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Lexical Access via an Orthographic Code? The Basic Orthographic Syllabic Structure (BOSS) Reconsidered

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Three lexical decision experiments tested the claim by M. Taft (*Journal of Verbal Learning and Verbal Behavior* 1979, **18**, 21–39) that lexical access is based on a word's Basic Orthographic Syllabic Structure (BOSS). Experiment 1 failed to replicate Taft's finding that lexical decisions were faster to monomorphemic words split at their BOSS boundary than those split at their Vocalic Center Group (VCG) boundary. In Experiments 2 and 3, preview of a word's BOSS for monomorphemic words produced no faster lexical decision than preview of the initial VCG. There was therefore no evidence that the BOSS is a word's unique lexical access entry. The results of Experiment 3, which employed polymorphemic words, suggested that morphemic units are more likely to be access codes than purely orthographic units.

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 candidate for the primary encoding process involved in visual word recognition is morphological encoding, which involves partitioning a word into its component morphemes prior to lexical access. Taft and Forster's (1975) morphological encoding hypothesis proposed that the internal lexicon subsumes representations of related affixed forms of a word under a representation of the root morpheme they share. Such a model makes explicit use of the rule-governed nature of the relationships among affixed forms of the same root. Morphological encoding seems particularly appropriate for the recognition of written English words when one considers the depth of English orthography. Our orthography is deep in that it tends to represent the morphophonological level of language rather than the level of surface phonology (Bradley, 1919; Chomsky & Halle, 1968). It has been argued (e.g., Chomsky, 1970; Katz & Feldman, 1979) that such a spelling system permits the reader of English to exploit graphemically invariant representations of morphemes, allowing direct access to morphemic representations in a visually based lexicon.

A second encoding process that has been proposed is syllabic encoding. 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). Spoehr and Smith (1973, 1975) adopted syllabic parsing rules developed by Hansen and Rodgers (1968) and proposed a phonologically mediated model of word recognition based on these rules. Hansen and Rodgers proposed the Vocalic Center Group (VCG) as the syllabic unit; their goal was to provide a phonological basis for the written syllable. In contrast, Taft (1979b) has recently proposed a written syllable based solely on orthographic and morphemic considerations, requiring no necessary correspondence with pronunciation. Taft's Basic Orthographic Syllabic Structure (BOSS) is 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 theory

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of lexical access rests on the two assumptions that (1) morphologically related words are accessed through an identical entry they share in the lexicon (the morphological encoding hypothesis) and (2) that words are accessed on the basis of their first syllable. Taft argued that lexical access based on a phonologically defined syllable such as the VCG would often result in morphologically related words being accessed through different 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 initial VCG of FASTER, both FASTER and FAST have FAST as their BOSS, allowing them both to be accessed through a lexical representation of FAST.

Forster's Two-Stage Model

A brief discussion of Forster's (1976) two-stage model of lexical access will provide a useful framework for discussion. In this model, the lexicon consists of a number of files. The *master* file, containing all of an individual's lexical information, cannot be consulted directly; it is contacted via an ordered search of an *access* file. Each lexical entry in the 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. Access entries are arranged in order of decreasing frequency of occurrence, so that a lexical search will find high frequency words before it finds low frequency words. The model thus handles the well-known finding that high-frequency words are generally more quickly and accurately processed than low-frequency words (e.g., Howes & Solomon, 1951; Forster & Chambers, 1973). Taft and Forster's (1975) morphological encoding hypothesis states that it is the root morpheme of a word that serves as its entry in the access file used in recognizing written words. In a later modification, Taft and Forster (1976) and Taft (1979b) proposed that lexical search is not based on the entire root morpheme but on the first syllable (the BOSS) of the root. The sections to follow will summarize the experimental evidence for morphemic access and BOSS access.

Empirical Evidence for Morphological Encoding

Taft and Forster (1975) proposed that a word's root is its representation in the lexicon's access file, its purpose being to provide the address of information about the various affixed forms in the master file. They reported a number of "interference effects" in lexical decision that were consistent with morphological encoding. Response 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, actual words (e.g., LISH, from RELISH). Taft and Forster's interpretation was that unlike LISH, VIVE accesses a real word in the lexicon, and the occurrence of this access causes a delay in deciding that VIVE by itself is not a word. In addition, 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 nonroot word fragment (e.g., DEPERTOIRE). The root JUVENATE seems to delay the decision that DEJUVENATE is not a word, suggesting that a word's prefix is stripped off so that a lexical search can be made for the root.

Several earlier studies reported results compatible with morphological analysis of affixed forms. Snodgrass and Jarvella (1972) studied suffixed, prefixed, and unaffixed letter strings and found that affixation increased lexical decision times for words. Murrell and Morton (1974) pretrained subjects in a tachistoscopic report task; some training words were identical to test words, some were suffixed variations, and others were morphologically 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 only visually similar. Murrell and Morton concluded that the unit of facilitation was morphemic in nature.

Two recent studies (Taft, 1979a; Bradley, 1979) used alternative methods of assessing word frequency to test the morphological encoding hypothesis. Taft found that the *total* frequency of a root, equal to the sum of the frequencies of all the words based on it, influenced lexical decision time for a relatively low frequency word containing that root. DISSUADE was classified more slowly than REPROACH; DISSUADE and REPROACH have similar *surface* frequencies, but SUADE is a less frequent root than PROACH, since the total frequency of PROACH is greater than that of SUADE. The implication 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 affect lexical access for a word containing that root. The picture is complicated, however, by the fact that *surface* frequency of a word influenced lexical decision time even when *total* frequency was held constant. It may be that the access file is affected by total frequency while the master file is affected by surface frequency.

Bradley's (1979) study used derivationally suffixed words. For nominalizations ending in -NESS or -MENT, and familiar forms ending in -ER, words high in total root frequency were classified more quickly than words with low total root frequency when surface frequency was held constant, agreeing with Taft (1979a). However, unlike Taft, Bradley found no reliable effect of surface frequency when total frequency was held constant, and no frequency effect at all for nominalizations ending in -ION, the latter result supporting neither access through roots nor access based on the entire word.

In a reply to studies critical of morphological encoding (Rubin, Becker, & Freeman, 1979; Stanners, Neiser, & Painton, 1979) Taft (1981) provided further support for morphological encoding in both lexical decision and naming experiments. Pseudoprefixed words, or words whose beginning letter sequences look like prefixes but do not function as such, had greater naming latencies than unprefixed words even when no genuinely prefixed words were included in the stimulus set. Taft concluded that pseudoprefixed words were mistakenly decomposed so that access could be carried out on the basis of the "root," causing a delay in access of the entire word. This result refuted the claim by Rubin, Becker, and Freeman (1979) that prefix stripping is a special strategy dependent upon a preponderance of prefixed items. Manelis and Tharp (1977) provided ambiguous evidence for the decomposition of pseudosuffixed words in a double lexical decision experiment. DARKER FATTER was not classified as a pair of words more quickly than SISTER SOMBER, but both were classified more quickly than SISTER SENDER. Thus, although two pseudosuffixed words did not take longer to classify than two suffixed words, the mixed case was more difficult, suggesting differential processing modes for the two types of words.

Evidence for Lexical Access Based on an Initial Syllable

Taft and Forster (1976) proposed that it is the initial syllable of a word's root which actually forms its access entry in the internal lexicon. In the case of compound nonwords, lexical decision took more time for compounds 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 than MOWDFLISK and TROWBREAK. Frequency of the first constituent affected lexical decision time for compound words matched on surface frequency and frequency of second constituent. HEADSTAND was classified more quickly than LOINCLOTH, apparently because HEAD is a higher frequency word than LOIN. Evidence was provided that access is achieved through the initial syllable in noncompound words as well: a nonword which was the first syllable of a word (e.g., PLAT) took longer to classify as a nonword than did a control (e.g., PREN). A word forming the first syllable of a morphologically unrelated word of higher frequency (e.g., NEIGH, the first syllable of NEIGHBOR) took longer to accept than did a control of similar frequency (e.g., SHREW). A stimulus string's status as the final syllable of a word did not, however, affect its lexical decision time. Forster's (1976) model specifies that higher frequency words are accessed before lower frequency words. If a word is indeed accessed on the basis of its first syllable, then the interference effect Taft and Forster observed should 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 an ending syllable of a word had little effect suggests that only the initial syllable is involved in lexical access.

The Case for the BOSS

Having obtained some evidence that the initial syllable of a word is its access code, as well as evidence that morphologically related words are accessed on the basis of the root morpheme they share, Taft (1979b) proposed the BOSS (Basic Orthographic Syllabic Structure) principle, which states that a word's access code is its BOSS, or that part of its first root morpheme that includes after the first vowel all consonants not violating rules of orthographic co-occurrence. In contrast to a phonologically based syllable such as the VCG (Vocalic Center Group), the BOSS generally results in morphologically related words (e.g., FAST and FASTER) being accessed through the same first syllable representation.

Taft's lexical decision experiments supported the BOSS as the unit of lexical access for unprefixed words and also suggested that a left-to-right parsing process is used to obtain the BOSS of a stimulus word. Stimulus strings were split into two subunits by means of a space (e.g., LANT ERN) or a case transition (e.g., FIBer). Taft reasoned that if the resulting subunits of a stimulus word coincided with the format of its lexical entry in the access file, then lexical decision for that divided word should be faster than lexical decision for the word split at some other point. Division of a word immediately after its initial VCG (e.g., FIber) caused significantly greater reaction times than division immediately after the BOSS (e.g., FIBer). Taft concluded that BOSSs of words, unlike their first VCGs, have representations in the lexicon. It was true, however, that undivided words (e.g., CHAPEL) were classified more quickly than divided words of either syllabic type. Using the logic that the least disruptive spatially grouped sets of letters are access codes, then the superiority of undivided words over BOSS divided words would suggest that words are more likely to be accessed on the basis of the entire word than on the basis of the BOSS. Alternatively, as Taft proposed, the superiority of intact words over BOSS divided words could be due to a reduction in the disruption of letter identification relative to the case-changed divided words.

Taft also suggested that word recognition entails a left-to-right parsing process, in which a lexical search is made for successive letter sequences beginning with the initial letter. The parse stops at the BOSS, at which point the correct access code is obtained and the word recognized. Interference would occur when another word's BOSS is contained at the beginning of the stimulus word's BOSS, because an inappropriate entry would be accessed before the correct one is reached. For example, 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 finally CAND, the BOSS of CANDLE. Taft indeed found that a word or nonword containing a word at its beginning took longer to classify in lexical decision than did a control: BEARD took more time than STORM. CLOVE and THUMB were classified equally quickly despite the fact that the last four letters of CLOVE form the word LOVE. Although these results are consistent with the idea of interference caused by inappropriate BOSSs at the beginning of stimulus strings, they are not conclusive, since these studies actually indicated only that entire *words* contained at the beginning of letter strings caused interference.

Purpose of the Experiments

The three lexical decision experiments reported here were intended as tests of Taft's (1979b) claim that a word is recognized through its initial syllable as defined by the BOSS principle. Experiment 1 was an attempt to replicate Taft's Experiments 1 and 2, in which nonwords and monomorphemic words were internally divided at various locations. Experiment 2 used various types of subword units as priming stimuli in a second test of BOSSs as the units of lexical access for monomorphemic words. Experiment 3 again used the priming paradigm, but polymorphemic as well as monomorphemic words were employed. It was intended to provide tests both for the use of BOSSs in recognizing words whose VCG syllabification would obscure morphological relationship (e.g., FASTER) and for the use of BOSSs defined on morphological grounds in recognizing words whose purely orthographically defined BOSSs obscure morphological relationship (e.g., NEARBY, TEAPOT). Experiment 3 is important because Taft's segmentation studies were with very few exceptions limited to monomorphemic words with strictly orthographically defined BOSSs.

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 two assumptions: (1) that the internal lexicon is accessed on the basis of certain important subword structures, and (2) 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 access file of the lexicon, 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's results confirmed the 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. The advantage of the BOSS division over the VCG division was 39 milliseconds in Experiment 1, in which words were divided by means of a space, and 18 milliseconds in Experiment 2, in which the division was signaled by a case transition. In addition, Taft reported in Experiment 1 that words divided at their BOSS were classified 42 milliseconds more quickly than words divided one letter after their BOSS. This finding appears to rule out the uninteresting hypothesis that BOSS division was superior to VCG division simply because a word's BOSS contains more letters than its initial VCG. 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 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 intact 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 nonwords were used in all treatments, allowing direct comparisons 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. The division indicator employed was a space rather than a case transition, since the former indicator led to the larger BOSS advantage in Taft's experiments.

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 predetermined 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 4 to 7 letters in length (although several 8-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 nonidentical medial consonants other than NG or NK. These criteria were designed to eliminate words having BOSSs identical to their initial VCGs, but they are 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 Taft's stated criterion of excluding polymorphemic words, his 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 14–46 were gathered, including 40 of the 44 words used in Taft (1979b), Experiment 2. The frequency range of Taft's stimuli was 20–30 and was expanded to provide an increased number of stimulus words in the present study. 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 number of 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 the BOSS principle of Taft (1979b). VCG items were divided immediately after their initial 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 was obtained.

Each experimental 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 trial blocks was randomized for each subject.

Apparatus. Letter strings were displayed one at a time in uppercase letters on a Hewlett Packard 1300 X-Y display oscilloscope controlled by an HP 2114B computer. Each letter was constructed by illuminating an appropriate pattern of points in a matrix 7 points high by 5 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 5 to 9 character spaces wide, subtending a vertical visual angle of approximately 0°18′ and a horizontal angle between 1°41′ and 3°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 the two response keys, and the letter string appeared 500 milliseconds later, remaining on the screen for 500 milliseconds. Subjects responded to each letter string by pressing one of two keys: A "word" decision was indicated by a response of the right index finger, a "nonword" decision by the left index finger. Subjects were instructed to ignore the spaces in divided stimuli and to respond on the basis of the letter string as a whole. Subjects were told to respond as quickly and accurately 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. 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, four randomly selected words or four randomly selected nonwords were combined into a group called an item*. In the resulting design, subject*s (16 levels) was thus completely crossed with the other variables and item*s (23 levels) was crossed with all variables except for word and nonword.

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 reported, if significant, when the quasi F ratio, F_2' (Myers, 1979, p. 191) failed to reach significance. (We will hereafter refer to this as F'.) An analysis of variance revealed that responses to words were 104 milliseconds faster than responses to nonwords, $F'(1,37) = 57.09$, $p < .005$. However, the advantage of words over nonwords may have been due in part to a confounding of lexicality (whether the item was a word or a nonword) with hand of response. Most relevant to the purpose of the experiment is the existence of a significant difference among the four stimulus presentation conditions, $F'(3,109) = 10.89$, $p < .005$. This effect indicates that the type of division performed on the stimulus letter string did affect the time taken to classify that letter string as a word or nonword. Moreover, the interaction of lexicality with stimulus condition did not come close to significance, indicating the pattern across conditions was about the same for words and nonwords ($F(3,45) = 1.37$, $p > .25$ over subject*s and $F(3,66) = .58$, $p > .25$ over item*s).

An inspection of Table 1 indicates that the only difference in the pattern of results for words and nonwords was that for words, response times to the BOSS and VCG division were equal and 16 milliseconds faster than the BOSS + 1 division, while for nonwords responses to the BOSS division were actually 16 milliseconds slower than to the VCG division and only 2 milliseconds faster than to the BOSS + 1 division. Although the ANOVA above suggests that this difference is easily explainable by sampling error, we de-

TABLE 1
MEAN REACTION TIMES AND ERROR RATES FOR WORDS AND NONWORDS AS A FUNCTION OF STIMULUS CONDITION (EXPERIMENT 1)

Condition	Example	Reaction time[a]	Percentage errors
Words			
BOSS	BURD EN	660	4.7
VCG	BUR DEN	660	4.6
BOSS + 1	BURDE N	676	4.4
WHOLE	BURDEN	627	3.3
Nonwords			
BOSS	HOLT ER	773	6.4
VCG	HOL TER	757	5.0
BOSS + 1	HOLTE R	775	4.8
WHOLE	HOLTER	735	6.5

[a]Reaction time in milliseconds.

cided to report planned comparisons for words and nonwords separately in order to be comparable to Taft's analysis. For words, both the VCG divided stimuli and BOSS divided stimuli were significantly faster than the BOSS + 1 divided stimuli, $F'(2,37) = 3.54$, $p < .05$; and $F'(2,36) = 4.04$, $p < .05$, respectively. There was a zero millisecond difference between the VCG and BOSS divisions ($SE = 5.09$ across subject*s and $SE = 7.09$ across item*s). For nonwords, the 18-millisecond advantage for VCG divided stimuli over BOSS + 1 divided stimuli was significant only on the item analysis, $F(1,22) = 7.02$, $p < .05$, and the difference between VCG and BOSS divided words was not significant. (There appeared to be greater variability in the nonword data.)

Thus, for the word data, which are the most relevant to Taft's theory, we failed to replicate Taft's finding that BOSS division was less disruptive than VCG division. However, our finding that both BOSS and VCG division are less disruptive than BOSS + 1 division suggests that syllabic units, described either orthographically or phonologically, are more helpful in lexical access than nonsyllabic units. It should be emphasized, however, that since the fastest times were for stimuli with no division, it is *not* the case that making the syllabic division of a word explicit facilitates lexical decision relative to the word presented in its usual undivided state. For words, the undivided stimuli were 33 milliseconds faster than the BOSS and VCG, $F'(1,37) = 12.94$, $p < .01$, and $F'(1,37) = 14.35$, $p < .005$, respectively. For nonwords, the 22-millisecond advantage of nondivision over VCG division was not significant, but the 38-millisecond advantage over BOSS division was, $F'(1,37) = 8.99$, $p < .01$. Taft felt that his theory predicted no differences among the nonword conditions. He reported only word data in Experiment 1 and his nonword conditions in Experiment 2 were indeed just about equal. The failure of most of our nonword differences to be significant weakly replicates his data. However, the lack of interaction in our overall ANOVA does not lend strong support to Taft's assertion that the pattern for words and nonwords is different. Since the prediction of the model for nonwords may depend on the similarity of the nonwords to words, we (like Taft) will focus on the word data.

Internal division of stimulus strings had similar disruptive effects for both words and nonwords in the present experiment. The simplest explanation of this disruption is probably that a whole letter string is more naturally treated as a unit than is a divided letter string. 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 factors, 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 of an effect of type of division on error rates, and no conclusive evidence for an effect of lexicality.

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 as words in lexical decision than words divided immediately after their BOSS. Experiment 2, using a priming paradigm in a lexical decision task, was intended as a second test of the BOSS as the syllable used in lexical access for visually presented words. The same words and nonwords used in Experiment 1 were used in Experiment 2, except that four stimulus strings were eliminated 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 milliseconds 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 word was delayed by 90 milliseconds. The 90-millisecond delay interval was selected based on pretesting which indicated that it was long enough to allow for a significant priming effect, but not so long that the prime would produce conscious guessing strategies.

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 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 the visual representation of 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 the subjects had participated in Experiment 1.

Materials. One hundred eighty of the one hundred eighty-four 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 milliseconds before the onset of the remainder of the letter string. For example, in the BOSS condition

. . . . . .
BURD . .
. . . . . .

appeared for 90 milliseconds, followed by the entire word BURDEN. The dotted lines above and below the priming stimulus indicated the length of the entire word. 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 followed by BURDEN. In the MVCG condition, the letter string minus its initial VCG appeared as the prime. In the control condition, the dotted lines indicating where the letters were to appear were presented for 90 milliseconds followed by the entire word.

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 the 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 milliseconds later, the remaining portion of the word appeared, the entire stimulus 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 time between a response and the onset of the parallel lines indicating the next trial was 500 milliseconds.

Subjects responded by pressing a key with their right index finger for a word response and a key with their left index finger for a nonword response, and were told to respond as quickly and accurately 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 and error rates are presented in Table 2. 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, and items were combined into groups of five words or nonwords and the mean item* was computed for each subject*. In all the analyses, therefore, there are 12 subject*s, and there were 18 item*s for words and 18 for nonwords. An analysis of variance on the response times indicated that responses to words were 83 milliseconds faster than responses to nonwords as in Experiment 1, $F'(1,27) = 63.38$, $p < .005$. However, the faster times for words may have been partly due to the fact that the right hand made the "word" response. Of primary interest was the significant difference among the five priming conditions, $F'(4,96) = 15.52$, $p < .005$, as well as a significant interaction of lexicality with priming condition, $F'(6,111) = 3.04$, $p < .025$.

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 as primes than either Ending Prime, that is, the MBOSS or the MVCG.

As in Experiment 1, however, the BOSS and VCG conditions appeared about equally effective. The 67-millisecond nonword priming effect for the BOSS primes (compared to the controls) and the 57 millisecond nonword priming effect for the VCG primes were both significant, $F'(1,28) = 5.64$, $p < .025$, and $F'(1,25) = 47.09$, $p < .005$, respectively. For words, the priming effects of 26 milliseconds for the BOSS and 17 milliseconds for the VCG were less robust: $F(1,17) = 4.50$, $p < .05$ over item*s and $F(1,11) = 16.06$, $p < .005$ over subject*s for the BOSS primes; $F(1,11) = 23.19$, $p < .01$, over subject*s for the VCG primes. Neither the overall difference between BOSS and VCG primes nor the separate differences for words and nonwords approached significance. Thus, as in Experiment 1, both BOSS and VCG syllabification

TABLE 2
MEAN REACTION TIMES AND ERROR RATES FOR WORDS AND NONWORDS AS A FUNCTION OF PRIMING CONDITION (EXPERIMENT 2)

Condition	Example of priming stimulus[a]	Reaction time[b]	Percentage errors
Words: example, BURDEN			
BOSS	BURD	591	5.3
VCG	BUR	600	4.5
MBOSS	EN	623	4.3
MVCG	DEN	618	4.3
CONTROL		617	3.0
Nonwords: example, HOLTER			
BOSS	HOLT	659	4.4
VCG	HOL	669	3.9
MBOSS	ER	713	3.8
MVCG	TER	698	4.4
CONTROL		726	5.6

[a]The parallel dotted lines have been omitted.
[b]Reaction time in milliseconds.

appeared to facilitate lexical decision, but there appeared to be little difference between them. Unlike Experiment 1, however, BOSS divisions had a slight advantage over VCG divisions.

On the other hand, it was clear that the Beginning Primes were appreciably better than the Ending Primes. The 25-millisecond advantage, for words, of the Beginning Primes (the average of BOSS and VCG) over the ending primes (the average of MBOSS and MVCG) and the corresponding 41-millisecond advantage for nonwords were both significant, $F'(1,27) = 16.59$, $p < .005$, and $F'(1,20) = 32.68$, $p < .005$, respectively. However, the average of BOSS and MVCG was not appreciably faster than the average of VCG and MBOSS, suggesting that there was little advantage in the presentation of the extra letter in the former case.

One aspect of the data which has not yet been considered is the larger priming effect for nonword stimuli than for word stimuli: the BOSS and VCG priming effects were on the average 21 milliseconds for words, but 62 milliseconds for nonwords. The interaction was significant for both BOSS primes and VCG primes, $F'(1,28) = 5.64$, $p < .025$, and $F'(1,27) = 7.35$, $p < .025$, respectively. The larger priming effect for nonwords was likely due in part to the greater overall reaction times for nonwords. Inspection of the nonword stimulus strings suggests the possibility that 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 to appear 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, $F'(7,100) = 2.11$, $p < .05$. 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" under the no-prime condition.

In Experiments 1 and 2 both BOSS and VCG syllables appeared to have some role in lexical access. First of all, the superiority of Beginning Primes over Ending Primes is consistent with the notion that a word is processed from left to right and that a beginning unit is an access code for the word. The superiority of both the BOSS and VCG divisions over the BOSS + 1 division suggests that a syllabically defined first unit is more likely to be an access code than a nonsyllabic first unit. However, the approximate equality of BOSS and VCG primes is obviously contrary to Taft's theory. This equality suggests two possible explanations. First, it could be that lexical access is being accomplished in parallel by two systems, one possibly involving orthographic structure and using BOSS codes and the other possibly involving phonological structure and using VCG codes. Alternatively, it could be that the access code is neither the BOSS nor VCG, but something partially confounded with both and producing the facilitation effects observed in Experiments 1 and 2.

Experiment 3

At this point, it would be useful to examine the assumptions motivating the BOSS hypothesis. The first assumption was that words sharing the same root morpheme are accessed through one entry in the internal lexicon. Evidence consistent with morphemic analysis in visual word recognition is plentiful (e.g., Taft & Forster, 1975; Taft, 1979a; Taft, 1981; Snodgrass & Jarvella, 1972). The second underlying assumption was that lexical access is achieved on the basis of a word's initial syllable (Taft & 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 a single access entry for morphologically related words whose relationship would be obscured by VCG syllabification. It was, however, necessary to include morphological criteria as well as orthographic criteria in the BOSS definition, so that, for example, the BOSS of NEARBY is NEAR rather than NEARB.

A troublesome aspect of both Experiments 1 and 2 was the small size of the effects, especially for words. Both experiments, like Taft's, employed monomorphemic words whose BOSSs were therefore determined solely by considerations of orthography. In these experiments, therefore, neither the BOSS nor the VCG have morphemic status, and no empirical tests have been provided either for 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). We decided to perform a third experiment, this time including polymorphemic words and various types of morphemic, syllabic, and nonsyllabic primes.

Experiment 3 employed three sets of words: (1) monomorphemic words like those used in Experiments 1 and 2, (2) inflected words (e.g., HUNTING, OLDER, FENCES, CROWDED) in which the morphemic boundary tends to coincide with the orthographically defined BOSS but not with the VCG, and (3) compound words (e.g., TEASPOON, HEADSTAND) where the morphemic boundary does not coincide with the orthographically defined BOSS, necessitating a BOSS defined morphologically (e.g., the orthographically defined BOSS of TEASPOON would be TEASP, not TEA). In addition to VCG and BOSS primes, we incldued primes ending one letter before the VCG (VCG − 1) and one letter after the BOSS (BOSS + 1) to test again whether the number of letters in a prime has any effect independent of the linguistic nature of the unit used. The difference between primes from the beginning portions of words and the ending portions seemed clear from the results of Experiment 2, so only beginning primes were employed in Experiment 3.

Experiment 3 also compared performance on two types of compound nonwords (word–word, such as SHIPSNACK, vs word–nonword, such as SUNKIB), in order to test Taft and Forster's (1976) claim that the presence of the second word in a word–word string does not cause interference in lexical decision because only the first constituent enters into lexical search.

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

Materials. A total of 300 letter strings were used. Three types of words were employed: monomorphemic, inflected, and compound. The 50 monomorphemic words were a randomly selected subset of the monomorphemic words used in Experiments 1 and 2. The mean frequency (Kucera & Francis, 1967) of this subset is 24.5. Fifty nonwords, most of them from the first two experiments, were also used.

The 50 inflected words were distributed as follows: 12 ended in *-er*, 13 ended in *-ing*, 12 ended in *-es*, and 13 ended in *-ed*. Inflected nonwords were constructed by combining an inflectional suffix with a word that would not normally take such a suffix (e.g., PERTING, RUNTER.) The mean Kucera and Francis frequency of these words is 25.7. The distribution of nonword suffixes was the same as the distribution of word suffixes.

The remaining 100 letter strings consisted of 50 compound words and 50 nonwords. The compound words have a mean Kucera and Francis frequency of 15.6. Half of the nonwords were constructed by combining two words which in conjunction do not form a legal English word (e.g., BOOKSALT, GRAINTRICK). The remaining nonwords begin with a word but end with a nonword (e.g., BANDSTIMP, TEADAKE).

Eighty-four practice stimuli were also employed, comprising an approximately balanced mix of monomorphemic, inflected, and compound words and nonwords. Stimuli are listed in the Appendix.

Design. Stimulus strings were presented under five different conditions, including four beginning prime conditions and the control condition in which no priming stimulus appeared. The sequence of events for an individual trial was the same as in Experiment 2; the prime appeared 90 milliseconds before the onset of the remainder of the letter string and dotted lines above and below the priming stimulus indicated the position and length of the entire letter string.

The exact nature of the four types of priming stimuli depended on the type of letter string (monomorphemic, inflected, or compound). Monomorphemic and inflected stimulus strings appeared under these four priming conditions: VCG − 1, VCG, BOSS, and BOSS + 1. For an inflected word, the BOSS division usually corresponded to its root morpheme. Compund words appeared under these four conditions: orthographically defined BOSS (oBOSS), morphologically defined BOSS (mBOSS), mBOSS − 1, and oBOSS + 1. For example, the primes for TEASPOON were TEASP (oBOSS), TEA (mBOSS), TE (mBOSS − 1), and TEASPO (oBOSS + 1). Thus, the mBOSS corresponds to the initial root morpheme of a compound word.

The 300 experimental letter strings were randomly assigned to 10 trial blocks, regardless of whether they were monomorphemic, inflected, or compound. As in Experiment 2, five subject groups were necessary, so that every letter string could appear in each of five conditions.

Apparatus. Apparatus was the same as in Experiments 1 and 2.

Procedure. The procedure was the same as in Experiment 2, except that subjects completed two practice trial blocks of 32 trials each, followed by 10 experimental trial blocks.

Results and Discussion

Although presentation of the letter strings was randomized, the three types of stimuli were analyzed separately since the items and priming conditions for the three types of stimuli were not strictly comparable. Mean reaction times and error rates are presented in Table 3. Reaction times exceeding a predetermined cutoff of 3000 milliseconds were discarded. As in Experiments 1 and 2, groups of subjects and items were averaged, resulting in 12 subject*s, 10 item*s for words, and 10 item*s for nonwords for each of the three types

TABLE 3
MEAN REACTION TIMES AND ERROR RATES FOR WORDS AND NONWORDS AS A FUNCTION OF PRIMING CONDITION (EXPERIMENT 3)

	Control	VCG − 1	VCG	BOSS	BOSS + 1
	Monomorphemic stimuli (Examples, GARDEN, FRAGEN)				
Words					
RT[a]	689	697	677	695	657
Percentage errors	1.8	3.7	5.2	3.7	3.2
Nonwords					
RT	807	770	741	742	729
Percentage errors	2.3	1.0	1.2	1.5	2.5
	Inflected stimuli (Examples: HUNTING, PERTING)				
Words					
RT	702	706	723	686	673
Percentage errors	1.5	4.3	5.5	5.0	3.8
Nonwords					
RT	908	862	831	862	829
Percentage errors	10.5	10.5	8.3	8.8	8.8
	Compound stimuli (Examples: TEASPOON, TEADOOR, BANDSTIMP)				
	Control	mBOSS − 1	mBOSS	oBOSS	oBOSS + 1
Words					
RT	738	730	687	753	723
Percentage errors	3.7	6.3	3.3	6.2	4.8
Nonwords					
RT	938	911	873	850	855
Percentage errors	3.3	2.7	2.7	2.5	2.5

[a]RT, reaction time: in milliseconds.

of stimuli. Reaction times were the data of primary interest and both subject*s and item*s were treated as random factors in the primary analyses.

The results for monomorphemic words did not agree with the results of Experiment 2. For nonwords, the VCG priming effect (66 milliseconds) and the BOSS priming effect (65 milliseconds) were both significant; $F'(1,20) = 21.88$, $p < .005$, and $F'(1,20 = 16.69$, $p < .005$, respectively. For words, however, the 12-millisecond VCG priming effect was not significant, and the BOSS "primes" actually led to reaction times 6 milliseconds slower than control reaction times; this negative priming effect was not significant. Furthermore, for both words and nonwords, the best prime of all was the BOSS + 1, although the only significant difference between VCG, BOSS, and BOSS + 1 primes was the BOSS + 1 advantage over the BOSS for words, $F'(1,20) = 9.58$, $p < .01$. (The BOSS + 1 advantage over the VCG for words was significant on the subject analysis, $F(1,11) = 7.59$, $p < .025$.) As in Experiment 2, words were faster than nonwords ($F'(1,16) = 28.53$, $p < .005$) and there was a priming condition by lexicality interaction ($F'(5,80) = 4.59$, $p < .005$) resulting from the larger priming effect for nonwords.

The pattern for the monomorphemic words is quite confusing. It seems that the effectiveness of the prime increases as its length in letters increases, except that the BOSS showed the *least* priming of all. This stands in contrast to the 26-millisecond BOSS priming effect found for words in Experiment 2. The results of Experiment 3 certainly argue against a unique role of the BOSS in lexical access.

In the case of inflected words, the root morpheme of the word coincided with the BOSS division in 28 of the 50 cases (e.g., HUNT-ING). The root morpheme coincided with the BOSS + 1 in 16 cases (e.g., FADED) and with neither the BOSS nor the BOSS + 1 in the remaining 6 cases (e.g., CLOSING). In no case did the root morpheme coincide with the VCG. While the VCG "primes" actually led to reaction times 21 milliseconds *slower* than the control words, the BOSS primes led to a 16-millisecond priming effect for word stimuli. The BOSS priming effect was not significant, however, and the 37-millisecond superiority of BOSS priming over VCG priming was significant only on the subject analysis ($F(1,11) = 6.95, p < .025$). As with the monomorphemic words, the BOSS + 1 was the best prime of all, and the BOSS + 1 was a significantly better prime than the VCG ($F'(1,17) = 7.98, p < .025$), but was not a significantly better prime than the BOSS. For nonwords, the VCG priming effect was 31 milliseconds faster than the BOSS priming effect ($F'(2,20) = 3.65, p < .05$), and only 2 milliseconds slower than the BOSS + 1 priming effect. The responses to words were much faster than those to nonwords for the inflected stimuli ($F'(1,16) = 95.88$, $p < .005$), and the larger priming effect for nonwords resulted in a significant interaction of priming conditions with lexicality ($F'(5,80) = 3.87, p < .01$).

Thus, there is some suggestion that the BOSS division is more helpful than the VCG division when it represents the root morpheme. However, as mentioned above, the BOSS prime was not always the entire root morpheme. Accordingly, a second analysis was performed, sorting the stimuli into three categories: BOSS = root morpheme, BOSS + 1 = root morpheme, neither = root morpheme (see Table 4). In this analysis, it is more obvious that the root morpheme is the essential priming ingredient. When the BOSS was the root morpheme, the BOSS prime had an 83-millisecond advantage over the VCG prime, $t(27) = 3.660$, $p < .002$, while when the prime BOSS + 1 was the root morpheme, there was only a 1-millisecond advantage of the BOSS prime over the VCG prime. Similarly, when the BOSS was the root morpheme, the BOSS prime was 34 milliseconds faster than the BOSS + 1 prime, $t(27) = 1.653$, $.20 > p > .10$, while when the BOSS + 1 was the root morpheme, the BOSS + 1 prime was 58 milliseconds faster than the BOSS prime, $t(15) = 2.978, p < .01$. (The significance was assessed in this post hoc analysis by computing the reliability over stimuli.) Moreover, the 92-millisecond reversal between the BOSS and BOSS + 1 primes, depending on which was the root morpheme, was also significant, $t(42) = 2.948$, $p < .01$.

The results for compound words seem consistent with the morphological BOSS hypothesis. The two priming conditions of the most interest were the morphemically defined BOSS (mBOSS) which corresponded to the first word of each compound word, and the orthographically defined BOSS (oBOSS) which passed the morphemic boundary. The mBOSS priming effect (51 milliseconds) was the largest effect of all for compound words, $F'(1,17) = 12.46, p < .005$, and the mBOSS primes led to a 66-millisecond superiority over the oBOSS "primes" ($F'(1,17) = 9.42$, $p < .01$). Thus it appears that in the case of compound words preview of the first morphemic unit led to faster lexical access than preview of the BOSS defined on orthotactic grounds alone. The mBOSS priming effect was 36 milliseconds faster than the oBOSS + 1, and this difference very nearly missed significance ($F'(1,20) = 4.31$, $p < .10$) although it was significant on both the item analysis ($F(1,9) = 10.26$, $p < .025$) and the subject analysis ($F(1,11) = 6.23$, $p < .05$). For the nonwords, both the mBOSS and the oBOSS were effective primes ($F'(1,20) = 19.37$, $p < .005$, and $F'(1,20) = 27.07, p < .005$, respectively). The oBOSS effect was not significantly larger than the mBOSS effect.

Two types of compound nonwords were in-

TABLE 4
MEAN REACTION TIMES FOR INFLECTED WORDS AS A FUNCTION OF STATUS OF THE BOSS OR BOSS + 1 AS THE ROOT MORPHEME

Condition	BOSS the root morpheme (e.g., HUNTING)	BOSS + 1 the root morpheme (e.g., RACES)	NEITHER a root morpheme (e.g., CLOSING)
Control	694[a]	721	690
VCG − 1	704	712	692
VCG	740	718	702
BOSS	657	717	740
BOSS + 1	691	659	648

[a]Mean reaction times in milliseconds.

cluded in Experiment 3: half of these nonwords consisted of two words (SHIPSNACK, TURNTRIBE) and half consisted of a word followed by a pronounceable nonword (SUNKIB, HILLSOSK). Taft and Forster (1976) reported that nonwords consisting of two words did not take longer to reject in lexical decision than nonwords consisting of a word and a pronounceable nonword. This result was seen as supporting the position that attempted lexical access for such nonwords is based solely on the first constituent morpheme and that the lexical status of the second constituent is therefore irrelevant to the process. It can be seen in Table 5, however, that the Taft and Forster (1976) finding of no difference between the two types of nonwords does not appear to be supported. For all five conditions, the word–word nonwords took longer and produced higher error rates than the word–nonword nonwords; the reaction time advantage for word–nonword nonwords was on average 78 milliseconds, and the average difference in error rates was 2.1%. The reaction time difference, although not significant on F' or on the item* analysis was highly significant on the subject* analysis, $F(1,11) = 92.62, p < .005$. The difference in error rates for the two types of nonwords was also significant only on the subject analysis, $F(1,11) = 12.92, p < .005$. The interaction of type of nonword with priming condition did not approach significance on any analysis. It can be concluded that at least for the compound nonwords used in this experiment, which on inspection seem comparable to those of Taft and Forster's (1976) Experiment 1, a nonword consisting of two words is more difficult to reject than one that only begins with a word, standing in disagreement with the Taft and Forster (1976) conclusion that only the first constituent morpheme enters into lexical access. The difference in reaction time for the two types of nonwords cannot be attributed to a difference in frequency of the first constituent word of word–word nonwords and word–nonword nonwords. The mean frequencies for the first constituents were 286 and 296 (Kucera & Francis, 1967), respectively. If anything, the slightly higher frequencies of the words in the word–nonword nonwords would have delayed, not hastened, the decision to reject such a nonword.

The pattern of error rates for the monomorphemic stimuli was as follows: There was a significant effect of priming condition ($F'(9,77) = 2.42, p < .05$) and a significant interaction of lexicality with priming condition ($F'(6,79) = 2.47, p < .05$). It appears that control nonwords had error rates as high or higher than primed nonwords, while control words had lower error rates than primed words. For inflected words, the only effect to reach significance was lexicality ($F'(1,16) = 12.31, p < .005$); nonwords had higher error rates than words. For compound words, no effects reached significance in the F' analysis of error rates, although the error rates were generally lower for the nonwords in all conditions; this effect reached significance only on the subject* analysis ($F(1,11) = 14.40, p < .01$).

TABLE 5
MEAN REACTION TIMES AND ERROR RATES FOR "WORD–WORD" NONWORDS AND "WORD–NONWORD" NONWORDS (EXPERIMENT 3)

	WORD–WORD nonwords (e.g., TURNTRIBE)		WORD–NONWORD nonwords (e.g., TEADAKE)	
Condition	Reaction time[a]	Percentage errors	Reaction time	Percentage errors
Control	977	4.6	901	2.0
mBOSS − 1	952	3.6	873	1.6
mBOSS	916	3.6	826	1.6
oBOSS	877	3.4	824	1.6
oBOSS + 1	901	3.6	810	1.4

[a]Reaction time in milliseconds.

GENERAL DISCUSSION

Monomorphemic Studies

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 Syllabic Structure, or BOSS, an initial syllable defined in terms of orthotactic and morphological factors rather than phonological factors. The VCG, in contrast to the BOSS, is a syllabic unit corresponding to phonology (Hansen & Rodgers, 1968). 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. Taft's critical finding, a superiority of BOSS-divided words over VCG-divided words, was clearly lacking in 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 the VCG boundary, over words divided one letter past their BOSS boundary. Therefore, although Experiment 1 argues against the unique status of BOSSs as lexical access codes, it does suggest that syllabic units defined orthographically, as well as syllabic units defined phonologically, may be involved in lexical access.

Another recent experiment employing internal division of letter strings has failed to replicate Taft's crucial RT advantage of the BOSS over the VCG. In their lexical decision study, Baldasare and Katz (1980) found no significant difference between BOSS-divided words and VCG-divided words, standing in empirical disagreement with Taft and agreeing with the present study. However, Baldasare and Katz did not find an advantage of syllabic division (BOSS or VCG) over nonsyllabic division in their uniform case condition, although they did find a syllabic division advantage under alternating case presentation (e.g., vIcT/iM). It should be mentioned that there are reasons to exercise caution in interpreting the results of Baldasare and Katz. First, reaction times were in general much greater than those in the experiments reported here and in Taft; second, error rates were not reported; and third, the design may have been quite insensitive since both type of stimulus division and case condition were between subjects variables.

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 responses than preview of a word's initial VCG. Both the BOSS and the VCG were effective priming stimuli relative to the no-prime control condition. Experiment 2 therefore refuted the hypothesis that a word is stored in the lexicon solely as a representation of its BOSS.

The priming stimuli leading to the fastest lexical decision responses were the Beginning Primes (BOSS or initial VCG), not the Ending Primes (the word minus its BOSS or the word minus its VCG.) The superiority of primes from the beginning of words is consistent with Taft's notion of a left-to-right parsing process and with the many studies which have suggested a processing bias favoring the beginning portions of words (e.g., Pillsbury, 1897; Bruner & O'Dowd, 1958; Broerse & Zwaan, 1966; Adams, 1979). Such a bias is not unexpected if a beginning portion of a word serves as its access code, and if a left-to-right process is involved in obtaining the access code.

Mewhort and Beale (1977) provided support for the hypothesis that VCGs are units in word perception. They 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 versus 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 results for monomorphemic words in Experiment 3 unfortunately do not agree with those found in Experiment 2; the BOSS primes in Experiment 3 led to no positive priming effect at all. Experiment 3, therefore, does not corroborate the suggestion in the results of Experiment 1 that syllabic units, defined either orthographically (BOSS) or phonologically (VCG), are more likely to be access codes than nonsyllabic units. The rationale underlying the two priming experiments (2 and 3) was that preview of an access code would lead to faster lexical decision times than preview of a word fragment that is not an access code. This line of reasoning would lead to the conclusion that BOSS + 1 units are more likely to be access codes than BOSSs or VCGs, and this conclusion does not seem particularly plausible. Alternatively, our priming paradigm may actually involve not one underlying process but two; in addition to facilitation at the stage of lexical access, there may also be facilitation at an earlier stage of letter identification, and this type of facilitation would indeed increase as the number of letters in the priming stimulus increased. Since the priming stimulus immediately preceded the stimulus word, this type of facilitation would be quite likely to occur, and it could therefore complicate the pattern of results even if syllabic codes are access codes. This two-process explanation may point out a difference between Experiment 1 and Experiment 3 with respect to the BOSS + 1 division. In Experiment 1, a word was internally divided by means of a space, but all the letters appeared simultaneously. The stage of lexical access was therefore adversely affected by the nonsyllabic (BOSS + 1) division, but no effect of the amount of letter information would be expected. In Experiment 3, however, the facilitation observed in the BOSS + 1 condition could be due to more letters being available in the priming stimulus.

It was suggested to us that the lack of a difference between the VCG and the BOSS conditions in Experiment 1 may have been artifactual. According to this argument, if the first segment is a word morphologically unrelated to the entire stimulus word (e.g., CAR BON), then lexical decision times may be slowed down. Since the BOSS was a word with slightly greater frequency than the VCG, this asymmetry would have worked against the BOSS division. (A similar argument could be made about the priming experiments.) To see whether this was the case, we reanalyzed the data for the monomorphemic words in all three experiments according to whether the VCG or BOSS of each stimulus string was itself a word (see Table 6). As can be seen from the table, there is no striking effect consistent with this hypothesis. The purest case occurs when neither the VCG nor the BOSS is a word. For these stimuli, the BOSS advantage over the VCG is 2, 18, and −10 mil-

TABLE 6
MEAN REACTION TIME ADVANTAGE OF BOSS AS FIRST UNIT OVER VCG AS FIRST UNIT AS A FUNCTION OF LEXICAL STATUS OF FIRST UNIT (MONOMORPHEMIC STIMULI ONLY)

	VCG a word (e.g., CARBON)	BOSS a word (e.g., STABLE)	Both are words (e.g., NOTION)	Neither is a word (e.g., RESCUE)
	a (b)	a (b)	a (b)	a (b)
Experiment 1	−17 (15)	5 (21)	−6 (5)	2 (51)
Experiment 2	−25 (15)	3 (21)	−36 (5)	18 (49)
Experiment 3	−22 (13)	1 (13)	−89 (4)	−10 (20)

Note. a = Reaction time for VCG as first unit or as priming stimulus minus reaction time for BOSS as first unit or prime. RT in milliseconds. (b) = Number of stimuli in this category.

liseconds for the three experiments, respectively. The data when the BOSS is a word look quite similar. The only effect that looks even suggestive in the table is that when the VCG is a word, it appears to facilitate lexical decision on the entire letter string.

Inflected Words and Compound Words

The data for the polymorphemic words demonstrate that a prime corresponding to a morphemic boundary tends to be facilitative relative to the no-prime condition. In the case of the compound words, preview of the BOSS defined morphologically (the first word of each compound word) led to faster lexical decision than the BOSS defined on orthotactic grounds. In the case of inflected words, the root morpheme tended to be the best prime, regardless of its status as a BOSS (as in HUNTING) or a BOSS + 1 (as in RACES).

An interesting finding of Experiment 3 was the long response times and high error rates for the inflected nonwords; these nonwords were constructed by appending an inflectional suffix to a word which does not actually form a word with that suffix (e.g., PERTING, RUNTER). Although a comparison across item sets is risky, the relatively high accuracy with which subjects classified *compound* nonwords like TEADOOR is striking, although the times for these nonwords were a bit longer than for the inflected words. The difficulty of processing the inflected nonwords may indicate that inflected words are stored in the lexicon in a different way than compound words. It may be that an inflectional suffix is not stored with a root morpheme in the same sense that a specific second root of a compound word is stored with its first root. The addition of inflectional suffixes to roots may, instead, be governed by rule.

The experiments reported here argue against the claim by Taft (1979b) that all words, including monomorphemic words, are accessed on the basis of their BOSS. Experiment 3 did suggest a role of BOSSs in lexical access for polymorphemic words in which the BOSS coincides with the initial morpheme. However, when the purely orthographically defined unit was longer than the first morpheme, the morphemic unit prevailed. This conforms with Taft's stipulation that when the BOSS defined on purely orthographic grounds bypasses the morphemic boundary, the BOSS is then defined as the first morpheme. In the case of monomorphemic words, the BOSS can be defined on the grounds of orthography alone. Experiment 1 suggested that the initial VCG of a monomorphemic word is as likely to be an access code as its BOSS, and that both of these types of beginning syllables are more likely access codes than nonsyllabic units. However, there was a total lack of evidence for a unique role of purely orthographically defined syllabic units in lexical access. (Experiment 2 also failed to find a superiority of BOSSs over VCGs.) It may be the case that syllabic units are helpful in lexical access, but Taft's claim that the only lexical representation of a word is its BOSS seems unconvincing in light of these studies.

APPENDIX

List of Word Stimuli, Experiments 1 and 2

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, Experiments 1 and 2

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

List of Stimuli, Experiment 3

Monomorphemic stimuli

Words

NOTION	SELDOM	HARMONY	FINANCE
BASKET	MARBLE	PARLOR	TEXTILE
FOCUS	MYSTERY	WHISKEY	CANDLE
HUMBLE	CYCLE	STUPID	FIBER

POWDER
FORTUNE
CUSTOM
NOBLE
RESCUE
GENTLE
DESTINY
ORBIT
PUPIL
GESTURE
STADIUM
FURNISH
RADAR
FLAVOR
CIRCUIT
VIRTUE
CLIMATE
EMPIRE
LABEL
SHELTER
STUDIO
MUSTARD
LICENSE
CRYSTAL
BUNDLE
AMPLE
SINCERE
FANTASY
GENIUS
SPLENDID
CARBON
PROTEIN
STABLE
RANDOM

Nonwords

MASPURE
SILPONTH
CRODAR
OMPIE
ELMIN
RALBANCE
RINDOL
MAPION
FOBAL
CARTISP
GLASTID
CHASPELLAN
SHRIDLE
GANSIC
FRAGEN
PRANSON
AMPOW
CALTAIN
SELPERNT
HIRNOLD
PROLAR
MARDITY
SUNAL
LUBAN
SPOTIND
FRIMPON
RIBEN
LASKIP
DEABERY
MASCOLP
FOSPAGE
GILBONT
BURNIP
TALSTIC
WROPENT
FARGEL
STORPIT
NATEN
MOOLITE
CHIMBER
BLUNDIN
FRESTID
SAPTYN
NARGEN
CORFIST
VARNET
HEMPLE
PITLE
FLENDIN
PRINDARL

Inflected Stimuli

Words

HUNTING
WIDER
HATED
QUOTED
SOFTER
FASTER
RACES
PAINTED
LANDING
FEEDING
BINDING
SERVING
SWEETER
BASES
DARKER
SENDING
CLOSING
SHORTER
VOTING
SEATED
CROWDED
GREETED
PARKING
CAMPING
OLDER
SHAKING
RISES
HIDING
RESTED
PHASES
DANCES
FADED
LARGER
LOSES
BEACHES
CHANCES
FIRMER
TENDED
HARDER
DEEPER
CHEAPER
SHIFTED
GUIDED
FENCES
REACHES
RAISES
ACTED
PAGES
SPENDING
HOPING

Nonwords

CARSES
ARTING
SINCES
RUDING
BADED
BRIDER
STOUTED
DRIPER
CURTED
FANSES
FLATSES
NICES
FORTER
RUNTER
PERTING
BOLDING
CLOTED
HAMING
COTED
WEPTING
HOTED
COWSER
FROZES
GUNSES
HELDER
FOODING
CATED
FLOPER
BUNSES
FLINTING
RINDED
LINTER
VASING
BRIMSES
LOTED
SCARFER
PLODER
SILTER
FURSES
QUIPING
COLTED
WARTER
MOPSES
HUTED
RIGING
PADED
SLEPTING
MADING
HILTING
BEATSES

Compound Stimuli

Words

AIRPLANE
NEARBY
BANDSTAND
MAILMAN
BARTENDER
SEASHORE
TEARDROP
MANPOWER
WORKSHOP
MILKSHAKE
GRANDSTAND
OFFSET

AIRPORT	GEMSTONE	HAIRCUT	MAINSTREAM
FOOTSTEPS	CHAIRMAN	SEASHELL	ARMPIT
AIRCRAFT	TURNPIKE	HANDSHAKE	HILLSIDE
SUNSET	SKYLIGHT	MOONSHINE	DOWNTOWN
NOBODY	HAILSTORM	GUNPOWDER	BLACKSMITH
SWEETHEART	NUTSHELL	HALFTIME	CHARCOAL
DOWNSTAIRS	HEADSTAND	MYSELF	UPSET
BOOKSHELF	UPSTAIRS	SUNSHINE	TEAPOT
BLOODSHOT	INPUT	MANKIND	WARFARE
GRANDSON	TEASPOON		

Nonwords

Word–Word

HARDSMALL	MANTOWN	NOLEAP	CARDRINK
SHIPSNACK	FANTRUST	UPSIN	TEADOOR
BOOKSALT	BANDSHELF	HILLTIME	HEARBE
GRAINTRICK	NAILSTRIDE	WOOLTRIP	CARDSNAIL
MEALPARK	MAILDIME	GEARFUN	SANDSTAMP
AIDSNAIL	TURNTRIBE	HALFTRAMP	MOONDRESS
SUNSAP			

Word–Nonword

SUNKIB	HEARPO	AIDSNOVE	BANDSTIMP
GEARFOT	CARDSOGH	TURNTHESS	FANTRAME
NOLEKE	MAILTREL	BOOKSELT	WOOLGRON
MOONDROZE	CARPRAND	SHIPSLAGE	GRAINDRISP
HILLSOSK	MANTORD	HARDSNEAD	TEADAKE
HALFTEASH	UPSOL	NAILSTRONK	SANDSPEFT
MEALBLIN			

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