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The syllable in visual word recognition.

Item Type	thesis
Authors	Lima, Susan D.
DOI	10.7275/ww1g-yn04
Download date	2025-05-09 08:29:30
Link to Item	https://hdl.handle.net/20.500.14394/45220

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THE SYLLABLE IN VISUAL WORD RECOGNITION

A Thesis Presented

By

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Submitted to the Graduate School of the
University of Massachusetts in partial fulfillment
of the requirements for the degree of

MASTER OF SCIENCE

September 1981

Psychology

THE SYLLABLE IN VISUAL WORD RECOGNITION

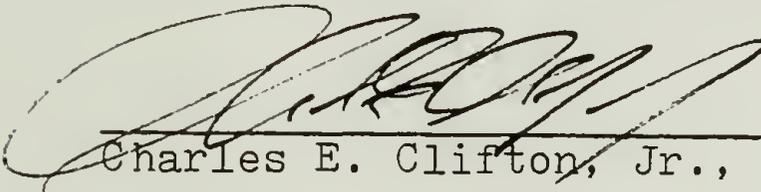
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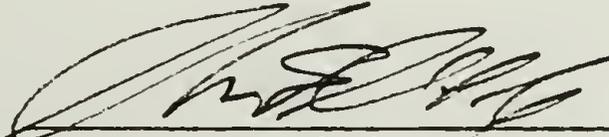
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ACKNOWLEDGEMENTS

I wish to express my thanks to the members of my committee, Charles Clifton, Lyn Frazier, and Arnold Well, for their support, advice, and valuable comments.

I wish to extend very special thanks to the amazing chairman of my committee, Alexander Pollatsek. Were it not for Sandy's technical expertise, wise counsel, and unceasing encouragement, it is extremely doubtful that this research would have ever been begun.

ABSTRACT

In a recent article, Taft (1979b) argued that lexical access for visually presented words is based on an initial syllabic unit called the Basic Orthographic Syllable Structure, or BOSS, defined as that part of a word's first root morpheme that contains the first vowel and all orthographically permissible following consonants. The BOSS theory of lexical access rests on the two assumptions that (1) morphologically related words are accessed through an identical entry they share in the internal lexicon and (2) that words are accessed on the basis of an initial syllabic unit. Taft argued that lexical access based on a phonologically defined syllable such as the Vocalic Center Group, or VCG, would often result in morphologically related words being accessed through different lexical entries. The BOSS, in contrast to the VCG, preserves these morphological relationships by assigning a common BOSS to all affixed forms of a root. Thus, although FAS is the VCG of FASTER, both FASTER and FAST have FAST as their BOSS.

Taft's first two lexical decision experiments employed letter strings split into two subunits either by means of a space or a case change. Taft found that words split at their BOSS boundary (e.g., BURD EN) were classified as words more quickly than words split at their VCG boundary (e.g.,

BUR DEN). Taft concluded that the reduced disruption in the BOSS condition was due to the fact that BOSSs are stored in the lexicon while VCGs are not. Taft also presented evidence for a left-to-right parsing process.

The two experiments reported here failed to replicate the crucial finding of an advantage of the BOSS over the VCG. In Experiment 1, letter strings were divided by a space at the BOSS, at the VCG, or one letter past the BOSS. BOSS-divided words and VCG-divided words were classified equally quickly in lexical decision, although both were classified more quickly than BOSS+1-divided words. Thus, Taft's BOSS superiority effect was not replicated, but it does seem that syllabic units like the BOSS and the VCG are more likely to have lexical representations than nonsyllabic units.

In Experiment 2, it was found that preview of a word's BOSS did not lead to significantly quicker lexical decision than preview of the initial VCG. However, both types of primes were more effective than primes from the endings of words. Thus, the importance of initial segments in lexical access was indicated, a result consistent with Taft's left-to-right parsing process. There was, however, no evidence for Taft's claim that the BOSS is a word's unique entry in the lexicon.

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C H A P T E R I

INTRODUCTION

It seems reasonable to believe that the recognition of words is an important component of reading. It would seem, then, that studying the processing of individually presented letter strings could tell us something about how people read. Although we cannot generalize all word recognition findings to the reading of prose passages, it seems unlikely, at least on logical grounds, that the processes underlying word recognition are irrelevant to reading, because our experience with visually presented words is gathered through our experience with reading.

How is a visually presented word encoded so that its match may be found in the internal lexicon, and what units are entailed in this encoding process? One possibility is phonological encoding, by which a visually presented word is converted into a phonological representation via rules of spelling-to-sound correspondence, such as grapheme-phoneme correspondence rules. The resulting phonological representation is then used to achieve lexical access in a phonologically based internal lexicon. The phonological encoding hypothesis has intuitive appeal for a number of reasons.

✓ Speech precedes reading developmentally, and therefore it must be true that words are phonologically represented in

the lexicon. The alphabetic orthography of English, in contrast with ideographic writing, enables a reader to "sound out" a word he has never seen before, even though he is unaware of the meaning of the new word. This suggests the possibility that pre-lexical phonological encoding could be a necessary step to achieving lexical access in reading. The precise role of phonological encoding has been an issue of interest for many years (e.g., Huey, 1908; Gough, 1972; Meyer, Schvaneveldt, & Ruddy, 1974; Rubenstein, Lewis, & Rubenstein, 1971) and is generally considered an unresolved question.

Another candidate for the primary encoding process involved in visual word recognition is morphological encoding, which involves partitioning the presented word into its component morphemes prior to lexical access (e.g., Murrell & Morton, 1974; Taft & Forster, 1975). A morpheme is generally defined as the minimal unit of language that recurs with constant meaning. Polymorphemic words may be formed by attaching affixes to a basic morpheme, usually referred to as the root; an affix that precedes the root is a prefix, and an affix that follows the root is a suffix. There is generally a distinction made between inflectional and derivational suffixes. Inflectional suffixes mark number, case, tense, and certain other characteristics. Three common inflectional suffixes in English are -S, -ED, and -ING. Inflectional suffixes never alter the grammatical class of the morphemes

to which they are attached: CAT and CATS are both nouns, and WALK and WALKED are both verbs. Derivational suffixes (e.g., -LY, -NESS, and -MENT), in contrast, can change the grammatical class of the root to which they are attached. For example, adding -LY to the adjective QUICK results in the adverb QUICKLY.

Taft and Forster's (1975) morphological encoding hypothesis proposes that morphemes are represented in the internal lexicon, and that words morphologically related to each other are accessed through the same representation in the lexicon. The notion that the mental lexicon subsumes representations of related affixed forms under a representation of the root morpheme is appealing for several reasons. First, such a model makes explicit use of the rule-governed nature of the relationships among affixed forms of the same base morpheme. Second, morphological encoding seems particularly appropriate for the recognition of written English words when one considers the depth of English orthography. In English spelling, the rules of grapheme-phoneme correspondence are far from simple; Venezky (1970) notes, for example, that the five vowels have a total of 48 possible phonemic assignments. Our orthography is deep in that it represents the morpho-phonological level of the language rather than the level of surface phonology (Bradley, 1919; Chomsky & Halle, 1970). Chomsky and Halle proposed that English spelling corresponds more closely to an underlying, abstract level of lexical

representation than it does to the actual pronunciation of words. Any phonetic variation predictable from rules, such as the vowel alternation occurring in NATION, NATIONAL, is not generally indicated in the orthography. It has been argued that such a spelling system permits the reader to exploit graphemically invariant representations of morphemes, allowing direct access to morphemic representations in a visually based lexicon (e.g., C. Chomsky, 1970; Katz & Feldman, 1979). (It should be noted, however, that MacKay, 1976, 1978, Fay and Cutler, 1977, and others have presented evidence for the use of derivationally organized lexical information in speech production tasks.) A third advantage of morphological encoding is that it provides an economy of storage, since many words are stored under one lexical entry, but this of course is likely to be accompanied by an increase in processing complexity. It is possible, however, that a process such as prefix removal could result in faster access of prefixed words than a system that stores prefixed words as wholes. Knuth (1973), for instance, noted that prefix removal would allow one to avoid listing an inordinately large number of words all beginning with the same sequence of letters: REJUVENATE could be located more quickly on the basis of JUVENATE rather than through a search of the many words beginning with the prefix RE-, such as RENEW, REPLY, RENOVATE, etc.

A word could conceivably be analyzed into a number of

different types of units in the process of word recognition, and many units have been proposed as the principal ones used in lexical access, such as spelling patterns (e.g., Gibson, Pick, Osser, & Hammond, 1962), syllables (e.g., Spoehr & Smith, 1973, 1975), and entire words (e.g., Johnson, 1975). The unit of interest in the present study is the syllable. Syllables have traditionally been defined in terms of phonology. They have been associated with physiologically observable, rhythmic breath groups in speech (Hockett, 1958), and with groups of phonemes consisting of a vowel nucleus and its preceding and following consonants (Langacker, 1972). Hansen and Rodgers (1968), expressing dissatisfaction with nebulous criteria for determining syllabic divisions between adjacent consonants, introduced the Vocalic Center Group (VCG), which was based on work in artificial speech production done by Liberman, Ingemann, Lisker, Delattre, and Cooper (1959). The work by Liberman et al. suggested that the syllable as defined by VCG rules could be characterized as the smallest unit of articulation within which all necessary rules of phonemic co-occurrence (phonotactic rules) could be fully specified. A VCG contains one vocalic element and may be preceded and/or followed by one or more consonants or semi-consonants. Spoehr and Smith (1973, 1975) adopted the syllabic parsing rules developed by Hansen and Rodgers (1968) and proposed a phonologically mediated model of word recognition based on these rules. The parsing process divides

medial consonants according to the following rules: VCV becomes V+CV, VCCV becomes VC+CV, and VCCCV becomes VC+CCV. For example, the VCCV type word, GARDEN, is syllabified as GAR+DEN. Spoehr and Smith (1973) provided empirical support for the involvement of VCGs in visual word recognition, including an effect of number of VCGs: tachistoscopically presented words containing two VCGs were identified less accurately in a recognition task than words of the same length containing only one VCG. Spoehr and Smith (1973) also found in a whole report task that accuracy in reporting two successive letters in a word was best when both letters were part of the same VCG.

What is the nature of the orthographic syllable in English? Hansen and Rodgers (1968) wrote of the orthographic syllable, "Contradictions between phonological, morphological, and historical criteria used in determining lexigraphic syllabification have been bitterly bewailed by the very lexicographers who perpetuate the system. The unfortunate syllable has fallen heir to the calumny and confusion of its definitions." (p. 75). Hansen and Rodgers proposed their VCG parsing rules in order to provide a strictly phonological basis for the orthographic syllabic unit. In contrast, Taft (1979b) proposed an orthographic syllable based solely on orthographic and morphological considerations, requiring no necessary correspondence with the pronunciation of the word. Taft hypothesized that

the syllabic unit operating in visual word recognition is not the VCG but the BOSS (Basic Orthographic Syllable Structure), defined by the principle, "Include in the first syllable as many consonants following the first vowel of the word as orthotactic factors will allow without disrupting the morphological structure of that word." (p. 24). The BOSS of GARDEN, for example, is not GAR but GARD. Taft devised the BOSS principle to encompass experimental evidence leading to two important conclusions: first, that morphologically related words are accessed through a common representation of their root morpheme (the morphological encoding hypothesis of lexical access), and second, that words are accessed on the basis of a representation of their first syllable. These two considerations led Taft and Forster (1976) and Taft (1979b) to argue that lexical access could not be based on the first VCG of a word, because this would result in some morphologically related words being accessed through different entries in the lexicon. FASTER, for instance, has the VCG syllabification FAS+TER, and access would be erroneously carried out on the basis of FAS rather than on the basis of the root morpheme FAST. On the other hand, the BOSS of FASTER is FAST, allowing the word FAST and its affixed form FASTER to both be accessed through a representation of the root FAST.

The sections to follow will first discuss evidence for morphological encoding in the recognition of visually presented words, and then will consider evidence questioning the

use of morphological encoding. The final sections will present experimental evidence for lexical access based on an initial syllable and will consider the case for the BOSS principle.

Empirical Evidence for Morphological Encoding

A brief discussion of Forster's (1976) two-stage model of lexical access will provide a useful framework for discussing the predictions made by Taft and Forster (1975, 1976) and Taft (1979a, 1979b, 1981). In Forster's model, the lexicon consists of a number of storage files containing representations called lexical entries. The master file contains all of the individual's lexical information, but it cannot be consulted directly; it can only be contacted via an ordered search of one of several peripheral access files, semantic, phonological, or orthographic. The semantic access file is used in speaking and writing, while the phonological file operates in listening. In the case of reading, the orthographic access file is used. Each lexical entry in an access file indicates the address of corresponding information in the master file. The access files are analogous to the card catalog in a library, providing the location of the needed information in the library of words represented in the master file of the lexicon. Entries in an access file are arranged in order of decreasing frequency of occurrence, so that a lexical search will encounter high frequency words before it

encounters low frequency words. Forster's model thus predicts the well-known effect of frequency on word recognition, i.e., the finding that high frequency words are generally more quickly and more accurately processed than low frequency words (e.g., Howes & Solomon, 1951; Forster & Chambers, 1973; Whaley, 1978). Other theories of lexical access, such as Morton's (1969) Logogen model, predict the frequency effect without assuming serial search. Because Forster's basic model was the one modified by Taft and Forster (1975, 1976) and Taft (1979a, 1979b, 1981) to handle their findings on morphemic and BOSS analysis in lexical access, it will be adopted here as a framework for discussion.

Taft and Forster's (1975) morphological decomposition hypothesis states that the root morphemes of words form the access entries in the orthographic access file of the mental lexicon. If the stimulus word is prefixed, the prefix is stripped off so that a search can be made for the root. A word's root, whether it is a free morpheme, i.e., one that is itself a word, or a bound morpheme, i.e., one that must occur in conjunction with another morpheme, is represented in the access file, its purpose being to provide the address of complete information about its various affixed forms in the master file. Access through roots preserves morphological relationships. Both PERSUADE and DISSUADE, for example, would be accessed through SUADE; SUADE therefore has lexical status even though it is a bound morpheme.

Taft and Forster (1975) predicted that a number of "interference effects" should be observed if morphological decomposition actually occurs in word recognition. They reported that lexical decision reaction time was greater for nonwords which were roots of prefixed words (e.g., VIVE, from REVIVE) than for nonwords which were parts of, but not roots of, words (e.g., LISH, from RELISH). This interference effect was explained in terms of lexical access. VIVE accesses a real word, and the occurrence of this access causes a delay in deciding that VIVE by itself is not a word. This nonword decision requires contact with the master file, which would indicate that VIVE is not a free morpheme. In another experiment, nonwords combining a prefix and a root (e.g., DEJUVENATE) took more time to classify as nonwords than did those combining a prefix and a non-root word fragment (e.g., DEPERTOIRE). This result suggested that a prefix is stripped off so that a lexical search can be made for the root, because the root JUVENATE seems to influence decision time for the prefixed nonword DEJUVENATE.

Several earlier studies reported results compatible with the idea of morphological partitioning of suffixed as well as prefixed words. Gibson and Guinet (1971) used a free report task and found that inflectional suffixes (e.g., -ING) were somewhat more accurately reported than noninflectional endings (e.g., -INT), suggesting the possibility that inflectional endings have representations in

the lexicon. Snodgrass and Jarvella (1972) studied letter strings under three affixation conditions (suffixed, prefixed, and unaffixed) and found that affixation increased lexical decision times for words and unpronounceable nonwords, but not for pronounceable nonwords. For example, PRESCHOOL took longer to accept than SCHOOL, and PREBDKUT took longer to reject than BDKUT, but PRESTUL took the same amount of time as STUL. Although the pronounceable nonword result may cause a problem for Taft and Forster's hypothesis, the other results suggest that affixation affects word recognition. Murrell and Morton (1974) pretrained subjects prior to a tachistoscopic report task; some training words were identical to test words, some were suffixed variations, and others were semantically unrelated words beginning with the same letter sequence as the test word. One test word was BORING, and its training words were BORING, BORED, and BORN. Recognition was best when subjects had previously memorized an identical word, but recognition after training on a morphologically related word was superior to recognition after training on a word that was similar only in initial letter sequence. Murrell and Morton concluded that the unit of facilitation was the morpheme rather than a pattern of letters.

Two recent studies (Taft, 1979a; Bradley, 1979) used two alternative methods of assessing word frequency to test the idea that morphologically related words are accessed

through a common entry in the lexicon. Many years earlier, Rosenberg, Coyle, and Porter (1966) studied recall of adverbs equated for word frequency and found that adverbs derived from high frequency adjectives were recalled better than those derived from low frequency adjectives, suggesting that the adverbs may have been accessed through representations of their adjectival roots. In Taft's (1979a) first two experiments, it was found that the total frequency of a root, equal to the sum of the frequencies of all the words which contain it as their root morpheme, influenced lexical decision time for a relatively low-frequency word containing that root. DISSUADE, for example, was classified more slowly than REPROACH; DISSUADE and REPROACH have similar surface frequencies, but SUADE is a less frequent root than PROACH, because the total frequency of PROACH is greater than that of SUADE. This effect of the total frequency of the root morpheme held for inflectionally suffixed as well as for prefixed words. The implication of these findings is that words are represented by their roots in the lexicon; otherwise, it would be difficult to explain how the total frequency of a root could exert an effect on lexical access for a word containing that root. Another experiment, however, revealed that the surface frequency of a stimulus word influenced lexical decision time when total frequency was held constant. For example, THINGS was accepted more quickly than WORLDS; THINGS is a more frequent word than

WORLDS, but THING and WORLD have equal total frequencies. To account for the observed effects of both total frequency and surface frequency, Taft proposed a dual locus of frequency effects. The search for lexical access is made in the access file on the basis of the root, and is therefore influenced by total root frequency. Contact with the information in the master file is affected by the surface frequency of the stimulus word, because every word in some way must be represented in the master file. Information about THINKS may be encountered before information about RETHINK in the master file, even though both THINKS and RETHINK are represented by THINK in the access file.

Bradley's (1979) study is similar to Taft's (1979a), except that Bradley employed four types of derivationally suffixed words, one type in each of four experiments, while Taft used various types of prefixed words in one experiment and various inflectional forms in the other. Bradley reported that for nominalizations ending in -NESS (e.g., SHARPNESS) or -MENT (e.g., ATTACHMENT), and for familiar agentives ending in -ER (e.g., TEACHER), words high in total root frequency were classified more quickly than words with low total root frequency when surface frequency was held constant. This suggests that derived words share lexical representations with their roots, and agrees with the results of Taft's first two experiments. However, unlike Taft, Bradley found no reliable effect of varying surface frequency while

holding total root frequency constant, and, surprisingly, found no effect of either total root frequency or surface frequency for nominalizations ending in -ION (e.g., DEDICATION), the latter result supporting neither access through roots nor access based on the entire word. With the exception of the -ION result, Bradley's findings suggest that derivationally suffixed words are accessed via representations of their root morphemes.

Studies Questioning Morphological Encoding

Stanners, Neiser, Hernon, and Hall (1979) and Stanners, Neiser, and Painton (1979) used priming and lexical decision to study whether words related by affixation are stored together or separately in the lexicon. Repetition priming of a target word (e.g., SELECT as a prime for SELECT) was superior to priming with a derivative form (e.g., SELECTIVE), but derivative forms did produce partial priming relative to the no-prime control condition. Similarly, repetition priming of a prefixed word was superior to the partial priming produced by the prefix and root separately. The effect of priming by prefixed words (e.g., UNAWARE) on their roots (e.g., AWARE) and of inflected forms (e.g., LIFTING) on their roots (e.g., LIFT) was not significantly different than repetition priming, although the trend of the data favored repetition priming. The pattern of results suggests that all suffixes may not be created equal; the inflections may be

more regular, more frequent, and more rule-governed than derivational forms, and therefore more likely to be stored with representations of root morphemes.

The general tendency for repetition priming to be more effective than the partial priming produced by related words (Murrell and Morton's, 1974, results were similar) may be explained by the master file, access file distinction. The partial priming of a target produced by a morphologically related word might be due to activation of an entry they both share in the access file. The full repetition priming effect would then be the sum of activation in the access file plus additional activation of the word's individual information in the master file. If this explanation were adopted, it would not be necessary to postulate, as Stanners and his associates did, that words are accessed both through representations of their roots and on the basis of their surface forms.

Manelis and Tharp (1977) claimed that their findings favored a single unit hypothesis, which in contrast to morphological encoding states that a suffixed word is stored as a separate access entry rather than under a representation of the root. Subjects saw two letter strings at a time and responded "yes" when both were words, "no" when one was a word and one was a nonword. Suffixed words and pseudo-suffixed words, or words whose endings looked like morphological suffixes but did not function as such, were used. Under

morphological encoding, pseudosuffixed words (e.g., SISTER) presumably take longer to process than genuinely suffixed words (e.g., SENDER) because a pseudosuffixed word is erroneously treated as if it were a genuinely suffixed word. It is first partitioned into its "suffix" and "root", and an unsuccessful search made on that basis, before the correct whole-word lexical entry can be accessed. The results showed that "same" pairs, in which both words were suffixed or both were pseudosuffixed, were classified more quickly than "mixed" pairs, in which one word was suffixed and one was pseudosuffixed. There was no significant difference between the two "same" conditions. For instance, DARKER FATTER and SISTER SOMBER were classified equally quickly, but SISTER SENDER took more time to classify. The authors concluded that because two pseudosuffixed words did not take longer to classify than two suffixed words, the single unit hypothesis was supported. The superiority of "same" pairs over "mixed" pairs, however, seems unlikely unless subjects processed pseudosuffixed words differently than suffixed words. Although Manelis and Tharp felt that this effect was simply due to semantic relatedness (similarly affixed words are semantically related), the result is consistent with morphological decomposition. In addition, "word fragment" nonwords (e.g., GARMER) and "word" nonwords (e.g., DESKER) took more time to classify as nonwords than did control nonwords (e.g., LOSKER). Since most of the word fragment nonwords actually

began with what Taft (1979b) later defined as BOSSs of English words, the nonword result is consistent with Taft's hypothesis. In Manelis and Tharp's second experiment, subjects first saw a base word (e.g., SNOW) and then a suffixed word or nonword (e.g., SNOWED or SNOWEN) and decided if the base word was contained in it. Reaction time to nonwords was greater than reaction time to words, and this was taken as a refutation of morphological decomposition, which would predict equal times for SNOWED and SNOWEN. Taft (1979a) replied that such equality would not be expected if the word suffixes were different in type than the nonword suffixes, and this was the case with Manelis and Tharp's stimuli, since most word targets ended in common inflectional suffixes while most nonwords did not. Also, basing a conclusion on a word-nonword comparison is generally problematic given the tendency for nonwords to be processed more slowly and less accurately than words.

Manelis and Tharp (1977) also questioned Taft and Forster's (1975) method of matching stimuli for frequency. Taft and Forster had assigned each root or non-root word fragment the surface frequency of one word which contained it, not the sum of the frequencies of all the words containing it (the total frequency). Manelis and Tharp found that the average total frequencies of Taft and Forster's root morphemes were much higher than those of non-roots, and it is therefore possible that high frequency word parts

are represented in the lexicon regardless of their morphological status. As noted previously, Taft (1979a) and Bradley (1979) both found effects of total root frequency on lexical decision time, supporting the idea that root morphemes are stored in the lexicon. However, the question of the possible lexical representation of very frequent but non-morphemic word parts has not been addressed in any experimental work.

Rubin, Becker, and Freeman (1979) argued against the necessity of a step of morphological decomposition in lexical access. They argued that Taft and Forster's effects were due to context-dependent strategies that subjects employed in order to cope with the predominantly prefixed stimuli they were faced with. Rubin et al. compared lexical decision times for prefixed and pseudoprefixed words when all nonwords were prefixed with decision time for these words in the context of unprefixed nonwords. Lexical decision generally took longer in the prefixed context. In this context, pseudoprefixed words took longer to classify than prefixed words, but the effect did not reach significance in the un-prefixed context. This context dependency was offered as a refutation of morphological encoding as the usual or necessary road to lexical access, because one does not encounter predominantly prefixed words in everyday reading.

Taft (1981) replied that Rubin, Becker, and Freeman (1979) very likely produced a strategy effect in their own

subjects' performance in the unprefixing context condition. In this condition, because any item that began with a genuine or apparent prefix was a word, while any item that did not have this type of beginning letter sequence was a nonword, it is possible that subjects could have performed the word-nonword decision task not on the basis of attempts at full lexical access but on the basis of the presence or absence of a letter sequence that formed a prefix, apparent or genuine, at the beginning of the letter string. Taft (1981) supported the earlier Taft and Forster (1975) lexical decision results with experiments using word naming latency, eliminating the need for any nonword stimuli. Taft reported that pseudoprefixed words (e.g., ENAMEL) had greater naming latencies than unprefixing words (e.g., MOUSTACHE) even when no genuinely prefixed words were included in the experiment. Taft concluded that the pseudoprefixed words were mistakenly decomposed, despite the lack of prefixed context, refuting the claim by Rubin, Becker, and Freeman that prefix stripping is a special strategy dependent on a preponderance of prefixed stimuli in the set of experimental items.

It should be noted that context-dependent strategies of some type could have been operating in several of the experiments which have been reported so far. Bradley (1979), for example, never used more than one derivational suffix in an experiment. Her first experiment involved a total of 180 letter strings, 90 of which ended in -NESS, and obviously

half the words one encounters in normal reading do not end in -NESS. Manelis and Tharp's (1977) finding of a superiority of "same" pairs over "mixed" pairs could be described as the result of a local context effect set up by the processing of the first member of the pair: a pseudosuffixed word facilitates processing of the following word if it is also pseudosuffixed, but does not facilitate the processing of a genuinely suffixed word. This local context effect contrasts with the Taft (1981) result reported above, in which pseudoprefixed words were named more slowly than unprefixed control words despite a total lack of genuinely prefixed context. A double lexical decision task like that of Manelis and Tharp (1977), using prefixed and pseudoprefixed words rather than suffixed and pseudosuffixed words, has not yet been reported. Prefixes and suffixes may well be treated differently in word recognition even if it is true that both prefixed and suffixed words are stored under their roots in the lexicon. In particular, if word recognition proceeds from left to right (as Taft, 1979b, proposes), then prefix stripping seems crucial to the process of obtaining the root morpheme, while initial suffix stripping may not be crucial because suffixes are to the right of, not to the left of, the root. In other words, the root morpheme may be extracted from the word before the suffix is recognized.

Evidence for Lexical Access Based on the Initial Syllable

Taft and Forster (1976) proposed that the recognition of a compound word is based on a lexical search for its first constituent morpheme. Lexical decision took longer for compound nonwords which began with words than for those which began with nonwords, regardless of the lexical status of the second constituent: DUSTWORTH and FOOTMILGE took more time to reject as nonwords than MOWDFLISK and TROWBREAK, but DUSTWORTH and FOOTMILGE took the same amount of time, and MOWDFLISK and TROWBREAK took the same amount of time. Frequency of the first constituent affected lexical decision time for compound words, even though all compound words were matched on surface frequency of the entire compound word and on surface frequency of the second constituent word. For example, HEADSTAND was accepted as a word more quickly than LOINCLOTH, and this was apparently due to the fact that HEAD is a higher frequency word than LOIN. The remaining experiments suggested that even in the case of non-compound polysyllabic words, access is achieved on the basis of the word's initial syllable. A nonword which is the first syllable of a word (e.g., PLAT) took longer to classify as a nonword than did a control nonword (e.g., PREN). In addition, a word forming the first syllable of a morphologically unrelated word of higher frequency (e.g., NEIGH, the first syllable of NEIGHBOR) took more time to accept as a word than did a

control word of similar frequency (e.g., SHREW). The nonword CULE, however, did not take longer to reject than SUNE, even though CULE is the last syllable of an actual word, MOLECULE. Similarly, LEDGE, the last syllable of a word higher in frequency than itself, KNOWLEDGE, took no longer to accept than the control word PROBE. The finding that a nonword's status as the first syllable of an actual word interfered with lexical decision for that nonword led Taft and Forster (1976) to conclude that the lexical entry for an unprefixed polysyllabic word, whether or not it is a compound word, must be the word's first syllable. The finding that a one-syllable word's status as the first syllable of a higher frequency polysyllabic word slowed lexical decision for that one-syllable word was also taken as evidence for the initial syllable hypothesis. Forster's (1976) serial search model of lexical access specifies that higher frequency words are accessed before lower frequency words. If polysyllabic words are accessed on the basis of their initial syllable, then an interference effect will occur whenever the stimulus word forms the first syllable of a word higher in frequency than itself. The finding that a word or nonword's status as the ending syllable of a word had no effect on lexical decision suggested that only initial syllables of words are involved in lexical access.

Taft and Forster's (1976) results imply a reformulation of the morphological decomposition hypothesis of lexical

access for prefixed words. (No prefixed stimuli were, however, tested by Taft and Forster, 1976). It would seem that in order to recognize a prefixed word with a polysyllabic root morpheme, the word would first be stripped of its prefix, and then a lexical search would be undertaken on the basis of the first syllable of the root, not the entire root. DISCOVER, for example, would be accessed not through COVER but through COV.

The method of measuring word frequency in Taft and Forster (1976) is subject to criticism. Surface frequencies were used throughout, even when total root frequency would have been preferable, because this latter measure presumably determines the relative position of an entry in the access file of the lexicon. For example, in the compound word experiment, constituent morphemes (e.g., HEAD and STAND of HEADSTAND) should have been assigned their total root frequency values rather than their surface frequencies. It is almost certain, however, that the two measures of frequency are positively correlated; in fact, it takes a great amount of effort to gather stimulus words in an experiment that attempts to separate the two measures (Bradley, 1979).

The Case for the BOSS

Having obtained some evidence that the initial syllable of a word is importantly involved in lexical access, as well as evidence that morphologically related words are accessed

on the basis of the root morpheme they share, Taft and Forster (1976) and Taft (1979b) proposed that the syllable involved in lexical access in reading is not phonologically based, but orthographically and morphologically based. Taft (1979b) proposed the BOSS principle, which states that a word's BOSS (Basic Orthographic Syllable Structure) is that part of its first root morpheme that includes after the first vowel all consonants not violating rules of orthographic co-occurrence. A syllabic unit defined in this way results in morphologically related words (e.g., FAST and FASTER) being accessed through the same representation. In contrast, a phonologically based syllable such as the VCG (Vocalic Center Group) would yield FAS as the initial syllable of FASTER, and FASTER would therefore not be accessed through the same entry as its root word FAST. The BOSS principle also preserves morphological relationship in case a purely orthographic syllable would obscure it. Thus, NEARBY has as its BOSS, NEAR, not NEARB, so that NEAR and NEARBY are accessed through the same lexical entry. It is important to note that Taft (1979b) provides no empirical tests of this latter aspect of the BOSS definition; the experiments used monomorphemic words and therefore virtually all BOSSs were defined purely on orthotactic grounds.

Taft's experiments supported the BOSS as the unit of lexical access of unprefixated words and suggested that a left-to-right parsing process is used to obtain the BOSS of a

stimulus word. The first two experiments used either a space or a case transition to split stimuli into two sub-units. If the stimulus division coincided with the format of the lexical entry in the access file, Taft reasoned, then lexical decision for that divided stimulus word should be faster than lexical decision for a word split at some other point. In Experiment 1, some stimuli were divided by a space immediately after the BOSS (e.g., LANT ERN), some were divided after the initial VCG (e.g., LAN TERN), and others one letter past their BOSS (e.g., BOYC OTT). The VCG division caused significantly greater decision times for word items than did the BOSS division, and the BOSS+1 decision times also tended to be greater than those for BOSS-divided words. Nonword data were not reported. Experiment 2, using a transition from one case (upper or lower) to the other as a demarcation, replicated the superiority of BOSS-divided words over VCG-divided words (e.g., CLIMate was classified more quickly than CLImate), but undivided words, such as CHAPEL, were classified more quickly than divided words of either type. Following the underlying rationale of the experiments, the superiority of intact words over words divided at their BOSS boundary suggests that words are more likely to be accessed on the basis of the entire word than on the basis of the BOSS. Taft attributed the superiority of intact words to a reduction of disruption in letter identification relative to case-changed, divided words,

rather than to access based on the entire word, but the latter possibility is not ruled out by the data. It was also found that nonwords which were the BOSSs of one-syllable words ending in silent E (e.g., STON) took longer to reject than control nonwords (e.g., SLON). Similarly, BOSSs of higher frequency words (e.g., SHIN) took longer to classify than control words (e.g., SWAN). This result suggests that the BOSS principle yields the lexical access entries for one-syllable words ending in silent E. Taft (1979b) concluded that the BOSS definition of the initial syllable of a word actually yields the access entry for that word.

The remaining experiments of Taft (1979b) suggested that word recognition involves a left-to-right parse. It was found that a stimulus string, whether a word or a nonword, containing a word at its beginning, took longer to classify in lexical decision than did a control item: BEARD, starting with the word BEAR, took longer to classify than STORM. A letter string ending with a word, on the other hand, did not take longer to classify than a control word: CLOVE and THUMB were classified equally quickly even though CLOVE ends in LOVE. Taft concluded that word recognition entails a left-to-right reiterative parsing process, in which a lexical search is made for successive letter sequences beginning with the initial letter. The parse stops at the word's BOSS, at which point the correct access code is obtained and the word recognized. Interference occurs when another word's BOSS is

contained at the beginning of the stimulus word's BOSS, since an inappropriate entry would be accessed before the correct one is reached. For instance, lexical access for CANDLE would involve a search for C, then CA, then CAN, which would contact a lexical entry that would be found incorrect, then CAND, the correct BOSS of CANDLE.

Summary

In summary, a number of studies reported results consistent with the hypothesis that prefixed words are stripped of their prefixes so that lexical access can be achieved on the basis of root morphemes. Taft and Forster (1976) suggested that an unprefixed word's first syllable, rather than its entire root, serves as its access entry in the internal lexicon. Taft (1979b) hypothesized that the initial syllabic unit operating in visual word recognition is not the VCG but the BOSS, because access based on a representation of a word's BOSS would allow morphologically related words to share the same lexical entry in the mental lexicon's access file in certain cases when a phonological syllable such as the VCG would not. In contrast to the VCG parsing process proposed by Hansen and Rodgers (1968) and adopted by Spoehr and Smith (1973, 1975), Taft (1979b) supported a left-to-right reiterative parse beginning with a word's first letter to obtain the BOSS partitioning of a word.

Although Taft (1979b) studied only unprefixed stimuli,

the BOSS hypothesis implies a modification of the morphological decomposition hypothesis for recognizing prefixed words: the BOSS begins with the first letter after the prefix, and lexical access is based on the BOSS, not the entire root morpheme.

Studies questioning morphological decomposition considered the recognition of suffixed words as well as prefixed words. Forster's (1976) access file, master file conception of the internal lexicon was useful in explaining the superiority of repetition priming over the partial priming caused by preview of a morphologically related word, and also helped to account for the observed influences of both total root frequency and surface frequency on lexical decision time. Morphological decomposition seems most likely to occur with prefixed words, and also seems likely to occur with inflectionally suffixed words, but may be somewhat less likely with derivationally suffixed words. Rubin, Becker, and Freeman's (1979) claim that morphological decomposition is a strategy effect dependent on prefixed context does not seem convincing (Taft, 1981).

Purpose of the Present Experiments

The two experiments to be reported were attempts to test Taft's (1979b) claim that words are recognized through their BOSSs. Experiment 1 was an attempt to replicate Taft (1979b), Experiments 1 and 2. Experiment 2 used different types of

priming stimuli in a lexical decision task as a second test of BOSSs as units of lexical access.

C H A P T E R I I

EXPERIMENT 1

Experiment 1 was essentially an attempt to replicate Taft (1979b), Experiments 1 and 2. Taft used letter strings divided into two parts in a lexical decision task, assuming that the location of the division within the letter string would be used by subjects as a guide in attempting lexical access for that letter string. Underlying the paradigm are the two assumptions that the internal lexicon is accessed on the basis of certain important subword structures, and that lexical decision will be relatively fast if the division within a stimulus word matches the format of an existing representation in the mental lexicon, but relatively slow if the stimulus division has no counterpart in the lexicon. Specifically, Taft proposed that BOSSs of words are represented in the lexicon's access file, and therefore he predicted that dividing a stimulus word at its BOSS boundary would lead to faster lexical decision than dividing the word at its VCG boundary.

Taft confirmed his BOSS hypothesis. When the stimulus letter string was a word, division at the BOSS boundary was less disruptive to lexical decision than division at the VCG boundary. In Experiment 2, Taft found that reaction times for VCG-divided nonwords did not differ significantly from

reaction times for BOSS-divided nonwords, presumably because nonwords have no lexical representations and therefore are disrupted equally by internal division at either location. (Taft did not report nonword results in Experiment 1).

The present experiment, like Taft's Experiment 1, used a gap, one letter space in width, to split each divided stimulus letter string into two subunits. This method was chosen because the use of a case change (i.e., changing from upper case letters to lower case letters or from lower case letters to upper case letters) as a division indicator in Taft's Experiment 2 reduced the reaction time difference between the BOSS-divided words and the VCG-divided words. Because a word's BOSS tends to be one letter longer than its initial VCG, it is possible that the faster mean reaction time for BOSS-divided words was not the result of differential representation of BOSSs and VCGs in the lexicon, but was simply due to the greater number of letters to the left of the dividing space in the BOSS-divided words. However, Taft reported that words divided one letter after their BOSS boundaries took more time, not less time, to classify in lexical decision than BOSS-divided words; this difference was significant on item and subject analyses but not on minF' (Clark, 1973). Taft's Experiment 2 did not include the BOSS+1 division condition, but it did introduce an undivided stimulus condition to test the possibility that making the BOSS division explicit actually facilitates lexical decision

relative to normal, intact presentation. It was found that BOSS division was actually disruptive relative to intact presentation, not facilitative. Because the intact letter strings formed a totally different set of items than the items used in the divided conditions, the difference Taft observed between the undivided condition and the divided conditions could possibly have been due to an item difference.

The present experiment included all four relevant stimulus treatments: BOSS division, VCG division, BOSS+1 division, and undivided presentation. The same set of words and non-words were used in all treatments, allowing direct comparison among the four forms of each letter string in data analysis. Thus, for example, the word BURDEN appeared in all four stimulus conditions: BURD EN, BUR DEN, BURDE N, and BURDEN, respectively.

Method

Subjects. Sixty-nine University of Massachusetts undergraduates served as subjects and received course credit for their participation. The data from five of these subjects were discarded because their error rates exceeded a pre-determined cutoff of 12%.

Materials. Word items were chosen according to Taft's criteria (Taft, 1979b, p. 27). These criteria stipulate that letter strings be from four to seven letters in length

(although several eight-letter items appear on Taft's list), monomorphemic, and polysyllabic. In addition, all letter strings have either a long first vowel or a pair of non-identical medial consonants other than NG or NK. These criteria were designed to eliminate words having BOSSs identical to their initial VCGs, but they were not actually sufficient to accomplish this; such words as WITNESS, PATROL, and BISHOP meet the criteria but do have BOSSs identical to their first VCGs. Because Taft in fact excluded such words, they were also excluded from the present experiment. Despite the criterion excluding polymorphemic words, Taft's stimuli included at least 12 words that could well be considered polymorphemic (e.g., CRUCIAL, URGENT, and VERBAL), and these words were also included in the present experiment. No prefixed or inflectionally suffixed words were used.

Ninety-two criterial words falling within the Kucera and Francis (1967) frequency range of 14 to 46 were gathered, including 40 of the 44 words used in Taft (1979b), Experiment 2. The frequency range of Taft's stimuli was 20 to 30 and was expanded here to provide an increased number of stimulus words. The mean frequency value in both experiments is approximately 24.5.

Nonwords were designed according to similar structural criteria as were the words; all nonwords are pronounceable, orthographically legal, polysyllabic, and have either a long first vowel or a pair of nonidentical medial consonants. In

addition, nonwords were matched with words on length in letters, and approximately matched with words on initial letter. Stimuli are listed in the Appendix.

Fifty-four practice words and 54 practice nonwords were also selected, all similar in structure to the experimental items.

Design. Letter strings were presented in four different forms; in the Whole condition, the letter string was presented in its normal, undivided form, and in the three divided conditions, the letter string was divided into two segments by means of a space. BOSS items were divided immediately after their BOSS (e.g., BURD EN), according to Taft's BOSS principle. VCG items were divided immediately after their first VCG (e.g., BUR DEN), according to the parsing rules in Hansen and Rodgers (1968) and Spoehr and Smith (1973). BOSS+1 items were divided one letter after their BOSS boundary (e.g., BURDE N). Nonwords were presented in the same four forms: HOLTER, HOLT ER, HOL TER, and HOLTE R are the Whole, BOSS, VCG, and BOSS+1 forms of HOLTER.

Four subject groups were used, since each subject saw any given letter string in only one of its four forms. For example, subjects in Group 1 saw BURD EN, Group 2 saw BUR DEN, Group 3 saw BURDE N, and Group 4 saw BURDEN. The four experimental lists, one for each subject group, each contained all 184 words and nonwords, equally divided among

the four stimulus conditions listed above. In other words, every subject saw 46 Whole items, 46 BOSS items, 46 VCG items, and 46 BOSS+1 items. Over the four experimental lists, then, every item appeared in every possible form. From a set of four subjects, one in each subject group, data for every item under every condition were obtained.

Each item was randomly assigned to one of eight trial blocks and it appeared, in one of its four forms, depending on subject group, in that trial block for all subjects. The order of trial blocks was always the same, but the order of trials within blocks was randomized for each subject.

Apparatus. Letter strings were displayed one at a time in upper case letters on a Hewlett Packard 1300A X-Y display oscilloscope controlled by a Hewlett Packard 2114B computer. Each letter was constructed by illuminating an appropriate pattern of points in a matrix seven points high by five points wide. The computer recorded responses and reaction times.

Subjects were run individually, sitting approximately one meter from the screen in a sound-damped room. The display for a single trial consisted of a letter string five to nine character spaces wide, subtending a vertical visual angle of approximately $0^{\circ}18'$ and a horizontal angle between $1^{\circ}41'$ and $3^{\circ}3'$. The space within divided stimuli was always one character space in width.

Procedure. The pacing of trials was controlled by the subject. At the start of each trial, a plus sign (+) appeared in the center of the screen. To initiate a trial, the subject pressed either of two response keys, and the letter string appeared 500 milliseconds (msec) later, remaining on the screen for 500 msec. Subjects responded to each letter string by pressing one of two keys; a word response was performed by pressing the right-hand key, and a nonword response was performed by pressing the left-hand key. Subjects were instructed to ignore the spaces in divided stimulus strings and to respond on the basis of the stimulus string as a whole. Subjects were told to respond as quickly as possible without making more than a few errors. The word ERROR appeared on the screen whenever an error was made.

Each subject completed four practice blocks of 25 trials each before beginning the eight experimental trial blocks. All subjects were presented with the same list of practice items, containing a balanced distribution of words and nonwords in all four stimulus conditions. Each of the eight experimental trial blocks started with two practice trials as warmup, followed without a break by 23 experimental trials.

Results and Discussion

Mean reaction times for correct responses, along with error rates, are presented in Table 1.

TABLE 1

MEAN REACTION TIMES (IN MSEC) AND ERROR RATES FOR WORDS AND NONWORDS AS A FUNCTION OF STIMULUS CONDITION

CONDITION	EXAMPLE	REACTION TIME	PERCENT ERRORS
<u>Words</u>			
BOSS	BURD EN	660	4.7
VCG	BUR DEN	660	4.6
BOSS+1	BURDE N	676	4.4
WHOLE	BURDEN	627	3.3
<u>Nonwords</u>			
BOSS	HOLT ER	773	6.4
VCG	HOL TER	757	5.0
BOSS+1	HOLTE R	775	4.8
WHOLE	HOLTER	735	6.5

Because of the four-group design of the experiment, the 64 subjects were grouped into 16 subject*s, each subject* contributing a reaction time value for each of the 184 items under each of the four stimulus conditions. In order to eliminate the problem of missing reaction time values due to the exclusion of reaction time data from error trials, the items were combined into groups of four and the mean reaction

time of each set of four words or nonwords, or, each word* or nonword*, was computed for each subject*. These mean reaction time values over subjects and items were used as the scores in all statistical analyses of reaction times. In all analyses, therefore, the number of subjects is 16, because there were 16 subject*s, and the number of words or nonwords is 23, because there were 23 word*s and 23 nonword*s.

Reaction time was the dependent variable of the most interest, and the primary analyses treated both subject*s and item*s as random factors. The results of subject and item analyses are also reported, if significant, when minF' failed to reach significance. An analysis of variance revealed that responses to words were 104 msec faster than responses to nonwords, minF'(1,37)=57.09, $p < .005$. The advantage of words over nonwords was probably due in part to a confounding of lexicality (whether the item was a word or a nonword) with hand of response; all word responses were made with the right hand, and all nonword responses were made with the left hand. More relevant to the purpose of the experiment is the existence of a significant difference among the four stimulus conditions, minF'(3,109)=10.89, $p < .005$. This effect indicates that the type of division performed on the letter string did affect the time taken to classify that letter string as a word or a nonword. The interaction of lexicality with stimulus condition did not reach significance.

The results of Taft's (1979b) Experiments 1 and 2

confirmed his prediction of differential effects of division condition on word and nonword items. For word items, the BOSS division led to shorter lexical decision reaction times than the VCG division; the advantage of the BOSS over the VCG was 39 msec in Experiment 1, in which stimuli were divided by means of a space, and 18 msec in Experiment 2, in which the division was signalled by a case transition. Both differences were significant on minF'. Taft's Experiment 1 also suggested that BOSS-divided words were classified more quickly than BOSS+1 divided words; this 42 msec advantage for BOSS words was not significant on minF' but was significant on both the item analysis and the subject analysis. In contrast, there was no significant reaction time advantage for BOSS-divided nonwords over VCG-divided nonwords; the observed difference in Taft's Experiment 2 was a 6 msec advantage for BOSS-divided nonwords. The observed effects of division condition on lexical decision for words supported Taft's hypothesis that the BOSS of a word has a special role as that word's access entry in the internal lexicon. The lack of an effect of division condition on lexical decision for nonwords was taken as a reflection of the fact that there is no information about nonwords stored in the lexicon, necessitating a search for all possible BOSSs when the stimulus string is a nonword. This search would not, Taft explained, be differentially facilitated by either the BOSS division or the VCG division.

Several planned comparisons were carried out on the BOSS, VCG, and BOSS+1 conditions in order to assess the degree to which the present experiment replicated the important effects of Taft (1979b). The most important of Taft's findings, that BOSS-divided words are classified as words more quickly than VCG-divided words, was obviously not replicated here; both types of word division resulted in identical mean reaction times of 660 msec. The lack of a BOSS advantage casts doubt on Taft's hypothesis that lexical access for a visually presented word is based on its BOSS and not on its initial VCG. Following the reasoning underlying the experimental manipulation, the finding of equal reaction times for the BOSS words and the VCG words suggests that these two types of syllabic units are equally likely to have representations in the internal lexicon.

Taft's results suggest that for words there should be an advantage of the BOSS over the BOSS+1 division, and this was confirmed by the results of the present experiment: BOSS+1-divided words took 16 msec longer to classify as words than either BOSS-divided or VCG-divided words, $\text{min}F'(2,36)=4.04$, $p<.05$, and $\text{min}F'(2,37)=3.54$, $p<.05$, respectively. This 16 msec difference is, however, much smaller than the 42 msec difference reported in Taft's Experiment 1. The greater reaction times for classifying BOSS+1 words, relative to BOSS and VCG words, in conjunction with the identical reaction times for each of the two syllabic word divisions,

rules out the uninteresting hypothesis that reaction time simply decreases as the number of letters to the left of the space increases. If this were the case, then BOSS+1 division would lead to the shortest rather than the longest lexical decision times, and the VCG division would lead to the longest reaction times of all. The fact that the BOSS+1 division caused more disruption than either the BOSS or the VCG division is consistent with the hypothesis that syllabic units, described either phonologically or orthographically, are more likely to have representations in the lexicon than nonsyllabic units.

The prediction that division condition should have little effect on nonword stimuli was supported in the present experiment. In the overall analysis of variance, the division condition by lexicality interaction failed to reach significance. When nonword data were analyzed separately, in no pairwise comparison among the BOSS, VCG, and BOSS+1 nonwords was there a significant effect of division condition, although the 18 msec advantage for VCG-divided nonwords over BOSS+1 divided nonwords reached significance on the item analysis, $F(1,22)=7.02$, $p<.05$. (The failure to reach significance on minF' was probably due to greater variability in the nonword data than in the word data). In contrast, as stated above, both the VCG and the BOSS division resulted in faster lexical decisions for words than did the BOSS+1 division.

The Whole condition was included to test the possibility that making the syllabic division of a word explicit by means of an internal dividing space actually facilitates lexical decision relative to the word presented in its usual undivided state. The results obviously argue against this possibility; the reaction times for Whole words were on average 33 msec less than those for BOSS- or VCG-divided words, and both differences were significant, $\min F'(1,37)=12.94$, $p<.01$, and $\min F'(1,37)=14.35$, $p<.005$, respectively. The 49 msec advantage of Whole words over BOSS+1-divided words was also significant, $\min F'(1,37)=27.33$, $p<.005$. Even though the BOSS and VCG divisions were less disruptive than the BOSS+1 division, any division of a stimulus into two segments by means of a space was detrimental to lexical decision compared to presenting the word in its usual undivided state.

While Taft also found that Whole words were classified significantly more quickly than words divided at either the BOSS boundary or the VCG boundary, he found no such difference for nonwords. The advantage for Whole nonwords over divided nonwords was only 3 msec, as opposed to 35 msec for words. In contrast, as explained above, in the present experiment there were no significant interactions of division condition with lexicality. The 22 msec advantage of Whole nonwords over VCG-divided nonwords was not significant, but the 38 msec advantage of Whole nonwords over BOSS-divided nonwords was significant, $\min F'(1,37)=8.99$, $p<.01$. Whole nonwords were

also rejected more quickly than BOSS+1-divided nonwords, $\min F'(1,37)=9.49$, $p<.01$. Thus it appears that internal division is disruptive to nonwords as well as to words in lexical decision.

Following the assumptions underlying the experiment, the advantage Taft found for Whole words over BOSS-divided words, in conjunction with the lack of such an advantage for the nonword stimuli, implied that words are more likely to be represented in the lexicon as whole words than as their BOSSs. Taft preferred to attribute the superiority of intact words over case-changed, divided words to a reduction in the disruption of letter identification caused by the case transition in divided letter strings: letter identification is disrupted in recognizing FORTune, but not in recognizing CHAPEL. The lack of evidence for this letter identification disruption in the case of nonwords caused obvious problems for Taft's interpretation.

Because the space division had similar disruptive effects for both words and nonwords in the present experiment, the simplest explanation of this disruption is probably a tendency to treat a letter space as a demarcation between two words; Whole letter strings are more naturally treated as units than are letter strings with an internal space. In normal text, the major function of spaces the width of one character is to separate words from each other, and the functional significance of this spacing in reading has been

demonstrated by Spragins, Lefton, and Fisher (1976), who reported that reading performance on normally spaced text was much better than performance on text in which spacing between words had been omitted. For adults, the mean reading rate under the normal spacing condition was 256 words per minute, compared to 134 words per minute under the absent spacing condition. Even though subjects in the present experiment were instructed to treat divided letter strings as units, this may have been somewhat difficult given the normal boundary-marking function of spaces. Therefore, the superiority of undivided letter strings over divided letter strings is not surprising.

An analysis of variance performed on error rates, treating both subject*s and item*s as random variables, indicated nonsignificant main effects for both lexicality and division condition, as well as a nonsignificant interaction between them. The effect of lexicality, a 1.4% superiority in accuracy for words, did reach significance on the subject analysis, $F(1,15)=8.29$, $p<.01$. There is therefore no evidence for an effect of type of division on error rates, and no conclusive evidence for an effect of lexicality.

C H A P T E R I I I

EXPERIMENT 2

Experiment 1 failed to replicate Taft's (1979b) major finding; words divided immediately after their initial VCG did not take longer to classify in lexical decision than words divided immediately after their BOSS. Experiment 2 was intended as a second test of the BOSS as the syllabic unit used in lexical access for visually presented words. This study employed a priming paradigm in a lexical decision task. The same words and nonwords used in Experiment 1 were again used in Experiment 2, except that four stimulus strings were omitted for convenience of design. Instead of dividing the letter strings into two subunits by means of a space, either the beginning subunit or ending subunit appeared 90 msec before the appearance of the entire word or nonword. Four types of subunits were used as primes. In the two Beginning Prime conditions, the BOSS or the VCG were the priming stimuli. In the two Ending Prime conditions, the word minus its BOSS (this will be referred to as the MBOSS) or the word minus its initial VCG (the MVCG) appeared as priming stimuli. There was also a fifth, control condition in which no priming subunit appeared and the onset of the entire item was delayed by 90 msec.

Taft's hypothesis would predict that, since lexical

access is based on a word's BOSS, the most facilitative priming stimulus should be the BOSS. The MBOSS and the MVCG conditions were included to test Taft's hypothesis that lexical access requires a left-to-right parse, beginning with the first letter of the word. The object of this parse is to obtain the word's BOSS. If a left-to-right parsing process does operate on a letter string, then lexical decision under the MBOSS and MVCG conditions should be slower than lexical decision under the BOSS and VCG conditions.

Method

Subjects. Sixty University of Massachusetts undergraduates served as subjects and received course credit for their participation. None of these subjects had participated in Experiment 1.

Materials. One-hundred eighty of the 184 items from Experiment 1 were used. Two words and two nonwords were omitted from the original list for convenience of design.

Design. Stimuli were presented in five different forms, including two Beginning Prime conditions, two Ending Prime conditions, and the control condition in which no priming stimulus appeared. In the BOSS condition, the BOSS of a letter string appeared 90 msec before the onset of the remainder of the letter string. Dotted lines above and

below the priming stimulus indicated the length of the entire letter string. For example, in the BOSS condition,

.....
BURD
.....

appeared for 90 msec, followed by the entire word,

BURDEN.

In the VCG condition, the letter string's first VCG acted as the prime. In the MBOSS condition, the letter string minus its BOSS acted as the prime. For example,

.....
EN
.....

was the MBOSS prime for BURDEN. In the MVCG condition, the letter string minus its initial VCG appeared as the prime. In the control condition, only the dotted lines appeared prior to the onset of the entire letter string.

In Experiment 1, four groups of subjects were used so that every letter string could appear in each of four forms. Similarly, in Experiment 2, five subject groups were necessary, and every subject was presented with 36 items in each of five conditions. Items were randomly assigned to six trial blocks. The order of trial blocks did not vary, but the order of trials within blocks was randomized for each subject.

Apparatus. Apparatus was the same as in Experiment 1.

Procedure. Subjects were instructed to pay careful attention

to the screen, because trial onset was controlled by the computer. At the start of each trial, two parallel, horizontal dotted lines appeared at the center of the screen, indicating the position and length of the letter string that would ultimately appear. One second later, the priming fragment appeared, in its appropriate position, or, in the control condition, the lines alone remained on. Ninety msec later, the remaining portion of the letter string appeared, the entire string remaining on until the subject made his or her response. Reaction time was always measured from the onset of the entire letter string.

The temporal sequence for a trial with the word BURDEN in the MBOSS condition was:

.....
 (for one second)

.....
 EN (for 90 msec)

BURDEN (until response).

The time between a response and the onset of the parallel lines indicating the next trial was 500 msec.

Subjects responded by pressing a right-hand key for a word response and a left-hand key for a nonword response, and were told to respond as quickly as possible without making more than a few errors. The word ERROR appeared on the screen when an error was committed.

Subjects completed two practice trial blocks of 32 trials

each, followed by six experimental trial blocks. Each experimental trial block started with two practice trials as warmup, followed by the 30 experimental trials.

Results and Discussion

Mean reaction times for correct responses are presented along with error rates in Table 2.

TABLE 2

MEAN REACTION TIMES (IN MSEC) AND ERROR RATES FOR WORDS AND NONWORDS AS A FUNCTION OF PRIMING CONDITION

CONDITION	EXAMPLE OF PRIMING STIMULUS*	REACTION TIME	PERCENT ERRORS
<u>Words: Example, BURDEN</u>			
BOSS	BURD	591	5.3
VCG	BUR	600	4.5
MBOSS	EN	623	4.3
MVCG	DEN	618	4.3
CONTROL		617	3.0
<u>Nonwords: Example, HOLTER</u>			
BOSS	HOLT	659	4.4
VCG	HOL	669	3.9
MBOSS	ER	713	3.8
MVCG	TER	698	4.4
CONTROL		726	5.6

*The parallel dotted lines have been omitted.

The reaction time data were handled much as they were in Experiment 1. Because of the five-group design of Experiment 2, the 60 subjects were grouped into 12 subject*s, each subject* contributing a reaction time value for each of the 180 items under each of the five stimulus conditions. In order to eliminate the problem of missing reaction time data due to the exclusion of error trials, items were combined into groups of five and the mean reaction time for each set of five words or nonwords, or each word* or nonword*, was computed for each subject*. These mean reaction time values over subjects and items were used as the data points in all statistical analyses of reaction times. In all these analyses, therefore, the number of subjects is 12, because there were 12 subject*s, and the number of items is 36, because there were 18 word*s and 18 nonword*s.

As in Experiment 1, reaction time was the dependent variable of major interest, and both subject*s and item*s were treated as random factors in the primary analyses. An analysis of variance indicated that responses to words were significantly faster than responses to nonwords, $\text{minF}'(1,27)=63.38, p<.005$. The average word superiority of 83 msec was partially due to a confounding of hand of response and lexicality (word or nonword). As in Experiment 1, word responses were made with the right hand and nonword responses with the left. There was a significant difference among the five priming conditions, $\text{minF}'(4,96)=15.52, p<.005$,

as well as a significant interaction of lexicality with priming condition, $\text{minF}'(6,111)=3.04$, $p<.025$.

Three predictions of major interest derived from Taft (1979b) are (1) that a word's BOSS should be an effective priming stimulus in lexical decision for the entire word, (2) that the BOSS should be a more effective prime than the initial VCG, and (3) that the BOSS and the VCG should both be more effective primes than either the MBOSS or the MVCG. If the results followed this predicted pattern, they could be taken as evidence for Taft's claim that a word's BOSS serves as its lexical access code and that lexical access involves a left-to-right parsing process.

Several planned comparisons were carried out in order to assess the validity of these predictions. Analyses were carried out on words and nonwords together, and separate analyses were done on words or nonwords if the combined analyses indicated an interaction of lexicality with priming condition.

A comparison of the BOSS condition with the control condition gave some evidence that supported the first prediction. The priming effect of the BOSS was greater for nonwords than for words, $\text{minF}'(1,28)=5.64$, $p<.025$. The 67 msec effect for BOSSs on nonword trials was highly significant, $\text{minF}'(1,28)=38.01$, $p<.005$. The 26 msec BOSS priming effect on word trials failed to reach significance on the primary analysis, $\text{minF}'(1,25)=3.89$, $p<.10$. The BOSS effect

for words did, however, reach significance on both the item analysis and the subject analysis, $F(1,17)=4.50$, $p<.05$, and $F(1,11)=16.06$, $p<.005$. There is, then, evidence that preview of a word's BOSS facilitates lexical decision relative to the no prime control condition, but it is clearly the case that the facilitation effect is larger for nonwords than for words.

The second prediction, that BOSS priming is superior to VCG priming, was not confirmed. Although the direction of the effects for both words and nonwords suggested a priming advantage for the BOSS, 9 msec for words and 10 msec for nonwords, the differences were not significant. The interaction of priming condition with lexicality was also non-significant. There is, therefore, no evidence that preview of a letter string's BOSS is more facilitative to lexical decision than preview of the letter string's initial VCG. Comparison of the VCG and the control condition did reveal a significant interaction of lexicality with priming condition, $\text{min}F'(1,27)=7.35$, $p<.025$, as well as a main effect of priming condition, $\text{min}F'(1,25)=47.09$, $p<.005$. The 57 msec VCG priming effect for nonwords was significant, $\text{min}F'(1,28)=36.25$, $p<.005$. The 17 msec effect for words reached significance only on the subject analysis, $F(1,11)=23.19$, $p<.01$. Because the BOSS-VCG comparison indicated no effect of priming condition, there is no conclusive evidence for the claim that the BOSS, unlike the initial VCG, is the access

code in the lexicon.

The third prediction, that the Beginning Primes (BOSS and VCG) should be more effective than the Ending Primes (MBOSS and MVCG), was supported. An additional analysis of variance was performed on the reaction time data in order to assess this prediction, comparing the BOSS and VCG priming conditions with the MBOSS and MVCG conditions. This analysis also assessed the possible effect of type of syllabification regardless of the location of the prime within the word (BOSS and MBOSS vs. VCG and MVCG) and the possible effect of number of letters in the priming stimulus (shorter primes, VCG and MBOSS, vs. longer primes, BOSS and MVCG). Of these three possible effects, the only one to reach significance was the first: BOSS and VCG primes produced a mean reaction time advantage of 33 msec over the MBOSS and MVCG primes, $\text{minF}'(1,27)=44.10$, $p<.005$. When words and nonwords were analyzed separately, again the Beginning Prime advantage over the Ending Primes (25 msec for words and 41 msec for nonwords) was the only effect to reach significance, $\text{minF}'(1,27)=16.59$, $p<.005$, and $\text{minF}'(1,28)=32.68$, $p<.005$, respectively. There is therefore no evidence that longer priming strings are more effective than shorter ones, and no evidence that type of syllabification regardless of prime location had an effect on lexical decision time. The results do, however, support the prediction that preview of beginning portions of letter strings facilitates lexical

decision performance to a greater extent than does preview of ending segments.

The above analyses revealed that the BOSS of a letter string is an effective prime, but the initial VCG is equally effective. Both the BOSS and the VCG were superior to the MBOSS and the MVCG as priming stimuli. Several planned comparisons were performed to assess whether or not the Ending Primes had any priming effect relative to the Control condition. Although performance under the MBOSS condition was not significantly better than that under the Control condition, there was a significant priming effect for the MVCG condition, $\text{minF}'(2,28)=6.84, p<.005$. A comparison of the MBOSS with the MVCG indicated no significant effect, implying that neither prime was actually more effective than the other.

One aspect of the data which has not yet been considered is the greater priming effect on nonword trials than on word trials: the BOSS and VCG priming effects were on the average 21 msec for words, but 62 msec for nonwords. The larger priming effect for nonwords was likely due in part to the greater reaction times on nonword trials. Inspection of the nonword stimuli suggests the possibility that the Beginning Primes were usually not possible beginning sequences of words in the range of word lengths and word frequencies used in the experiment. Such primes may have been useful in ruling out the possibility that the entire letter

string could be a legal English word. One would have expected that BOSS primes would allow faster rejection of nonwords, if only because BOSSs are longer than VCGs and hence contain more information, but this was not the case.

An analysis of variance was performed on error rates, treating subject*s and item*s as random factors. Neither lexicality nor priming type reached significance. The interaction of lexicality with priming type did, however, reach significance, $\text{minF}'(7,100)=2.11$, $p<.05$. Specifically, for words the lowest error rate, 3.0%, occurred in the Control condition, while for nonwords the opposite was true; the highest error rate, 5.6%, occurred in the Control condition. There is some evidence, therefore, of a tendency to respond "Word" in the Control condition.

C H A P T E R I V
GENERAL DISCUSSION

Experiment 1: A Failure to Replicate

The results reported here argue against Taft's (1979b) hypothesis that the unique lexical access entry of a visually presented word is its Basic Orthographic Syllable Structure, or BOSS, an initial syllable defined in terms of orthotactic and morphological factors rather than phonological factors. A word's BOSS is defined as that portion of its first root morpheme which includes the first vowel and all following consonants not violating rules of orthographic co-occurrence. Taft's first two experiments compared lexical decision performance on words divided at their first Vocalic Center Group, or VCG, boundary. The VCG, in contrast to the BOSS, is a syllabic unit corresponding to phonology (Hansen & Rodgers, 1968). Taft found that lexical decision reaction times were significantly faster on words with BOSS divisions than on words with VCG divisions. Taft interpreted this result in terms of lexical access: the BOSS division was less disruptive to lexical decision than the VCG division because BOSS division of a stimulus word coincides with the unit of representation in the internal lexicon's orthographic access file, while the VCG structure is not represented in this access file.

Experiment 1 was not identical in design to either of Taft's first two experiments, but it was essentially similar and was intended as a replication of Taft. The critical finding, a superiority of BOSS-divided words over VCG-divided words, was clearly lacking in Experiment 1: there was no difference between the mean response times for words under BOSS division and words under VCG division. The lack of a BOSS advantage stands in marked empirical disagreement with the 39 msec effect found in Taft, Experiment 1. In both Taft's Experiment 1 and the present Experiment 1, letter strings were presented in upper case typography, and the division within a letter string was indicated by a space. Taft's Experiment 2 revealed an 18 msec advantage of BOSS-divided words over VCG-divided words. In that study, a case transition marked the internal letter string divisions. Even though the apparently more powerful space division technique was used in the present Experiment 1, no BOSS advantage was found when BOSS-divided words were compared with VCG-divided words.

Although Experiment 1 showed no advantage of BOSS division over VCG division, there was an advantage of words divided syllabically, either at the BOSS boundary or at the VCG boundary, over words divided one letter past their BOSS boundary. This effect (16 msec) was smaller than the corresponding advantage (42 msec) Taft reported for BOSS-divided words over BOSS+1-divided words, but it does argue

for the conclusion that syllabic units are useful in the recognition of visually presented words. Therefore, although Experiment 1 argued against the unique status of BOSSs as access entries in the mental lexicon, its results do suggest that syllabic units defined orthographically, as well as syllabic units defined phonologically, may be involved in lexical access.

It is difficult to specify any important methodological differences between Experiment 1 and Taft's experiments that could plausibly account for the failure to replicate the advantage of BOSSs over VCGs in lexical decision. Taft's reaction times tended to be shorter than those found in the present study; the overall mean in Taft's two experiments was 605 msec, compared to 708 msec in Experiment 1. This discrepancy may have been due to the difference in subject populations and to Taft's use of voice responses rather than key presses to indicate lexical classifications. It is also possible that the use of vocal responses may have discouraged phonological encoding in Taft's experiments. Taft's subjects received substantially fewer practice trials than subjects in either Experiment 1 or Experiment 2. Both of these experiments included more than twice as many experimental strings than Taft's studies, but it is unlikely that subjects in the present experiments became fatigued given that an experimental session rarely took more than 18 minutes to complete, including all practice trials. The only other

obvious difference was that Experiment 1 included all four relevant stimulus division conditions, while each of Taft's studies included three conditions. These differences should not have altered basic findings. The failure to replicate is especially puzzling because the stimuli used in the present studies were carefully selected according to Taft's criteria, and in fact most of Taft's words and nonwords were included in the two studies reported here.

Another recent experiment employing internal division of letter strings has also failed to replicate Taft's critical finding of a reaction time advantage for BOSS-divided words over VCG-divided words. Baldasare and Katz (1980) used the same stimuli used in Taft (1979b), Experiment 2. In their lexical decision study, Baldasare and Katz divided letter strings by means of a diagonal slash mark at either the BOSS boundary, the VCG boundary, or at a nonsyllabic location either one or two letters to the right or left of the VCG or BOSS division. In addition, strings were presented either in uniform lower case (e.g., vict/im) or in alternating case (e.g., vIcT/iM). The authors found no significant difference between BOSS-divided words and VCG-divided words in either the uniform case condition or the alternating case condition: vict/im and vic/tim were classified as words equally quickly. Similarly, performance on nonwords was unaffected by type of syllabification. The failure to find an advantage of the BOSS division over the VCG division stands in disagreement

with Taft but corroborates the lack of a BOSS advantage in the experiments reported here.

Baldasare and Katz (1980) did not find a reaction time advantage of syllabic division (either BOSS or VCG) over non-syllabic division in the uniform case condition: vict/im and vic/tim were not accepted as words more quickly than victi/im. This lack of a syllabic unit advantage contrasts with the advantage of BOSS- and VCG-divided words over BOSS+1-divided words found in Experiment 1. Baldasare and Katz did find a significant advantage of syllabic division over nonsyllabic division under mixed case presentation; this effect held for both words and nonwords. For example, vIcT/iM and vIc/TiM were classified more quickly than vIcTi/M, and LoB/eN and Lo/BeN were classified more quickly than LoBe/N, disagreeing with the lack of a syllabic division superiority effect on nonword trials in Experiment 1 and Taft's Experiment 2.

Baldasare and Katz's interpretation of their results was that skilled readers normally do not use syllable information in recognizing written words. Syllable information is used only when the letter strings are visually disrupted; hence, syllabic division was more helpful than nonsyllabic division only in mixed case presentation, and not in uniform case presentation. It is difficult to imagine, however, why syllable coding is not also disrupted by mixed case presentation of stimulus strings.

There are methodological reasons to exercise caution in

interpreting the results of Baldasare and Katz. First, reaction times were in general very long; the mean reaction time was approximately 1260 msec for the mixed case stimuli and approximately 970 msec for the uniform case stimuli. Response times in such a high range even under uniform case presentation may indicate the operation of special processes not normally active in visual word recognition. Second, error rates were not reported. Third, the type of stimulus division as well as type of presentation (uniform case or mixed case) were between-subjects variables. This design is open to two criticisms: it may have been too insensitive to detect a difference between the BOSS division and the VCG division, since the effects Taft reported were not large, and presentation of items under only one type of division may have encouraged subjects to develop context-dependent strategies not normally used in word recognition.

Experiment 2

Experiment 2 corroborated the primary conclusion of Experiment 1. Just as BOSS division did not lead to faster lexical decision responses than VCG division in Experiment 1, preview of a word's BOSS did not lead to significantly faster lexical decision responses than preview of a word's initial VCG. The BOSS prime should have been the best prime if Taft's hypothesis that BOSSs are the only units of lexical access were valid. Because this was not the case, the BOSS

hypothesis was not supported by the results of Experiment 2, just as it was not supported by the results of Experiment 1.

Both the BOSS and the VCG were effective priming stimuli relative to the no prime condition. This result, in conjunction with the advantage of syllabic division over non-syllabic division in Experiment 1, suggests the possibility that initial syllabic units have an important role in lexical access. Experiment 2 did not, however, provide any basis for concluding that initial syllabic primes, defined either according to the BOSS principle or according to VCG parsing rules, are more effective than nonsyllabic primes beginning with the initial letter of the stimulus string. No non-syllabic priming stimuli were included in Experiment 2 and therefore the hypothesis that preview of beginning syllabic units is more facilitative to lexical decision performance than preview of nonsyllabic beginning units remains to be tested.

Taft's Left-to-Right Parsing Process

Taft (1979b), Experiments 4 and 5 supported the hypothesis that word recognition involves a left-to-right parse beginning with the word's first letter. A letter string, whether a word or a nonword, containing a word at its beginning, took more time to classify in lexical decision than a control letter string. A stimulus string ending in a word did not take longer to classify than a control stimulus string.

The finding that the presence of a word within a stimulus word or nonword caused disruption in lexical decision only if it was contained at the very beginning of the stimulus string supported the notion that lexical access involves a left-to-right process. In Taft's view, lexical access is attempted for successive groups of adjacent letters, all beginning with the initial letter of the stimulus string. When a lexical entry is contacted, it is checked in order to determine whether or not it is the appropriate entry for that item; such checking presumably occurs via consultation of that portion of the lexicon's master file accessed by the lexical entry under consideration. If this lexical entry is found to be inappropriate, then the left-to-right parse continues, producing successively longer letter groupings until the appropriate entry, the word's BOSS, is achieved. At this point, lexical access will be successful, and the word will be recognized. For example, the lexical entry for GRIN is GRIN, and GRIND begins with GRIN. In attempting to recognize GRIND, the entry for GRIN is an early candidate for the BOSS of GRIND; when GRIN is accessed, the lack of information in the master file stating that GRIN+D is a word necessitates continuing the parse. GRIND is the next candidate BOSS, and lexical access succeeds. In contrast, SLANT is not subject to interference from ANT.

Experiment 2 refuted the hypothesis that a word is stored in the lexicon's access file solely as a representation of

its BOSS, but its results are consistent with the hypothesis that some type of left-to-right parse is involved in visual word recognition. The priming stimuli leading to the fastest lexical decision responses were the Beginning Primes (BOSS or initial VCG), not the Ending Primes (the string minus its BOSS or the string minus its VCG). Because preview of a beginning segment of a letter string facilitated lexical decision to a much greater extent than did preview of an ending segment, it can be concluded that beginning portions of words have special roles in lexical access.

The superiority of primes from the beginning of words is consistent with the results of many studies which have indicated the importance of beginning letters in word recognition. Pillsbury (1897), for example, displayed words with one letter omitted, a letter substitution, or a letter with an X typed over it, and found that misprints were most often detected if they occurred at the beginning of the word. Adams (1979) measured full report accuracy for letter strings across a range of exposure durations and found that letter report was best for beginning letter positions. These are but a few examples of the many studies suggesting a processing bias favoring the beginning portions of words. (See also Bruner & O'Dowd, 1958; Broerse & Zwaan, 1966; Horowitz, White, & Atwood, 1968). Such a bias is not unexpected if the beginning segment of a word serves as its access code, and if a left-to-right process is involved in obtaining the

access code.

Although Taft did not precisely explain the operation of the left-to-right process he proposed, a detailed examination of what is entailed in this process reveals that a number of substages must be involved. If BEARD is presented in a lexical decision task, the subject first considers B, finds it not to be a BOSS, and proceeds to BE, which is a word and hence a BOSS. BE contacts the lexicon, where it is ascertained that BE+ARD is not a legal combination of morphemes. Notice that by this point, the subject must have identified all the letters in BEARD, because he has had to complete a check of BE+ARD. Next, the subject fails to find BEA in the access file, but the next attempt, BEAR, results in another disruptive access. Finally, BEARD is obtained and lexical access succeeds. For a word with several possible BOSSs at its beginning, access involves multiple passes at the entire string of fully identified letters. Therefore, Taft's proposal should not be confused with a claim that letter identification itself is a serial process proceeding from left to right. Taft assumes a preliminary stage of letter identification, but makes no claim about whether this stage proceeds in serial or in parallel.

Taft's evidence for a parsing process with the goal of obtaining the BOSS is not conclusive. Although he offered the results of Experiments 4 and 5 as evidence of interference effects caused by inappropriate beginning BOSSs, these

studies actually indicated only that entire words contained at the beginning of letter strings caused interference. (One of Taft's examples of a control word, STORM, actually begins with an inappropriate BOSS, STOR of STORY or STORE). Whether or not an inappropriate BOSS that is not a word causes a slowdown in lexical decision has not, therefore, been tested. Such a study, comparing performance on words such as TRUCK (containing the BOSS of TRUCE) and LATCH (containing the BOSS of LATE) with performance on controls such as GUEST and BRIDE would be advisable.

Manelis and Tharp (1977) did report a nonword result relevant to the question of BOSS interference. As noted before, in a double lexical decision task, nonwords beginning with words (e.g., HOLDY) and nonwords beginning with word fragments (e.g., MURDY) were classified more slowly than controls (e.g., MALDY). Inspection of the word fragment nonwords revealed that most of them consisted of the BOSS of a common word plus a common suffix. The result therefore seems consistent with the left-to-right BOSS parsing process, but its interpretation is not straightforward because most of the control nonwords also began with BOSSs, these BOSSs tending to be shorter than the BOSSs contained at the beginning of the word fragment nonwords.

The BOSS as a Unique Lexical Access Code

The results of Experiments 1 and 2 did not replicate

Taft (1979b) and therefore do not support the BOSS as the one and only access code for a visually presented word, but they do suggest that syllabic units of the VCG type or the BOSS type are useful in word recognition. The only experimental support for the unique status of BOSSs as lexical access codes appears to be the results of Taft's two division experiments and his Experiment 3, in which nonwords which were BOSSs of one-syllable words ending in silent E took more time to classify in lexical decision than did control nonwords. Also, BOSSs of higher frequency words (e.g., SHIN, BOSS of SHINE) took more time to classify as words than did control words (e.g., SWAN). The results are consistent with the notion that the BOSS principle yields the access code of a one-syllable word ending in silent E. The results of Taft and Forster (1976) suggest access on the basis of the initial syllable of a word, but they did not provide an explicit comparison of BOSS syllabification and VCG syllabification.

In the discussion of his findings, Taft claimed to have provided strong evidence against the use of phonological encoding in lexical access for written words. Such a claim seems overstated. Although Taft was not unjustified in stating that BOSS division was less disruptive than VCG division, his results do not provide any direct evidence against the operation of grapheme-phoneme correspondence rules. It is also the case that despite its orthographically based definition, the BOSS principle generally yields

a pronounceable syllable. The BOSS could in fact be described as the largest possible initial VCG of a letter string. Two kinds of words were used in Taft's studies and the present studies, words with medial consonant clusters and words with long first vowels. A word such as PLAST ER may be no harder to convert to a phonological representation than PLAS TER, although SPID ER may be more difficult to encode phonologically than SPI DER.

The Role of VCGs in Word Recognition

Spoehr and Smith's (1973, 1975) model has as its goal an internal articulatory code of a visually presented letter string, and includes the VCG (Hansen & Rodgers, 1968) because VCGs are characterized as the minimal units in which all important phonotactic constraints can be specified. VCGs are the smallest units that can be intelligibly pronounced in isolation. The VCG articulatory code in Spoehr and Smith's model is available for lexical access. The basic finding supporting the model was the effect of the number of VCGs on tachistoscopic recognition: words containing two VCGs were identified less accurately than words with the same number of letters containing one VCG (Spoehr & Smith, 1973). In addition, in a total-report tachistoscopic task, accuracy scores on two adjacent letters were more highly correlated if the letters were both part of the same VCG than if they were part of two different VCGs.

Frederiksen and Kroll (1976), however, found little effect of the number of syllables in naming one-syllable and two-syllable words, and there was no effect of the number of syllables in their lexical decision task. Forster and Chambers (1973) also found little evidence of effects of the number of syllables in naming and lexical decision. These studies are in disagreement with experiments reporting effects of the number of syllables on naming latencies for words (e.g., Klapp, Anderson, & Berrian, 1973). Other studies (e.g., Klapp, 1974) found an effect of syllables on number naming even when the numbers were presented in digital form, although Henderson, Coltheart, and Woodhouse (1973) did not find this effect. These rather confusing results point out the obvious possibility that an effect of the number of syllables need not reflect an early parsing process operating on the visual stimulus. The fact that some experimenters have found that a number represented as a digit (e.g., 7) takes longer to name when its name contains more syllables places the locus of the syllable effect at the stage of programming vocal output. In addition, even when significant effects have been found, they are small; the advantage in latency for naming three-syllable numbers over four-syllable numbers was 6 msec in Klapp (1974).

At least one study, Mewhort and Beale (1977), provided support for the hypothesis that VCGs are units in word perception. Mewhort and Beale presented words in letter groups.

Letter groups were presented sequentially, and they either corresponded to the word's VCGs or they did not. Presentation was either from right to left or from left to right. It was found that the VCG letter groupings led to much more accurate word identification performance than nonsyllabic groupings, and that presenting the letter groups in left-to-right order led to superior accuracy than presenting them from right to left. The study did not, of course, provide a comparison of BOSS groupings vs. VCG groupings, but it does suggest an early role of syllables in visual word recognition, and it provides support for a left-to-right process.

The Relative Advantages of Taft's BOSS Theory

What might be the relative advantages of Taft's model of word recognition compared with that of Spoehr and Smith? The two experiments reported here failed to replicate Taft's evidence that the visual syllabic unit should necessarily be defined by the BOSS principle. There may, however, be reasons for preferring a model of syllabic mediation like Taft's rather than a model like that of Spoehr and Smith.

Coltheart (1978) and Henderson (1975) found Spoehr and Smith's model untenable on several grounds, and a consideration of these grounds points out some advantages of Taft's type of model. Both Coltheart and Henderson questioned the viability of applying VCG parsing rules during visual word recognition. These rules are cumbersome; they first require

not only that each letter be identified, but also that each letter must be marked as a vowel or consonant. The primary parsing rules do not always yield the correct syllabification of a word; Hansen and Rodgers (1968) provide reparsing rules which could be called on if the initial parsing process yields an incorrect syllabification, but Spoehr and Smith found this aspect of VCG parsing unimportant, despite their assumption that the function of VCGs is to yield an internal articulatory representation.

It is Coltheart's contention that even in cases in which the primary parsing process does yield the correct syllabification, ambiguities present at the syllabic level would actually be made unambiguous if one simply discarded syllabic cuts and applied spelling pattern-phoneme correspondence rules. One of Coltheart's examples is DAGGER, which would be syllabified as DAG+GER, making difficult the decision about whether the second G is hard or soft. This difficulty would not arise if the GG spelling pattern were left unparsed, since in this case the hard G pronunciation would be indicated.

What, then, might be the advantages of Taft's model? The first advantage is that it does not require a step of phonological encoding. A second advantage is that it clearly specifies that the initial syllable is the most important syllable, a claim for which there is experimental evidence. Because the only important syllable is the initial

syllable, the necessary parsing process is likely to be far less cumbersome than the one needed in the Spoehr and Smith model to arrive at the full syllabification of the stimulus word. The left-to-right parsing routine Taft proposed seems viable. It starts with the first letter and stops when the appropriate syllable has been located, avoiding the difficult problem of arriving at syllabic cuts by noting the relative positions of letters which have previously been tagged as vowels or consonants. In short, Taft's model, whether or not one believes that BOSSs are unique access codes, plausibly proposes that first syllables are access codes, and suggests a parsing process that could quite workably obtain the necessary access code.

Important Tests of the BOSS Hypothesis

At this point, it would be useful to re-examine the assumptions motivating Taft's BOSS proposal, and to consider the relevance of Taft's experiments as tests of the value of these underlying assumptions. The first assumption was that words sharing the same root morpheme, or, more specifically, those morphologically related words whose relationship is orthographically transparent, share the same unique lexical representation in the access file. Evidence consistent with the hypothesis that morphologically related words are decomposed so that lexical access can proceed on the basis of the root morpheme was provided by Taft and Forster (1975)

and Taft (1979a, 1981); other experiments (e.g., Murrell & Morton, 1974; Snodgrass & Jarvella, 1972; Bradley, 1979) provided additional evidence for the role of morphemic analysis in visual word recognition. The second assumption underlying the BOSS principle was that lexical access is achieved on the basis of a word's initial syllable. The primary evidence for this assumption was provided by Taft and Forster (1976).

These two assumptions led Taft to propose the BOSS as the unit of lexical access, because an initial syllabic unit defined by the BOSS principle makes possible one access entry for morphologically related words whose relationship would be obscured by VCG syllabification: thus, both FAST and FASTER would be accessed through their BOSS, FAST. It was, however, necessary to include both orthographic and morphological criteria in the BOSS definition, so that the BOSS of NEARBY is not NEARB but NEAR. Because Taft's BOSS evidence was based virtually entirely on monomorphemic words with strictly orthographically defined BOSSs, he has provided no empirical support for either the use of BOSSs in recognizing words whose VCGs obscure morphemic relationship (e.g., FASTER) or for the use of morphologically defined BOSSs in recognizing words whose orthographically defined BOSSs obscure morphemic relationship (e.g., NEARBY). Experiments using stimuli of these two types seem crucial to Taft's hypothesis. An additional question is the access

code for prefixed words; presumably, if prefixes are stripped off in lexical access, then the BOSS of a prefixed word must begin with the first letter after the prefix.

An experiment to test the possible morphological significance of the BOSS has been planned. This study uses the priming paradigm of Experiment 2 with two types of polymorphemic words: inflected words ending in -S, -ED, -ER, or -ING, and compound words, or words made up of two constituent root morphemes. An inflected letter string is presented under one of four priming conditions (BOSS, VCG, BOSS+1, or VCG-1) or under the no prime control condition. For the word FARMER, the BOSS, VCG, BOSS+1, and VCG-1 primes are FARM, FAR, FARME, and FA, respectively. If the BOSS hypothesis is valid, then the BOSS of a word should be the most effective priming stimulus.

The compound words provide an assessment of the relative priming effectiveness of the orthographically defined BOSS and the morphologically defined BOSS. Compound strings are presented under four priming conditions (orthographic BOSS, morphemic BOSS, orthographic BOSS+1, morphemic BOSS-1) or under the no prime control condition. If the BOSS principle holds, then the morphemic BOSS should be the most effective prime for lexical decision. For example, BAR should be a more effective prime than BART for BARTENDER; BAR is the morphemic BOSS while BART is the orthographic BOSS. In addition, two types of compound nonwords are included to

test the Taft and Forster (1976) claim that in lexical access for a compound word, only the first root morpheme enters into lexical access. One type of nonword contains two words that do not form a legal English word when combined (e.g., BOOKSALT, TURNTRIBE, and GRAINTRICK). The other type begins with a word but ends with a nonword (e.g., BANDSTIMP, TEADAKE, and MANTORD). Taft and Forster's finding would be replicated if both types of nonwords take the same amount of time to classify in lexical decision.

Monomorphemic words from Experiments 1 and 2 are included in the proposed experiment also, both to provide a replication of Experiment 2 and to assess the validity of the claim that syllabic units are more likely to be lexical access entries than nonsyllabic units. If this is the case, then one would expect that the BOSS and the VCG would tend to be more effective primes than either the BOSS+1 or the VCG-1. If, on the other hand, it is simply the number of letters in a prime that determines its facilitative effect, then the priming effect should be greatest for the BOSS+1 and smallest for the VCG-1.

Two major conclusions can be drawn from the two experiments which have been reported here. The first is that there is no evidence for the BOSS as a unique lexical access code, in contrast to the findings of Taft (1979b). There is, however, some evidence that syllabic units are more likely to be lexical access codes than nonsyllabic units. The

second conclusion, consistent with a left-to-right process in visual word recognition, is that beginning letter sequences are more likely to be lexical access entries than ending letter sequences. The third experiment, outlined above, would provide a crucial test of the underlying assumptions of Taft's BOSS principle.

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APPENDIX

List of Word Stimuli

RANDOM	STUDIO	ORBIT	POWDER
MARBLE	CYCLE	LABEL	AMPLE
SOBER	SHELTER	CLIMAX	SELDOM
CRUCIAL	PILOT	GENTLE	HUMBLE
MUSTARD	SPLENDID	PLASTER	COUNSEL
URGENT	TRACTOR	ENTRY	BUNDLE
EMPIRE	CAMPUS	PISTOL	VIRGIN
CLIMATE	BURDEN	CANDLE	STUPID
PARLOR	FANTASY	PRESTIGE	CANCER
BORDER	MUTUAL	SPONSOR	TUMOR
MYSTERY	VICTIM	STADIUM	ARGUE
LUMBER	FORTUNE	SINCERE	NOTION
CIRCUIT	PASTURE	BASKET	ALIEN
NOBLE	RATIO	GESTURE	ARTERY
FEVER	CARBON	CRYSTAL	TARGET
TIMBER	GENIUS	STABLE	MARSHAL
FOCUS	EAGER	VERBAL	CHAMBER
IVORY	THUNDER	RADAR	DESTINY
TEXTILE	VIRTUE	WHISKEY	FOSTER
FIBER	SILVER	HARMONY	RESCUE
FURNISH	FINANCE	SLENDER	PUPIL
CUSTOM	CLOVER	SUPERB	LICENSE
FLAVOR	ALTER	MOVIE	PROTEIN

List of Nonword Stimuli

TARBEY	ZABLE	UVANT	VARNET
BISCORP	ELMIN	LUBAN	TIPLE
RUNTLE	NOODATE	GLASTID	RITER
BLATER	LATIRE	ISPIAL	NATEN
RAMONY	AMPOW	TOSCARP	STORPIT
HEMPLE	FOBAL	FRAGER	MAPION
PLANDIT	LOBEN	RIBEN	ALMIAN
CAVURE	CRODAR	HIRNOLD	DARPLE
DOSPAGE	CLAMEDY	NARGEN	FRIMPON
THANDER	PADONY	LASKIP	PRUSTIN
SILPONTH	FEEBATE	FLENDIN	PROLAR
PRANSON	TANDLE	BLENTON	ENPOSK
WRODET	NULKET	SPADOR	STALID
RALPARCH	BLUNDIN	MOOLITE	HUREAL
OLBERD	WOSTEN	AVEND	SHIDLE
BASTOP	RINDOL	GOMEN	SPOTAR
SERODY	DEABERY	UMPUE	GANSIC
INTID	CATULE	CORFIST	ARCOME
SUNAL	FARGEL	RASCOLP	GAVIAL
PHALPER	HOLTER	TALSTIC	FRESTID
CALTAIN	CHIMBER	GRONDIN	HODUM
SHENKER	MARDITY	OMPIE	MUPIC
JIMPER	BURNIP	PITLE	DAVER

