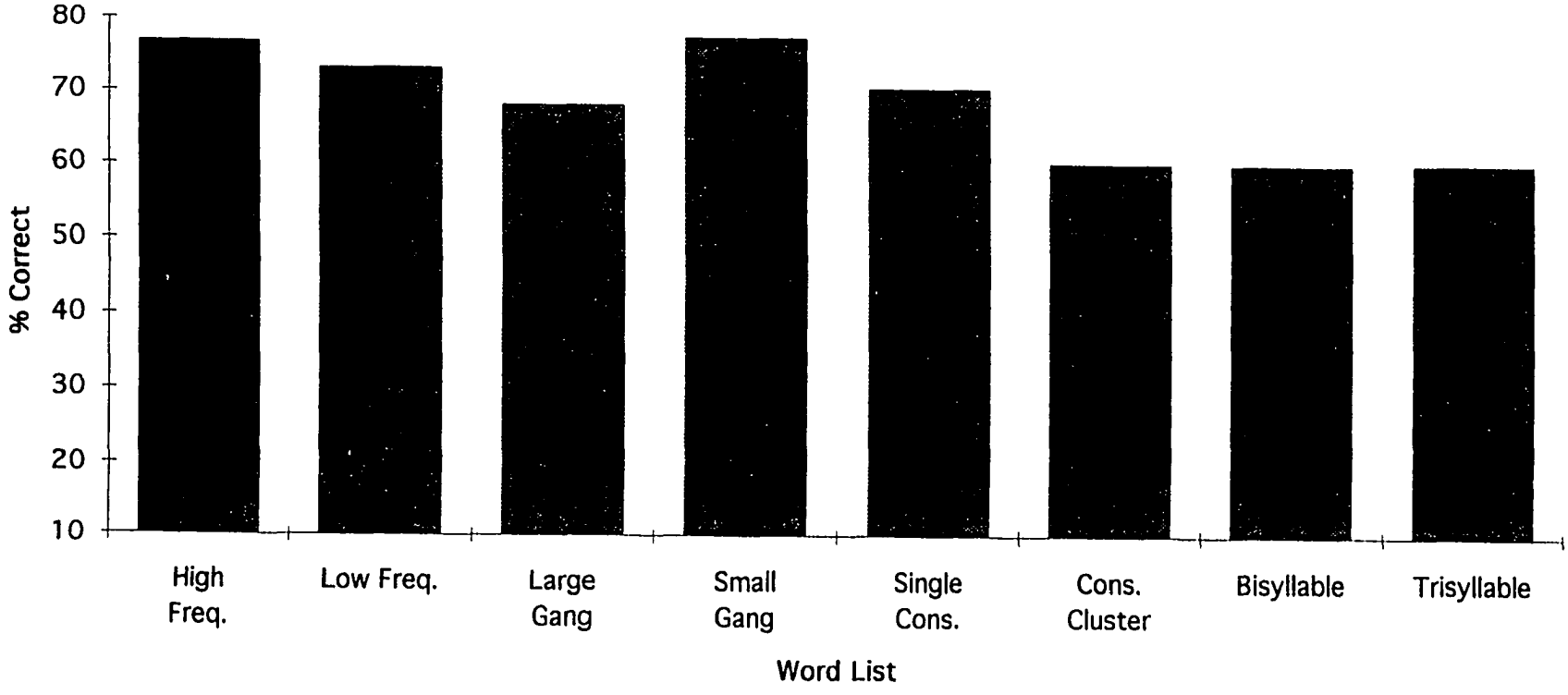


Figure 9 Percent Correct for Stem Production Across Word Lists for 3 Tasks X 2 Affixes

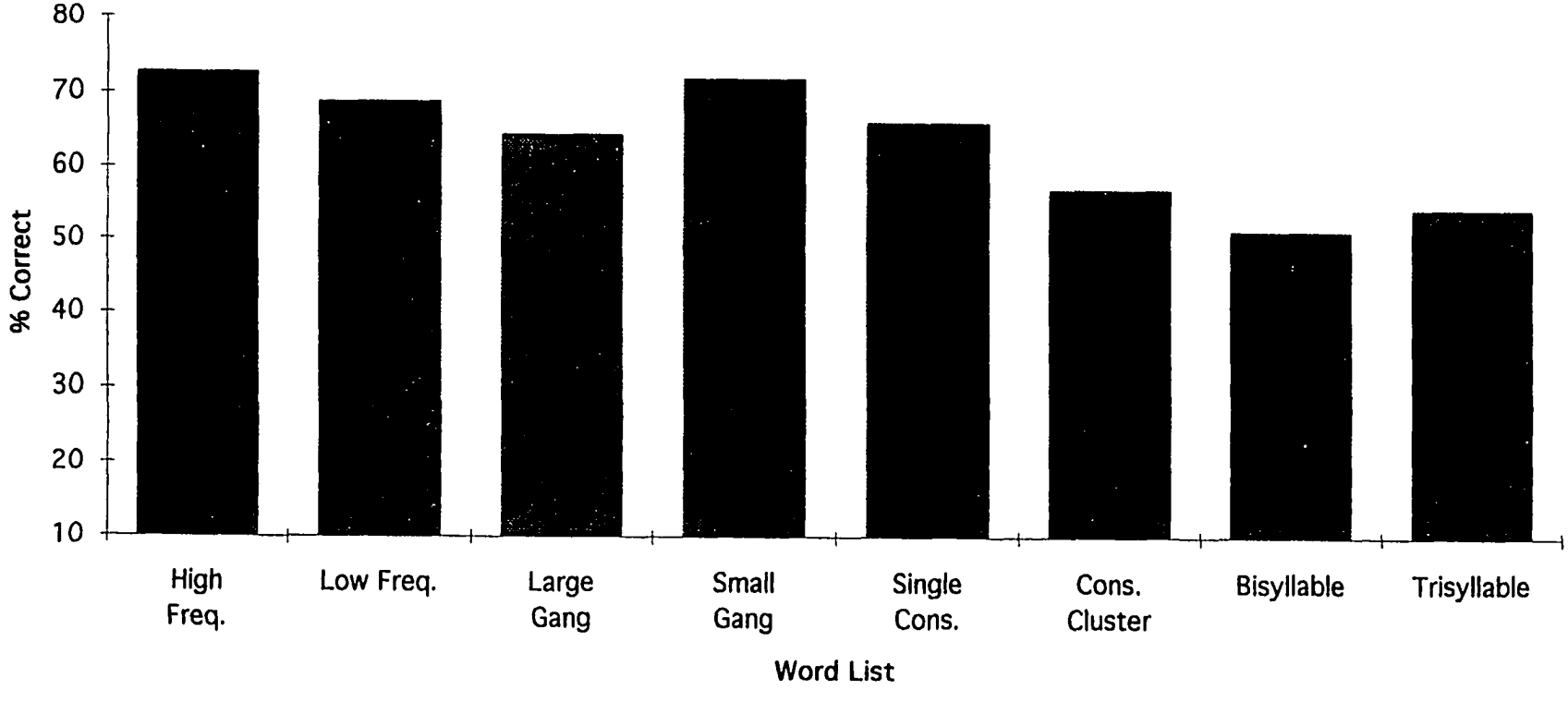


Figure 10 Percent Correct for Stem Production Across Affixes for 2 Tasks X 3 Affixes

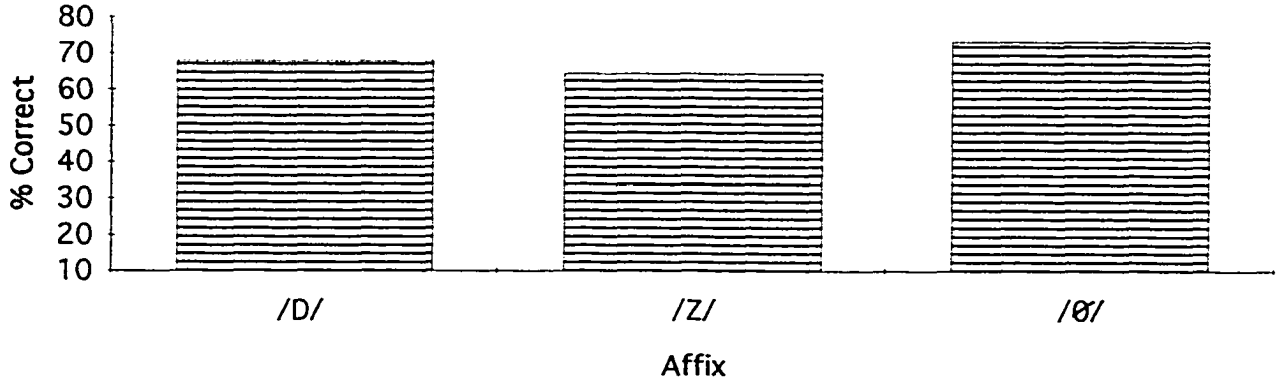


Figure 11 Percent Correct for Stem Production Across Tasks for 2 Tasks X 3 Affixes

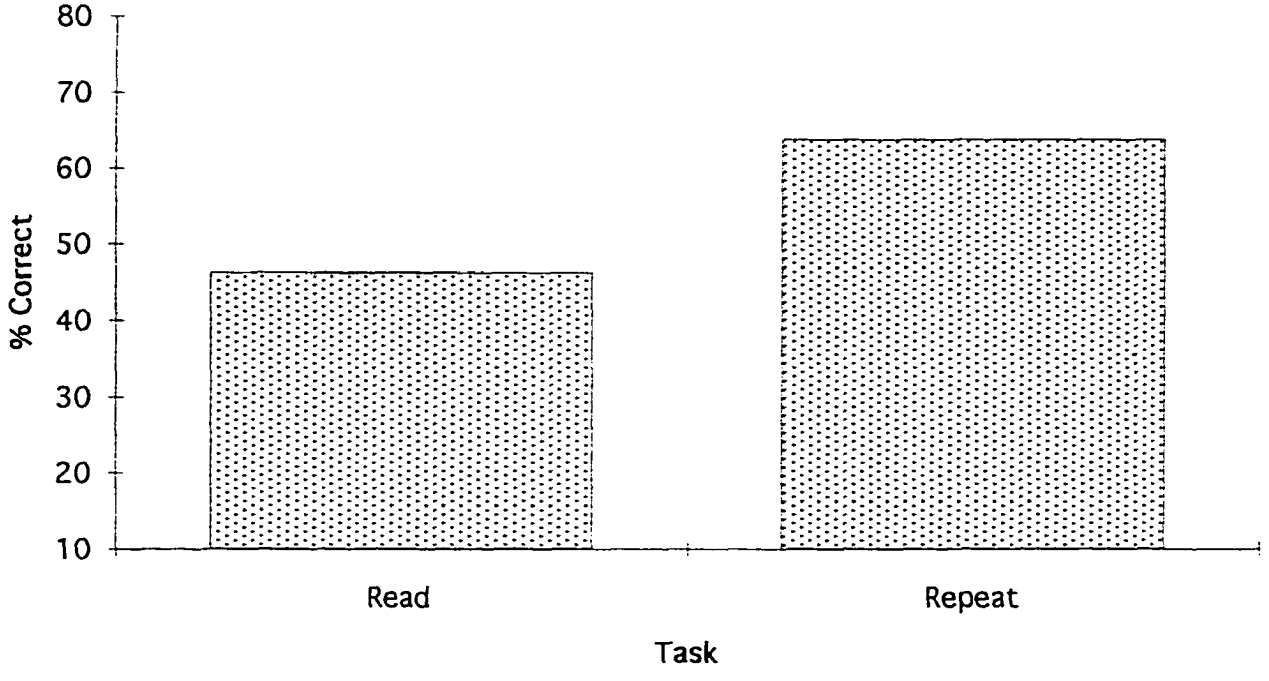
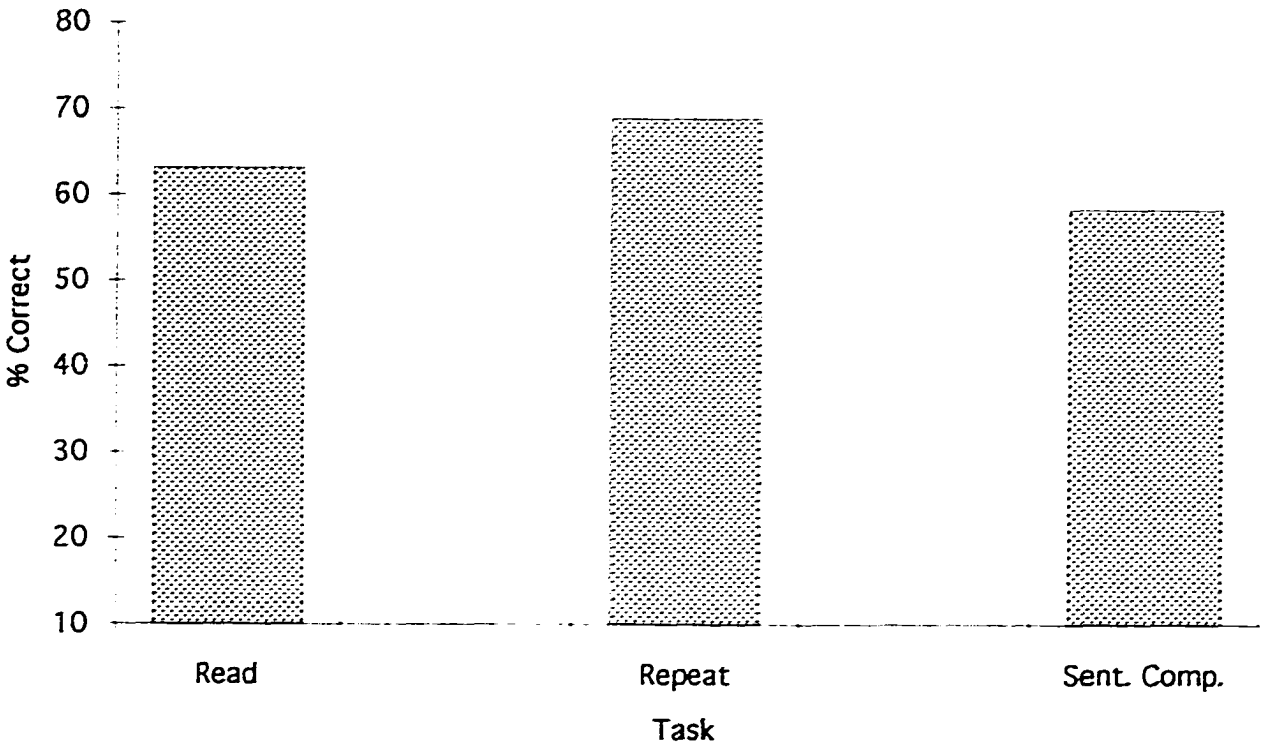


Figure 12 Percent Correct Stems Across 3 Tasks for 2 Affixes



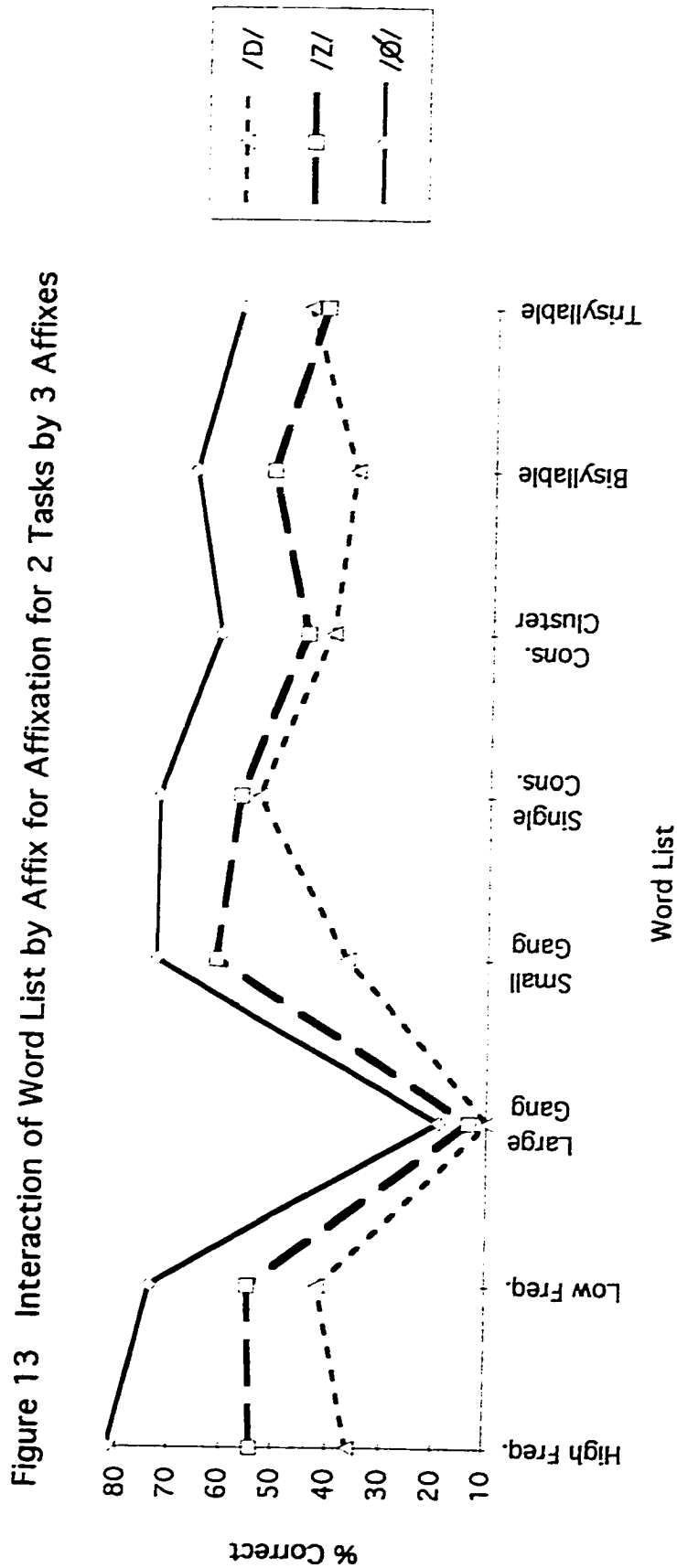
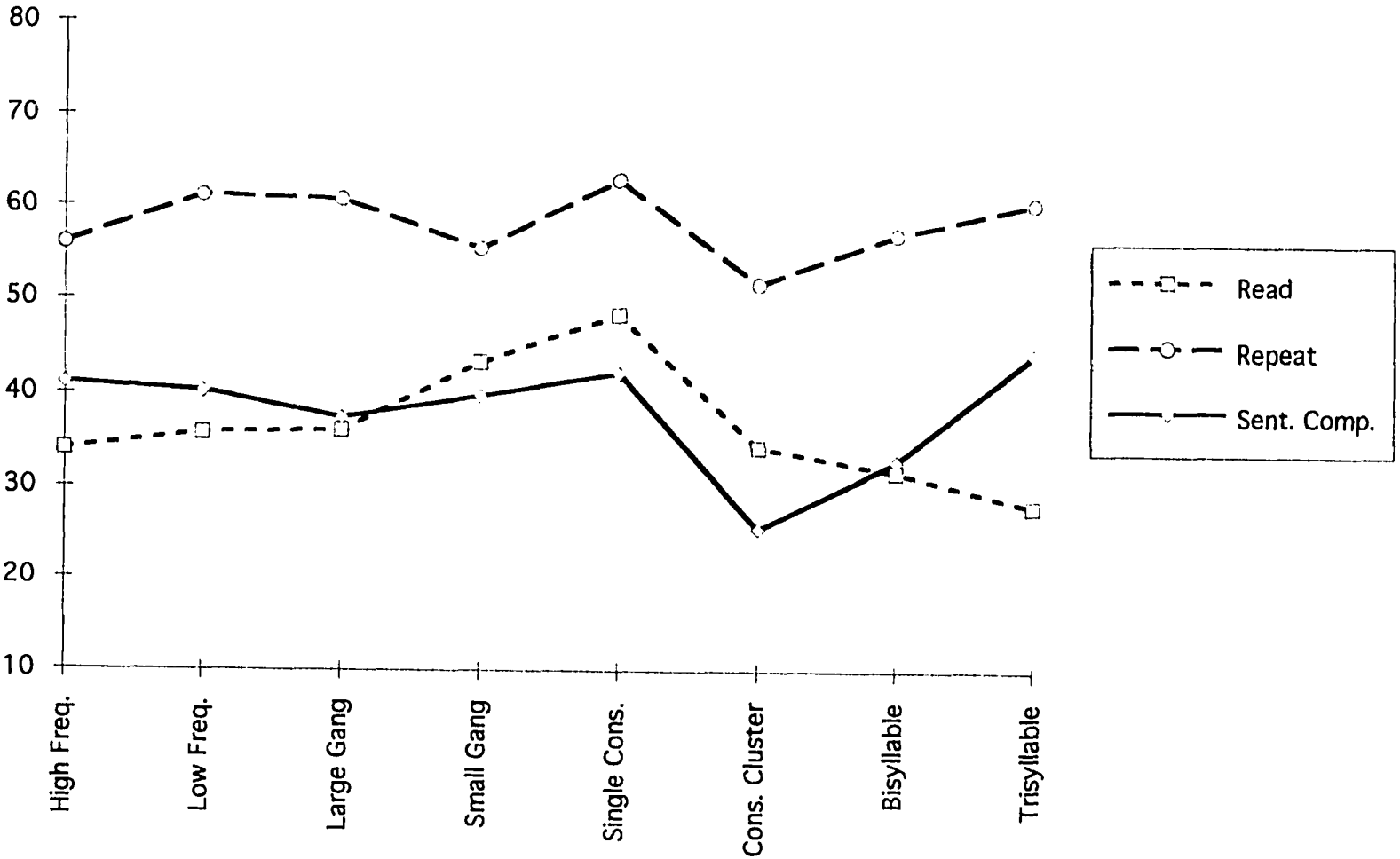


Figure 13 Interaction of Word List by Affix for Affixation for 2 Tasks by 3 Affixes

Figure 14 Task by Word List Interaction for Affixation 3 Tasks by 2 Affixes



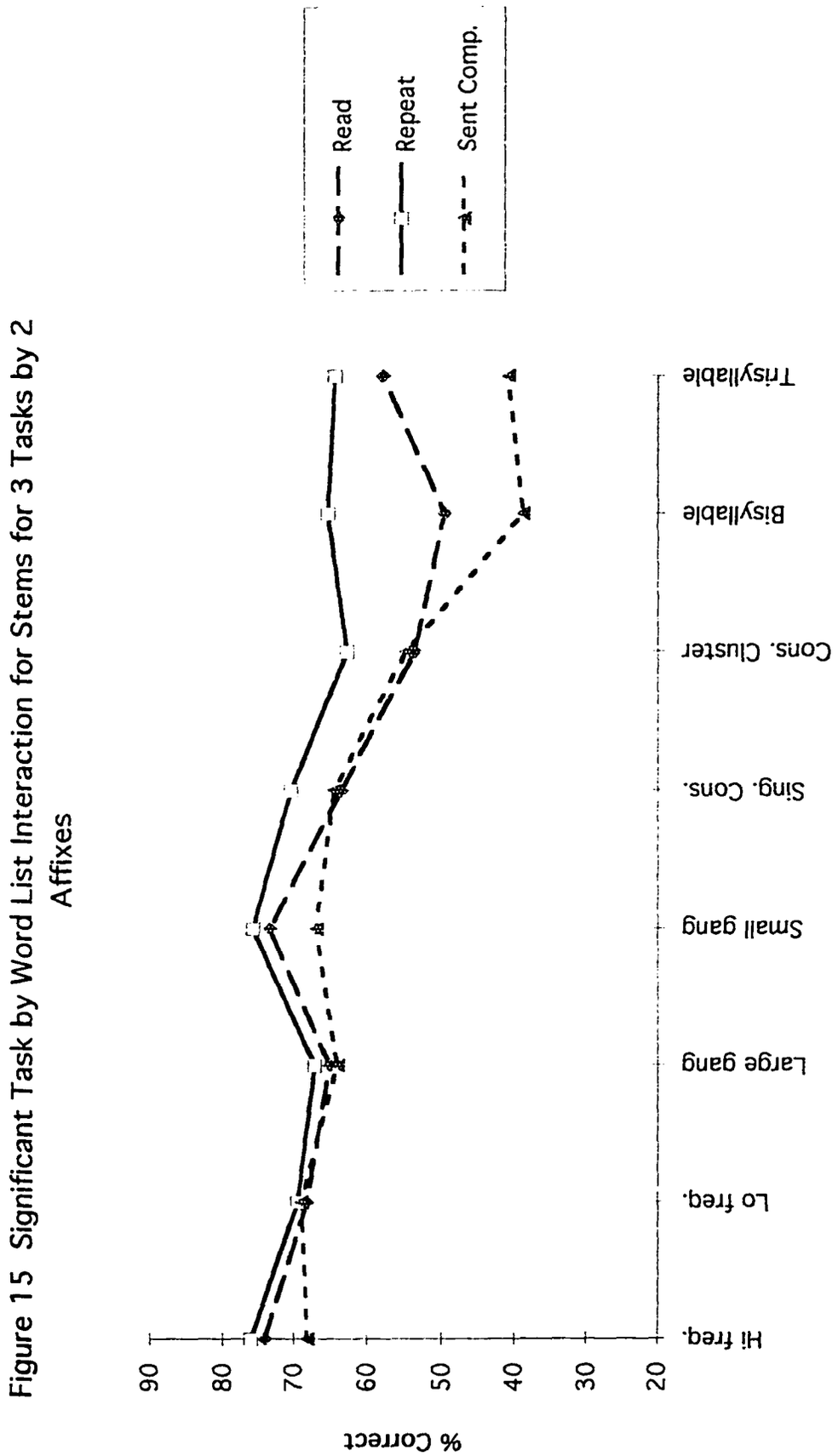


Figure 15 Significant Task by Word List Interaction for Stems for 3 Tasks by 2 Affixes

Figure 16 Task and Word List Interaction for Stem Production for 2 Tasks and 3 Affixes

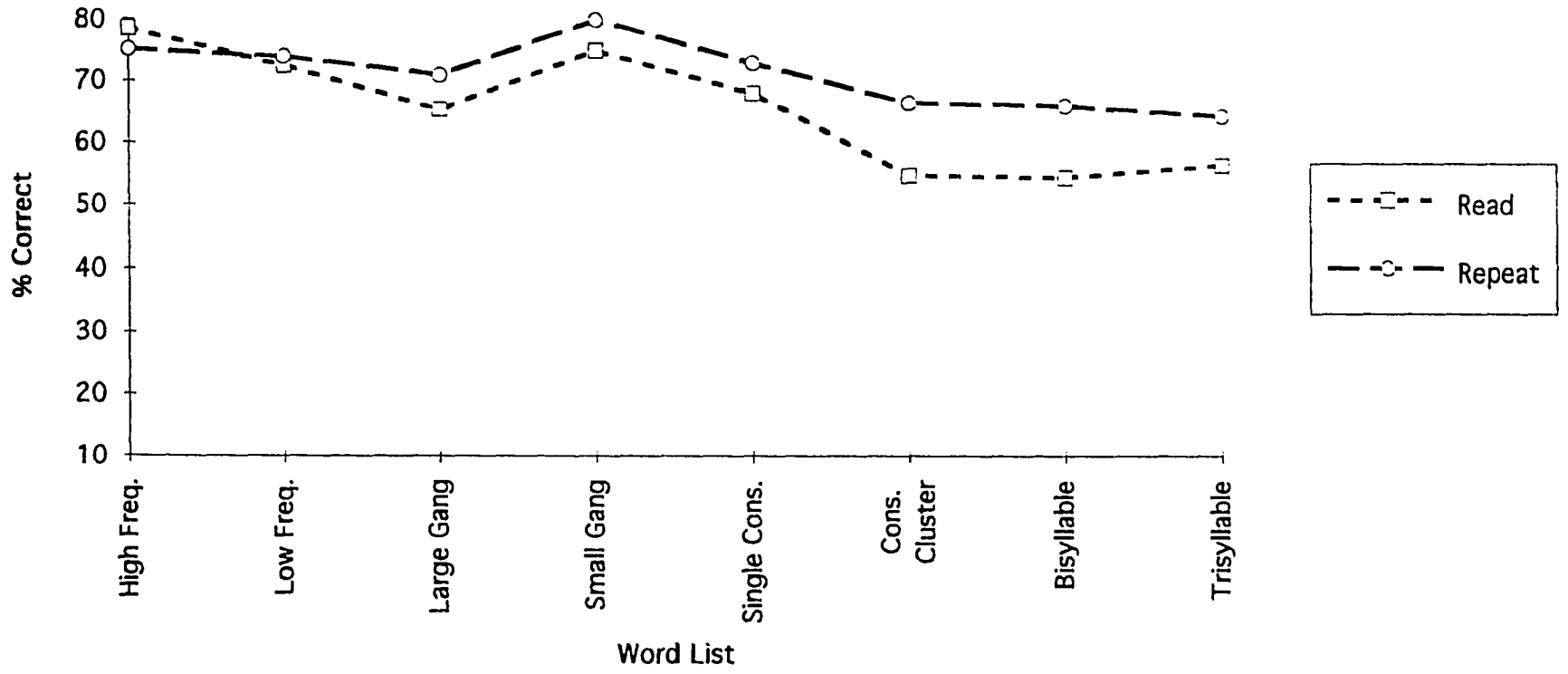


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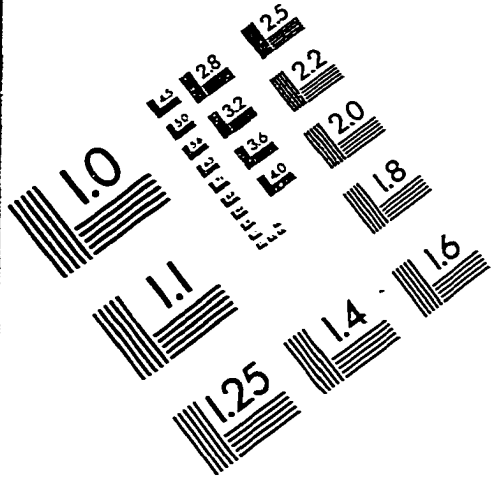
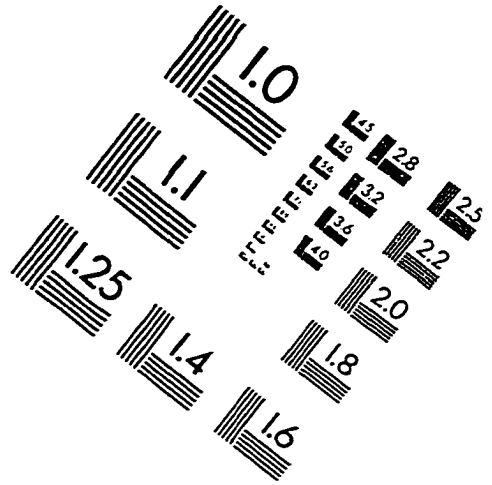
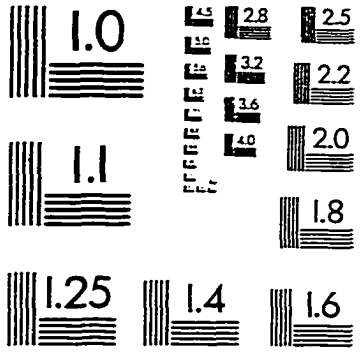
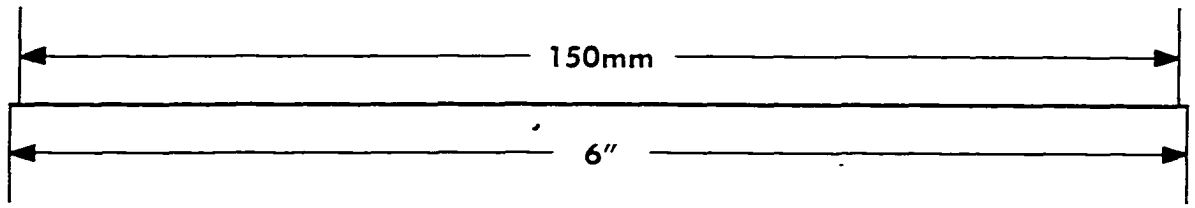
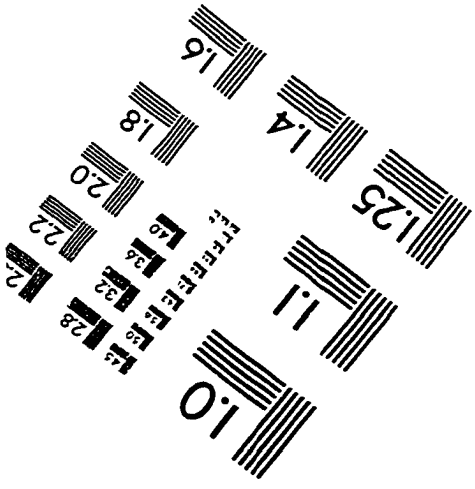
IMAGE EVALUATION TEST TARGET (QA-3)











APPLIED IMAGE, Inc
1653 East Main Street
Rochester, NY 14609 USA
Phone: 716/482-0300
Fax: 716/288-5989