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Morphological encoding in the reading of sentences.

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MORPHOLOGICAL ENCODING IN THE READING OF SENTENCES

A Dissertation Presented

by

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ABSTRACT

Morphological Encoding in the Reading of Sentences

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In two experiments, subjects read sentences containing either a prefixed word (e.g., REVIVE) or a pseudoprefixed word (e.g., RELISH) while their eye movements were monitored. Despite the fact that the prefixed and pseudoprefixed words were closely matched on frequency, length, apparent prefix, syntactic category, and number of syllables, and despite identical sentence-initial neutral context, the pseudoprefixed words required more fixation time than the prefixed words. Also, the first saccade leaving a pseudoprefixed word was shorter than the first saccade leaving a prefixed word, implying that the post-target word was fixated in a more word-initial position when the target was pseudoprefixed than when it was prefixed. These observations are consistent with the view that lexical access of a prefixed word is achieved via the stem morpheme after the prefix is "stripped off." Pseudoprefixed words are at a relative disadvantage because their apparent prefixes are indiscriminately "stripped off" even though they do not have true prefix+stem structures. It was concluded that morphological analysis obtains in fluent reading and does not require a more artifical

task such as lexical decision or letter cancellation.

These experiments also manipulated the amount of parafoveal target word information available to the subject. It was found that pseudoprefixed words required more fixation time than prefixed words even when no parafoveal preview of the target was available, indicating that prefix stripping can be a foveal operation. Also, prefixed words did not derive more benefit from parafoveal preview than pseudoprefixed words, suggesting that prefix stripping does not usually occur in the parafovea.

Discussion of these findings includes consideration of various models of lexical representation and lexical access. A morpheme-based model of representation and access is offered.

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CHAPTER I

INTRODUCTION

Most of the sentences we read or hear are new to us, and yet we understand them with astonishing ease. Our ability to understand even novel sentences rests partially on the fact that most of the words in the sentences we read or hear are not new to us. Understanding a sentence requires that information about its component words be retrieved from that part of memory usually referred to as the mental or internal lexicon (Oldfield, 1966; Treisman, 1961). The lexicon contains information about the meaning, syntactic functions, pronunciation, and spelling of words.

The process of contacting the internal lexicon during language comprehension is termed lexical access. An externally presented word is said to be accessed or recognized when some encoded representation of the sensory stimulus is found to match an entry in the internal lexicon. Much experimental work in lexical access has proceeded on the tacit assumption that each lexical entry corresponds to one word in the language. This view may be an oversimplification, however, because it fails to take into account intra-word linguistic structure. Consider the word UNTIE. Users of English would agree that it is breakable into two meaningful units, UN and TIE; UN and TIE are English morphemes. Our ability to make judgments about morphemic structure naturally leads to the speculation that the internal lexicon is organized to reflect morphemic structure. A stronger claim is that an

entry in the internal lexicon corresponds not to one word but to one morpheme.

Evidence from speech production points to a lexicon that represents morphemes. When a number-marking or tense-marking morpheme appears in a speech error, its phonological realization depends on the preceding phoneme in the actual utterance. For example, when "tap stobs" was uttered instead of the intended "tab stops," the plural marker was realized as /z/ (Fromkin, 1971). Had STOPS been stored in the lexicon as an unanalyzed whole, the plural marker in STOBS would have been realized as /s/. Also, no speech error involves the exchange of a content morpheme and a grammatical morpheme, but many speech errors involve exchanges of morphemes of the same type. For example, "groupment" was uttered instead of "grouping," and "nationalness" instead of "naturalness" (Fromkin, 1971).

When the need for a neologism arises, speakers and writers often put familiar morphemes together in new combinations, such as NONSTICK and DE-ESCALATE (Bauer, 1983). Transparency of the base word is important in determining choice of neologism. Speakers tend to prefer a form that preserves the phonology of the base word: SINISTERNESS is preferred to SINISTERITY (Cutler, 1981). People call on morphemic knowledge to comprehend as well as produce novel words. SINISTERNESS and RESTUFF are not likely to be listed in everyone's internal lexicon, and yet they seem to be acceptable words and can be understood even in the absence of context. Knowledge of morphemes is accompanied by the ability to apply morphological rules; readers would agree that

*STUFFRE is not meaningful, even though it contains the same morphemes as RESTUFF. Given that readers use their stored knowledge of morphemic structure to comprehend novel combinations of familiar morphemes, could it be that they also use this knowledge to comprehend familiar combinations of familiar morphemes? The major question to be addressed here is how morphological structure is used during lexical access in normal fluent reading.

Morphological Structure in English

Traditionally, the morpheme has been defined as the smallest linguistic unit that has meaning and that recurs with the same meaning. More recent definitions de-emphasize semantics, defining the morpheme as the minimal distributionally classifiable unit (Matthews, 1974). A morphological analysis hypothesis of lexical access states that the stem morpheme of a word provides access to the internal lexicon (D. Bradley, 1979; Murrell & Morton, 1974; Taft & Forster, 1975). In reading REVIVE, RE is stripped off and access is achieved when the entry VIVE is located in the lexicon.

Does the morphological structure of English make appealing the hypothesis of morphological analysis in lexical access? The ideal language to support this mode of lexical access would have to satisfy several criteria: it would produce a high proportion of polymorphemic words, each of which is unambiguously analyzable into continuous segments, each segment representing one and only one morpheme. Morphemes

would be transparent, i.e. they would not vary in phonological or orthographic form depending on their environment. Each morpheme would have one and only one surface realization, or morph. In addition, words would be semantically compositional; the meaning of a word would be the composite of the meanings of its morphemes.

English words far outnumber English morphemes. Many words are polymorphemic, and many polymorphemic words are transparently analyzable into continuous segments corresponding to morphemes. Although morpheme boundaries are not marked in writing (as word boundaries are), positional constraints on certain classes of morphemes could aid in morphemic segmentation during lexical access. A distinction is made between free and bound morphemes; only the former can stand alone as words. A polymorphemic word can be formed by conjoining two free stems into a compound (e.g., PICKPOCKET) or by attaching a bound affix to a free or bound stem. Affixes that precede a stem are prefixes (e.g., RE-) and affixes that follow a stem are suffixes (e.g., -NESS). In English, prefixation is derivational, while suffixation is either derivational or inflectional. The inflectional suffixes form a small set and mark number and tense. The derivational suffixes form a larger set, and a derivational suffix may produce a change in syntactic category: KIND is an adjective but KINDNESS is a noun.

It should be easy, then, to analyze English words into their morphemes based on their orthographic forms. However, the morphological structure of English is not ideal. A given word segment may function as several different morphemes, and may have morphemic status in

one word but not in another. For example, the word IN does not have the same meaning as the IN- in INDIRECT, and the IN in INK doesn't mean anything. In word formation by derivation, one function can be shared by several morphemes, and it is not easy to predict which derivational affix is to be used with which stem: nominalization of ENTERTAIN is in -MENT, but nominalization of INTERRUPT is in -ION. With a few exceptions, inflection is far more regular than derivation. Inflectional suffixes are added according to strict rules, and they tend to be transparent in their phonology and orthography. Many derivational suffixes do perturb the phonology of their roots. These Class I affixes (e.g., Selkirk, 1984) can alter the stress pattern and syllabication of a root. Class II affixes are neutral with respect to the phonology of their stem. -ITY is a Class I suffix (e.g., PROSPERITY) and -NESS is a Class II suffix (e.g., KINDNESS).

English prefixes tend not to carry primary lexical stress and are usually in Class I (Bauer, 1983). Some prefixes are highly productive (e.g., RE-, UN-) while others have dropped from use in creating neologisms. SE- for example, has the general meaning "withdrawal from" and appears in SECLUDE, SECRETE, SELECT, and SEDUCE, but is entirely unproductive. In English, derivation by suffixation is generally more productive than derivation by prefixation. One of the limitations on prefixation is that it rarely changes the syntactic category of the stem.

In terms of semantic compositionality, it is the inflectional system that most closely approaches the ideal. DESKS doesn't mean

anything but more than one desk, and KILLED is simply the past tense of of KILL. Derivations often exhibit a much smaller degree of semantic compositionality. Consider STATIONARY and ELEMENTARY. In both cases, an adjective has been derived from a noun by suffixation in -ARY, but STATIONARY means something besides "pertaining to a station." Similarly, the meaning of a prefixed word may differ from the composite of the meanings of its morphemes: REMOVE does not mean "move again."

It is evident that English favors morphemic transparency in its orthography, but does not strongly favor semantic compositionality except in its inflectional structure. If the morphological analysis hypothesis of lexical access is correct, so that a derived form is accessed through the stem, then the lexicon also needs a way to represent idiosyncratic aspects of the meaning of the derived form as a whole. Recovering the entire meaning of a polymorphemic word from its morphemes and the relations between the morphemes would succeed in some cases, but not all.

Orthography and Morphology

The focus here is morphological analysis in processing written English. Since the early twentieth century, it has been observed that English orthography preserves morphemic transparency in cases where the phonology does not (e.g., H. Bradley, 1919), suggesting that morphological encoding may be particularly evident in lexical access during reading. For example, NATION is spelled the same despite its different

pronunciations in NATION, NATIONAL, and NATIONALITY. N. Chomsky and Halle (1968) claimed that variations in the phonetic realizations of morphologically related words are largely predictable by rule, and that all predictable variation is ignored in lexical representation. N. Chomsky (1970) argued that unlike the phonology, the orthography is virtually a direct mapping of the underlying morphophonological level of lexical representation. By this account, the homophones SIGN and SINE have divergent underlying representations. Specifically, the underlying representation of SIGN includes /g/ because [g] is pronounced in the related words SIGNIFY and SIGNAL. Accordingly, SIGN is spelled with a G even though /g/ is not among its phonemes. It has been claimed on this basis that English spelling enables fluent readers to achieve efficient visual access to a morphophonologically based lexicon (e.g., C. Chomsky, 1970; Katz & Feldman, 1981).

Taft (1984) provided some evidence that visually presented words are represented in morphophonological form in the lexicon. Subjects were instructed to respond "yes" to a target word if there existed another word that is pronounced the same as the target. Subjects had difficulty with targets whose homophones have a different morphological structure: fewer subjects said "yes" to FINED (homophonic with FIND) than said "yes" to KNEAD (homophonic with NEED). Such a result would follow from the view that FINED is represented as #fīn#d while FIND is represented as #fīnd#. In contrast, both KNEAD and NEED would be represented as #nēd#.

As a cautionary note, there are arguments against the view that

all the information needed to spell a word is in its underlying morphophonological representation. The example of KNEAD and NEED illustrates that two words can be spelled differently despite their identical underlying representation. Another problem is to explain how the putative morphophonological principle arose from the diverse diachronic forces that shaped the orthography (Scragg, 1974). A third problem is that there do exist sets of words whose predictable morphophonological changes <u>are</u> indicated by spelling changes (e.g., PROFOUND, PROFUNDITY).

It is instructive to note that much of the departure from morphophonology in English orthography is in the disambiguation of homophones such as KNEAD and NEED. In such cases, it seems that the orthography sometimes favors morphology over phonology, and there was in fact a deliberate effort on the part of sixteenth-century printers to avoid homography, resulting in such pairs as SOME, SUM (Scragg, 1974). Unpredictable disambiguation of homophones (KNEAD NEED), principled disambiguation of homophones (SIGN SINE), and principled spelling invariance (NATION NATIONAL) all favor visually-based access to a lexicon that represents morphemes, and a consequence of this is that access through phonological mediation is not optimal. Phonological access in reading is often said to operate via grapheme-phoneme conversion, but the grapheme-phoneme correspondences in English are complex and morphologically conditioned (Venezky, 1970). Some functional graphemes are digraphs, and some digraphs are functional graphemes only when they do not cross a morpheme boundary: EA in REACH corresponds to

one phoneme, but EA in REACT does not. Morphemic segmentation seems a necessary precursor to correctly pronouncing a written word.

There is evidence that readers of an orthography with simple grapheme-phoneme correspondences rely more heavily on phonological mediation than do readers of English. In Serbo-Croatian, spelling follows phonology quite closely. The language can be written in either the Roman or the Cyrillic alphabet, and some of the letters shared by the two alphabets have different pronunciations. It was found that lexical decision for a phonologically bivalent word was slower and less accurate than lexical decision for a univalent word (Lukatela, Popadic, Ognjenovic, & Turvey, 1980). It has also been found that readers of Serbo-Croatian benefit more from explicit syllable marking than do readers of English (Katz & Feldman, 1981).

The Model of Taft and Forster

A model of lexical access in reading needs a component that produces a morphemic analysis as well as a component containing any idiosyncratic spelling, phonological, and semantic information that may be associated with each word. Little idiosyncratic information would be needed for inflections, but a great deal would be needed for derivations and compounds. The lexicon should be organized to facilitate access without incurring great processing costs due to complicated morphological decompositions.

The view of Taft and Forster (1975, 1976; Taft, 1979a, 1979b,

1981) meets some of the requirements sketched above. In this model, the emphasis is not on morphological reconstruction of word meaning but on quick access to the lexicon via the stem morpheme. Taft and Forster's model is an elaboration of Forster's (1976) two-stage model, which states that the lexicon has a master file and three peripheral access files (semantic, phonological, and orthographic). During reading, lexical entries in the orthographic access file provide the addresses of full lexical information in the master file. Entries in the orthographic file are arranged in order of decreasing frequency of occurrence, so that lexical search encounters high frequency words before low frequency words. Taft and Forster's elaboration states that each lexical entry in the orthographic access file is a stem morpheme. A word's stem, whether it is free or bound, is represented in the lexicon, its purpose being to provide the address of full information in the master file. In reading a prefixed word, the prefix is stripped off so that a search can proceed on the basis of the stem. In reading a suffixed word, the stem may be isolated through suffix stripping, or through a left-to-right parsing process.

Taft and Forster's model has several appealing qualities. Access through stems enables (but does not require) words sharing the same stem to be accessed through a single, shared entry. Both PERSUADE and DISSUADE could be accessed through the entry SUADE, for example. This achieves an economy of storage. More importantly, a shared entry allows closely related forms to be listed together in the lexicon. Also, prefix removal could result in faster access than would a process

that leaves prefixed words intact. Knuth (1973) noted that prefix stripping allows one to avoid listing an unduly large number of words all beginning with the same letter sequence: REVIVE could be located more quickly via VIVE than through a search of all words beginning with RE. Word-specific information about REVIVE could be obtainable in the master file even though access to that information is provided by VIVE. The model does not preclude differences in the lexical representations of inflected forms and derived forms; as stated, it is quite general. One possibility is that inflected forms (e.g., DESKS) have no full representation, but are accessed through the stem (DESK) and comprehended by application of inflectional rules.

The Case for Morphological Analysis in Lexical Access

Interference effects in lexical decision. Taft and Forster (1975) found that lexical decision was slower for a nonword that is the root of a prefixed word (e.g., VIVE) than for a nonword that is a non-morphemic word part (e.g., LISH, part of RELISH). It appears that VIVE accesses the actual word REVIVE, and it is the occurrence of this access that delays the decision that VIVE by itself is not a word. Also, words like VENT took longer to accept than words like COIN, demonstrating that a word whose bound form is more frequent than its free form (PREVENT is more frequent than the unrelated word VENT) is unusually difficult to access because of interference from the higher-frequency bound form. Evidence for prefix stripping was

provided in an experiment showing that nonwords combining a prefix and a root (DEJUVENATE) took longer to reject than nonwords combining a prefix and a non-root word part (DEPERTOIRE). This finding suggests that DE- was stripped off and lexical search for JUVENATE was successful. If morphological analysis had not occurred, it is difficult to explain how JUVENATE would cause more interference than PERTOIRE, since both JUVENATE and PERTOIRE are parts of words beginning in RE (REJUVENATE, REPERTOIRE).

Effects of stem priming. If two morphologically related words share an entry in the lexicon, then prior activation of that representation should facilitate, or prime, the recognition of either word. In agreement with this claim, Stanners, Neiser, and Painton (1979) found that prior presentation of UNAWARE was just as facilitory to lexical decision on AWARE as was prior presentation of AWARE itself. Similarly, presenting LIFTING prior to LIFT facilitated the decision on LIFT as much as presenting LIFT itself (Stanners, Neiser, Hernon, & Hall, 1979). The observation that prefixed words and inflected words fully prime the recognition of their free stems is difficult to reconcile with a lexicon that lists each word as an unanalyzed whole. Under the morphological analysis hypothesis, UNAWARE is accessed via AWARE, and the activation of the entry for AWARE persists. This persisting activation facilitates recognition of AWARE on a subsequent trial because AWARE is accessed through the very same entry as UNAWARE.

If related affixed forms are accessed through the stem they

share, then SELECTIVE might be expected to be as good a prime for SELECT as is SELECT itself. This turned out not to be quite true: although SELECTIVE did produce some priming of SELECT (relative to the no-prime condition), SELECT produced more. Perhaps LIFTING is a better prime for LIFT than SELECTIVE is for SELECT because LIFTING is put together by rule, while SELECTIVE is listed with its full semantic information specified. Derivationally suffixed words such as SELECTIVE are likely to require such specific information. Perhaps the derivationally suffixed words used by Stanners et al. were more idiosyncratic than their prefixed words; UNAWARE doesn't mean much more than "not aware," but SELECTIVE means more than "tending to select."

A further complication is that prior presentation of the morphemic components themselves did not produce full priming of a subsequently presented affixed word containing those components. When COMFORT and DISARM were presented prior to DISCOMFORT, responses to DISCOMFORT were not as fast as when DISCOMFORT itself had been presented (Stanners, Neiser, & Painton, 1979). However, prior presentation of COMFORT and DISARM did produce some facilitation in the response to DISCOMFORT. This result need not be detrimental to the morphological analysis hypothesis, since presenting COMFORT before DISCOMFORT would activate COMFORT but not the check on the meaning of DIS+COMFORT. The partial priming produced by COMFORT may, therefore, originate from a shared access entry, while the full priming produced by DISCOMFORT originates both from the access entry and the full comprehension of DISCOMFORT.

Morphemic priming is distinct from the sort of semantic priming produced between close associates (DOCTOR NURSE). Henderson, Wallis, and Knight (1984) reported that lexical decision for a target word was facilitated more by prior presentation of a morphemically related word than by prior presentation of a morphemically unrelated but semantically related word. Unlike the semantic priming effect, the morphemic priming effect scarcely diminished over time. At the 1-second prime-target interval, the morphemic priming effect was 53 milliseconds (msec), dropping to 40 msec at the 4-second interval; the semantic priming effect dropped from 34 msec to 7 msec.

Just as morphemic priming is not equivalent to semantic priming, neither is it equivalent to letter-pattern priming. Lima and Pollatsek (1983) found that lexical decision on an inflected word was faster when the word followed very brief (90 msec) presentation of its stem than when it followed very brief presentation of any other word part, even when that word part contained more letters than the stem: HUNT was more facilitory to HUNTING than was HU, HUN, or HUNTI. Murrell and Morton (1974) had subjects memorize words prior to a tachistoscopic report task. For the test word BORING, recognition was best when subjects had previously memorized BORING, but recognition after memorizing BORED was superior to recognition after memorizing the merely visually similar BORN. Kempley and Morton (1982) replicated the finding with auditory presentation. Finally, Henderson, Wallis, and Knight (1984) found that primes which were only orthographically similar to target words actually caused inhibition relative to orthographically

dissimilar, unrelated controls. It can be concluded that the effects of priming by morphologically related forms constitute particularly strong evidence that what two morphologically related words share is a stem morpheme and not just a similar meaning or a similar spelling.

Effects of stem frequency. TELEGRAPHY and TEMERITY are equally frequent, but TELEGRAPHY seems more familiar than TEMERITY (Foss & Hakes, 1978), and this is difficult to explain if the lexicon simply lists words as wholes. Recognition of the low frequency word TELEGRAPHY may be enhanced by the higher frequency of its stem, TELEGRAPH. In support of this notion, Rosenberg, Coyle, and Porter (1966) showed that adverbs derived from high frequency adjectives were recalled better than those derived from low frequency adjectives. Similar results have been reported in lexical decision studies (D. Bradley, 1979; Taft, 1979b). Bradley found that derived nominals high in stem frequency were accepted more quickly than those low in stem frequency even though surface frequency was held constant. (Stem frequency was computed by summing the frequencies of all related forms containing a given stem). The high-frequency stem advantage held for nominals in -NESS and -MENT and familiar agentives in -ER but not for nominals in -ION; for these, neither stem frequency nor surface frequency had a significant effect. Except for the -ION result, Bradley's findings suggest that two suffixed words sharing a stem are accessed through one representation of that stem in the lexicon, and that the lexicon is organized according to stem frequency,

since surface frequency had no reliable effect when stem frequency was held constant.

Taft (1979b) reported a similar result with prefixed words. REPROACH was classified as a word more quickly than DISSUADE, even though REPROACH and DISSUADE are of equal frequency. REPROACH has a higher frequency stem than DISSUADE because APPROACH is higher in frequency than PERSUADE. The same result was found with inflected words, but the picture is complicated by the finding that surface frequency exerted an effect on lexical decision time when stem frequency was held constant. It could be that frequency effects have a dual locus corresponding to the access file/master file distinction; the possible inflectional rules for a word may be listed in order of decreasing likelihood of occurrence, so that once a stem is accessed, one inflected form may be recognized more quickly than another. One of Taft's pairs was THINGS, WORLDS; THINGS has a higher surface frequency than WORLDS, although THING and WORLD are equally frequent as stems. That WORLDS took longer to access than THINGS might reflect the low probability of needing to pluralize WORLD.

The claim that frequency effects have a dual locus would seem to predict a surface frequency effect in Bradley's experiment with derived nominals, but no reliable effect was observed. It may be that Bradley unwittingly encouraged her subjects to strip suffixes from letter strings, since each of her experiments was blocked by suffix. In the -NESS experiment, for example, subjects saw 60 -NESS words and 60 unaffixed words, and could have simply disregarded

-NESS in performing word-nonword classifications.

Irregular inflections. The hypothesis that a word is accessed after its stem has been isolated from the remainder of its orthographic form leads to the claim that only words with transparent stems can be represented under the lexical entry for their stem. LIKED would be subsumed under the entry for LIKE, but HUNG would have an access entry distinct from that for HANG. By this view, irregular inflections such as HUNG should show no evidence of stem activation: presenting HUNG will not facilitate subsequent recognition of HANG. Also, the stem frequency of HANG should contribute nothing to the time it takes to recognize HUNG.

In partial confirmation of these predictions, Stanners, Neiser, Hernon, & Hall (1979) found that although LIKED was as good a prime for LIKE as LIKE, HUNG was not as good a prime for HANG as HANG. However, HUNG did produce a partial priming effect on HANG relative to the no-prime condition. This partial priming effect may be wholly attributable to the semantic relationship between HUNG and HANG; this interpretation would be supported if it could be shown that the partial priming effect decays as quickly as would a pure semantic priming effect, but there is no empirical evidence on this point. Alternatively, it may be that HUNG produces true morphemic priming of HANG, but that this priming is weaker than the priming produced by a regular inflection on its stem. The lexical entry for HUNG may direct the reader to the master file entry for HANG, even though

bypasses the access entry for HANG.

In their auditory study, Kempley and Morton (1982) showed that memorizing a related form facilitated subsequent identification of a target word only if the target was transparently related to the word that had been memorized: memorizing HELD had no facilitory effect on subsequent identification of HOLDING in a background of noise. The lack of even a small facilitory effect may reflect a lack of sensitivity in the design, or there could be a genuine difference in the way that words are recognized in speech comprehension than in reading.

Turning to the question of stem frequency, it appears that no published study has manipulated the stem frequency and surface frequency of irregular inflected or derived words. If HUNG had a lexical entry unconnected to that for HANG, then the surface frequency of HUNG would be the only frequency measure determining recognition time for HUNG. If the access entry for HANG is bypassed in accessing HUNG, but information in the master file entry for HANG is consulted, then there would be no reason to expect a discernible influence of the frequency of HANG on the time to recognize HUNG. Only if HUNG is accessed via HANG would there be a strong stem frequency effect.

Converging evidence that only regular inflections are accessed via their stems was reported by Jarvella and Snodgrass (1974). When subjects judged whether or not a pair of simultaneously viewed words shared the same stem, their judgments were faster when the root was spelled the same in both words (FISH FISHED) than when it was spelled

differently (RING RANG). Interestingly, judgment time was unaffected by the pronunciation of the same-spelling pairs: RISE RISEN was classified as quickly as FISH FISHED. One unfortunate aspect of the study is that the "no" trials contained few pairs that were highly orthographically similar, so that subjects could have performed the stem judgment on FISH FISHED or RISE RISEN by noting that they shared the same initial letter sequence, leading to fast responses that would not require lexical access. Words in the "no" pairs usually differed from each other before the second or third letter position (SHAKE SHOUTS, COME CALLED).

Effects of pseudoprefixation. A model which assumes that prefixes are detected and stripped off prior to lexical access predicts that RESCUE will take more time to recognize than REVIVE. The nonfunctional "pseudoprefix" RE in RESCUE cannot be pre-lexically distinguished from the genuine prefix RE- in REVIVE. Because of the presence of RE, RESCUE would be stripped down to SCUE and REVIVE would be stripped down to VIVE. While REVIVE would be successfully accessed via VIVE, the attempt to access RESCUE via SCUE is doomed to failure. Only after SCUE is found to be absent from the access file can a second lexical search be made on the basis of RESCUE, and it is this additional search time that increases the time to recognize RESCUE.

Rubin, Becker, and Freeman (1979) found that pseudoprefixed words took longer to classify as words than prefixed words. The effect was reliable when the nonword foils were all prefixed, but

not when the nonword foils were all unprefixed. This context-dependent pseudoprefixedness disadvantage was taken as a refutation of morphological encoding as the usual lexical access route, because one does not encounter a predominance of prefixed words in reading text. Taft (1981) pointed out a flaw in the Rubin et al. study: because any apparently prefixed item in the unprefixed-nonword condition was a word, subjects could have responded "yes" simply on the basis of the presence of an apparent prefix, and this might occur before lexical access takes place. Taft reported strong empirical support for a general disdvantage due to pseudoprefixation. Pseudoprefixed words not only took longer to classify as words than prefixed words, but also had longer naming latencies than prefixed words. Pseudoprefixed words also had longer naming latencies than unprefixed words. These findings are remarkable in light of the subtlety of Taft's prefixed words. Where Rubin et al. had used obviously prefixed words of the form prefix+free stem (INDIRECT), Taft used words of the form prefix+ unique bound stem (ADVANCE). Because such words violate one of the usual criteria of prefixation, the combinability of the stem with other prefixes, Taft needed to ask judges to rate a pool of ADVANCE-type words on their degree of prefixedness, and this proved to be a difficult task. Taft's results lead to the somewhat counterintuitive conclusion that even a prefixed word with a unique stem is accessed via that stem.

Henderson, Wallis, and Knight (1984) reported lexical decision results in accord with Taft's findings. Henderson et al. found that

pseudoprefixed words took longer to accept than prefixed words in a varied context of prefixed and unprefixed words and nonwords. The prefixed words used in this study had combinable free or bound stems (RECOVER, PERMIT). However, interpretation of this finding is complicated by the fact that pseudoprefixed words did not take longer to accept than monomorphemic words (ORANGE, VOLCANO). The lack of a disadvantage for pseudoprefixed words relative to monomorphemic words without apparent prefixes could be a real problem for the morphological analysis hypothesis, but it may be explainable as a difference in the familiarity of the initial letter sequence of the two types of words. Pseudoprefixed words begin with very common word-initial bigrams (e.g., RE) or trigrams (e.g., PRE-), while other monomorphemic words will often have less common word-initial sequences (e.g., OR, VOL). Lima and Inhoff (1984) have shown that a word beginning with a highly familiar bigram or trigram (e.g., CLOWN) received a shorter fixation than a frequency- and length-matched word beginning with a less familiar bigram or trigram (e.g., DWARF). In comparing a pseudoprefixed word (e.g., REGATTA) with a non-pseudoprefixed monomorphemic word (e.g., VOLCANO), the disadvantage of reduced initial-sequence familiarity in VOLCANO may cloud the pseudoprefixedness disadvantage in REGATTA, so that VOLCANO takes about as much time to recognize as REGATTA. Under this interpretation, pseudoprefixed words are most meaningfully compared against prefixed words, since both types have the advantage of highly familiar word-initial letter sequences.

<u>Effects of prefixation</u>. The natural confounding of prefixedness and initial-letter sequence familiarity also complicates the comparison of prefixed words with non-pseudoprefixed monomorphemic controls. If there were a processing cost due to prefix stripping, then a prefixed word would take longer to recognize than a monomorphemic word. This prediction has been refuted in lexical decision studies that found no reliable difference between prefixed and unprefixed words (Fay, 1980; Taft, Forster, & Garrett, 1974). Also, Cutler (1983) described an unpublished auditory study showing that phoneme detection latency was unaffected by the presence of a negative prefix. In the sentence pair "The recommendations of the environmental impact study were sure to disappoint/gratify backers of new development," detecting /b/ in "backers" took no longer after "disappoint" than after "gratify." The same set of prefixed and unprefixed critical words also showed no prefixedness disadvantage in lexical decision. These findings suggest either that prefix stripping is cost free or that prefix stripping does not occur, but they are difficult to interpret given the advantage accorded to familiar word-initial letter patterns.

The only investigation to report slower recognition of prefixed words was that of Snodgrass and Jarvella (1972), who found that a prefixed word (e.g., PRESCHOOL) took longer to accept as a word than its stem (SCHOOL). Note that the comparison in this study is between a word and a prefixed form of the same word, while other studies compared a prefixed word with an unrelated monomorphemic

word. It is not unreasonable to expect that a prefixed form of a word will take longer to recognize than the word itself, if that prefixed form is less likely to occur than the free form, and this was the case with the stimuli used by Snodgrass and Jarvella. In fact, the PRESCHOOL-type words were associated with a 15% error rate, suggesting that for some subjects they were only marginally recognizable as known words.

Effects of pseudosuffixation. Are pseudosuffixed words at a disadvantage relative to suffixed words? Manelis and Tharp (1977) compared pseudosuffixed words and suffixed words in a double lexical decision task. Subjects saw two letter strings and responded "yes" only when both were words. The results showed that "same" pairs, in which both words were suffixed (DARKER FATTER) or both were pseudosuffixed (SISTER SOMBER), were accepted more quickly than "mixed" pairs (SISTER SENDER), but there was no reliable difference between the two "same" conditions. Because two pseudosuffixed words did not take longer to accept than two suffixed words, a morphological analysis hypothesis was deemed untenable. Superiority of "same" pairs over "mixed" pairs, however, seems unlikely unless subjects were processing suffixed words differently than pseudosuffixed words. The first word in a pair could have set up an encoding strategy for the second word. Meyer, Schvaneveldt, and Ruddy (1974) have reported a phonological strategy effect in double lexical decision, suggesting that the double lexical decision task may produce other local strategy effects as well.

When Henderson et al. (1984) compared pseudosuffixed and suffixed words in a conventional lexical decision task, they found results agreeing with the "same" pair results of Manelis and Tharp: pseudosuffixed words took no longer to accept than suffixed words. It can be concluded that suffix stripping is an optional strategy. Unlike prefix stripping, it does not appear to be a necessary step in lexical access. The morphological analysis hypothesis can accomodate this conclusion by positing that stems are isolated from the remainder of a word via a left-to-right parse of the orthographic form. Only in the case of prefixation is it necessary to remove the affix so that the stem can be isolated, since only prefixes appear to the left of stems in words.

Effects in letter cancellation. In a letter cancellation experiment, a subject reads a passage of text while at the same time cancelling every exemplar of a particular target letter. Smith and Sterling (1982) reported that the E in a prefix (e.g., in REMIND) or a pseudoprefix (ENOUGH) was more often missed than the E in a non-prefix (CREATE). Similarly, apparent suffixes showed more letter cancellation errors than non-suffixes. Neither in the case of prefixes nor suffixes did it matter if the affix were genuine or merely a pseudoaffix. Increased error rates in letter cancellation are generally interpreted as indicating reading units larger than letters, suggesting that apparent affixes are unitized in reading. The observation that genuine prefixes were not associated with more errors than pseudoprefixes

argues for a prelexical process that detects potential prefixes; only a prelexical process would have insufficient information to distinguish functional prefixes from pseudoprefixes. Thus, Smith and Sterling's results are consistent with Taft and Forster's claim that prefixes are stripped off prior to lexical access.

These findings might suggest that inflections and pseudo-inflections will show indistinguishable error rates in letter cancellation, but Smith and Groat (1979) found that E in inflectional -ED (e.g., HUNTED) was more often missed than E in pseudo-inflectional ED (HUNDRED). Similarly, Drewnowski and Healy (1980) found that N was more often missed in -ING when it was truly inflectional. The finding that letter cancellation is sensitive to the morphemic status of an inflectional suffix suggests that the individual letters in these suffixes receive little attention after stem access; they are not usually removed prior to stem access, since if they were, then pseudo-inflectional suffixes would show the same number of errors in letter cancellation. Smith and Sterling (1982) found no difference between suffixes and pseudosuffixes, but the suffixes in that experiment were usually derivational. Derivational suffixes may be less unitized than the more frequent inflectional suffixes.

<u>The BOSS hypothesis</u>. In a modification of the morphological analysis hypothesis, Taft and Forster (1976; Taft, 1979a) proposed that the first syllable of a word's stem, rather than the entire stem, serves as its access code in the lexicon. Lexical decision took more time

for compound nonwords beginning with a word (DUSTWORTH, FOOTMILGE) than for those beginning with a nonword (TROWBREAK, MOWDFLISK). Also, compound words beginning with a high frequency word (HEADSTAND) were accepted more quickly than those beginning with a low frequency word (LOINCLOTH), even though surface frequency was held constant. In addition, a nonword which is the first syllable of a word (PLAT) took longer to reject than a control (PREN), and a word which is the first syllable of an unrelated higher frequency word (NEIGH) took longer to accept than a control (SHREW). These findings led the authors to conclude that a word's initial syllable is its access entry. For example, NEIGH accesses NEIGHBOR, so that it takes longer to decide that NEIGH is a word in its own right. Had NEIGH been morphologically related to NEIGHBOR, then it would not have met with any interference in lexical search.

Having obtained evidence for both initial-syllable access and stem morpheme access, Taft (1979a) defined an initial syllable that would allow morphologically related words to be accessed through the same lexical entry. The BOSS (Basic Orthographic Syllabic Structure) definition states that a word's access code is that part of its first stem morpheme that includes after the first vowel all consonants not violating orthotactic rules. The BOSS, unlike the traditional phonological syllable, enables morphologically related words (e.g., FAST and FASTER) to be accessed through the same representation (FAST). Taft's experiments supported the BOSS hypothesis. Stimulus strings divided at their BOSS boundary (LANT ERN, gardEN) were classified

as words more quickly than those divided at their phonological syllable boundary (LAN TERN, garDEN). Taft reasoned that lexical decision for a divided word should be fastest when the stimulus division coincides with the format of the word's lexical entry. Since BOSS division led to faster lexical decisions, it was concluded that the BOSS is a word's lexical entry.

Lima and Pollatsek (1983) did not replicate Taft (1979a), finding instead that BOSS division and phonological-syllabic division of monomorphemic words led to equal lexical decision times. Both BOSS division and phonolgical-syllable division were, however, superior to non-syllabic "BOSS+1 letter" division (GARDE N). In a second experiment, brief preview of the target word's BOSS was not more facilitative to lexical decision on the target than was brief preview of the word's initial phonological syllable. There was therefore no support for the claim that the BOSS is a word's lexical entry. Baldasare and Katz (1980) also failed to find a BOSS advantage.

Lima and Pollatsek tested the BOSS hypothesis on polymorphemic words, and again found no evidence for BOSS representation. The presentation of a target word was preceded by brief presentation (90 msec) of some part of the target word. The best prime for an inflected word (RACES) was not its BOSS (RAC) but its entire stem (RACE). For compound words, the best prime was the initial stem (TEA was the best prime for TEASPOON). Another result disagreeing with the BOSS principle was that word-word nonwords (TURNTRIBE) took longer to reject than word-nonword nonwords (TEADAKE). Taft and

Forster (1976) had found that only the first stem in a compound nonword affected its lexical decision time. The conclusion is that evidence for the BOSS principle is not robust, but evidence for access via stems is robust. The lack of a BOSS advantage for inflected words is particularly damaging, because the BOSS was motivated by the need for shared lexical representations for related words such as RACE, RACING.

Using Eye Movement Measurement to Study Reading Processes

A drawback of the evidence for morphological encoding in lexical access is that it rests so heavily on the lexical decision task. Generalizing from lexical decision to fluent reading is complicated by several factors. First, the same set of words can show different results depending on the set of nonwords from which they are to be discriminated (Rubin, Becker, & Freeman, 1979; Shulman, Hornak, & Sanders, 1978). Second, response times in lexical decision are usually more than 500 msec, but a fixational pause in reading takes about half this amount of time. Third, some findings supporting morphological analysis involved comparing different types of nonwords, and the process of deciding that a letter string is not a word is not fully understood. In reading, one proceeds on the assumption that all the letter strings on the page are real words.

A few studies have compared prefixed and unprefixed words in sentence context. For example, Sherman (1973) found that the presence of a negative adjective prefixed in -UN increased the time it took

to decide whether a sentence was plausible or implausible. However, this result does not say much about lexical access; the delaying effect of negativity could exert itself well after the prefixed word had been accessed, and even after the sentence had been comprehended. Cutler's (1983) unpublished finding that negatively prefixed words did not take longer to process in lexical decision than unprefixed controls places the locus of Sherman's effect after lexical access. What is needed is a way to measure the time to access a word in a sentence.

Studies using letter cancellation have suggested that affixes are unitized in reading, and this task does use words in sentences. However, reading speed in letter cancellation is about 80 words per minute (Smith & Sterling, 1982) compared to speeds of 200 words per minute or more in unencumbered reading (Rayner, 1978a). Observing subjects' eye movement behavior while they read sentences would remove the need for a secondary task that slows down reading. Before discussing the rationale for the experiments done here, background information about eye movement behavior will be presented.

Eye movements in reading. The eyes scan a line of text through saccadic movements of short duration (20 to 40 msec) separated by fixational pauses of longer duration (200 to 250 msec, on average) (Rayner, 1978a). The visual information supporting reading is gathered during the fixations and not during the saccades. Writing conventions constrain the direction of eye movements. In reading English,

most saccades are from left to right and are about 8 to 9 character spaces in length. These forward saccades bring new text into the fovea, the field of the central retina where visual acuity is highest. Only about 10 to 20 percent of saccades are from right to left; these are termed regressions.

There is a great deal of variability in fixation duration, even within one subject reading one line of text. The range of fixation durations is approximately 100-500 msec (Rayner, 1978a). A substantial body of research has indicated that much of this variability is due to differences in cognitive processing occurring during particular fixations. Increases in processing load and particularly difficult linguistic operations at some point in a sentence give rise to relatively long fixations at that point (e.g., Just & Carpenter, 1978; Rayner, 1977; Wanat, 1971). Because many factors affect eye movements, it is desirable to control all variables except the one in question.

<u>The effective visual field</u>. Parafoveal vision, although less acute than foveal vision, is essential for optimal reading. The effective visual field, the area of text from which useful information can be extracted on one fixation, has been studied most directly through the eye-contingent window technique: normal text is displayed in a small window that moves in synchrony with the reader's point of fixation. Outside the window, letter and spacing information can be altered in various ways. If all letter information to the right of fixation is made unavailable, then reading rate declines to only

60 percent of normal (Rayner, Well, Pollatsek, & Bertera, 1982). The maximal effective visual field in reading English is asymmetric, extending from the beginning of the currently fixated word (or about 4 letters to the left of fixation, whichever is less) to about 9 or 10 characters to the right of fixation for letter identification and up to 15 characters to the right of fixation for word boundary information (McConkie & Rayner, 1975; Rayner, 1975; Rayner, Well, & Pollatsek, 1980). There is a tendency to fixate a word of a given length at the point in the word referred to as the preferred viewing location (Rayner, 1979) or convenient viewing position (O'Regan, 1980). This location is generally between the beginning and middle letters of the word. Usually, then, the most useful parafoveal information is information from the word currently fixated and the word immediately to its right.

Beginning-letter information in the parafovea. The conclusion that readers benefit from partial information about the word to the right of the fixated word was supported by the findings of Rayner, Well, Pollatsek, & Bertera (1982). When the first three letters to the right of the fixated word were visible and the letters beyond were replaced by visually similar letters, reading rate was only slightly impaired relative to when the entire word to the right of fixation was visible. An individual word may, therefore, be processed on more than one fixation.

Several other studies converge on the conclusion that information

about the beginning two or three letters of a word can be obtained before the word is fixated. Beginning-letter information acquired parafoveally on one fixation facilitated the naming of a word available foveally on the next fixation (Rayner, 1978b; Rayner, McConkie, & Ehrlich, 1978; Rayner, McConkie, & Zola, 1980). Results from text reading also suggest the importance of the beginning few letters of the word in the parafovea (Rayner, 1975; Rayner & Bertera, 1979).

A plausible interpretation of facilitation due to parafoveal preview of word-initial letters is that preliminary letter or letter pattern identification in the parafovea is used in identifying the word when it is subsequently brought under foveal scrutiny. Alternatively, it could be that semantic expectations are generated in the parafovea and confirmed on subsequent fixation. Several fndings refute the latter interpretation. Inhoff and Rayner (1980; Inhoff, 1982) showed that presenting a disambiguating word in the parafovea did not affect judgments of the meaning of an ambiguous word presented in the fovea. Rayner, Inhoff, Morrison, Slowiaczek, and Bertera (1981), using a foveal mask that moved in synchrony with the eyes, found that the errors subjects made in reporting what they read tended to be visually rather than semantically similar to the information available beyond the mask.

Letter and letter pattern information must be integrated in some way across fixations, but this integration is not a simple addition of visual features or of fully identified letters. McConkie and Zola (1979) presented text in alternating case, and found that changing

the case (and hence the visual features) of letters across a fixation had virtually no effect on eye movement behavior. Rayner, McConkie, and Zola (1980) argued against a simple model of letter addition across fixations. They reasoned that if letter information were simply combined from one fixation to the next, then presenting TRAIN in a particular location in the parafovea and then replacing it with CLASH during the saccade to that location would sometimes result in subjects reporting TRASH, but this never happened. Readers appear to foveally check the validity of the beginning-letter information they have obtained parafoveally. This conclusion is consistent with the fact that word-initial letter sequences are high in information value and with the finding that the preferred viewing location for a word is slightly to the left of center.

<u>The possibility of processing prefixes in the parafovea</u>. It is evident that word-initial letter information is often extracted from a word before it is foveally fixated, but no previous study has directly addressed the issue of parafoveal processing of prefixes. Because most of the prefixes in common use have from one to three letters, and because prefixes form a small set of highly familiar word-initial letter patterns, they are excellent candidates for parafoveal letter and letter pattern identification. Prefix stripping could begin before fixation, and this could have different consequences for a pseudoprefixed word than for a prefixed word. These experiments examined the foveal and parafoveal processing of the two types of words.

CHAPTER II

EXPERIMENT 1

The goal of Experiment 1 was to determine the role of prefix stripping in lexical access during fluent reading. Increased fixation time on pseudoprefixed words relative to prefixed words would support the morphological analysis hypothesis, which claims that a word with an apparent prefix is prelexically stripped of that apparent prefix to isolate the word's stem. If the fixated word were truly prefixed, then lexical access via the stem will succeed, and the reader can move his or her eyes to the next word in the sentence. However, if the word were pseudoprefixed, then lexical access via the putative stem would fail, and the reader will delay moving his or her eyes until access based on the entire word has succeeded. Longer viewing times on pseudoprefixed words than prefixed words would corroborate previous findings from lexical decision experiments (Henderson, Wallis, & Knight, 1984; Rubin, Becker, & Freeman, 1979; Taft, 1981) and naming experiments (Taft, 1981) and would demonstrate that these findings were not specific to the demands of the tasks employed. Also, Experiment 1 employed word pairs matched exactly on initial letter sequence, length, and syntactic category, so that any observed differences could not be attributable to these other variables. Previous studies have used many prefixed verbs but almost no pseudoprefixed verbs; most of the pseudoprefixed words were nouns.

An important difference between fluent reading and reading a

word in isolation is that only fluent reading allows the extraction parafoveal information prior to fixation on the word. It is possible that apparent prefixes are detected while a word is still to the right of fixation. Parafoveal detection of an apparent prefix could activate the process of treating a word as a prefix+stem upon fixating it. By this account, prefix stripping is set into motion particularly quickly when the reader has reason to believe that the word about to come under foveal regard is prefixed.

Experiment 1 employed an eye-contingent display change technique to examine the foveal and parafoveal processing of prefixed and pseudo-prefixed words in sentences. One sentence pair was:

The boy didn't remind his mother to pick him up after school.

The boy didn't relish the thought of eating liver for dinner.

The first sentence contains the prefixed target word REMIND, and the second contains the pseudoprefixed target word RELISH. The two members of a sentence pair were identical up to the target word, so that prior context was the same for both target words, and an effort was made to keep the prior context neutral with respect to either target word. One caveat is that although target pairs were matched as closely as possible on surface frequency, it was impossible to also match them on stem frequency. This could mean that prefixed words were higher in stem frequency than pseudoprefixed words, and the possible difference in stem frequency could contribute to shorter fixations on prefixed words than on their pseudoprefixed counterparts. However, even if this were the case, the result would not be without

interest. If pseudoprefixed words take longer to process than prefixed words because prefixed words are of higher stem frequency, then it must be the case that words are accessed via their stems. If words are invariably accessed as wholes, then there would be no basis for predicting either a disadvantage due to a pseudoprefix or an advantage due to a high frequency stem.

The display change technique used in Experiment 1 was developed by Rayner (1975). A sentence was displayed on a display screen, and most of the sentence remained unchanged throughout the trial. The only word that changed was the target word, and the change occurred during the saccade that brought the target word into the fovea. Prior to this saccade, the contents of the target word location consisted of one of three types of letter strings: the target word itself, the word's apparent prefix followed by Xs, or a string of Xs equal in length to the target word. For REMIND, the three possible prefixation letter strings were REMIND, REXXXX, and XXXXXX. After the saccade to the target location began, REMIND appeared in the target location. The Xs condition in effect denied parafoveal preview of the target word prior to fixation.

Predictions

Effect of pseudoprefixedness. If morphological analysis is a necessary step in lexical access, and if prefix stripping is a prelexical process supporting lexical access, then pseudoprefixed words will be mistakenly

treated as prefixed words. Therefore, in reading, pseudoprefixed words would be at a disadvantage compared to prefixed words, and this disadvantage should manifest itself as increased fixation time on pseudoprefixed words compared to prefixed words.

Effect of viewing condition. Prior research suggests that fixation duration on target words will be greatest in the Xs condition, which denies parafoveal preview of the target, and smallest in the whole word condition, which allows parafoveal preview of the target word intact. The prefix+Xs condition should lead to shorter fixations than the Xs condition, since this condition allows preview of the first two or three letters of the target. Fixation durations may not be much greater in the prefix+Xs condition than in the whole word condition; this would follow if it is true that most of the parafoveal facilitation in reading can be traced to information about word-initial bigrams or trigrams (Rayner, Well, Pollatsek, & Bertera, 1982).

Interaction of prefixedness/pseudoprefixedness with viewing condition. In normal reading, it is possible that activation of a prefix+stem analysis process in lexical access depends on detecting and perhaps identifying an apparent prefix at the beginning of the word about to be fixated. If this were the case, then in the Xs condition, pseudoprefixed words would be processed more quickly than prefixed words, since there would have been no opportunity to detect a prefix

in the parafovea. In the prefix+Xs and the whole word conditions, pseudoprefixed words would be processed more slowly than prefixed words, since there would have been an opportunity to detect a prefix in the parafovea. The pseudoprefixedness disadvantage may be more evident in the prefix+Xs condition than in the whole word condition, since in the prefix+Xs condition the apparent prefix is the only letter pattern available and may therefore be particularly salient.

If the detection of a prefix in the parafovea is a helpful but not necessary prelude to prefix stripping, then prefixed words would benefit more from parafoveal preview than would pseudoprefixed words. By this account, the expected prefixedness advantage in the prefix+Xs and whole word conditions will be greater than the expected prefixedness advantage in the Xs condition.

Method

Subjects. Subjects were 18 members of the University of Massachusetts community and were paid for participation in the experiment. All subjects had normal vision or could read the sentences without wearing corrective lenses.

Materials.

Sentence pairs. Stimuli were drawn from a set of 36 pairs of sentences. One member of a sentence pair contained a prefixed target word, and the other contained a pseudoprefixed target word in the

same sentence location. Sentence pairs are presented in the Appendix. The following are three examples:

> The corporation <u>imported</u> gallons of oil from abroad.
> The corporation <u>imitated</u> the products of its competitors.
>
> Carolyn's <u>beloved</u> cat was run over by a car yesterday.
> Carolyn's <u>bearded</u> friend is a guitar player.
>
> They tried to <u>revive</u> the dying man, but they were too late.
> They tried to <u>rescue</u> the dying man, but they were too late.

Each prefixed-target sentence appears above its pseudoprefixed-target mate. The two members of a sentence pair were identical up to the target word and usually differed from each other after the target. Care was taken to make a given sentence beginning neither more nor less predictive of the prefixed target than the pseudoprefixed target. The context was kept as neutral as possible, and in no case was a target anomalous with respect to its context. The target was in second through fifth sentence position; sentence-initial position was avoided because the first fixation on a line of text tends to be unusually long (Rayner, 1977). The mean position of a target in a sentence was 3.5. The two members of a sentence pair were approximately matched on length in words; the mean sentence length for both target types was 10.2 words (range=7 to 16).

<u>Word pairs</u>. The 36 pairs of prefixed and pseudoprefixed targets used in the stimulus sentences were matched on their apparent prefix and on length in letters. Word pairs were approximately matched on word frequency (Kucera & Francis, 1967); the mean frequency of prefixed targets was 22.2 per million (range=1 to 195) and the mean

frequency of pseudoprefixed targets was 21.4 (range=1 to 171). Target word pairs were also matched on syntactic category, although sometimes a target had several possible categories. Targets were approximately matched on number of syllables (2.3 for prefixed words and 2.4 for pseudoprefixed words; range=1 to 4). Target words are listed in Table 1.

Assessing prefixedness. Assessment of prefixedness was guided by intuition. The prefixes used were AB-, AC-, BE-, COM-, DE-, DIA-, EM-, IM-, IN-, MIS-, MON-, PER-, PRE-, PRO-, RE-, and UN-. All are listed as prefixes in the abridged Random House Dictionary (1975). As can be seen in the second column of Table 1, each prefixed word is analyzable into at least a partially meaningful prefix+stem meaning composite. The most obviously prefixed words are those combining a prefix and a free stem; these are indicated by their stems printed in upper case in the second column of Table 1. When a prefixed word's stem was bound, the word satisfied three criteria of prefixedness: (1) its meaning was at least partly compositional, (2) it etymology indicated prefixation, and (3) there existed at least one other word with the same stem, as shown in the third column of Table 1.

Assessing pseudoprefixedness. Pseudoprefixedness is less straightforward than prefixedness. Some pseudoprefixed words (e.g., PREACHES) are obviously unanlyzable as prefix+stem. Others are not obviously unanalyzable (ABSURD), but they are not semantically compositional, and there does not exist another prefixed word with the same stem. Some words of this type were used as pseudoprefixed words in the experiment. In any event, the counting of a prefixed word as pseudoprefixed

TABLE 1

PREFIXED AND PSEUDOPREFIXED WORDS USED IN EXPERIMENT 1

Prefixed Word	Prefix+Stem Analysis	Related Word	Pseudoprefixed Word
ABRUPT	away from+break	disrupt	ABSURD
ACCLAIM	toward+shout	proclaim	ACTRESS
ADMITS	toward+send+S	remits	ADORES
BELOVED	intensive+LOVED	loved	BEARDED
COMMUTER	with+change+ER	permute	COMEDIAN
DELAY	off+lay	relay	DEVIL
DEMAND	from+order	command	DEGREE
DENOUNCE	out+speak	pronounce	DECORATE
DESCENT	reverse+climb	ascent	DENTIST
DIAGRAM	around+drawing	program	DIAMOND
DIALECT	between+speak	elect	DIAPERS
EMBRACE	verb formative+BRACE	brace	EMERALD
IMPORTED	in+carry+ED	exported	IMITATED
IMPROVE	verb formative+profit	approve	IMAGINE
INCREASE	verb formative+grow	decrease	INDUSTRY
INDECISION	negative+DECISION	decision	INITIATION
INJUSTICE	negative+JUSTICE	justice	INTELLECT
INSANE	negative+SANE	sane	INFANT
INTRUDER	in+push+ER	extruder	INTRIGUE
MISTRUST	negative+TRUST	trust	MISTRESS
MONARCH	one+ruler	anarch	MONSTER
PERSISTS	through+stand+S	insists	PERISHES
PREDICTS	before+say+S	contradicts	PREACHES
PROCURED	for+care+ED	secured	PROMPTED
PRONOUN	for+NOUN	noun	PROPHET
PROTEST	toward+witness	attest	PROTEIN
REACT	back+ACT	act	REIGN
REACTION	back+ACTION	action	RELIGION
REAPPEAR	again+APPEAR	appear	REGULATE
REBIRTH	again+BIRTH	birth	REMNANT
REFUND	back+FUND	fund	RENTAL
REMIND	again+MIND	mind	RELISH
REVIVE	again+live	survive	RESCUE
REVIVAL	again+live+AL	survival	RESIDUE
UNABLE	not+ABLE	able	UNIQUE
UNTIE	reverse+TIE	tie	UNITE

can only work against the hypothesis of a processing time difference between prefixed and pseudoprefixed words.

Design. Two lists were constructed, each containing 36 sentences. A list contained 18 prefixed-target and 18 pseudoprefixed-target sentences. The prefixed-target member of a sentence pair appeared in one list, and its pseudoprefixed-target mate appeared in the other. Half of the subjects were randomly assigned to each list.

Each subject read 6 prefixed and 6 pseudoprefixed sentences in each of three viewing conditions: the whole word condition, the prefix+Xs condition, and the Xs condition. In the first condition, the letter string in the target location was always the whole target word. In the prefix+Xs condition, the sentence was intact throughout the trial except for the target location. The target location contained the word's apparent prefix followed by Xs (REXXXX instead of REMIND) until the subject began a saccade crossing an imaginary boundary two letter spaces to the left of the target. During this saccade, the target location string was replaced by the target word (REXXXX became REMIND). The third condition proceeded in an anologous fashion, except that the stimulus in the target location before the saccade across the imaginary boundary was a string of Xs equal in length to the target (XXXXXX instead of REMIND).

Order of presentation of sentences and viewing conditions was randomized for each subject. A set of 6 subjects provided one eye movement record for each sentence under each viewing condition, barring

the occasional loss of data due to either eyetracking failure or the subject's having been likely to have noticed the display change. Display changes were rarely noticed, but any trial on which the subject fixated the boundary location or one character to its right was excluded to ensure that the data did not reflect disruption due to conscious awareness of display changes.

Apparatus. A bite plate was prepared for each subject to reduce head movement during eyetracking. The subject's eyes were held 46 centimeters from a Hewlett-Packard 1300A cathode ray tube (CRT) that was used to present sentences. The CRT has a P-31 phosphor with the characteristic that removing one character results in a drop to 1% of maximum brightness in .25 msec. Three character spaces equalled one degree of visual angle. A black theater gel covered the screen to enhance sharpness, and the CRT was adjusted to a comfortable brightness level for each subject. Sentences were presented in conventional format, i.e. the first letter was in upper case, as was the first letter of a proper noun, but the other letters were lower case, and the sentence was followed by a period.

Eye movements were recorded with a Stanford Research Dual Purkinje Eyetracker interfaced with a Hewlett-Packard 2100A computer that controlled the experiment. The eyetracker has a resolution of 10 minutes of arc and the output is linear over the angle subtended by a line of text. The computer sampled the signal from the eyetracker every millisecond, and each 4 msec of output was compared with the

output of the previous 4 msec to determine whether the eyes were fixed or moving. Display changes were accomplished within 5 msec of the critical saccade. The computer kept a complete record of the duration, sequence, and location of each fixation.

Procedure. Subjects were tested individually. A two-dimensional calibration at the start of the session ensured that the eyetracker was accurately determining the horizontal and vertical coordinates of the subject's point of fixation.

After the calibration, three crosses were displayed, one at the left, one at the center, and one at the right of the screen. The subject's fixation point was marked by a fourth cross moving in synchrony with the eyes. The subject was instructed to superimpose the fixation-marking cross on the left-hand cross, and when this was accomplished, the experimenter displayed the first sentence. When the subject finished reading the sentence, he or she pressed a key that removed the text from the screen. The cycle of superimposing the fixation marker on the cross, reading a sentence, and pressing a key to signal completion was repeated for each trial.

A sentence occupied two lines on the CRT, each line of text being 42 or fewer characters in length. Each subject read 9 practice sentences before going on to the 36 experimental sentences. A second calibration routine was necessary at the start of the experimental trials. Subjects were told nothing about the linguistic variable or the viewing conditions being manipulated; they were simple told

to read for normal comprehension. As a comprehension check, subjects were occasionally asked to repeat the sentence they had just read.

<u>Scoring of data</u>. A target word was considered fixated if the subject's point of fixation fell on one of its component letters or on the space immediately preceding it. Individual fixations of unusually long duration (more than 600 msec) were excluded because they were probably due to eyeblinks. Very short fixations (less than 100 msec) occurring in succession on identical or adjacent characters were cumulated and counted as one fixation. Extremely short fixations (less than 80 msec) occurring in isolation were discarded. Data were also discarded when the eyetracker failed to track and when the subject was likely to have seen a display change in the Xs or prefix+Xs condition.

The dependent measure of primary interest was the duration of the first fixation placed on the target word, since this measure should be sensitive to early lexical processing of the target. Of secondary interest was gaze duration on the target word. Gaze duration includes the duration of the first and any subsequent fixations on the target before another word is fixated.

In the subject analysis, a data point for a given dependent measure consisted of the mean value of that dependent measure for the 6 prefixed and 6 pseudoprefixed sentences in each of the three viewing conditions. In the item analysis, a data point was the mean of the three observations in each of the 6 cells of the design.

Results and Discussion

Mean first fixation duration and gaze duration on prefixed and pseudoprefixed target words are presented in Table 2.

Effects of pseudoprefixedness. As predicted by the hypothesis that prefixes are prelexically stripped off, pseudoprefixed words received longer first fixations (240 msec) than prefixed words (226 msec); this 14 msec pseudoprefixedness disadvantage was reliable [$minF'(1,51)=4.84$, $p<.05$]. Since the duration of the first fixation placed on a word is likely to reflect early lexical processing of the word, this result suggests that the pseudoprefixedness effect originated early in word recognition.

A pseudoprefixedness disadvantage was also apparent in the gaze durations on target words. Pseudoprefixed words received gazes averaging 293 msec, while prefixed words received gazes averaging 282 msec. This 11 msec difference was not reliable either in the subject analysis (treating items as a fixed effect) [$F(1,17)=2.83$, $p<.11$] or in the item analysis (treating subjects as a fixed effect) [$F(1,35)<1$]. The direction of the effect is consistent with the prefix stripping hypothesis; subjects were somewhat delayed in moving their eyes to the post-target word when the target word was pseudoprefixed, and this delay was primarily due to longer first fixations on pseudoprefixed words than on prefixed words.

TABLE 2

MEAN FIRST FIXATION DURATION AND GAZE DURATION (IN PARENTHESES) ON PREFIXED AND PSEUDOPREFIXED TARGETS AS A FUNCTION OF VIEWING CONDITION [EXPERIMENT 1]

	TARGET TYPE	
VIEWING CONDITION	PREFIXED	PSEUDOPREFIXED
Xs	222 (293)	243 (306)
PREFIX+Xs	232 (277)	244 (288)
WHOLE WORD	223 (277)	234 (286)

Effects of viewing condition. It was predicted that target words in the Xs condition would be fixated longer than those in either the prefix+Xs or whole word conditions because of prior research indicating that words benefit from prior parafoveal availability. The pattern of the gaze durations appeared to corroborate this prediction: gazes averaged 300 msec in the Xs condition but 282 msec in the prefix+Xs condition and 282 msec in the whole word condition. This 18 msec disadvantage due to the lack of parafoveal preview missed reliability [$F(2,34)=2.33$, $p < .11$ in the subject analysis and $F(2,70)=1.62$, $p<.20$ in the item analysis]. Although the effect of viewing condition was not reliable, the direction of the effect suggests that parafoveal preview was of benefit to the subsequent foveal processing of the target words. The similar gaze durations in the prefix+Xs condition and the whole word condition suggest that it was the parafoveal presence of the word-initial two or three letters that facilitated foveal processing.

Unfortunately, the pattern of first fixation durations does not mirror the pattern of gaze durations. First fixations on target words in the Xs condition (232 msec) were slightly longer than those in the whole word condition (228 msec), but the prefix+Xs condition yielded the longest first fixations (238 msec). Furthermore, prefixed words showed no benefit of parafoveal preview: the shortest first fixations were in the Xs condition (222 msec), followed by 223 msec in the whole word condition and 232 msec in the prefix+Xs condition. The effect of viewing condition was not reliable [$F(2,34)=$

1.06, $p<.36$ in the subject analysis and $F(2,70)<1$ in the item analysis]. When the first fixation data from the Xs condition were compared with those in the whole word condition to determine if there was a difference between no parafoveal information and full parafoveal information, the effect of viewing condition was far from reliable [$F<1$ in both the subject analysis and the item analysis]. It seems that the design of Experiment 1 may have been deficient in power with respect to effects of viewing condition. It is possible that the expected benefit in first fixation duration due to prior parafoveal information was not evident because the target words were positioned near the beginning of the stimulus sentences. Subjects may be less sensitive to letters in the parafovea when they are just beginning to read a sentence. It is also possible that the presence of a uniform string of Xs on one-third of the trials somehow discouraged subjects from processing the parafoveal word on any trial; strings of Xs have not been used in previous experiments using the boundary-crossing display change technique used here.

Interaction of prefixedness/pseudoprefixedness with viewing condition. It was hypothesized that if parafoveal prefix detection caused prefix stripping, then there would be no pseudoprefixedness disadvantage in the Xs condition, and this was obviously not the case. In the Xs condition, pseudoprefixed words received first fixations 21 msec longer than prefixed words, and gaze durations 13 msec longer than prefixed words. Prefix stripping seemed to occur even when

parafoveal prefix detection was impossible.

The weaker hypothesis that the parafoveal detection of an apparent prefix could increase the likelihood of attempting to strip off a prefix received no support. In the gaze durations, where some benefit of parafoveal information was observed, prefixed words did not benefit more from complete prior availability in the parafovea than did pseudoprefixed words; the advantage was 16 msec for prefixed words and 20 msec for pseudoprefixed words. In the first fixations, prefixed words were fixated 1 msec longer in the whole word condition than in the Xs condition, while pseudoprefixed words were fixated 9 msec longer in the Xs condition than in the whole word condition. If anything, prefixed words benefit less from parafoveal preview than pseudoprefixed words, but this conclusion is unsupported by statistics; the interaction of prefixedness/pseudoprefixedness with viewing condition was unreliable in ANOVAS comparing the Xs condition and the whole word condition [$F(1,17) < 1$ in the subject analysis and $F(1,35)=1.12$, $p < .30$ in the item analysis for first fixations; $F < 1$ in both analyses for gaze durations]. Neither was the interaction reliable in ANOVAs including all three viewing conditions [$F<1$ in all analyses].

Summary. Pseudoprefixed words received longer first fixations and somewhat longer gazes than prefixed words matched on length, apparent prefix, syntactic class, frequency, and prior context, suggesting that prefixes are prelexically stripped from both

prefixed and pseudoprefixed words. Prefix stripping occurred during foveal fixation of target words, and prefixed words enjoyed no special benefit from preview in the parafovea.

CHAPTER III

EXPERIMENT 2

Experiment 1 established that a pseudoprefixed word took longer to access than a prefixed word even when the two followed identical sentence-initial context appropriate to either word. The observed pseudoprefixedness disadvantage did not require the presence of an apparent prefix in the parafovea prior to fixation, suggesting that prefix identification in reading occurs foveally. Before concluding that prefix stripping does not occur while a target word is in the parafovea, it is necessary to address some of the troublesome aspects of the findings in Experiment 1. Effects of viewing condition on gaze duration, although consistent with the prediction that lack of parafoveal information increases viewing time, failed to reach statistical reliability. Effects of viewing condition on first fixation duration were not only statistically unreliable but also in some disagreement with the gaze durations. Given the slightness of the main effects of viewing condition, it is perhaps too much to hope for that there would be a reasonable opportunity to discover a reliable interaction of prefixedness/pseudoprefixedness with viewing condition. Concluding that the presence of the prefix in the parafovea did not enhance the foveal processing of a prefixed word rested on acceptance of the null hypothesis, and this may have been risky given the apparent low power of the experimental design with respect to viewing condition.

One purpose of Experiment 2 was to increase the power of the

design. Power was increased by adding 24 new target word pairs to the original 36 pairs and by running 24 subjects instead of 18. In addition, the stimulus sentences were improved in three ways. First, target words were placed in somewhat more medial sentence positions than in Experiment 1, without sacrificing the neutrality of the preceding context. Second, whenever possible, the post-target word was of the same length when it followed either the prefixed word or its pseudoprefixed counterpart. In Experiment 1, the post-target word was free to vary in length, and this could have introduced extraneous variability in fixation duration on the targets. Third, sentence pairs were written to be nearly identical in their length in character spaces; this was also done to remove a possible source of extraneous variability.

Experiment 2 was similar in design to Experiment 1: Sentences containing either a prefixed or a pseudoprefixed target word were presented in three viewing conditions, one of which allowed full parafoveal availability of the target word. However, the two other viewing conditions were different from those in Experiment 1. The nonsense string condition in Experiment 2 replaced the Xs condition in Experiment 1. In the nonsense string condition, a meaningless string of letters appeared in the target location prior to the saccade that brought the target word into foveal view: CWXYJQ appeared in the target location prior to the fixation on REMIND. The other-word condition in Experiment 2 replaced the prefix+Xs condition in Experiment 1. In the other-word condition, the other member of the target word pair appeared

in the target position prior to the saccade that brought the target word into foveal view: RELISH appeared in the target location prior to fixation on REMIND. The other-word condition allowed parafoveal preview of the apparent prefix common to either word. These two new conditions obviate the need for uniform strings of Xs in the parafovea while still allowing assessment of the detrimental effects of not having the entire word available in the parafovea prior to its fixation.

The predictions for the second experiment are similar to those for the first. Because of increased power, it was possible to use other dependent measures in addition to first fixation duration and gaze duration to determine if pseudoprefixed words take longer to process than prefixed words. These additional measures included length of saccade to and from the target word and the duration of the fixation prior to that on the target word.

Method

Subjects. Subjects were 24 members of the University of Massachusetts community and were paid to participate in the experiment. All subjects had normal vision or could read the sentences without wearing corrective lenses.

Materials.

Sentence pairs. Stimuli were drawn from a set of 60 pairs of sentences. As in Experiment 1, one member of a sentence pair contained

a prefixed target word, and the other contained a pseudoprefixed target word in the same sentence location. The two members of a target pair were identical up to the target word and usually differed from each other after the target. In Experiment 2, unlike Experiment 1, sentence pairs were approximately matched on the length in letters of the post-target word. The mean length of the post-target word was 3.6 letters (range=2 to 7) for both the prefixed-target sentences and the pseudoprefixed-target sentences.

Care was taken to make a given sentence-beginning equally appropriate to the prefixed target and the pseudoprefixed target. The target positions were somewhat more rightward than those in Experiment 1. Targets were in second through seventh position, with a mean position of 3.9. The two members of a sentence pair were approximately matched on length in words; the mean sentence length for prefixed-target sentences was 10.5 words and the mean sentence length for pseudoprefixed-target sentences was 10.4 words (range=6 to 16). Also, sentences were approximately matched on length in character spaces so that they presented similar configurations on the CRT. Sentences are listed in the Appendix.

<u>Word pairs</u>. The 60 pairs of prefixed and pseudoprefixed targets included the 36 pairs from Experiment 1. Pairs were matched on apparent prefix and length in letters (mean=7.3, range=5 to 10). Pairs were approximately matched on frequency (Kucera & Francis, 1967); the mean frequency for prefixed words was 20.2 (range=1 to 195) and the mean frequency for pseudoprefixed words was 20.15 (range=1 to 171).

Word pairs were matched on syntactic category and approximately matched on number of syllables; the means were 2.4 (range=2 to 4) and 2.5 (range=2 to 4) for prefixed and pseudoprefixed targets, repectively.

Assessing prefixedness and pseudoprefixedness. Deciding whether a word was prefixed or pseudoprefixed was guided by the same criteria used in Experiment 1. Table 3 lists the 24 new target pairs along with a prefix+stem meaning analysis for each prefixed word and another word sharing the same stem as each prefixed word. The new prefixes used in Experiment 2 were AN-, AS-, CON-, DIS-, and EN-.

Design. Two lists were constructed, each containing 60 sentences. A list contained 30 prefixed-target and 30 pseudoprefixed-target sentences. No list contained both members of a sentence pair. Half of the subjects were randomly assigned to each list.

Each subject read 10 prefixed and 10 pseudoprefixed sentences in each of three viewing conditions: the correct word condition, the other-word condition, and the nonsense string condition. The correct word condition presented the correct target word in it entirety before and after the saccade to the target location. In the other-word condition, the other member of the target pair appeared in the target location prior to the saccade to the target location; during this saccade, the correct target word replaced the incorrect one. In the nonsense string condition, a nonsense string of letters equal in length to the target word appeared in the target location prior to the saccade to the target location, at which time the correct

TABLE 3

ADDITIONAL PREFIXED AND PSEUDOPREFIXED WORDS USED IN EXPERIMENT 2

Prefixed Word	Prefix+Stem Analysis	Related Word	Pseudoprefixed Word
ABUSE	away+USE	use	ABBEY
ACCOUNT	toward+COUNT	count	ACADEMY
ANARCHY	without+rule+Y	monarchy	ANTENNA
ASSEMBLED	toward+gather+ED	resembled	ASTOUNDED
BEHEADING	verb formative+HEAD+ING	head	BECKONING
BESTOWED	verb formative+STOW+ED	stow	BELLOWED
CONFLICTS	together+fight+S	inflicts	CONTRASTS
CONTAINS	with+hold+S	attains	CONTROLS
DEFEATED	reverse+do+ED	feat	DEAFENED
DEMOTED	back+move+ED	promoted	DELUGED
DETACH	reverse+hold	attach	DEVOUR
DETAIN	away+hold	attain	DEEPEN
DEVOID	from+VOID	void	DEVOUT
DISCOUNT	away+COUNT	count	DISTANCE
DISCOURAGE	away+COURAGE	courage	DISCIPLINE
ENCOURAGE	verb formative+COURAGE	courage	ENTERTAIN
ENJOY	verb formative+JOY	joy	ENTER
IMPURITY	not+PURE+ITY	purity	IMBECILE
INDIRECT	not+DIRECT	direct	INTIMATE
INNOVATION	in+new+TION	renovation	INSTRUMENT
PRONOUNCE	for+shout	announce	PROMENADE
RENEWAL	again+NEW+AL	new	REALTOR
RESTRICT	back+hold	strict	REGISTER
UNWELCOME	not+WELCOME	welcome	UNANIMOUS

word appeared in the target location. For example, the three possible pre-saccade target location contents for REMIND were REMIND (correct word condition), RELISH (other-word condition), and CWXYJQ (nonsense string condition).

Order of presentation of sentences and viewing conditions was randomized for each subject. A set of 6 subjects provided one eye movement record for each sentence under each viewing condition.

Apparatus. Apparatus was the same as in Experiment 1.

Procedure. The procedure was identical to that used in Experiment 1, with the exception that each subject read 60 experimental sentences rather than 36.

Scoring of data. Data were scored much the same as in Experiment 1. The dependent variable of primary interest was the duration of the first fixation on each target word, and gaze durations on target words were also of interest. In Experiment 2, the new dependent variables were the length in character spaces of the saccade to the target location and the saccade from the target location, the duration of the fixation prior to that on the target location, and the number of fixations placed on a target word.

In the subject analysis, a data point for a given dependent variable was the mean value of that dependent variable for the 10

prefixed or 10 pseudoprefixed sentences in each of the three viewing conditions for each subject. In the item analysis, a data point was the mean of the 4 observations in each of the 6 cells of the design. Some observations had to be discarded due to track losses or to possible conscious awareness of the display change in the nonsense string and the other-word conditions.

Results and Discussion

First fixation durations and gaze durations. Mean first fixation duration and gaze durations on the prefixed and the pseudoprefixed words are presented in Table 4.

Effects of pseudoprefixedness. As in Experiment 1, pseudoprefixed words received longer first fixations (237 msec) than prefixed words (225 msec); this 12 msec disadvantage for pseudoprefixed words was reliable in both the subject analysis [$F(1,23)=20.59$, $p<.001$] and the item analysis [$F(1,59)=3.97$, $p<.05$], although it missed reliability on minF' [$minF'(1,77)=3.33$, $p<.10$]. Similarly, pseudoprefixed words received longer gazes (306 msec) than prefixed words (289 msec). In contrast to Experiment 1, the 17 msec pseudoprefixedness disadvantage in gaze durations in Experiment 2 was reliable [$F(1,23)=9.25$, $p<.01$ in the subject analysis and $F(1,59)=3.97$, $p<.05$ in the item analysis], although it was not reliable on minF' [$minF'(1,82)=2.78$, $p<.10$]. Once again, the view that a pseudoprefixed word is mistakenly treated as prefixed was supported.

TABLE 4

MEAN FIRST FIXATION DURATION AND GAZE DURATION (IN PARENTHESES) ON PREFIXED AND PSEUDOPREFIXED TARGETS AS A FUNCTION OF VIEWING CONDITION [EXPERIMENT 2]

	TARGET TYPE	
VIEWING CONDITION	PREFIXED	PSEUDOPREFIXED
NONSENSE STRING	232 (301)	247 (313)
OTHER WORD	224 (295)	241 (320)
CORRECT WORD	218 (272)	224 (284)

Effects of viewing condition. Experiment 2 provided clear evidence that less time was spent reading a prefixed or pseudoprefixed target word when it had been previously available in the parafovea. First fixations averaged 221 msec in the correct word condition (identical to the whole word condition in Experiment 1), a decrease of 19 msec compared to the mean first fixation duration of 240 msec in the nonsense string condition, in which no parafoveal information about the target word was available. First fixation durations in the other-word condition averaged 232 msec, representing an 8 msec decrease relative to the nonsense string condition and an 11 msec increase relative to the correct word condition. The main effect of viewing condition was reliable [$minF'(2,127)=4.73$, $p<.025$]. The unexpectedly small amount of benefit due to availability of the other member of the target pair in the parafovea (the other-word condition) suggests that the parafoveal advantage in the correct word condition was not simply due to the initial bigram or trigram. Most of the effect of viewing condition was due to the difference between the nonsense string condition and the correct word condition. When the data from the correct word condition were removed from the analyses, the difference between the nonsense string condition and the other-word condition failed to reach reliability in the subject analysis [$F(1,23)=2.93$, p .10 but $F(1,59)=5.30$, $p<.03$ in the item analysis].

Like the first fixation duration data, the gaze durations show that less time was spent reading a target word that had been present in the parafovea prior to fixation. Gazes averaged 278 msec in the

correct word condition, 29 msec less than in the nonsense string condition(307 msec). The overall main effect of viewing condition was reliable [minF'(2,139)=6.23, p<.005]. However, although first fixation durations were 7 msec less in the other-word condition than in the nonsense string condition, gaze durations were actually 1 msec more in the other-word condition than in the nonsense string condition. Table 4 shows that this discrepancy is solely attributable to the gaze durations on pseudoprefixed targets in the other-word condition. Pseudoprefixed targets in this condition received gazes 7 msec longer than pseudoprefixed targets in the nonsense string condition. In contrast, prefixed words in the other-word condition received gazes 6 msec shorter than prefixed words in the nonsense string condition. It seems that it was more difficult to process a pseudoprefixed word when a prefixed word had been in the parafovea than when no word had been in the parafovea, but that a prefixed word does derive some benefit from the parafoveal presence of a pseudoprefixed word. However, when the nonsense string condition was compared with the other-word condition, the interaction of prefixedness/pseudoprefixedness was not reliable [F<1 in both the subject analysis and the item analysis], so that this conclusion remains very tentative. It is certainly not the case that preview of the other member of a target pair was as beneficial as preview of the target itself, as would be predicted if parafoveal facilitation were solely due to initial letter sequence.

Interaction of prefixedness/pseudoprefixedness with viewing condition. The hypothesis that prefix stripping depends on parafoveal

detection of an apparent prefix received no support in Experiment 2, just as it received no support in Experiment 1. Pseudoprefixed words required longer fixation times than prefixed words even in the nonsense string condition, in which no prefix was parafoveally available; the difference between the two types of target words was 15 msec in the first fixation durations and 12 msec in the gaze durations. Also, prefixed words did not benefit more from prior target word availability than pseudoprefixed words in either the first fixation durations or the gaze durations; the interaction of prefixedness/pseudoprefixedness was far from reliable [first fixation durations: $\underline{F}(2,46)=1.65$, $p<.20$ by subjects and $\underline{F}<1$ by items; gaze durations: $\underline{F}<1$ both by subjects and by items]. There is a suggestion in the first fixation durations that pseudoprefixed words benefit more from full parafoveal preview than prefixed words, but this interaction was not reliable either [$\underline{F}(1,23)=2.31$, $p<.14$ in the subject analysis and $\underline{F}(1,59)<1$ in the item analysis].

<u>Initial bigrams and initial trigrams</u>. It was evident in both the first fixation durations and the gaze durations that preview of the other member of the target pair was not as facilitory as preview of the correct target word. This tendency was particularly striking in the case of pseudoprefixed targets. One of the consequences of the longer fixations in the other-word condition than in the correct word condition is that more than the initial letter sequence was processed in the parafovea.

Inspection of the target pairs offers some insight into why

preview of the correct word was more beneficial than preview of the other word. Only 17 of the word pairs shared an initial trigram; the remaining 43 pairs shared only an initial bigram, differing in their third letter. Of the 17 pairs which share an initial trigram, 15 have the same three-letter prefix and two have the same two-letter prefix plus the same third letter (DEVOID, DEVOUT; INTRUDER, INTRIGUE). The fixation time decrease in the correct word condition compared to the other-word condition might have been due to the fact that most target pairs did differ in their third letter. In the other-word condition, the parafoveal preview would have included an incorrect letter in third position. Previous research has shown that intact initial trigrams in the parafovea did lead to better reading performance than intact initial bigrams (Rayner, Well, Pollatsek, & Bertera, 1982).

Table 5 shows the first fixation and gaze duration data for the 43 shared-bigram pairs and for the 17 shared-trigram pairs. The first fixation durations lend some support to the hypothesis that most of the parafoveal facilitation was due to the initial trigram. In pairs sharing their initial trigram, first fixations averaged 233 msec in both the other-word and the correct word conditions, while in pairs sharing only their initial bigram, first fixations averaged 230 msec in the other-word condition, 13 msec more than in the correct-word condition (217 msec). The gaze durations do not agree with the first fixation durations, however; even in pairs sharing their initial trigram, the other-word condition led to longer gazes than did the correct word

TABLE 5

MEAN FIRST FIXATION DURATION AND GAZE DURATION (IN PARENTHESES) ON SHARED-BIGRAM AND SHARED-TRIGRAM TARGET PAIRS AS A FUNCTION OF VIEWING CONDITION [EXPERIMENT 2]

	PAIR TYPE	
VIEWING CONDITION	BIGRAM	TRIGRAM
NONSENSE STRING	239 (304)	250 (332)
OTHER WORD	230 (309)	233 (321)
CORRECT WORD	217 (271)	233 (290)

condition. For the shared-bigram targets, gaze durations were 38 msec longer in the other-word condition than in the correct word condition. For the shared-trigram targets, the corresponding difference was 31 msec. It seems that an identical third letter was not the only factor behind the overall advantage of the correct word condition compared to the other-word condition.

One highly speculative possibility is that lexical access had begun even while a target word was yet to be fixated, and that prefixed words are more easily accessed in the parafovea than pseudoprefixed words. This speculation is inspired by the following tendencies in the data (See Table 4): (1) Gaze durations on pseudoprefixed words were lengthened by prior parafoveal viewing of a prefixed word; (2) Gaze durations on prefixed words were somewhat shortened by prior parafoveal viewing of a pseudoprefixed word; (3) First fixations on pseudoprefixed words in the other-word condition were more like those in the nonsense-string condition than those in the correct word condition; and (4) First fixations on prefixed words were equally similar to those in the nonsense string condition and those in the correct word condition. Perhaps it is the presence of a stem morpheme in the parafovea that initiates access through morphological analysis, causing disruption in accessing a pseudoprefixed word as a whole when it is read in the foveal target location.

Saccade length. One unpredicted but supportive finding was that the saccade leaving the target word was longer if the target was

prefixed than if it was pseudoprefixed. Table 6 presents the mean length of the first rightward saccade leaving the target word. Saccades from prefixed words averaged 8.6 character spaces while saccades from pseudoprefixed averaged 8.1 character spaces and this ½-character space difference was reliable over subjects [$F(1,23)= 9.25$, $p<.01$] and reliable over items [$F(1,59)=4.76$, $p< .03$]. Shorter saccades from pseudoprefixed words held over all three viewing conditions, but there was no reliable effect of viewing condition [$F(2,46)=1.33$, $p< .28$ in the subject analysis and $F(2,118)= 1.96$, $p<.15$ in the item analysis]. Saccades averaged 8.4, 8.2, and 8.4 character spaces in the nonsense string, other-word, and correct word conditions, respectively, indicating a slight tendency for shorter fixations from target words (particularly pseudoprefixed target words) in the other-word condition.

The longer saccades from the prefixed target words support the claim that pseudoprefixation leads to a delay in lexical access. The increased time needed to access a pseudoprefixed target word in the fovea could reduce the time available for processing information from the post-target word in the parafovea, so that the post-target needs to be fixated in a more word-initial position when it follows a pseudoprefixed target than when it follows a prefixed target.

It was not the case that shorter saccades <u>from</u> pseudoprefixed words were due to shorter saccades <u>to</u> pseudoprefixed targets. As can be seen in Table 7, the first saccade to the pseudoprefixed

TABLE 6

MEAN LENGTH OF SACCADE FROM THE PREFIXED OR PSEUDOPREFIXED TARGET TO THE NEXT WORD AS A FUNCTION OF VIEWING CONDITION [EXPERIMENT 2]

	TARGET TYPE	
VIEWING CONDITION	PREFIXED	PSEUDOPREFIXED
NONSENSE STRING	8.7	8.2
OTHER WORD	8.4	8.0
CORRECT WORD	8.6	8.2

TABLE 7

MEAN LENGTH OF SACCADE TO THE PREFIXED OR PSEUDOPREFIXED TARGET AS A FUNCTION OF VIEWING CONDITION [EXPERIMENT 2]

	TARGET TYPE	
VIEWING CONDITION	PREFIXED	PSEUDOPREFIXED
NONSENSE STRING	8.1	8.3
OTHER WORD	8.4	8.2
CORRECT WORD	8.3	8.2

target averaged 8.2 character spaces, similar to the average of 8.3 character spaces for prefixed targets. The .1 character space difference was not reliable [$F<1$ in both the subject and item analyses.] Also, the length of the first saccade to the target location was virtually unaffected by the contents of the target location at the time of the saccade. Saccade lengths were 8.2, 8.3, and 8.2 spaces in the nonsense string, other-word, and correct word conditions, respectively. The effect of viewing condition was unreliable [$F<1$ in both the subject and the item analyses]. The lack of influence of the type of parafoveal information in the target location suggests that detailed information in the parafovea did not determine the length of the eye movement to the target word. It seemed instead that it was the difficulty of processing the word currently in the fovea that had a small influence on the length of the eye movement from that word to the word in the parafovea. Since the pre-target word was the same regardless of whether a target was the prefixed or pseudoprefixed member and regardless of viewing condition, saccades from pre-targets to targets were of similar length in all conditions. But since the target could be prefixed or pseudoprefixed, and the pseudoprefixed targets were more difficult to process, the saccade from the pseudoprefixed word was slightly shorter than the saccade from the prefixed word.

Shorter saccades from prefixed words were not due to a different number of refixations on prefixed targets and pseudoprefixed targets. Table 8 presents the mean number of fixations on both types of target words. (The fixation count included only the number of

TABLE 8

MEAN NUMBER OF FIXATIONS ON PREFIXED AND PSEUDOPREFIXED TARGETS PER TRIAL AS A FUNCTION OF VIEWING CONDITION [EXPERIMENT 2]

VIEWING CONDITION	TARGET TYPE	
	PREFIXED	PSEUDOPREFIXED
NONSENSE STRING	1.36	1.34
OTHER WORD	1.40	1.36
CORRECT WORD	1.31	1.33

successive fixations on a target word before another word was fixated, i.e., only the fixations included in the target word's gaze duration). On average, prefixed words received 1.36 fixations, compared to 1.34 fixations on pseudoprefixed words. The difference was not reliable, and there was no reliable effect of viewing condition and no reliable interaction of target type with viewing condition. Table 9 shows that there were slightly fewer fixations per target in the correct word condition (1.32 fixations) than in the nonsense string condition (1.35 fixations), and the other-word condition had the greatest number of fixations per target (1.38 fixations).

Finally, it was not the case that shorter saccades from pseudoprefixed targets than from prefixed targets occurred only when targets were fixated more than once. As can be seen in Table 9 , shorter saccades from pseudoprefixed words were observed even in trials in which the target word was fixated only once; saccades from pseudoprefixed words averaged 8.3 character spaces and saccades from prefixed targets averaged 8.7 character spaces. The .4 character space difference was reliable in the subject analysis [$\underline{F}(1,23)=8.59$, $p<.01$] although it missed reliability in the item analysis [$\underline{F}(1,59)=2.86$, $p<.10$].

Duration of the pre-target fixation. Did the parafoveal contents of the target location affect the duration of the fixation prior to that on the target location? As can be seen in Table 10, there was only a slight effect of viewing condition on the duration of the pre-target fixation. When a nonsense string was present in

TABLE 9

MEAN LENGTH OF SACCADE FROM THE PREFIXED OR PSEUDOPREFIXED TARGET TO THE NEXT WORD FOR TRIALS IN WHICH THE TARGET WAS FIXATED ONLY ONCE [EXPERIMENT 2]

	TARGET TYPE	
VIEWING CONDITION	PREFIXED	PSEUDOPREFIXED
NONSENSE STRING	8.7	8.3
OTHER WORD	8.6	8.2
CORRECT WORD	8.8	8.4

TABLE 10

MEAN DURATION OF THE FIXATION PRECEDING THAT ON THE PREFIXED OR PSEUDOPREFIXED TARGET [EXPERIMENT 2]

	TARGET TYPE	
VIEWING CONDITION	PREFIXED	PSEUDOPREFIXED
NONSENSE STRING	203	202
OTHER WORD	197	193
CORRECT WORD	189	198

the parafovea, pre-target fixations averaged 202 msec, compared to 195 msec in the other-word condition and 194 msec in the correct word condition. The slightly longer pre-target fixations in the nonsense string condition suggest that fixation durations may have been lengthened by the presence of unusual configurations of letters in the parafovea. However, the effect of viewing condition was not reliable [$F(2,46)=1.61$, $p<.21$ in the subject analysis and $F(2,118)<1$ in the item analysis]. An interesting trend is that the presence of a pseudoprefixed word in the parafovea led to slightly longer pre-target fixations than did the presence of a prefixed word in the parafovea. In the two cases in which a pseudoprefixed word was in the parafovea (the other-word condition for prefixed words and the correct word condition for pseudoprefixed words), the average pre-target fixation duration was 198 msec. In the two cases in which a prefixed word was in the parafovea (the correct word condition for prefixed words and the other-word condition for pseudoprefixed words), the average pre-target fixation was 191 msec in duration. This trend suggests that pseudoprefixed words are more difficult to process than prefixed words even while they are still in the parafovea, but the interaction of prefixedness/pseudoprefixedness with viewing condition was not reliable [$F(2,46)=1.12$, $p<.34$ in the subject analysis and $F(2,118)<1$ in the item analysis].

Predictability of the target word. Finally, it would be reassuring

to verify that longer fixations on pseudoprefixed words were not due to context effects. To minimize the possibility that one type of target was more contextually predictive than the other, the context prior to the target was identical and as neutral as possible with respect to either member of the target pair. It is highly unlikely that any target word could be predicted on the basis of prior context alone. The data corroborate the unpredictability of the targets. Predictable words would not always receive fixations, but the prefixed and pseudoprefixed targets were very rarely skipped in reading. In trials with prefixed-target sentences, the target was skipped only 14 times, and in trials with prefixed-target sentences, the target was skipped only 11 times, representing approximately .2% of trials.

Summary. As in Experiment 1, pseudoprefixed words received longer first fixations than prefixed words. Also, pseudoprefixed words received reliably longer gaze durations than prefixed words. There was no evidence that prefix stripping required parafoveal information, although both prefixed and pseudoprefixed words benefitted from parafoveal availability of the target word prior to fixation. Saccades launched from prefixed words were reliably longer than saccades launched from pseudoprefixed words. These findings and several statistically unsupported tendencies in the data converged on the conclusion that pseudoprefixed words are more difficult to access than prefixed words, suggesting prelexical prefix stripping.

CHAPTER IV

GENERAL DISCUSSION

Summary of Findings

In the two experiments reported here, it was found that prefixed words required less reading time than matched pseudoprefixed words: REVIVE was read more quickly than RESCUE despite the similarity of REVIVE and RESCUE in their apparent prefix, word frequency, length, number of syllables, and syntactic category, and despite the identical sentence-initial context that preceded each word. Prefixed words received reliably shorter first fixations than pseudoprefixed words, suggesting that the pseudoprefixedness disadvantage originates early in foveal processing. Prefixed words received shorter gazes than pseudoprefixed words as well (this effect was reliable in Experiment 2), suggesting that readers delay moving their eyes to the next word when the word in the fovea is pseudoprefixed. Also, the first saccade leaving a prefixed word was longer than the first saccade leaving a pseudoprefixed word, implying that the post-target word was fixated in a more word-initial position when the target was pseudoprefixed than when it was prefixed. This observation is consistent with the view that pseudoprefixed words are more difficult to access than prefixed words, leading to a decrease in the resources and time available for parafoveal processing of the post-target word.

Delayed recognition of pseudoprefixed words relative to prefixed

words has been reported in lexical decision experiments (Henderson, Wallis, & Knight, 1984; Rubin, Becker, & Freeman, 1979; Taft, 1981) and in naming experiments (Taft, 1981). Another finding consistent with prelexical prefix stripping was Smith and Sterling's (1980) observation that true prefixes and pseudoprefixes were associated with equal error rates in a letter cancellation task, implying that the stem had not been accessed when the prefix was processed. The present findings extend previous work in several ways. First, they argue against the claim by Rubin et al. that prefix stripping is only employed in the context of a disproportionately high number of prefixed items. The pseudoprefixed words in the present experiments were embedded in a balanced mix of monomorphemic and polymorphemic words. Second, the present findings demonstrate that the pseudoprefixedness disadvantage obtains in fluent reading; emergence of the effect does not require isolated presentation of target words or an unusual task such as lexical decision or letter cancellation. Third, the present findings were based on prefixed and pseudoprefixed words matched in a pair-wise fashion on apparent prefix, length, and syntactic category, indicating that differences along these other dimensions do not underlie the observed difference in fixation time on prefixed and pseudoprefixed words.

The present investigation differed from previous ones in another particularly important way: it examined the role of parafoveal information in reading prefixed and pseudoprefixed words. Normal reading of text differs from reading an isolated word in that reading text permits some parafoveal preview. Reading efficiency decreases when

parafoveal information to the right of fixation is denied, and there is evidence that parafoveal preview of a word's initial few letters is of substantial benefit (e.g., Rayner, 1978b; Rayner, McConkie, & Zola, 1980; Rayner, Well, Pollatsek, & Bertera, 1982). The implication is that letter or letter pattern information is integrated across the pre-target fixation and the target fixation. If the identification of a a prefix in the parafovea were a necessary precursor to prefix stripping, then there would be no pseudoprefixedness disadvantage if parafoveal information about the target was denied. This possibility was discomfirmed: the pseudoprefixedness disadvantage was evident even when no target-word information was displayed prior to fixation on the target word (i.e., in the Xs condition in Experiment 1 and the nonsense string condition in Experiment 2). The stability of the size of the pseudoprefixedness effect across parafoveal viewing conditions suggests that prefix stripping occurs during foveal fixation of the prefixed or pseudoprefixed target. Although both types of target words did benefit from parafoveal preview, prefixed words did not benefit more from parafoveal preview than pseudoprefixed words.

A few aspects of the data did hint that lexical access of target words had begun while the target was still in the parafovea. First of all, first fixation durations and gaze durations on target words were not decreased as much by preview of the other member of the target pair as by preview of the target itself. If all that were being extracted from the parafoveal region were beginning-letter information, then viewing time on targets would have been similar

whether preview was of the correct target word or the other member of the target pair. Closer scrutiny of the data suggested that prefixed words were easier to process in the parafovea than pseudoprefixed words: gazes on pseudoprefixed words were slightly longer when parafoveal preview was of the prefixed counterpart than when parafoveal preview was of a nonsense string. This tendency contrasts with the pattern of gaze durations in Experiment 1: gazes on target words were shorter when preview had been of the apparent prefix followed by Xs than when preview had been of a string of Xs. In Experiment 1, therefore, the importance of beginning-letter information was confirmed. What distinguishes the other-word condition in Experiment 2 from the prefix+Xs condition in Experiment 1 (for pseudoprefixed trials) is the presence of a true stem following an apparent prefix in the parafovea. Activation of the lexical entry for a prefixed word may have begun while the prefixed word was in the parafovea, so that when on fixation the prefixed word had been replaced by the pseudoprefixed word, lexical access was disrupted. A second hint of the relative ease of initiating access of a prefixed word in the parafovea was that the pre-target fixation was a bit shorter if the pre-fixation contents of the target location had been a prefixed word than if it had been a pseudoprefixed word (Experiment 2). These hints in the data are indeed just hints, since they don't reflect statistically reliable interactions. They are mentioned here as a cautionary note on the conclusion that prefix stripping is only a foveal operation.

Implications for a Model of Lexical Representation and Lexical Access

That RESCUE was apparently harder to access than REVIVE argues strongly against a lexicon that simply represents each word in English with a unitary lexical entry. Under a unitary view of lexical representation, there is nothing to distinguish the ease with which REVIVE and RESCUE will be accessed, since the principal difference between REVIVE and RESCUE is a difference in word-internal linguistic structure. In contrast, a morphemic view of lexical representation does distinguish the ease with which REVIVE and RESCUE are accessed. Three basic assumptions of the morphemic view are (1) that there exists a list of prefixes, (2) that this list is used by a process that pre-lexically removes any prefix from a stimulus word in order to isolate the stem, and (3) that the accessible lexical representation of a prefixed word is its stem. To a parser equipped only with a list of prefixes, RESCUE looks like a prefixed word; accordingly, the parser strips RE- from RESCUE and leaves the potential stem SCUE, which turns out to be absent from the lexicon of accessible representations since it is not a true stem. Only after the absence of SCUE has been confirmed can access succeed: RE- is re-attached to SCUE, and the lexical entry RESCUE is contacted. Because VIVE is a true stem, REVIVE is accessed correctly the first time.

<u>The assumption of prefix stripping</u>. Is preliminary prefix stripping a necessary part of a model of lexical access? The logical argument

in favor of prefix stripping is that without it, the stem could not be isolated. An alternative view is that detection and identification of the stem is accomplished without any prior removal of the prefix. The tacit assumption underlying the argument for prefix removal is either (1) that a word is processed from left to right or (2) that there is a processing bias favoring word-initial information over word-medial and word-terminal information. Many studies have indicated the importance of word-initial letters (e.g., Broerse & Zwaan, 1966; Bruner & O'Dowd, 1958; Pillsbury, 1897), and the left to right scanning direction in reading a line of text has led some theorists to postulate a left-to-right attentional scan during a single fixation in reading a word (e.g., Gough, 1972). Consistent with this view are results demonstrating that presenting word-terminal letters before word-initial letters is more detrimental to word recognition than presenting word-initial letters before word-terminal letters (Lima & Pollatsek, 1983; Mewhort & Beal, 1977). The very weakest conclusion that can be drawn is that a delay in processing word-initial letters is substantially harmful to lexical access. The implication for prefixed words is that a delay in processing the prefix seems unwise.

Turning to the empirical arguments specific to prefixed words, the finding that pseudoprefixed words took longer to read than prefixed words would appear to rule out the model of stem detection without prefix removal. Pseudoprefixed words do contain letter sequences that look like true prefixes, but they don't contain letter sequences that look like true stems, and therefore it must be the apparent prefix

that triggers the mistaken morphological partitioning. However, there is an alternative interpretation that assumes a lexicon of stems but not prefix stripping. Under this interpretation, stem frequency underlies the pseudoprefixed-word disadvantage. Because stem frequency exerts an effect on word recognition time (D. Bradley, 1979; Taft, 1979b), even words matched on surface frequency can require different amounts of time to access. The prefixed words used in the present experiments had stems that appeared in other words, so that they could have had higher frequency stems than the pseudoprefixed words (a pseudoprefixed word is a stem itself). The possible frequency boost for prefixed words would lead to faster access for prefixed words than for pseudoprefixed words, even though both types had the same surface frequency.

Several lines of evidence militate against the pure stem detection view, however. First, Taft (1981) reported a pseudoprefixedness disadvantage relative to prefixed words with unique stems (e.g., ADVANCE), and it is unlikely that uniquely stemmed prefixed words have higher stem frequencies than pseudoprefixed words matched on surface frequency. Second, the finding of equal difficulty for prefixes and pseudoprefixes in letter cancellation (Smith & Sterling, 1982) argues that apparent prefixes are unitized without regard to the morphemic status of the remainder of the word. Third, prefixed nonwords without true stems (DENOLD) took longer to reject in lexical decision than unprefixed nonwords (LOMALK) matched on length-sensitive initial bigram frequency (Taft, 1976). It seems that the apparent

prefix itself lengthened the time to decide that DENOLD was not a word by necessitating a search for NOLD in addition to a search for DENOLD.

It would be illuminating to discover whether a nonword combining a non-prefix with a stem (LOJUVENATE) would take as long to reject in lexical decision as a nonword combining a prefix and a stem (DEJUV-ENATE), as would be predicted by the pure stem detection view. DEJUVENATE did take longer to reject than DEPERTOIRE (Taft & Forster, 1975), but the LOJUVENATE-DEJUVENATE comparison has not been tested. One relevant finding is that CLOVE did not take longer to accept in lexical decision than THUMB, but BEARD took longer to accept than STORM (Taft, 1979a). BEARD starts with BEAR, and CLOVE ends with LOVE, but only when the word-internal word was in initial position did it cause lengthened lexical decision times. One interpretation is that LOVE didn't delay access for CLOVE because C is not a prefix and so was not stripped off.

<u>The time course of lexical access</u>. The evidence presented so far argues that prefix stripping aids in isolating a prefixed word's stem. Assuming that a prefixed word's sole accessible representation in the lexicon is a representation of its stem, the logical possibilities for the time course of lexical access for a prefixed word or a pseudo-prefixed word are (1) the first attempt at access is via the stem; if the stem is absent from the lexicon, then a second attempt at access is made via the entire word; (2) the first attempt at access is via

the entire word; if the entire word is not accessible, then a second attempt at access is made via the stem; or (3) an attempt at access via the stem occurs in parallel with an attempt at access via the entire word. Possibility (1) is obviously consistent with the present results, since it predicts that pseudoprefixed words will take longer to access than pseudoprefixed words. By this view, it is prefixed words that are at an advantage; they require one attempt at access while pseudoprefixed words require two. Possibility (2) is inconsistent with the present results, since it predicts that prefixed words will take longer to access than pseudoprefixed words. By this view, it is pseudoprefixed words that are at an advantage, since prefixed words will require two attempts at access. It seems, then, that the only serial model supported by the data is Possibility (1).

Possibility (3), a parallel model, seems inconsistent with the present results, since it predicts equal access time for prefixed words and pseudoprefixed words. If both an attempted stem access and an attempted entire-word access start at the same time and proceed in parallel, then for prefixed words the stem search would succeed and the entire-word search would fail; for pseudoprefixed words, the stem search would fail and the entire-word search would succeed. Therefore, for both types of words, one attempted access succeeds and one attempted access fails, so that either type of word will take the same amount of time to access. The parallel model could be saved by adding the assumption that the stem access process is generally faster than the entire-word access process or by adding the assumption

that the entire-word access process starts later than the stem-access process but does not wait for the outcome of the stem-access process. A parallel model modified by either of these assumptions is consistent with the results at hand, and is difficult to empirically distinguish from Possibility (1), the serial model giving priority to stem access. The serial model seems less post hoc than the modified parallel model, but one point in favor of the parallel model is that the effects observed in Experiments 1 and 2 are so small that they are unlikely to include the entire time needed for a second lexical access process subsequent to a failed first lexical access process. The observed increase in first fixation durations on pseudoprefixed words compared to prefixed words was 14 msec in Experiment 1 and 12 msec in Experiment 2, but first fixation durations ranged from 218 msec to 247 msec.

The assumption of access via the stem. What would happen to a parallel model of lexical access if the assumption of the stem as the sole access entry were modified? The modified model would assume that prefixed words have two accessible lexical representations, a stem representation and an entire-word representation. Such a view could be consistent with the results reported here. Consider the prefixed word REVIVE and the pseudoprefixed word RESCUE. In recognizing REVIVE, the search for VIVE can succeed and the search for REVIVE can succeed. In recognizing RESCUE, the search for SCUE cannot succeed, but the search for RESCUE can succeed. To the extent that two confirmatory access attempts are superior to two access attempts at odds with each other, REVIVE

will be recognized faster than RESCUE. Even if each attempted access proceeds independently from the other, it is still better to have two horses in a race than just one, so that REVIVE would still be accessed faster than RESCUE. Thus, a model assuming dual access representations for prefixed words can accomodate the present findings. One logical argument against dual representation is that it violates economy of storage. However, dual representation is not implausible in light of the developmental course of learning a prefixed word: REVIVE is first heard or read as a whole. Perhaps a lexical entry for VIVE arises later, and the entry REVIVE continues to co-exist with the entry VIVE. Perhaps the number of stem representations in an individual's lexicon is a reflection of the individual's morphological sophistication, so that little evidence of morphological analysis in reading familiar words would be expected prior to the development of the ability to produce and comprehend novel combinations of morphemes.

Even a view that posits two accessible representations for a prefixed word must assign particular importance to the stem representation. It has been found that a prefixed word with a free stem (e.g., UNAWARE) was as facilitory to subsequent lexical decision on its stem alone (AWARE) as was the stem itself (Stanners, Neiser, & Painton, 1979). This finding suggests that UNAWARE and AWARE are accessed through one entry, but the dual representation view claims that on some proportion of trials, access for UNAWARE would have been achieved via the wholistic entry UNAWARE.

Orthotactic constraint. One unattractive aspect of prelexical prefix stripping is that it causes so many words (all the pseudoprefixed ones) to be misanalyzed over and over again. Perhaps some pseudoprefixed words have characteristics which short-circuit any attempted morphological analysis. One characteristic that might protect a pseudoprefixed word from unwarranted morphological analysis is orthotactic constraint. For some pseudoprefixed words, the putative "stem" (the remainder of the word after the apparent prefix is removed) begins with a sequence of letters that cannot be the initial letter sequence of a morpheme because they violate the orthotactic rules of English. Those pseudoprefixed words that have orthotactically illegal putative stems (e.g., REMNANT, the putative stem of which is MNANT) may be accessed as quickly as prefixed words. There are two possible mechanisms by which orthotactics could constrain lexical access. One possibility is that stem searching proceeds from left to right and aborts as soon as the illegal sequence is registered. The second possibility is that the illegal sequence suppresses prefix stripping altogether, so that stem access is never attempted. By either account, reading an orthotactically constrained pseudoprefixed word would not take more time than reading a prefixed word.

The present data offer some evidence that prefix+stem analysis is blocked by orthotactic constraint. Eight pseudoprefixed words used in Experiment 2 have orthotactically unlikely putative stems; seven of these have orthotactically impossible putative stems (PROMPTED, DENTIST, REIGN, REMNANT, RENTAL, BECKONING, and BELLOWED) and one (DEEPEN)

contains a geminate that would probably be hyphenated if the word were prefixed (*DE-EPEN). As can be seen in Table 11, these pseudoprefixed words received first fixations averaging 229 msec, 13 msec less than those on their prefixed mates (242 msec). The gaze durations show a diminished pseudoprefixedness disadvantage; there was little difference between the orthotactically constrained pseudoprefixed words (305 msec) and their prefixed mates (303 msec). Interestingly, the only viewing condition to show a pseudoprefixedness disadvantage in either the first fixations or gaze durations was the other- word condition, suggesting that the presence of a truly prefixed word in the parafovea prior to fixation on a pseudoprefixed target led to an overriding of the orthotactic constraint. Another relevant observation is that the orthotactically constrained pseudoprefixed words were read a bit more quickly than the other pseudoprefixed words. Constrained pseudoprefixed words received first fixations of 229 msec and gaze durations of 305 msec, compared to 237 and 308 msec for other pseudoprefixed words (not shown in Table 11). This slight reduction is unexpected since the orthotactically constrained words were lower in surface frequency than the others.

These exploratory examinations of the data are based on so few items that statistical tests are of insufficient power to be of much worth, but they do suggest interesting directions for further research. More detailed experiments would be needed to establish an effect of orthotactics and to rule out factors that covary with orthotactic constraint, such as phonotactic constraint and syllabication.

TABLE 11

MEAN FIRST FIXATION DURATION AND GAZE DURATION ON PREFIXED AND PSEUDO-PREFIXED TARGETS FOR ITEM PAIRS IN WHICH A STEM INTERPRETATION OF THE PSEUDOPREFIXED TARGET IS ORTHOTACTICALLY UNLIKELY [EXPERIMENT 2]

	TARGET TYPE	
VIEWING CONDITION	PREFIXED	PSEUDOPREFIXED
NONSENSE STRING	250 (309)	228 (285)
OTHER WORD	240 (329)	254 (366)
CORRECT WORD	235 (271)	205 (264)

Lexical representation of high frequency words. Prefix stripping could possibly be bypassed if the prefixed or pseudoprefixed target is a high frequency word. It is reasonable to expect that a high frequency word would have its own wholistic representation in the lexicon even if it is a prefixed word. An anologous demonstration has been reported with high and low frequency words that varied in the regularity of their grapheme-phoneme correspondences (Seidenberg, Waters, Barnes, & Tanenhaus, 1982). Many researchers have found that irregular words are processed more slowly than regular ones (e.g., Baron & Strawson, 1976; Gough & Cosky, 1977; Parkin, 1982; Stanovich & Bauer, 1978). What Seidenberg et al. discovered was that the irregular-word disadvantage did not obtain for words high in frequency; for these, regularity of grapheme-phoneme correspondence was irrelevant, suggesting that direct readout was responsible for their naming latencies. The corresponding prediction within the present framework is that, for high frequency pairs of prefixed and pseudoprefixed words, reading times will be identical, reflecting access based on a wholistic entry in the lexicon.

Examination of the present data offers no support for wholistic access of high frequency prefixed words: for the 7 highest frequency item pairs in Experiment 2 (mean frequency=93.6), the pseudoprefixedness disadvantage relative to the matched prefixed words was 17 msec in the first fixation durations and 21 msec in the gaze durations, and these effects are roughly comparable to the experiment-wide effects. This may not constitute strong evidence, however, since the range

of frequencies in the highest frequency items was 24-195, compared to a mean of about 700 in the Seidenberg et al. experiments. It could be that very high frequency prefixed words are accessed as wholes. However, there are almost no very high frequency prefixed words. A scan through the Kucera and Francis (1967) frequency norms reveals only three prefixed words with frequencies over 350 (AROUND, PROGRAM, and PRESENT). The intuitive impression that these words seem pseudoprefixed may be taken as support of the claim that they are accessed as wholes. Just as the question of orthotactic constraint cannot be settled on the basis of the present experiments, neither can the question of representation of high frequency prefixed and pseudoprefixed words, but the preliminary conclusion is that high frequency prefixed words are accessed in much the same way as other prefixed words.

Summary. A model of lexical representation and lexical access of prefixed and pseudoprefixed words needs to assume prelexical prefix stripping and accessible representations of stem morphemes. If the model assumes that stems are the only accessible representations of prefixed words, then it must posit either that wholistic access is only attempted if stem access has failed or that wholistic access starts later or proceeds more slowly than stem access. If the model assumes that prefixed words have accessible stem entries and accessible wholistic entries, then parallel stem access and wholistic access is plausible, but such a model has difficulty explaining how a prefixed

word fully facilitates subsequent recognition of its stem. It is possible that an orthotactically illegal putative "stem" protects a pseudoprefixed word from attempted access via the stem, but it does not seem likely that high frequency prefixed words do not have stem representations.

A Model of Lexical Representation and Lexical Access

The present results join an ample collection of research suggesting that recognition of a stimulus word entails access to a lexical representation of its stem. A model of lexical representation and lexical access that accomodates many of the findings to date and makes some predictions that have yet to be tested is sketched below.

Representations in the lexicon. The lexicon has a central list of accessible representations (the access file of Taft and Forster, 1975). This list contains one and only one representation for each stem morpheme. Stem representations are listed in order of decreasing frequency. Each stem representation points to a subfile (part of the master file of Taft and Forster) which contains sufficient information or instructions to recognize any permissible unaffixed or affixed form of the stem. The subfile information about an affixed form is a complete entry in its own right only if the affixed form is not semantically, orthographically, or phonologically compositional from its morphemes. Otherwise, the prefix or suffix is indicated

along with a referral to the complete lexical information stored with the subfile entry for the unaffixed form. For example, UNAWARE is accessed via $|AWARE|_{acc}$, and the subfile entry corresponding to UNAWARE is something like $|$+ prefix UN=negative $|AWARE|_{sf}\ |_{sf}$ (where access entries are denoted by $||_{acc}$ and subfile entries are denoted by $||_{sf}$.) By this view, semantic details need be listed only once, under $|AWARE|_{sf}$, rather than listed redundantly under $|UNAWARE|_{sf}$. In contrast, a less compositional word like RECEIVE may be accessed through $|CEIVE|_{acc}$, but its subfile lexical entry is complete in its own right; it might look something like |+prefix RE=to get|. An irregular form like HUNG is accessed through its own access entry $|HUNG|_{acc}$ rather than through $|HANG|_{acc}$ (because the stem of HUNG is not transparent), but the subfile entry for HUNG contains a referral to the subfile entry for HANG, i.e. $|$HUNG=past $|HANG|_{sf}|_{sf}$.

This view accomodates both stem priming effects and stem frequency effects. Presenting UNAWARE prior to recognition of AWARE was as facilitory as presenting AWARE prior to recognition of AWARE (Stanners, Neiser, & Painton, 1979) because recognizing UNAWARE entails an access pathway through both $|AWARE|_{acc}$ and $|AWARE|_{sf}$. However, COMFORT was only a partial prime for recognizing DISCOMFORT because COMFORT entails an access pathway through $|COMFORT|_{acc}$ and $|COMFORT|_{sf}$ but not through $|$+DIS=negative $|COMFORT|_{sf}|_{sf}$. SELECTIVE was only a partial prime for SELECT (Stanners, Neiser, Hernon, & Hall, 1979) because its subfile entry does not contain a referral to $|SELECT|_{sf}$, but is listed completely, as something like $|$+IVE=choosy$|_{sf}$(here, the arguable assumption

is that SELECTIVE is not entirely semantically compositional). LIFTING is a full prime for LIFT, but HUNG is only a partial prime for HANG, because the access pathway for HUNG bypasses $|HANG|_{acc}$ but does not bypass $|HANG|_{sf}$.

Stem frequency effects arise because the central list of accessible representations is in order of decreasing total frequency of the stem. For example, REPROACH was recognized more quickly than DISSUADE (Taft, 1979b) because PROACH is a higher frequency stem than SUADE. One consequence of ordering the access entries by stem frequency is that a low frequency word that looks like a high frequency bound stem (e.g., the word VENT looks like but is not the stem of PREVENT) will take longer to recognize than a control (e.g., COIN), and this result was reported by Taft and Forster (1975). By the model of lexical organization sketched above, surface frequency effects should be less striking than stem frequency effects, and there is some support for this claim, at least for nominals in -NESS, -ER, and -MENT (Bradley, 1979). Presumably, any surface frequency effects that do arise are attributable to an ordering within the subfile addressed by a specific access entry, but there would not seem to be enough entries within one subfile to cause a very healthy surface frequency effect. This view seems jarringly inadequate, since effects of surface frequency have been documented since the beginning of psychological studies of language. Most of this research did employ unaffixed forms, however, and the surface frequency of an unaffixed form may be correlated particularly closely with total stem frequency. Of course, if a derived word

is so unfamiliar as to be a neologism, then that word will take a longer time to decipher than a word that has been seen more often. The deciphering process would probably involve using the subcategorization frame of the affix and the syntactic category of the stem to access a generic representation or rule somewhere in the lexicon. For example, if the stimulus word were UNBLUE, it could be understood through activation of $|\text{BLUE}|_{acc}$ and $|\text{BLUE}|_{sf}$, where it will be stated that BLUE is an adjective. UNBLUE could then be understood with reference to a generic entry such as |+prefix UN=negative |adjective||.

Recognizing a stimulus word. With respect to lexical access of a stimulus word, the goal is to isolate the stem morpheme. The parser responsible for isolating the stem is armed with a list of prefixes and suffixes. Processing begins with the first letter of a stimulus word and proceeds from left to right. If a prefix is detected and identified, it is marked off, thus marking a new initial boundary for the stem. If the first letter sequence encountered following any prefix partitioning is orthotactically illegal as a morpheme-initial sequence, then the parser decides the word is unprefixed and reinstates the prefix, moving the stem marker back to the beginning of the word. The parser continues adding letters until it discovers a sequence that corresponds to a stem representation in the central list. Once a stem representation is activated, the parser unitizes any suffix it identifies, and checks the subfile under the stem access representation to see if the parsed stimulus word corresponds to

a legal entry there. If it does not, the parser considers larger and larger chunks until the correct stem has been activated. If no correct analysis has emerged by word-end, then prefix partitions are removed and the stem search restarts, this time from the initial letter of the word.

This view of lexical access predicts longer recognition time for pseudoprefixed words than prefixed words but roughly equal recognition times for suffixed words and pseudosuffixed words, since suffix partitioning occurs <u>after</u> a stem has been activated in the lexicon. Postlexical suffix stripping is supported by the finding that inflectional suffixes were associated with more errors in letter cancellation than orthographically identical pseudosuffixes (Drewnowski & Healy, 1980; Smith & Groat, 1979). The two lexical decision studies which have compared suffixed words and pseudosuffixed words did find that recognition times were not longer for pseudosuffixed words than for suffixed words (Henderson, Wallis, & Knight, 1984; Manelis & Tharp, 1977), although a pseudosuffixed word paired with a suffixed word required more time than either a pseudosuffixed word paired with a pseudosuffixed word or a suffixed word paired with a suffixed word (Manelis & Tharp, 1977). This latter finding suggests that context can play a role in reordering the steps in lexical retrieval. If a local context has been set up that favors one type of analysis over another, then that analysis may be tried first. In reading text, syntactic or semantic context could constrain lexical access. One prediction of such a view would be that if a pseudoprefixed word

were strongly predicted by its prior context, than it would not take longer to access than a prefixed word strongly predicted by prior context. If context is minimal or nonexistent, then lexical access proceeds through the steps outlined above.

The model of lexical access presented here makes the following predictions about recognition of words in isolation or in neutral context: (1) A pseudosuffixed word with an initial letter sequence that looks like a stem (a pseudostemmed pseudosuffixed word) such as SISTER (SIST is the stem of INSIST, CONSIST, and RESIST) will take longer to read than a suffixed word, because a wayward access attempt will be made on the basis of the pseudostem. (2) A prefixed word with an initial letter sequence that looks like a word (e.g., REDUCE, REAPPEAR) will take no longer to read than a prefixed word with an initial sequence that does not look like a word, because prefix partitioning will prevent attempted access via RED or REAP. However, an unprefixed word will suffer if it has an apparent word at its beginning. This result has been found with monomorphemic words (Taft, 1979a). (3) Access of an unprefixed word will be unaffected by any word-internal apparent word that does not include the first letter of the stimulus word, e.g., recognizing CLOVE does not entail activation of LOVE (Taft, 1979b corroborated this.) However, a prefixed word with a medial apparent word that starts with the first letter after the prefix (e.g., REPUTE) will be delayed in recognition.

Recognizing a word of high morphological complexity. Most of the prefixed words used in these experiments had a prefix+stem structure (e.g., REVIVE); the others were inflected forms of prefixed words (e.g., DEMOTED) or derived forms of prefixed words (e.g., INTRUDER). The model sketched above predicts that words with one prefix and no more than one suffix will require less time to access than correspondingly suffixed pseudoprefixed words, but it cannot explain lexical access of words more morphologically complex than this, such as DISRESPECT or DISRESPECTFUL or DISRESPECTFULNESS. One way to handle such words would be to claim that the stimulus-word parser partitions the first prefix and any second prefix, resulting in DIS/RE/SPECT. Such a view assumes that sufficient information or instructions to comprehend DISRESPECT is stored under SPECT, and makes the prediction that a prefixed word with an inner prefixed word will take less time to access than a prefixed word with an inner pseudoprefixed word (e.g., UNREAL). A modification to this view would be that the inner prefix (RE- in DISRESPECT) is only partitioned off if the stimulus word is long; otherwise, the stem parsing begins with the first letter of the apparent inner prefix. By this modified view, UNREAL would be accessed via UN/REAL, with no attempted access via UN/RE/AL, but UNREGISTERED might have an attempted access via UN/RE/GISTER/ED.

One potential problem with simply partitioning a complex word into its morphemes is that such partitioning does not indicate the nested structure of the word. Words are not linear concatenations of morphemes. Consider PREFIXATION (prefixedness) and PREFIXATION

(prior to fixation). They appear to be identical strings of morphemes, but they have entirely different meanings because the relations among their morphemes are different. Selkirk (1984) has provided a theoretical framework of word-formation in English that characterizes morphology as word-level syntax. Her view posits a system of word structure rules that assign a structural description (a labeled tree or a bracketing) to every word. An important feature of the rules is that they are binary, so that each node in the tree can dominate no more than two other nodes. Thus, DISRESPECT has the structure [DIS[[RE][SPECT]]], so that RESPECT is the stem of DISRESPECT and SPECT is the stem of RESPECT. The structure of PREFIXATION (prefixedness) is [[[PRE][FIX]]ATION], while the structure of PREFIXATION (prior to fixation) is [PRE[[[FIX][ATE]]ION]]. The characterizability of English morphology as word-level syntax raises the possibility that rules of word syntax are realized as processing operations in lexical production and/or lexical access, and that intermediate levels of word structure are represented in the lexicon. If this were the case, then prior presentation of a true constituent of a stimulus word (IMPORT before IMPORTABLE) will be more facilitory to lexical access of the stimulus word than prior presentation of a word part that is not a true constituent (PORTABLE before IMPORTABLE). Future work in this vein will help determine the role of morphological rules in lexical access.

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APPENDIX

SENTENCE PAIRS USED IN EXPERIMENT 1

Prefixed-target sentence
Pseudoprefixed-target sentence

1)
The student's reaction to his bad grade was to cry.
The student's religion is very important to him.

2)
He cannot improve the poor conditions at the hospital.
He cannot imagine why he isn't a famous movie star yet.

3)
The teacher procured a new supply of chalk and erasers.
The teacher prompted the tongue-tied student in the school play.

4)
Daniel is completely unable to chew gum and walk at the same time.
Daniel is completely unique in his ability to juggle seven things at once.

5)
The freshman's indecision about what courses to take bothered him.
The freshman's initiation into the fraternity was unpleasant.

6)
The teenager's abrupt answer made his parents angry.
The teenager's absurd answer made his parents angry.

7)
Her husband's mistrust of women made her life miserable.
Her husband's mistress lived in an apartment downtown.

8)
We knew that the descent down the mountain would be dangerous.
We knew that the dentist was always kind to his nervous patients.

9)
This particular pronoun makes the sentence hard to understand.
This particular prophet says that the end of the world is near.

10)
The child's dialect made it difficult for him to communicate with us.
The child's diapers were falling off as he crawled on the floor.

11)
The major <u>increase</u> in sales was due to lower prices.
The major <u>industry</u> in this area is the manufacturing of shoes.

12)
The company's <u>refund</u> offer expires next month.
The company's <u>rental</u> cars are the cheapest ones available.

13)
Carolyn's <u>beloved</u> cat was run over by a car yesterday.
Carolyn's <u>bearded</u> young friend is a guitar player.

14)
The tired <u>commuter</u> was sick of the heavy traffic.
The tired <u>comedian</u> was sick of show business.

15)
We should <u>untie</u> our shoes before removing them.
We should <u>unite</u> in our fight against racism.

16)
The mysterious <u>intruder</u> was never identified by the police.
The mysterious <u>intrigue</u> was understood only by the secret agents.

17)
The judge will <u>reappear</u> after the courtroom recess.
The judge will <u>regulate</u> the behavior of the jury.

18)
The group will <u>denounce</u> the recent actions taken by the administration.
The group will <u>decorate</u> the shopping mall for the Christmas season.

19)
He said that the <u>delay</u> was unavoidable, but no one really believed him.
He said that the <u>devil</u> had possessed his mind when he committed the murder.

20)
The student <u>admits</u> that he cheated on the geology exam.
The student <u>adores</u> her anthropology professor.

21)
They tried to <u>revive</u> the dying man, but they were too late.
They tried to <u>rescue</u> the dying man, but they were too late.

22)
The corporation <u>imported</u> gallons of oil from abroad.
The corporation <u>imitated</u> the products of its competitors.

23)
The little fish persists in trying to jump out of the tank.
The little fish perishes if he isn't given fresh food.

24)
The woman's injustice will be dealt with by the governing board.
The woman's intellect helped her get a job in a government agency.

25)
The most famous monarch is Queen Elizabeth of England.
The most famous monster is King Kong, the great ape.

26)
Her father predicts that the candidate will be elected.
Her father preaches at the church in town every week.

27)
Sally's demand for a raise was refused by her boss.
Sally's degree from Harvard impresses all her friends.

28)
We expected a rebirth of interest in the ancient art of astrology.
We expected a remnant of the falling meteor to land in our yard.

29)
He reported that the protest march was entirely non-violent.
He reported that the protein content of peanut butter is high.

30)
We didn't like the revival of the old broadway musical.
We didn't like the residue settling in the bottom of our coffee cups.

31)
The man will react with anger when he finds out that his car is missing.
The man will reign as the king of his country for the rest of his life.

32)
The great acclaim that the movie received made us want to see it.
The great actress made a spectacular entrance at the movie premiere.

33)
The wonderful embrace was still on her mind even after John left.
The wonderful emerald was a birthday present from her boyfriend.

34)
This little diagram explains the phases of the moon.
This little diamond is worth over ten thousand dollars.

35)
The boy didn't remind his mother to pick him up after school.
The boy didn't relish the thought of eating liver for dinner.

36)
They feel that the insane should not run around loose in society.
They feel that the infant can be brought home tomorrow.

SENTENCE PAIRS USED IN EXPERIMENT 2

Prefixed-target sentence
Pseudoprefixed-target sentence

1)
The student's reaction to his bad grade was to cry.
The student's religion is very important to him.

2)
The helpful teacher procured new supplies of chalk and erasers for the classroom.
The helpful teacher prompted the tongue-tied student in the school play.

3)
The teenager's abrupt answer made his parents angry.
The teenager's absurd answer made his parents angry.

4)
Her husband's mistrust of women made her life miserable.
Her husband's mistress is living in an apartment downtown.

5)
We knew that the descent down the mountain would be dangerous.
We knew that the dentist kept his patients waiting for hours.

6)
The major increase in sales was due to lower prices.
The major industry in this area is the making of shoes.

7)
Edward cannot improve the poor conditions at the hospital.
Edward cannot imagine why he isn't a famous movie star yet.

8)
Daniel is truly <u>unable</u> to chew gum and walk at the same time.
Daniel is truly <u>unique</u> in his ability to juggle six things at once.

9)
The young man's <u>indecision</u> about what courses to take bothered him.
The young man's <u>initiation</u> into the fraternity was very unpleasant.

10)
This particular <u>pronoun</u> makes the sentence hard to understand.
This particular <u>prophet</u> talks about the end of the world.

11)
The child's <u>dialect</u> made it difficult for us to understand him.
The child's <u>diapers</u> were falling off as he crawled on the floor.

12)
The company's new <u>refund</u> offer expires next month.
The company's new <u>rental</u> rates are extremely cheap.

13)
We feared that the <u>anarchy</u> in the city streets would spread to the suburbs.
We feared that the <u>antenna</u> on the roof would fall off in the violent storm.

14)
The queen's <u>beheading</u> brought tears to the eyes of the crowd.
The queen's <u>beckoning</u> glances soon caught the king's attention.

15)
The network president was <u>demoted</u> to a less important position.
The network president was <u>deluged</u> with mail about the new program.

16)
Joe thought that the <u>impurity</u> in the air was intolerable.
Joe thought that the <u>imbecile</u> on the platform should stop talking.

17)
The officials will <u>detain</u> the prisoner for further questioning.
The officials will <u>deepen</u> the reservoir to provide more water.

18)
Most parents <u>discourage</u> their children from smoking cigarettes.
Most parents <u>discipline</u> their children when they misbehave.

19)
Sarah really wanted to enjoy the party tonight.
Sarah really wanted to enter the beauty pageant.

20)
The man on the stage was devoid of any real acting ability.
The man on the stage was devout in his religious beliefs.

21)
The bored, tired commuter was sick of the heavy traffic.
The bored, tired comedian was sick of show business.

22)
Everyone should untie their shoes before removing them.
Everyone should unite in the fight against racism.

23)
The mysterious intruder was never identified by the secret agents.
The mysterious intrigue was understood only by the secret agents.

24)
The group will denounce the recent actions taken by the administration.
The group will decorate the shopping mall for the Christmas season.

25)
They tried to revive the dying man, but they were too late.
They tried to rescue the dying man, but they were too late.

26)
The corporation has imported many gallons of oil from abroad.
The corporation has imitated many products of its competitors.

27)
My sister's beloved kitten was run over by a car yesterday.
My sister's bearded friend is a guitar player in New York.

28)
He said that the delay was unavoidable, but no one really believed him.
He said that the devil had possessed his mind when he committed the murder.

29)
The judge will reappear soon after the courtroom recess.
The judge will regulate the behavior of the entire jury.

30)
The student admits that he cheated on the math exam.
The student adores that handsome geology professor.

31)
The little fish <u>persists</u> in trying to jump out of the tank.
The little fish <u>perishes</u> if he is not given fresh food.

32)
The woman's <u>injustice</u> will be dealt with by the governing board.
The woman's <u>intellect</u> will help her get very high test scores.

33)
Margaret would often <u>pronounce</u> words incorrectly.
Margaret would often <u>promenade</u> around town in her Volvo.

34)
He received <u>unwelcome</u> letters in the mail yesterday.
He received <u>unanimous</u> support from the committee.

35)
A good bartender should <u>encourage</u> his customers to remain sober.
A good bartender should <u>entertain</u> his customers with witty stories.

36)
He knows that the <u>account</u> has to be paid by tomorrow.
He knows that the <u>academy</u> has a very fine reputation.

37)
The gym teacher <u>assembled</u> his pupils for a basketball game.
The gym teacher <u>astounded</u> his students with his athletic ability.

38)
We learned that the <u>renewal</u> of library books could be done by mail.
We learned that the <u>realtor</u> who sold our house was actually a crook.

39)
This small computer <u>contains</u> every bit of information that we need.
This small computer <u>controls</u> every aspect of the experiment.

40)
The reporter obtained <u>indirect</u> evidence about Brooke Shield's love life.
The reporter obtained <u>intimate</u> details about Brooke Shield's love life.

41)
Her father <u>predicts</u> that the candidate will be elected.
Her father <u>preaches</u> at the church in town every week.

42)
We expected a <u>rebirth</u> of interest in the ancient art of astronomy.
We expected a <u>remnant</u> of the falling meteor to land in our yard.

43)
He reported that the protest march was entirely non-violent.
He reported that the protein content of peanut butter is high.

44)
The great acclaim that the movie received made us want to see it.
The great actress made a spectacular entrance at the movie premiere.

45)
This little diagram is an explanation of the phases of the moon.
This little diamond is worth more than ten thousand dollars.

46)
The boy didn't remind his mother to pick him up after school.
The boy didn't relish the thought of eating liver for dinner.

47)
Unfortunately, Sally's demand for a raise was refused by her unappreciative boss.
Unfortunately, Sally's degree from Harvard did not guarantee a good job offer.

48)
He didn't like the revival of the old broadway musical at the theater.
He didn't like the residue of mud that settled to the bottom of the river.

49)
The man will react with anger when he finds out that his car is missing.
The man will reign as the king of his country for the rest of his life.

50)
The wonderful embrace was still on her mind even after John left.
The wonderful emerald was a birthday present from her boyfriend.

51)
They feel that the insane should not run around loose in society.
They feel that the infant should be brought home in a few more days.

52)
The most famous monarch is Queen Elizabeth of England.
The most famous monster is King Kong, the great ape.

53)
Charlotte should restrict her comments to the facts.
Charlotte should register her car in Northampton.

54)
This amazing innovation will revolutionize the science of biology.
This amazing instrument will revolutionize surgery in the future.

55)
The arrogant tycoon bestowed his entire fortune on his favorite son.
The arrogant tycoon bellowed his orders to the frightened servants.

56)
Erica can detach the front wheel from her bicycle.
Erica can devour the entire batch of cookies at once.

57)
Our boys were nearly defeated by the visiting team.
Our boys were nearly deafened by the shouts of the crowd.

58)
The huge discount on winter clothes was successful in attracting buyers.
The huge distance between the stars makes interstellar travel difficult.

59)
The family noticed many conflicts between the dog and the cat.
The family noticed many contrasts between the two children.

60)
We studied the abuse of children in our state.
We studied the abbey where nuns lived long ago.