Abstract. In a naming task conducted with bi-alphabetic readers of Serbo-Croatian, it was shown that letter strings that can be assigned both a Roman and a Cyrillic alphabet reading incur longer latencies than the unique alphabet transcription of the same word, and that the magnitude of the difference depended on the number of ambiguous characters in the ambiguous letter string. While this within-word phonological ambiguity effect obtained for both words and pseudowords, it was more consistent with words. The same pattern of results occurred in a lexical decision task, and the correlation between latencies (for words and pseudowords) in the two tasks was significant. It was concluded that both lexical decision and naming in Serbo-Croatian necessarily involve a phonological strategy.

INTRODUCTION

Alphabetic Writing Systems: The Legacy of a Phonographic Orthography

Writing systems differ in terms of the units with which they transcribe the spoken language. Logographies such as Chinese and Japanese Kanji have characters that correspond to words or morphemes. Japanese Kana and Hebrew are examples of (approximately) syllabic orthographies where each character of the written language corresponds most closely to a syllable unit (Gelb, 1952). Perhaps the most complex orthographies to learn are alphabetic, where words are transcribed by phonemes that are abstract units relative to the syllable and the word (Mattingly, 1972). Both the syllabary and the alphabet are phonographic orthographies where the characters that comprise the written form correspond most closely to segments of speech. In the evolution of writing systems based on the spoken language, the introduction of a phonographic principle represents greater complexity as it exploits the abstract relation between orthographic characters that comprise the word and the word as spoken.

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Consequently, this suggests greater demands on the analytic capabilities of the reader. The benefits, however, would appear to compensate the disadvantages: As far as mastering a written vocabulary, the phonographic principle reduces the task of learning and recognizing new word forms (Gibson & Levin, 1975; Gleitman & Rozin, 1977).

Among alphabetic systems, the depth of the orthography and the relation between the written and spoken forms may vary. Written Serbo-Croatian respects a phonographic principle fully, retaining a very consistent relation between (classical) phoneme and grapheme. In contrast, the graphemes and phonemes in English are less direct and more variable in their mapping: English graphemes tend to represent (systematic) phonemes or morphophonemes. The consequence of this systematicity at the morphophonemic level is that for many words of English, the orthographic form does not directly specify the surface phonetic form. (For example, the morphological relationship of "HEAL" to "HEALTH" is captured in the written form of the words, while the specification of the differing vowel sounds is sacrificed.) In addition, the letter-sound correspondences are variable in English, as there are many exception words (e.g., "HAVE" versus "SAVE"). In general, theories of word recognition and reading have been described for English and have accommodated the idiosyncracies of the English orthography into an account of the strategies for word recognition. The present studies constitute an attempt to evaluate the word recognition strategies delineated for English when they are applied to the phonologically shallow orthography of Serbo-Croatian.

For alphabetic orthographies, a reader may derive a word's phonological form in one of three ways. Two of these may be termed both phonological and word-nonspecific, and one may be termed visual and word-specific. The two varieties of phonological word-nonspecific strategies are analytic in that they exploit the phonographic principle that relates the written form to the spoken form. Consequently, they can apply equally to both words and pseudowords and proceed independently of word-specific knowledge. Exploiting general grapheme-phoneme correspondence rules (Venezky, 1970) that abstractly map between print and speech is one possible strategy, and it will work successfully for any letter string that does not violate the correspondence rules. These mapping rules analyze independent grapheme units (Gough, 1972) or functional graphemes (Gibson, 1962, 1970) in order to arrive at a phonological description. Therefore, to the extent that the generation of a phonological code is the sole determiner of response time, recognition latencies for words and for pseudowords with similar orthographic structure should be equal, and latency should be a function of the number and complexity of independent graphemic units.

A second phonologically analytic, word-nonspecific strategy proposed minimizes the importance of individual grapheme-phoneme correspondences and promotes procedures involving the coordination and synthesis of several phonological representations (each of which may be a multi-letter unit). Here, the phonology of a letter string is derived by a process of (automatic) analogy based on its orthographic similarity to other strings of letters (Glushko, 1979, 1981). Pseudowords and words are pronounced by analogy with the same multi-letter units, termed orthographic neighborhood, as they occur in other real words rather than by application of context-insensitive letter-sound correspondence rules. In general, the two phonological, word-
nonspecific strategies subsume both words and pseudowords as they are analytic and, therefore, do not depend on the familiarity of particular lexical entries. To the extent that a phonological strategy is neutral with respect to lexical status of a letter string in a reading task, no interactions of lexicality with phonological variables are predicted. In general, evidence of phonological strategies is weak with real words that are exceptions to the grapheme-phoneme correspondence rules, that is, words such as "SWORD" or "TONGUE," but this may reflect how "regular" and "exception" words are defined (Glushko, 1979; Bauer & Stanovich, 1980). Nevertheless, for pseudowords and for words that are regular and obey the correspondence rules, either phonological strategy is always adequate.

The third strategy distinguishes among letter strings on the basis of their lexical status and the regularity of their letter-sound correspondences. This strategy is visual and word-specific (or morpheme specific, see Taft, 1979) and it entails a lexical look-up by which the reader goes from some aspect of the written form to an entry in the internal lexicon. Only in the lexicon is a phonological representation (as well as a phonetic representation) adequately specified for a particular word or sequence of morphemes. Within the lexicon, entries are organized and searched according to their frequency of occurrence and, within this strategy, response time is based on the ease of identifying a familiar visual form as an instance of a particular lexical entry. As a result, a strong correlation between reaction time and word frequency is usually interpreted as evidence of a lexical contribution to recognition (e.g., Rubenstein, Garfield, & Millikan, 1970).

By a word-specific strategy, the essential part of the letter string is treated holistically, or at least not analytically in any phonographic sense. (In some accounts, e.g., Taft [1979], the letter string must be freed of affixes or nonessential segments. It is not always obvious how this procedure would operate given that the distinction between an essential and a nonessential letter sequence may require word-specific knowledge.) This strategy encompasses real words, both regular and exceptions, but it cannot apply to the reading of pseudowords, as a search of the lexicon would fail to locate an entry for them. To complement this strategy, one of the two word-nonspecific procedures need be introduced. This supplementary strategy is indistinguishable in kind from either of the phonologically-analytic word-nonspecific strategies described above, but since it is only used when the visual, word-specific strategy fails, it is only implemented for pseudowords.

In summary, in word recognition and reading, the phonologically analytic word-nonspecific strategies of grapheme-phoneme conversion or (automatic) analogy can be applied both for regular words and for pseudowords as they exploit a phonographic principle that is analytic and does not focus on particular lexical entries. The lexical strategy is not phonologically analytic. Because it is tied to a specific word's visual form, it can only succeed for real words. As the word-specific strategy is limited in effectiveness, it must be complemented sometimes by a phonological strategy. Whereas a word-specific strategy need not be sensitive to component orthographic structure or to phonological complexities, the effectiveness of a phonological strategy may depend on the lexical status of a letter string. There is empirical evidence that subjects have the option to alter the balance of recognition strategies according to the nature of the letter strings and the experimental task and that, at least in English, it is the relative
Evidence for a Phonological Recognition Strategy in English

In the literature on word recognition based on English, there are three sources of support for a phonological recognition strategy, although all are subject to frequent criticism: (1) effects of orthographic structure; (2) adherence to grapheme-phoneme correspondence rules; (3) effects of homophony. The nature of a strategy that exploits a phonographic principle implies the importance of orthographic structure to the processes of word recognition. In general, naming latency is sensitive to number of letters for both words and pseudowords, while in lexical decision, this structural variable is only important for pseudoword performance (Frederiksen & Kroll, 1976; Forster & Chambers, 1973). Likewise, the complexity and position of consonant clusters significantly affects naming but not lexical decision times (Frederiksen & Kroll, 1976). When naming protocols differ from lexical decision protocols, logical task requirements are generally invoked: where lexical decision requires specific word knowledge, naming may proceed independent of the lexicon (Baron, 1977; Coltheart et al., 1979). As a result, phonological effects demonstrated only in the naming task do not provide convincing evidence of a phonological recognition strategy.

With other factors controlled, time to decide that a letter string is a word (lexical decision) is generally shorter for those regular words that comply with grapheme-phoneme correspondence rules (Venezky, 1970) than for words that are exceptions to those rules (Baron & Strawson, 1976; Edgmon, cited by Gough & Cotsky, 1977; Stanovich & Bauer, 1978; Barron, 1978). Similarly, when grapheme-phoneme regularity is redefined in terms of the consistency of an orthographically specified neighborhood (Glushko, 1979, 1981), words from phonologically consistent neighborhoods are recognized faster in lexical decision than are words from phonologically inconsistent neighborhoods (Bauer & Stanovich 1980). Here, it is assumed that only when the grapheme-phoneme correspondences are consistent and regular is a phonologically analytic strategy appropriate. If recognition were exclusively dependent on the lexicon, then as long as word frequency were controlled, regular words should not be faster than exception words. The assumption here is that regular words are faster than exception words because there is an advantage to operating a frequency-sensitive word-specific strategy and a phonologically-analytic word-nonspecific strategy together.

Early support for a phonological strategy was derived from the detriment to performance on lexical decision with word homophone letter strings such as weak/week and pseudoword homophone strings such as burd and blud (Rubenstein, Lewis, & Rubenstein, 1971). Later replications (Coltheart, Davelaar, Jonasson, & Besner, 1977) found that the effect of homophony was tied to lexical search in that it only occurred for the lower frequency word in the homophonic pair and that the visual similarity of the pseudoword (but not the real word) to other real words affected reaction time. (Similarity was defined by how many words could be produced by changing any one letter in the pseudoword.) Generally, the detriment due to homophony, as evidence of a phonological strategy, is more robust for pseudowords than for words. As Coltheart et al. (1977) point out, however, the failure to find effects of
homophony for words indicates that possible lexical entries are not both searched in a serial fashion (from high to low frequency) and phonologically specified. Alternatively, failure to demonstrate evidence of a phonological strategy might reflect readers' skill level or the constraints on strategy imposed by the experimental task.

From a developmental perspective, good beginning readers were slower with pseudoword homophones than with control items, while poor readers performed equally with both types of letter strings (Barron, 1978). While poor readers may never employ a phonological analysis, skilled readers can use a phonological recognition strategy, although it is optional and may be suppressed when necessary. With skilled readers, a detriment to performance does occur for the lower frequency homophone word (e.g., altar, beech) when the accompanying pseudowords are not homophones of real words (e.g., slint). If the pseudowords are homophones of real words, however (e.g., brane, brume), then subjects can suppress a phonological strategy (Davelaar, Coltheart, Besner, & Jonasson, 1978; McQuade, 1981).

The effect of homophony, like the influence of phonological consistency in orthographic neighborhoods, is often treated as a post-lexical condition, resulting from a mismatch between a letter string and one (or several) lexical entries (Bauer & Stanovich, 1980). This account assumes an interference due to the inconsistent phonological descriptions provided by different (word-specific) lexical entries. It is not necessary that the knowledge structure of plausible phonological interpretations for multi-letter units be word-specific, however. And, to the extent that these phonological effects occur among pseudowords, they cannot be lexically derived.

In most conceptualizations, the strategies operate simultaneously and interdependently with the assumption that either of the phonological strategies generally acts more slowly than the word-specific strategy. Thus, the latency difference between words and pseudowords is explained: Responding by a visual strategy, an option that is only viable for words, will be faster than responding by a phonological strategy, such as would be necessitated by pseudowords (e.g., Meyer, Schvaneveldt, & Ruddy, 1974; Coltheart et al., 1977; Coltheart et al., 1979). Likewise, phonological effects will be more easily demonstrated with pseudowords than with words.

For words in English, Coltheart et al. (1979) have claimed that the phonological strategies are always optional, but the word-specific visual strategy is sometimes mandatory. From the perspective of task, this word-specific strategy is not necessary for naming, while the phonological strategies may or may not contribute to lexical decision. Henderson (1977) has claimed that the participants in the reading debate have not adequately considered the preservation of morphology in the orthography (but see Taft & Forster, 1975). In support of this, there is a suggestion that within the experimental setting, the number of morphemes in a word affects recognition strategy (Rubin, Becker, & Freeman, 1979). All of the studies on word recognition mentioned above were conducted in English, but it is possible that some of these results reflect peculiarities of English and do not apply to reading in other languages. It therefore becomes essential to test the dominant theory of word recognition and reading in languages that differ from English in the relation between phonology, morphology, and the written form.
Serbo-Croatian: A Phonologically Shallow Orthography

In contrast to the English orthography, which tends to be morphophonemic in its referent (Chomsky, 1970), the writing system of Serbo-Croatian preserves a very close relation to (classical) phonemics and reveals morphological relatedness only when the phonology is similar. In Serbo-Croatian, all similar orthographic patterns will sound alike. Even fully systematic phonological alternations in surface forms are represented in the orthography so that visual or orthographic similarity of morphologically related forms may be obscured; for example, nominative singular RUJK+A, dative singular RUIC+I; nominative singular SNAH+A, dative singular SNASIC+I. (Note: Inflection is the major grammatical device of Serbo-Croatian. The preceding are Roman transcriptions of the English words, ARM and DAUGHTER-IN-LAW, respectively.) In addition, as a result of the tendency toward open syllables, the possible patterning of consonants and vowels is much more restricted in Serbo-Croatian than in English. Not only do the orthotactic (Taft, 1979) rules fully mimic the phonotactic rules, but the possibility for ambiguous syllable boundaries due to sequences of consonants is greatly reduced.

The depth of an alphabetic orthography is reflected by the extent to which the spoken form is specified by the orthographic form: That is, by the complexity of the derivational rules that relate the orthographic transcription to some (abstract) description appropriate for speaking. A deep orthography with a complex relation to the spoken form may induce a word-specific strategy that avoids the derivations. In English, the complex relation between written and spoken form is increased because, historically, the written form and the speech form have not evolved in the same way. Therefore, the graphemic transcription often does not correspond exactly to the phonology and this could influence recognition strategy.

In comparison with the derivational rules for English, Serbo-Croatian has maintained a close correspondence between the written and spoken forms. This is the outcome of deliberate alphabet reforms introduced by Karadžić and Gaj in the last century that reconstructed the Roman and Cyrillic alphabets in which the Serbo-Croatian language is written according to the simple rule: "Write as you speak and speak as it is written." As a result, the Roman and the Cyrillic orthographies transcribe the sounds of the Serbo-Croatian language in a direct and consistent manner, and there are no (nontrivial) derivational rules. In summary, the orthography is shallow and there are no exception words in Serbo-Croatian. Consequently, a word-specific strategy would never be required.

Since the Roman and Cyrillic alphabets transcribe the same language, their graphemes must map onto the same set of phonemes. These two sets of graphemes are, with certain exceptions, mutually exclusive (see Table 1). Most of the Roman and Cyrillic letters are unique to their respective alphabets. There are, however, a number of letters that the two alphabets have in common. The phonemic interpretation of some of these shared letters is the same whether they are read as Cyrillic or as Roman graphemes; these are referred to as common letters. Other members of the shared letters have two phonemic interpretations, one in the Roman reading and one in the Cyrillic reading; these are referred to as ambiguous letters (see Figure 1).
<table>
<thead>
<tr>
<th>ROMAN</th>
<th>CYRILLIC</th>
<th>LETTER NAME IN I.P.A.</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRINTED UPPER CASE</td>
<td>PRINTED LOWER CASE</td>
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<tr>
<td>A</td>
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<td>lj</td>
<td>ЛЈ</td>
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</table>

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Figure 1. Letters of the Roman and Cyrillic alphabets.
Given the nature of and the relation between the two Serbo-Croatian alphabets, it is possible to construct a variety of types of letter strings. A letter string of uniquely Roman and common letters or of uniquely Cyrillic and common letters would be read in only one way and could be either a word or nonsense. A letter string composed of the common and ambiguous letters could be pronounced in one way if read as Roman and pronounced in a distinctively different way if read as Cyrillic; moreover, it could be a word in one alphabet and nonsense in the other or it could represent two different words, one in one alphabet and one in the other, or finally, it could be nonsense in both alphabets (see Table 2).

Whatever their category, the individual letters of the two alphabets have phonemic interpretations that are virtually invariant over letter contexts. Moreover, all the individual letters in a string of letters, be it a word or nonsense, are pronounced—there are no letters made silent by context. Finally, but not least in importance, a large portion of the population uses both alphabets competently. This is due, in part, to an education requirement that both alphabets be taught within the first two grades. The Roman alphabet is taught first in the western part of Yugoslavia and the Cyrillic alphabet is taught first in the eastern part of Yugoslavia.

In sum, the Serbo-Croatian orthography relative to the English orthography permits less variability in its orthotactic patterning relative to phonotactic patterns, but more variability in the written form of some base morphemes. It is less concerned with preserving morphological relatedness and closely relates to the spoken language. The depth of an orthography reflects the extent to which the phonetic rendition is specified by the orthographic form: Serbo-Croatian is characterized as a shallow orthography.

Word Recognition in Serbo-Croatian

The complex relation between letter and sound in English reflects its phonologically deep orthography and the opaqueness of this relation is offered as a reason why phonological involvement in the fluent reading of English is not efficient (Goodman, 1976; Kolers, 1970; Smith, 1971). This reasoning would not preclude a phonological strategy in the fluent reading of Serbo-Croatian, however. Due to the systematic relation of graphemes and phonemes, in principle, a reader of Serbo-Croatian could arrive at a phonological description of a word correctly without ever relying on knowledge about the specific word. Differences among orthographies in structure and in phonological depth may influence reading strategies, in which case a model of word recognition delineated for English may prove inadequate when applied to Serbo-Croatian.

The shallow character of the Serbo-Croatian orthography rationalizes a phonological priority relative to a word-specific priority in reading and word recognition and there is empirical support for this claim. In Serbo-Croatian, an effect detrimental to performance on lexical decision with phonologically bivalent grapheme strings was demonstrated for words (Lukatela, Savić, Gligorijević, Ognjenović, & Turvey, 1978) and later, for both words and pseudowords (Lukatela, Popadić, Ognjenović, & Turvey, 1980). In the earlier experiment, both the design of the experiment and the instructions to the subjects were selected to restrict the task to the Roman alphabet, but subjects were unable
Table 2
Types of Letter Strings and Their Lexical Status

<table>
<thead>
<tr>
<th>Composition of Letter String</th>
<th>Phonemic Interpretation</th>
<th>Meaning</th>
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</thead>
<tbody>
<tr>
<td><strong>AMBIGUOUS and COMMON</strong></td>
<td></td>
<td></td>
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<tr>
<td>CABAHA*</td>
<td>Cyrillic /savana/</td>
<td>savanna</td>
</tr>
<tr>
<td></td>
<td>Roman /tsabaxa/</td>
<td>nonsense</td>
</tr>
<tr>
<td></td>
<td>Cyrillic /kovas/</td>
<td>nonsense</td>
</tr>
<tr>
<td>KOBAC</td>
<td>Roman /kobats/</td>
<td>hawk</td>
</tr>
<tr>
<td>KACA</td>
<td>Cyrillic /kasa/</td>
<td>safe</td>
</tr>
<tr>
<td></td>
<td>Roman /katsa/</td>
<td>pot</td>
</tr>
<tr>
<td>HEPETAC*</td>
<td>Cyrillic /neretas/</td>
<td>nonsense</td>
</tr>
<tr>
<td></td>
<td>Roman /xepetats/</td>
<td>nonsense</td>
</tr>
<tr>
<td><strong>COMMON</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>JAJE</td>
<td>Cyrillic /jaje/</td>
<td>egg</td>
</tr>
<tr>
<td></td>
<td>Roman /jaje/</td>
<td>egg</td>
</tr>
<tr>
<td>TAKA</td>
<td>Cyrillic /taka/</td>
<td>nonsense</td>
</tr>
<tr>
<td></td>
<td>Roman /taka/</td>
<td>nonsense</td>
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<tr>
<td><strong>UNIQUE and COMMON</strong></td>
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<tr>
<td>SAVANA*</td>
<td>Cyrillic impossible</td>
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<tr>
<td></td>
<td>Roman /savana/</td>
<td>savanna</td>
</tr>
<tr>
<td>NERETAS*</td>
<td>Cyrillic impossible</td>
<td>nonsense</td>
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<td></td>
<td>Roman /neretas/</td>
<td>nonsense</td>
</tr>
<tr>
<td>KOBAC</td>
<td>Cyrillic /kobats/</td>
<td>hawk</td>
</tr>
<tr>
<td>PUDAJ</td>
<td>Cyrillic /pudal/</td>
<td>nonsense</td>
</tr>
<tr>
<td></td>
<td>Roman impossible</td>
<td></td>
</tr>
</tbody>
</table>

(*indicates those letter string types included in the present experiment)
to suppress a Cyrillic alphabet reading when the letter string permitted one. In the later experiment (Lukatela et al., 1980), no alphabet restriction was imposed. This detriment could be interpreted as either a (visual) alphabet or a phonology-induced ambiguity. Because the phonological bivalence of those ambiguous graphemes should exert no influence on visual matching and because those words composed of shared characters with a common phonemic value in both alphabets were no slower than pure Roman strings, it was concluded that for the phonologically shallow orthography of Serbo-Croatian, lexical decision always proceeds with reference to phonology. Not only was the effect replicated for pseudowords (Lukatela et al., 1980), but the influence of phonological bivalence on words occurred both when the alternate reading produced a word or a pseudoword (Lukatela, Savić, Gligorijević, Ognjenović, & Turvey, 1978). Therefore, this effect is not easily characterized in terms of the differing lexical status of the alternate reading. In that experiment, however (Lukatela, Savić, Gligorijević, Ognjenović, & Turvey, 1978), subjects responded positively only to those letter strings that were words in Roman. Therefore, words in Cyrillic, as well as all pseudowords, required a negative response. A better test of the influence of lexical status of the alternate readings is currently underway (Feldman, Note 1).

The present work continues to investigate whether the phonological coding strategy for word recognition is optional in the phonologically shallow orthography of Serbo-Croatian. In the original bivalent phonology experiments (Lukatela, Savić, Gligorijević, Ognjenović, & Turvey, 1978; Lukatela et al., 1980), different words occurred in the phonologically unique and phonologically bivalent conditions. Therefore, the effect of phonological bivalence was assessed between words. Although word frequency range was balanced across conditions, the effect of a unique or a bivalent phonology was measured on different letter strings. In sum, evidence for a phonological recognition strategy for lexical decision on words has been demonstrated for Serbo-Croatian by comparing between different word types. In the present experiment, the internal orthographic structure of the letter string was constructed in such a way that the punitive effect of phonological coding could be assessed within (two forms of the same) words for both the naming and lexical decision tasks.

As discussed above, there are two possible strategies or codes by which access to the lexicon or the process of word recognition can occur. If, as sometimes implied for English, there is only one phonological code and if this phonological description is lexically derived such that word identification must rely on some familiar visual form or an unanalyzed pattern, then word recognition should be independent of phonological factors and be closely tied to a holistic orthographic form. In this case, effects of phonological variables should not impair (or facilitate) word performance on linguistic tasks such as lexical decision. This word-specific strategy is differentially effective according to lexical status. For words, either the word-specific strategy or its secondary phonological strategy could operate in principle. For pseudowords, however, a phonological strategy is the only possibility, as the pseudowords are not familiar and have not been encoded previously. As a result, a word-specific strategy would predict that variables that introduce phonological complexity should have a greater effect on pseudowords than on words (see Coltheart, 1978).
To the extent that phonological strategies are sensitive to the components of orthographic structure and to the position of phoneme clusters within the letter string (Frederiksen & Kroil, 1976), the impairment due to phonological bivalence should vary as a function of the number and distribution of ambiguous characters within the letter string. In a recent experiment (Feldman, Kostić, Lukatela, & Turvey, 1981, this volume), overall effect of a phonologically bivalent sequence of letters could be alleviated if a unique letter appeared in the final position. In addition, and more important to the present investigation, in a fully ambiguous string the magnitude of the impairment depended on the number of ambiguous characters. In that experiment, all comparisons were within words in that they were made on the difference between the ambiguous and unique readings of the same word (or morpheme-based unit). Therefore, there was no contamination due to word frequency, word length, or richness of meaning. While there is evidence that skilled readers in Serbo-Croatian exploit syllable units (Katz & Feldman, 1981), in the experiment reported by Feldman et al. (1981), number of ambiguous letters was confounded with number of ambiguous syllables and all letter strings had two syllables.

In the present experiment, the within-word effect of phonological bivalence on naming was investigated and the effect on lexical decision was replicated. If phonological bivalence impairs performance for both words and pseudowords, then these results would suggest that a phonological strategy is mandatory regardless of the lexical status of the letter string. If the impairment due to phonological bivalence is greater for words than for pseudowords, then the notion of a phonological strategy employed only as the complement of a word-specific strategy is invalid. If the effect obtains for naming as well as for lexical decision such that a correlation is obtained between latencies in the two tasks, then a common knowledge structure must participate in both tasks. And, if the effect of phonological bivalence varies with the number or position of the ambiguous letters within the string, then a phonographically analytic phonological strategy must be operative.

METHODS

Subjects

Sixty-two first year students of psychology at the University of Belgrade participated in this study in partial fulfillment of course requirements. Twenty-eight subjects performed lexical decision judgments and thirty-four subjects performed a naming task. Subjects were eliminated from the study if their error rate exceeded 10%. This occurred with six subjects in the naming portion. In all, there were 56 subjects, 28 in each task, whose data were included in the statistical analysis.

Stimuli

Each subject viewed 246 slides, which included 30 practice trials. Half of the letter strings were words and half were pseudowords that were actually derived from other real words by changing two or three letters in the latter portion of the letter string. Half of the items contained two syllables (with five or six letters) and half contained three syllables (with six or seven
letters). All words were nouns in the mid-frequency range as judged by
consensus among several native speakers. Each subject saw three types of
words and pseudowords defined by the manner in which they were presented
across subject groups. CONTROL items were printed in Roman for both groups of
subjects, e.g., MUZIKA. PURE items were printed in Cyrillic for half the
subjects (Group One) and in Roman for the other half (Group Two). These PURE
letter strings contained characters that are unique to an alphabet (either
Cyrillic or Roman), in both their Roman and their Cyrillic transcriptions.
The third type were AMBIGUOUS items, chosen such that they contain only common
and ambiguous characters in the Cyrillic rendition. In contrast, in the Roman
version, these letter strings contain characters that are unique to the Roman
alphabet. As a result, the Cyrillic form permits two different readings while
the Roman form specifies a unique reading. Within the ambiguous letter
strings, number and position of ambiguous characters were systematically
varied. For the three syllable items, two or three ambiguous characters were
distributed over two or three syllables. For the two syllable items, one or
two ambiguous characters were distributed over one or two syllables (see Table
3).

Procedure

Twenty-eight subjects performed a lexical decision task. As each word
appeared, they had to tap a key with both hands to indicate "yes" (further
key) or "no" (closer key), in deciding whether or not each stimulus was a
word. The other twenty-eight subjects performed the naming task. That is,
y they had to read each word aloud as rapidly as possible. All stimuli were
typed on Prima U Film and the Cyrillic and Roman typeface were closely matched
for size and form. (Common characters were identical in the two typefaces.)
In contrast to the lexical decision task, responses in the naming task were
timed with a voice-operated relay that began counting with the onset of the
visual display.

In the instructions for lexical decision, subjects were informed that
words would appear both in Roman and in Cyrillic. During the experimental
session, subjects were advised of their mistakes. In the naming task,
subjects were given the same description of the stimulus set as in the lexical
decision task. They were instructed to pronounce each string as a word if it
could be read as such. For all subjects, stimuli were presented for 750 msec
in one channel of a Scientific Prototype model GB Tachistoscope. A blank
field immediately preceded and followed the display interval. The interval
between experimental trials was about 2000 msec and reaction times were
measured from the onset of the stimulus display. A brief pause was introduced
halfway through the experimental session.

Each group of subjects saw eighteen Cyrillic words and eighteen Cyrillic
pseudowords intermixed with ninety Roman words and ninety Roman pseudowords.
For both lexical decision and naming, Group Two subjects saw eighteen
AMBIGUOUS Cyrillic words, e.g., CABAHA (/savana/) (which could also be read as
a pseudoword in Roman /tsabaxa/) and eighteen PURE words in Roman, e.g.,
FABRIKA (/fabrika/), as well as eighteen AMBIGUOUS Cyrillic pseudowords, e.g.,
HEPETAC (/neretas/ or /xepetats/) and eighteen PURE pseudowords in Roman,
e.g., EDOGOM (/edogom/). In addition, they saw a CONTROL set of seventy-two
words and seventy-two pseudowords written in Roman. Group One subjects saw
### Table 3

Distribution of Ambiguous Letters and Phonemic Interpretation for AMBIGUOUS Cyrillic Letter Strings

<table>
<thead>
<tr>
<th>Three Syllable Letter Strings</th>
<th>Phonemic Interpretation</th>
<th>Meaning</th>
<th>Number of Ambiguous Letters</th>
<th>Number of Ambiguous Syllables</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>CABAHA</em></td>
<td>Cyrillic /savana/</td>
<td>savanna</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Roman /tsabaxa/</td>
<td>nonsense</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>KAPABAH</em></td>
<td>Cyrillic /karavan/</td>
<td>caravan</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Roman /kapabax/</td>
<td>nonsense</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>OCTABKA</em></td>
<td>Cyrillic /ostavka/</td>
<td>resignation</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Roman /otstabka/</td>
<td>nonsense</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Two Syllable Letter Strings</th>
<th>Phonemic Interpretation</th>
<th>Meaning</th>
<th>Number of Ambiguous Letters</th>
<th>Number of Ambiguous Syllables</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>OPMAH</em></td>
<td>Cyrillic /orman/</td>
<td>cabinet</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Roman /opmax/</td>
<td>nonsense</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>CAHTA</em></td>
<td>Cyrillic /santa/</td>
<td>iceberg</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Roman /tsaxta/</td>
<td>nonsense</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>KOTBA</em></td>
<td>Cyrillic /kotva/</td>
<td>anchor</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Roman /kotba/</td>
<td>nonsense</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
the same AMBIGUOUS words, now written in Roman, e.g., SAVANA, where they are no longer ambiguous, and the PURE words written in Cyrillic, e.g., ФАЙЛЫ, as well as eighteen AMBIGUOUS pseudowords written in Roman and eighteen PURE pseudowords written in Cyrillic. Group One, like Group Two, saw the CONTROL words and pseudowords written in Roman, e.g., MUZIKA.

In summary, for both the lexical decision and naming tasks there were two groups of subjects. The PURE Cyrillic words (18) and pseudowords (18) for Group One were presented to Group Two in Roman and the unique Roman version of the AMBIGUOUS words (18) and pseudowords (18) from Group One were presented to Group Two in their AMBIGUOUS Cyrillic form. In addition, both groups saw the same set (72 each) of Roman words and of pseudowords. As a result, the ratio of Cyrillic words to Roman words was one to five for both groups of subjects. All comparisons between groups were therefore performed on the same set of words where the alphabet changes (for the PURE and for the AMBIGUOUS word sets) across subject groups.

As noted above, if Group One saw a particular word type in its Roman version, then Group Two saw that same word type in an AMBIGUOUS Cyrillic version. Conversely, the PURE Cyrillic word type from Group One appeared in Roman for Group Two. The two types of Cyrillic words differ in one important respect: The Cyrillic words for Group Two, i.e., AMBIGUOUS words, are also readable in Roman. This is not true for the other type, the PURE words, which were presented to Group One. Phonological bivalence is restricted to Group Two's Cyrillic words and pseudowords.

RESULTS

Lexical Decision

An analysis of variance for lexical decision, with minimum and maximum latencies set at 250 msec and 2500 msec, revealed highly significant effects for lexicality (word/pseudoword), min $F'(1,21) = 21.15$, $p < .001$; for group (one/two), min $F'(1,15) = 20.28$, $p < .001$; for word type (ambiguous/pure/control), min $F'(2,16) = 22.35$, $p < .001$; and for length in syllables (two/three), min $F'(1,11) = 6.22$, $p < .05$. In addition, the type x group interaction was significant with min $F'(2,16) = 20.73$, $p < .001$. The lexicality x type x group interaction was also significant with min $F'(2,20) = 6.66$, $p < .01$.

Mean number of errors per subject for lexical decision was 4 for Group One and 12 for Group Two. Considering only the ambiguous type items, mean errors were 2 for Group One and 8 for Group Two (see Table 4). For all items for both groups, there was no evidence of a speed-accuracy trade-off. In fact, reaction time and errors were positively correlated; for Group One, $r = .33$, for Group Two, $r = .50$. These correlations were significantly different, $z = 2.09$, $p < .05$, but the difference is most likely due to the restricted range of scores for Group One. In order to assess the possibility that subjects altered their strategy as they proceeded through the task, the correlation of the difference between the unique Roman and the ambiguous Cyrillic latency for each word (and pseudoword) and position of the item in the list was computed for each item. (A large number indicates a position
Table 4

Summary of Data for Lexical Decision on AMBIGUOUS Cyrillic/Unique Roman Letter Strings

<table>
<thead>
<tr>
<th>LENGTH IN SYLLABLES</th>
<th>TWO WORD</th>
<th>TWO PSEUDOWORD</th>
<th>THREE WORD</th>
<th>THREE PSEUDOWORD</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEXICALITY</td>
<td>ORMAN</td>
<td>VAMAS</td>
<td>SAVANA</td>
<td>NERETAS</td>
</tr>
<tr>
<td>ROMAN</td>
<td>MEAN</td>
<td>STANDARD</td>
<td>ERRORS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>632</td>
<td>717</td>
<td>677</td>
<td>769</td>
</tr>
<tr>
<td></td>
<td>86</td>
<td>76</td>
<td>89</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>.4</td>
<td>.3</td>
<td>.7</td>
<td>.6</td>
</tr>
<tr>
<td>CYRILLIC</td>
<td>OPMAH</td>
<td>BAMAC</td>
<td>CABAHA</td>
<td>HEPETAC</td>
</tr>
<tr>
<td></td>
<td>MEAN</td>
<td>STANDARD</td>
<td>ERRORS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>945</td>
<td>925</td>
<td>984</td>
<td>993</td>
</tr>
<tr>
<td></td>
<td>106</td>
<td>144</td>
<td>123</td>
<td>139</td>
</tr>
<tr>
<td></td>
<td>3.3</td>
<td>.5</td>
<td>3.9</td>
<td>.4</td>
</tr>
</tbody>
</table>
late in the list.) For lexical decision, the correlation was not significant 
\( r = .19 \). This result suggests that reliance on a phonological strategy did 
not diminish during the experimental session. Similarly, in order to assess 
the possibility that reliance on a phonological strategy varied with word 
frequency, the reaction time to the unique Roman version of each word was used 
as an estimate of word frequency, and the correlation between unique Roman 
latency and the difference between the unique Roman and ambiguous Cyrillic 
form of each word was computed. In lexical decision, the correlation was not 
significant \( r = -.17 \). Therefore, reliance on a phonological strategy did 
not vary as a function of word frequency.

Protected t-tests between mean reaction times for lexical decision (with 
the estimate of variance computed from the subject's analysis of variance) 
showed that the significant interactions of type x group and type x group x 
lexicality could be attributed to a significant difference between AMBIGUOUS 
Cyrillic/unique Roman form of words, (CABAHA/SAVANA), \( t(13) = 8.89, p < .001 \) 
(see Figure 2). Groups did not differ significantly on uniquely Cyrillic or 
Roman PURE words, (GASPINKA/FABRIKA), \( t(13) = 1.09 \). Therefore, there is no 
general tendency for Roman items to be recognized more quickly than the 
Cyrillic version of those same items. The between-group difference on CONTROL 
words (MUZIKA) only approached significance, \( t(13) = 1.96, p < .10 \). Nevertheless, the magnitude of the AMBIGUOUS and CONTROL word difference 
across groups varied significantly, \( t(13) = 7.91, p < .001 \). The unique Roman 
and the ambiguous Cyrillic forms of the AMBIGUOUS type words differed more 
than the (consistently) Roman forms of CONTROL words. Pseudowords demonstrated 
a smaller effect of ambiguity than did words, \( t(13) = 3.6, p < .001 \). For 
Group One the difference between (unique) word types was not significant, 
while for Group Two, the difference between word types was significant. Group 
Two was always slower than Group One; however, the magnitude of the difference 
between groups varied over word types. Finally, ambiguous type pseudowords 
differed more in their Roman and Cyrillic forms than did PURE type pseudo-
words, \( t(13) = 3.74, p < .01 \).

In order to ascertain the effect of ambiguous characters, another 
analysis of variance was performed including only the ambiguous Cyrillic and 
unique Roman forms of the AMBIGUOUS type words and pseudowords. Because of 
the special constraints on selecting these words, no Clark analysis (1973) was 
performed. Instead, the results of an analysis of variance using subject 
variability as the error term(s) are reported.

In this analysis, letter strings were classified according to the number 
and distribution of ambiguous characters within the letter string. As in the 
more complete lexical decision analysis discussed above, there were significant 
main effects of group, \( F(1,26) = 99.44, MS_e = 159087, p < .001 \), and 
length of word in syllables, \( F(1,26) = 9.62, MS_e = 11117, p < .01 \). In 
contrast to previous analyses, however, lexicality only approached significant 
ance, \( F(1,26) = 2.48, MS_e = 57878, p < .20 \). Importantly, the distribution x 
group interaction was significant, \( F(2,52) = 4.88, MS_e = 8398, p < .05 \), as was 
the distribution x group x lexicality interaction, \( F(2,52) = 10.55, MS_e = 
218937, p < .01 \).

Protected t-tests on the within-word difference between means for the 
unique Roman and ambiguous Cyrillic transcription of the same words (pooled
Figure 2. Mean reaction time for lexical decision on AMBIGUOUS (CABAHA), PURE (FABRIKA) and CONTROL (MUZIKA) words and pseudowords written in Roman and in Cyrillic.
over two- and three-syllable words) revealed that when number of ambiguous syllables was controlled, number of ambiguous characters increased latencies significantly, \( t(13) = 3.65, p < .01 \). And when number of ambiguous characters was controlled, clustering two ambiguous characters within one syllable was more difficult than having the two ambiguous letters distributed through different syllables, \( t(13) = 2.62, p < .05 \) (see Table 5). For pseudowords, none of the contrasts among various distributions of ambiguous letters was significant.

An analysis of variance conducted on the errors in judging the lexical status of unique Roman and ambiguous Cyrillic forms of the AMBIGUOUS word type provided the same basic results as did the reaction time analysis: Main effects of lexicality and group were significant, as was their interaction; \( F(1,26) = 38.20, \text{MS}_e = 65.93, p < .001 \); \( F(1,26) = 39.08, \text{MS}_e = 56.32, p < .001 \), and \( F(1,26) = 31.85, \text{MS}_e = 65.93, p < .001 \), respectively. Here, length of the word in syllables was not significant, \( F(1,26) = 2.16, \text{MS}_e = 27.0, p > .20 \). And, in the error analysis, the distribution of ambiguous characters was not significant, \( F(2,52) = 1.0, \text{MS}_e = 12.78 \) and did not interact with group, although it did interact with other variables: distribution x syllable, \( F(2,52) = 3.25, \text{MS}_e = 25.41, p < .05 \); distribution x syllable x lexicality, \( F(2,52) = 17.74, \text{MS}_e = 34.48, p < .001 \); distribution x lexicality x group, \( F(2,52) = 3.82, \text{MS}_e = 21.29, p < .05 \).

Naming

In the analysis of variance performed on the naming data, with the same criteria for minimum and maximum latencies, a very similar pattern emerged. There were highly significant results for lexicality: \( \text{min } F'(1,16) = 50.49, p < .001 \); for group, \( \text{min } F'(1,15) = 20.76, p < .001 \); for word type, \( \text{min } F'(2,12) = 45.55, p < .001 \), and for length in syllables, \( \text{min } F'(1,10) = 29.04, p < .001 \). As above, the type x group interaction was significant, \( \text{min } F'(2,20) = 90.96, p < .001 \), but in contrast to the lexical decision results, the lexicality x group interaction was also significant, \( \text{min } F'(1,20) = 7.81, p < .05 \), and the lexicality x type x group interaction was not: \( \text{min } F'(2,11) = .08 \).

In naming, mean number of errors per subject was 11 in Group One and 15 in Group Two. For the ambiguous word type alone, mean number of errors was 2 in Group One and 9 in Group Two (see Table 6). Once again, there was no evidence of a speech-accuracy trade-off. The correlation between reaction time and errors for both word and pseudoword items was \( r = .61 \) for each group. When the difference between the unique Roman and the ambiguous Cyrillic form of each word was correlated with the position of the item within the list, the correlation (\( r = .19 \)) was not significant. These data suggest that reliance on a (detrimental) phonological strategy did not diminish during the experimental session. As in the lexical decision task, in order to examine whether reliance on a phonological strategy varies with word frequency, reaction time to the unique Roman form of each word was treated as an index of word frequency, and a correlation between the unique Roman form and the difference between the unique Roman and the ambiguous Cyrillic form of each word was computed. In the naming task, in contradistinction to the lexical decision task, this correlation was significant and positive, \( r = .54, p < .05 \). It suggests that the detriment due to phonological bivalence decreases with frequency.
### Table 5

Mean Reaction Time by Distribution of Ambiguous Characters for Lexical Decision on AMBIGUOUS Cyrillic Words (and Their Roman Controls)

<table>
<thead>
<tr>
<th>Three Syllable Letter Strings</th>
<th>Number of Ambiguous Letters</th>
<th>Number of Ambiguous Syllables</th>
<th>Cyrillic Reaction Time</th>
<th>Roman Reaction Time</th>
<th>Difference Between Cyrillic and Roman</th>
</tr>
</thead>
<tbody>
<tr>
<td>CABABA</td>
<td>3</td>
<td>3</td>
<td>981</td>
<td>676</td>
<td>305</td>
</tr>
<tr>
<td>KAPABAH</td>
<td>3</td>
<td>2</td>
<td>1038</td>
<td>646</td>
<td>392</td>
</tr>
<tr>
<td>OCTABKA</td>
<td>2</td>
<td>2</td>
<td>934</td>
<td>709</td>
<td>245</td>
</tr>
</tbody>
</table>

<p>| Two Syllable Letter Strings   |                               |                               |                        |                     |                                       |
| OPMAB                         | 2                             | 2                             | 927                    | 645                 | 273                                   |
| CAHTA                         | 2                             | 1                             | 1027                   | 650                 | 377                                   |
| KOTBA                         | 1                             | 1                             | 880                    | 625                 | 255                                   |</p>
<table>
<thead>
<tr>
<th>LENGTH IN</th>
<th>SYLLABLES</th>
<th>LEXICALITY</th>
<th>TWO WORD</th>
<th>TWO PSEUDOWORD</th>
<th>THREE WORD</th>
<th>THREE PSEUDOWORD</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROMAN</td>
<td>ORMAN</td>
<td>VAMAS</td>
<td>SAVANA</td>
<td>NERETAS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MEAN</td>
<td>621</td>
<td>668</td>
<td>686</td>
<td>724</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STANDARD</td>
<td>41</td>
<td>83</td>
<td>66</td>
<td>59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DEVIATION</td>
<td>.1</td>
<td>.1</td>
<td>.1</td>
<td>1.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ERRORS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CYRILLIC</td>
<td>OPMAN</td>
<td>BAMAC</td>
<td>CABAHYA</td>
<td>HEPETAC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MEAN</td>
<td>1009</td>
<td>1194</td>
<td>1132</td>
<td>1258</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STANDARD</td>
<td>207</td>
<td>248</td>
<td>166</td>
<td>204</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DEVIATION</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ERRORS</td>
<td>2.2</td>
<td>2.1</td>
<td>1.8</td>
<td>2.9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6
Summary of Data to Name
AMBIGUOUS Cyrillic/Unique Roman Letter Strings
Protected t-tests on mean naming latencies (with the mean square error term derived from the subjects' analysis of variance) confirmed that latencies to name ambiguous words and pseudowords were prolonged. While there was no significant difference between groups on Roman CONTROL words, t(13) = 1.51, groups did differ on AMBIGUOUS Cyrillic/unique Roman words, t(13) = 14.95, p < .001. And the difference between groups was greater for the AMBIGUOUS type items than for the PURE type items, t(13) = 13.45, p < .001. In contrast to the lexical decision data, the difference between naming ambiguous Cyrillic and unique Roman appeared greater for pseudowords than for words, t(13) = 4.01, p < .01. This result is difficult to evaluate (and a protected t-test is not strictly legal) since the lexicality x group type interaction was not significant. Because there was no "correct" reading of an ambiguous pseudo-word, both Cyrillic and Roman readings were included in the analysis, and, in fact, this condition had a larger variance than its unique Roman counterpart. (Standard deviations for ambiguous Cyrillic pseudowords of two and three syllable length were 248 and 204, respectively, while their Roman equivalents were 83 and 59.) Finally, Group Two was slower on Ambiguous Cyrillic than on Pure Roman strings, t(13) = 15.08, p < .001. For Group One, there was no evidence of an alphabet bias as Pure Cyrillic and Unique Roman string were equal, t(13) = .72 (see Figure 3).

In order to evaluate the effect of the distribution of ambiguous characters on naming, an analysis of variance including only the ambiguous Cyrillic and unique Roman naming latencies of the AMBIGUOUS type words and pseudowords was also performed. As in the analogous lexical decision analysis, a Clark analysis (1973) was not appropriate due to the severe selection constraints on words. Therefore, the results reported below are based on an analysis of variance of naming latencies using subject variability as the error term(s).

In agreement with the larger naming analysis discussed above, there were significant main effects of group, F(1,26) = 89.54, MS_e = 210297, p < .001, length in syllables, F(1,26) = 34.41, MS_e = 14409, p < .001, and lexicality, F(1,26) = 68.32, MS_e = 12020, p < .001, and a significant group x lexicality interaction, F(1,26) = 21.86, MS_e = 12020, p < .001. When letter strings were classified according to the number and distribution of ambiguous characters (distribution), distribution was significant, F(2,52) = 5.31, MS_e = 11313, p < .01, as were the interactions of distribution x syllable, F(2,52) = 12.07, MS_e = 10582, p < .001; distribution x lexicality, F(2,52) = 4.80, MS_e = 14941, p < .05 and, most important, distribution x group, F(2,52) = 3.48, MS_e = 11313, p < .05. The second order interactions of distribution x syllable x group and distribution x syllable x lexicality were also significant: F(2,52) = 7.55, MS_e = 10582, p < .01 and F(2,52) = 14.40, MS_e = 10626, p < .001, respectively. Finally, the fourth order interaction of distribution x lexicality x group x syllable was also significant, F(2,52) = 19.78, MS_e = 10626, p < .001.

Protected t-tests on the naming data resembled the results for lexical decision. For words, when number of ambiguous characters was controlled, two ambiguous characters within one syllable were slower than one ambiguous character within a syllable, t(13) = 2.54, p < .05 for three-syllable words, and t(13) = 2.82, p < .05 for two-syllable words (see Table 7). There were no other significant results for words and, probably due to their large variances, no significant results for pseudowords.
Figure 3. Mean reaction time to name AMBIGUOUS (CABAHA), PURE (FABRIKA) and CONTROL (MUZIKA) words and pseudowords written in Roman and in Cyrillic.
<table>
<thead>
<tr>
<th>Three Syllable Letter Strings</th>
<th>Number of Ambiguous Letters</th>
<th>Number of Ambiguous Syllables</th>
<th>Cyrillic Reaction Time</th>
<th>Roman Reaction Time</th>
<th>Difference Between Cyrillic and Roman</th>
</tr>
</thead>
<tbody>
<tr>
<td>CABABA</td>
<td>3</td>
<td>3</td>
<td>1049</td>
<td>661</td>
<td>388</td>
</tr>
<tr>
<td>KAPABAH</td>
<td>3</td>
<td>2</td>
<td>1047</td>
<td>609</td>
<td>438</td>
</tr>
<tr>
<td>OCTABKA</td>
<td>2</td>
<td>2</td>
<td>933</td>
<td>594</td>
<td>339</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Two Syllable Letter Strings</th>
<th>Number of Ambiguous Letters</th>
<th>Number of Ambiguous Syllables</th>
<th>Cyrillic Reaction Time</th>
<th>Roman Reaction Time</th>
<th>Difference Between Cyrillic and Roman</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPMAB</td>
<td>2</td>
<td>2</td>
<td>1125</td>
<td>703</td>
<td>422</td>
</tr>
<tr>
<td>CAHTA</td>
<td>2</td>
<td>1</td>
<td>1201</td>
<td>687</td>
<td>514</td>
</tr>
<tr>
<td>KOTBA</td>
<td>1</td>
<td>1</td>
<td>1071</td>
<td>667</td>
<td>404</td>
</tr>
</tbody>
</table>
An analysis of variance conducted on errors in naming the unique Roman and ambiguous Cyrillic forms of the AMBIGUOUS word type was generally consistent with the reaction time results. Significant main effects of group, $F(1,26) = 23.83$, $M_{S_e} = 129.9$, $p < .001$, and lexicality, $F(1,26) = 4.82$, $M_{S_e} = 63.23$, $p < .05$ occurred, although length in syllables was not significant, $F(1,26) = 3.04$. In contrast to the results for lexical decision, the distribution of ambiguous characters in the error analysis was significant, $F(2,52) = 31.18$, $M_{S_e} = 20.63$, $p < .001$, and distribution interacted with group, $F(2,52) = 7.06$, $M_{S_e} = 20.63$, $p < .01$. The interaction of distribution x syllable and distribution x syllable x lexicality were also significant, $F(2,52) = 9.79$, $M_{S_e} = 26.49$, $p < .001$ and $F(2,52)5.16$, $M_{S_e} = 27.77$, $p < .01$, respectively, as was the interaction of distribution x syllable x lexicality x group, $F(2,52) = 12.96$, $M_{S_e} = 27.77$, $p < .001$.

The correlation between means for individual letter strings in the naming and lexical decision tasks was computed for the two groups of subjects who saw the ambiguous Cyrillic letter strings (Group Two's) and separately for the two groups of subjects who saw the unique Roman version of the same items (Group One's). Each correlation was computed on all items, both words and pseudowords, as well as on words alone. While the correlations were slightly higher for words alone than for words and pseudowords combined, these differences were not significant, $z = 1.19$, $p > .25$ for Cyrillic and $z = .69$, $p > .25$ for Roman. Subsequently, all correlations computed between lexical decision and naming included both words and pseudowords, although AMBIGUOUS and CONTROL type items were treated in separate correlations. The correlation between lexical decision and naming was $r = .34$ for unique Roman version of the AMBIGUOUS items (Group One) and $r = .48$ for the AMBIGUOUS Cyrillic version (Group Two). For the Control items, the correlations were $r = .56$ (Group One) and $r = .73$ (Group Two). The difference between the correlations for AMBIGUOUS and CONTROL type items was not significant whether both types of items appeared in Roman, which permitted a unique reading (as for Group One), $z = 1.14$, $p > .25$, or whether the AMBIGUOUS type appeared in its ambiguous form while the CONTROL items uniquely specified a Roman reading (as for Group Two), $z = 1.64$, $p > .10$. These results suggest that the relation between lexical decision and naming did not vary significantly with word type, phonological bivalence, or lexicality.

DISCUSSION

The results of the present experiment demonstrated that phonologically bivalent letter strings retard word recognition relative to the unequivocal form of the same letter string. Similar phonological effects occurred both in naming and in lexical decision, implying a common phonological influence in both tasks. This interpretation was supported by the high correlation between tasks that obtains for both words and pseudowords, and, given the nature of the Serbo-Croatian orthography, it implies a strategy that is not specific to real words alone. Given the nature of the Serbo-Croatian orthography, however, phonological bivalence and visual (alphabetic) bivalence are usually confounded. Before concluding that this effect of phonological bivalence is definitive evidence of a phonological strategy in word recognition, an interpretation in terms of a lexically-based visual search must be invalidated. Most obviously, this detriment occurred for pseudowords as well as words that are not real words.
and it is usually assumed that only words are in the lexicon. To anticipate, allowing that pseudowords as well as words comprise the lexicon and then introducing several further modifications to the lexicon will justify most of the data, but not all: By definition, no account based on a visual search of the lexicon can be sensitive to phonographic analysis of component orthographic structure as the significant effect of the distribution of ambiguous characters would require. It will be concluded that word recognition in Serbo-Croatian is necessarily phonological.

In general, both the lexical decision and the naming paradigms revealed an effect of phonological bivalence that could not be accounted for in terms of any overall difference between subject groups or alphabets. Protected t-tests confirmed that Group One demonstrated no difference between word types and no systematic preference for letter strings in either a Roman or a Cyrillic form. In contrast, Group Two, which was always slower than Group One, was especially impaired on the Ambiguous Cyrillic forms. To the extent that experience with a word in printed text occurs equally often with its Roman and with its Cyrillic form, there should be no difference in latency as alphabet varies. To the extent that the experimental condition can introduce an alphabet bias, this bias should have been similar for both groups and insensitive to word type: The ratio of Cyrillic to Roman items was constant across subjects, all subjects had learned Cyrillic first, and subjects were randomly assigned to experimental groups. And, as predicted, for those subjects who saw PURE (FABRIKA) words in Cyrillic and CONTROL (MUZIKA) and AMBIGUOUS (SAVANA) words in Roman (Group One), there was no difference between alphabets or word types. In assessing any general difference among word types, each contrast entailed a within-words comparison between the Roman and the Cyrillic renditions of the same word displayed to different groups of subjects. Therefore, orthographic and semantic factors as well as word frequency were fully controlled. The effect of phonological bivalence was the difference between the unique Roman and the ambiguous Cyrillic rendition of the same letter string, once any overall difference between groups had been considered. This within-word effect of bivalence was evident in the significant group x type and in the group x type x lexicality interactions.

In summary, the results of the present experiment showed that the possibility of two phonological interpretations of a visually presented letter string affected performance on lexical decision and on naming in a way that one phonological interpretation did not. Whether this effect is actually less robust for pseudowords than for words or less reliable in naming than in lexical decision should not confuse the overall conclusion. Latency differences on the order of 300 msec computed on two forms of the same letter string, one phonologically equivocal and one phonologically unequivocal, provide strong evidence of a mandatory phonological strategy in visual word recognition. Before concluding that phonological bivalence need be interpreted as evidence of a phonographically analytic phonological strategy in word recognition, two versions of a visually-based, lexical search interpretation will be examined.

**Two Lexical Searches as an Alternative to a Phonological Option**

Assuming that word recognition always proceeded by a purely visual strategy, all phonological specifications for words would be lexically mediat-
ed so that any effect of phonological bivalence should have been restricted to pseudowords. By a word-specific strategy where response latency for words depends on finding a visual match for a particular entry, the phonologically bivalent nature of a visual array of characters should have been irrelevant. Clearly, in the present word recognition studies, subjects never employ a pure (single lexicon) visual strategy, but rather they engage a strategy that is sensitive to phonological or at least alphabetic ambiguity. Experimental manipulations that affect words and pseudowords differentially are generally interpreted to indicate the involvement of a word-specific strategy. In the present experiment, the ambiguity by lexicality interaction indicated that the degree of detriment due to ambiguity for words and pseudowords differed. Nevertheless, the stronger effect on words introduced by phonologically ambiguous letter strings is consistent with the original bivalent experiment (Lukatela, Savić, Gligorijević, Ognjenović, & Turvey, 1978), where the effect of bivalence was significant only for words. It is possible, therefore, that the effect of phonological bivalence originates with the problem of matching holistic letter string patterns with particular lexical entries and that word recognition in Cyrillic and Roman requires two distinct (visually-defined) lexicons.

The general pattern of results for lexical decision and naming were impressively similar and the correlation between tasks supported the claim of the participation of a common knowledge structure in both tasks. (Note that for a correlation, the naming lexicon and the lexical decision lexicon need not be identical, they only need to be organized in the same way.) One possibility is that this correlation reflects a lexical contribution and that the phonological effect occurs because the letter string matches with two entries in the lexicon. The standard interpretation of this correlation between tasks (Forster & Chambers, 1973; Frederiksen & Kroll, 1976) is that it reflects a visually-defined search on some non-segmented letter pattern that is specific to real words. In the present experiment, however, this systematicity extended to pseudowords. Because pseudowords do not have particular entries in a visually-defined lexicon, the effect could not be visual or holistic and specific to particular words (or morphemes), unless one supposed that pseudowords as well as words can be described by the Roman and Cyrillic lexicons. Allowing that a response could follow immediately when an entry was identified or that multiple decisions could arise, different degrees of impairment to performance for ambiguous words and pseudowords could be expected and these modifications will be considered.

1. Alphabet-governed Lexical Searches: Terminating

Respecting the assumption that phonologically bivalent strings are slower because they entail a parallel visual search of two lexicons (one for Roman forms and one for Cyrillic forms), there are two possible ways in which the different visual alphabets are searched: If they are searched in parallel such that operating in two files slows all latencies, then performance on words composed entirely of shared letters should be impaired, regardless of whether the shared letters correspond to the same phoneme in each alphabet (common letters), e.g., JAJE read as /jaje/, or correspond to different phonemes in Roman than in Cyrillic (ambiguous letters), e.g., KACA read as /kasa/ or as /katsa/. In fact, words containing only common letters are no slower than words that contain letters unique to one alphabet (Lukatela et al., 1980; Feldman et al., 1981).
Alternatively, the alphabet files may be searched in a successive fashion. Actually, Lukatela, Savić, Gligorijević, Ognjenović, and Turvey, (1978) have refuted an account of phonological bivalence based on two serial visual alphabet searches, because lexical decision to bivalent strings that were words by either alphabet reading, e.g., KACA (so that search would be successful in either alphabet file) was no faster than to strings that were words in Roman and pseudowords in Cyrillic, e.g., KOBAC. Likewise, pseudowords composed exclusively of common letters, e.g., TAKA (so that they have the same phonological reading in both Roman and Cyrillic) were no slower than pseudowords that contained letters unique to one alphabet (Lukatela et al., 1980). In sum, accounts of this detriment based on successive visual searches of two lexicons would predict that the presence of letters shared by the Roman and Cyrillic alphabets, regardless of their common or ambiguous phonemic value, should influence recognition, but this result was not observed.

Alternatively, perhaps only letter strings containing both ambiguous and common (and no unique) characters foster two alphabet searches. While the distinction between ambiguous and common letters shared by the two alphabets is phonological rather than visual, this option is worthy of consideration here because it encompasses both words and pseudowords and it treats bivalence as the result of complications in lexical search. If the probability of beginning search in either alphabet is equal, then for an ambiguous Cyrillic word (which is a Roman pseudoword), search will start in the correct alphabet file one half of the time. On the average, the subject need search one and one half files to recognize an ambiguous word. To reject an ambiguous pseudoword (which is a pseudoword in both Roman and Cyrillic), however, two full alphabet files need be examined on every trial. This terminating search-based account would predict that phonologically bivalent letter strings should be slower when they are pseudowords than when they are words: Both alphabets always must be considered before a "no" response is possible. For words, however, sometimes the search will begin with the appropriate alphabet and responding will not be delayed. Counter to this prediction, in the present experiments, latencies for lexical decision on ambiguous words and pseudowords did not differ (while analogous latencies for the unequivocal alphabet transcription of the same strings did differ). Moreover, a visual search might predict a trade-off between errors and reaction time (at least for real words), and higher variances among reaction times for individual ambiguous words—where lexical search can terminate—than for ambiguous pseudowords—where lexical search is necessarily exhaustive of two lexicons. In the present experiment, however, these measures were positively correlated and an analysis of variance on errors produced the same general results as on reaction time. Finally, in the present experiments, counter to the predictions of any visual search based account, the effect of phonological bivalence assessed within forms of the same letter string was greater for lexical decision on words than on pseudowords. (The type x group x lexicality interaction was not significant for naming due to the high variability in the pseudoword data. Therefore, no comparison of word and pseudoword latencies in naming is offered.) One other modification to the two-visualy-defined lexical search model will be considered because it can account for the relative degree of bivalence among words and pseudowords.
2. Alphabet-governed Lexical Searches: Nonterminating

The larger effect of phonological bivalence for words than for pseudowords in lexical decision invites the notion of competing responses: For words, subjects must decide between the "yes" response engendered by the Cyrillic reading and the "no" response engendered by the Roman reading. For pseudowords, however, both readings would necessitate a "no" response. Until now, it was assumed that lexical search terminated immediately when a lexical entry was selected (or equivalently, as Coltheart has suggested, that visual and phonological strategies did not operate at the same rate). If search does not terminate immediately, then response competition becomes a viable description (and further, responding by a phonological strategy such as pseudowords traditionally require need not be slower than responding by a visual strategy). In this case, the phonologically derived pseudoword reading could influence the lexical reading of an ambiguous letter string so that both a positive and a negative decision are indicated. In fact, this account could work for naming as well as for lexical decision. Remember that in naming, the detrimental effect of bivalence appeared greater for pseudowords. There, there were two acceptable articulations while for words, only one reading produced a word. (Instructions specified to read the letter string as a word if it could be read as such.)

In general, attributing the detriment due to phonological bivalence to interfering responses complements the claim (Shulman, Hornak, & Sanders, 1978) that phonological effects in English may reflect a supplemental storage medium to improve visually-based performance rather than the descriptors by which a word was recognized. Since the memory-based account suggests a contribution by the lexicon to this phonological effect, it would not explain why the evidence of a phonological storage should be so much more pronounced in Serbo-Croatian than in English. More important, a nonterminating visual search of two alphabetically-defined lexicons and its consequence, a lexically-derived description of bivalence, cannot account for one crucial aspect of the present data.

In the present experiments, the detriment incurred by phonologically bivalent letter strings varied as a function of the number and distribution of ambiguous characters. Counter to any visually-defined search account of word recognition, these phonological results were exaggerated for words relative to pseudowords and were more stable in lexical decision, where there was no correlation between word frequency and degree of impairment, than in naming. In general, the degree of impairment increased with number of ambiguous characters, and two ambiguous characters within one syllable were more difficult than two ambiguous characters in different syllables. As an alternative to a visually defined search, if the nature of the Serbo-Croatian orthography and the general effect of phonological bivalence are reconsidered in terms of procedural knowledge or pattern analyzing operations (Kolers, 1975a), then perhaps this effect can be better captured in phonologically analytic rather than purely visual terms.

Recognition Strategies in Serbo-Croatian: A Phonological Priority

By tradition, visual strategies are presumed to be word-specific and are not appropriate for pseudowords. But the appropriateness of different stra-
Strategies for word and pseudoword recognition must be the outcome of, not the starting point, for a description of lexical knowledge. Therefore, it is important to note that even if words and pseudowords were described by common lexical predicates, so that a visual, word-specific strategy is in principle possible, the effect of phonological bivalence cannot be rationalized by searches through a visual lexicon of even two lexicons. In the later experiment by Lukatela (Lukatela et al., 1980), as in the present experiment, an effect of bivalence was obtained for pseudowords. Because it slowed words and pseudowords in the same way and was independent of the number of lexical readings for each letter string, those investigators (Lukatela et al., 1980) proposed an account of the detriment due to phonological bivalence that was independent of word-specific knowledge and was based on the rate at which a description of the letter string that was appropriate for lexical search could be derived. This is reminiscent of a pattern analyzing procedure (Kolers, 1975a, 1975b, 1976) in that the systematic variability in word recognition is captured by the operations to apprehend visual patterns, rather than a search among substantive knowledge structures such as the lexicon model usually implies. Given the nature of the Serbo-Croatian language and the systematic relation between orthography and phonology, the present results suggest a pattern analysis for word recognition that proceeds in terms of the phonology, is independent of the lexicon, and is sensitive to component orthographic structure.

The pattern of results for lexical decision and naming was remarkably similar and the consistently high correlations between lexical decision and naming suggested that a common knowledge operation proceeded for all types of words and pseudowords in both tasks. Traditionally, this correlation has been interpreted as implicating the lexicon, a visually-defined word (or morpheme) specific knowledge structure, but in the present experiments, this correlation obtained for pseudowords as well as for words. In general, the major results demonstrated a very robust effect of phonological bivalence, and any account of this effect in terms of visual search of lexical structure, even one that allowed the inclusion of pseudowords, proved incomplete to encompass the significant effect of the distribution of ambiguous characters. In sum, there was no reason to conclude that the bases for lexical decision and for naming diverged: Both tasks entailed a phonological strategy even when it actually hindered performance.

GENERAL DISCUSSION

In the word recognition studies conducted in English, the phonological word-nonspecific strategy is often characterized as optional while the visual word-specific strategy is characterized as mandatory. The possibility of two strategies should actually diminish any phonological effect since, at least in English, the visual strategy is purported to operate faster than a phonological strategy (Coltheart et al., 1977). Nevertheless, the present experiment on Serbo-Croatian provided no evidence favoring this claim. On the same grounds, larger phonological effects (or weaker lexical effects) would be expected for the naming of words than for lexical decision to words, but this was not confirmed. In addition, the subjects in the present experiments all learned Cyrillic as their first alphabet and there is evidence that this early experience governs facility with the alphabets, even in mature readers.
(Lukatela, Savić, Ognjenović, & Turvey, 1978). In the present experiments, all the ambiguous strings that were words, were words in their Cyrillic reading. If subjects had an option of employing a word-specific strategy exclusively, then in these experimental conditions it would have been optimal to reduce the availability of the (Roman) pseudoword reading and engage only the (Cyrillic) word reading. Nevertheless, these readers could not eliminate a phonological strategy in word recognition even when it was obviously detrimental to performance. In sum, the magnitude of the effect of phonological bivalence for words and pseudowords suggests that for skilled readers of Serbo-Croatian, the phonological strategy is neither slower nor optional.

Phonologically bivalent letter strings retarded performance relative to the unique alphabet transcription of the same form and this has been interpreted as evidence of a phonological strategy in word recognition. The question of a lexical contribution to the specification of phonology has not been resolved, however. Although there is evidence of a phonological strategy that is sensitive to sub-morphemic component structure, this does not eliminate the possibility of exploiting morpheme or word units, that is, a lexical specification of other aspects of phonology. Nevertheless, no currently available visually defined word-specific search model has proven adequate because that class of model proceeds holistically and is not phonographically analytic. In this discussion, no consideration of a lexical contribution that works concurrently with a lexically independent contribution has been delineated, and yet there is no reason why a lexicon-independent and a lexicon-derived phonological specification could not be implicated if, ultimately, the magnitude of the detriment due to phonological bivalence depends, among other factors, on the lexical status of the alternate reading.

In the word recognition literature, there has been a tendency to treat all aspects of knowledge about words in terms of substantive knowledge and to assume that the connection between newly presented words and previously acquired knowledge about words entails a search and match procedure in the internal lexicon. Issues in current theories of reading and word recognition focus on whether this match occurs in terms of predicates that reference visual aspects or predicates that reference phonological aspects of the written word. For alphabetic orthographies in general and for the shallow orthography of Serbo-Croatian in particular, these predicate types are not easily distinguished. Instead, in the present experiments, the distinction between strategies has been recast in terms of a contrast between holistic word-specific and phonologically analytic word-nonspecific strategies where the focus of a word-specific strategy is the word or morpheme and the focus of the word-nonspecific strategy is the phoneme. It was concluded that naming and lexical decision for both words and pseudowords are non-optionally phonologically analytic.

The dominant theories of reading and word recognition have been developed in English and have assimilated the idiosyncracies of this phonologically deep orthography into the theory. Comparisons with Serbo-Croatian, with its phonologically shallow orthography, invites the differentiation of the universal aspects of this particular theory of reading from the language-specific contribution. In the literature on word recognition based on English, it is often claimed that the acquisition of reading skill entails a shift away from a phonological recognition strategy (LaBerge & Samuels, 1974; Frederiksen,
1981) and, given that the English orthography references morphology as well as phonology, this may be true. By contrast, the written form of Serbo-Croatian has preserved a consistent reference to phonology and the character of this orthography is evident in the present studies of word recognition among skilled readers. Unlike reading in English that demonstrates a priority for a visual strategy, skilled reading in Serbo-Croatian retains a phonological priority.

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(a)


**FOOTNOTES**

1There are exceptions to this characterization: For example the "d" in presednik is generally interpreted as /t/. The number of violations is small, however.
Two aspects of vowel accent (tone: rising/falling, length: long/short) are not captured by the written form. While vowel accent may differentiate between two semantic interpretations, this distinction is often ignored especially in the dialects of the larger cities (Magner & Matejka, 1971). Moreover, vowel identity, at least as it is defined by formant structure in some restricted phonemic environments, is not distorted by variations in accent (Kalić, 1964).