1 Introduction

The relation between script and speech differs among the various orthographic categories. In general, alphabets maintain a closer link than do logographies. Comparisons between instances of each category, say between English and Chinese, are instigated in order to uncover whether or not different orthographic styles might be reflected in differing processing strategies used by readers. A number of investigators have pointed out, however, that "alphabet" does not constitute a monolithic category and English is, in no sense, to be taken as typical of all alphabets. Nonetheless, a majority of the reading data have been collected for English and the conclusions they suggest have been accepted, more or less by default, for alphabets in general. But a growing body of data for Serbo-Croatian, the (alphabetically transcribed) language of Yugoslavia, reveals important differences with English. We will summarize these data and elaborate their implications for linguistic issues, particularly the role of phonology in reading, that may be important for Chinese.

2 Linguistic Issues in Cross-language Comparisons

Orthographies can be distinguished along a number of dimensions, two of which will concern us here. First, they differ with respect to the particular units that are overtly represented, be they morphemes or syllables or the more (linguistically) abstract phonemes. Second, orthographies can be considered deep or shallow depending on their relative remoteness from the sounds to be read. As will be illustrated in the following characterizations of Serbo-Croatian, English, and Chinese, these dimensions are orthogonal--orthographies of "equal depth" can differ in the unit represented.

Serbo-Croatian uses an alphabet that represents phonemes in a straightforward symbol-to-sound mapping: Each letter has only one pronunciation. A novel word or pseudoword can be named (in the sense of pronounced) simply by generating the sounds from the letters. A letter such as a will be pronounced /a/ regardless of the letters that precede or follow it (Ignoring, of course, subtle changes as a consequence of coarticulation). In order to

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preserve this mapping, the etymological relationships among words are sacrificed. Wherever the spoken language has imparted phonological variation in, say, declensions of a given noun, the variations are enforced in the spelling (e.g., nominative singular RUk-A, dative singular RUCI; nominative singular SNAHA, dative singular SNASI). It is, therefore, considered to be a shallow orthography (Liberman, Liberman, Mattingly, & Shankweiler, 1980).

In contrast, English uses an alphabet that also represents phonemes but enforces morphological continuity. Where the spoken language changes the pronunciation of a root morpheme, its spelling does not necessarily change. The sounds are determined by phonological rules with the result that etymological hints are retained (e.g., the relationship between "bomb" and "bombard" is preserved in their spellings despite alteration in the sound of the second "b"). A novel word or pseudoword can be named by generating the sounds from the letters and phonological rules. An alphabet that does not represent phonological variations that are determined by phonological rule¹ can be said to be deep.

Finally, Chinese uses a logography to represent morphemes. Although a large proportion of characters are phonograms--comprising both a semantic and a phonetic component--the hints to sound are not completely reliable (Wang, 1973). Using the phonetic component to sound out a character yields only 39% accuracy (Tseng & Hung, 1980). By and large, therefore, the character names must be memorized in order to be read. Because of the opacity of the phonology, Chinese can be considered a deep orthography.

The fact that orthographies differ with respect to both the units they represent and the phonological transparency of those representations suggests that orthographies might also vary in the linguistic demands that they place on the reader, particularly the beginner. In other words, the effective use of orthographies might depend on how much readers know about the structure of their languages, with certain orthographies requiring an explicit understanding of the more abstract (and, presumably, harder to come by) aspects. Limiting our discussion to structural units, speaker-hearers can become aware of the words, morphemes, syllables, and phonemes that comprise their spoken language. If they are to become readers of that language, alphabets require an appreciation of the phonemic structure that logographies do not. Whatever the orthography, the level of linguistic awareness (Mattingly, 1972) must be compatible with the units represented, while using the orthography might be said to tune one to the level of awareness demanded. By this reasoning, fluent readers of Chinese are less likely to be aware of the phonemic structure of their language than are fluent readers of English because fluency in the morpheme-based orthography does not demand such awareness.

A similar circular causality is found in what has been termed phonological maturity (Liberman et al., 1980), the appreciation that readers have, to varying degrees, of the (morpho-)phonological rules which rationalize spellings that are related complexly to sound. That is to say, phonological maturity helps in reading words where phonological variation is determined by rule rather than orthographic representation (e.g., real is read /rēl/, reality is read /rē.al'eti/); reading experience, in turn, promotes phonological development. The demands of linguistic awareness and phonological maturity can be said to parallel, more or less, the dimensions we identified as distinguishing orthographies—the represented unit and its phonological transparency, respectively.²
3 Serbo-Croatian: A Bi-alphabetic, Inflected Language

Phonological transparency is only one characteristic that distinguishes Serbo-Croatian from English. The major language of Yugoslavia is also highly inflected. Nouns, pronouns, and adjectives are declined in seven plural and seven singular cases (nominative, locative, dative, instrumental, genitive, accusative, and vocative). Verbs are conjugated by person and number in six forms. But, because of the dictum to "Write as you speak and read as it is written" (the guiding principle behind the mid-19th century alphabet reforms directed by the Serbian language scholar Vuk Karadžić), root morphemes often are varied orthographically when an inflectional element is added.

Of primary relevance to transforming the linguistic issues of the last section into experimental questions, however, is the fact that Serbo-Croatian is written in two alphabets. Both the Cyrillic script (learned first in eastern parts of the country) and the Roman script (learned first in the West) map onto the same set of 30 phonemes but in an interesting way. While most letters are unique to one or the other alphabet, seven are common (i.e., are read the same way in the two scripts) and four are ambiguous (i.e., receive a different phonetic interpretation in each script). Since Yugoslavs are typically facile with both alphabets, the letters can be combined in a variety of ways for experimental purposes, which will become apparent in Section 5.0.

4 Assessing Lexical Access

We are interested in whether or not variations in the speech-script relationship promote differing processing strategies in reading. Since reading involves recognizing words, one process that has received considerable scrutiny is the pattern recognition step--how is a written letter string matched to its lexical representation? This question of lexical access has been addressed with (primarily) two paradigms: (1) In lexical decision tasks, subjects must decide as rapidly as possible whether or not a given letter string is a word; (2) In naming tasks, subjects must simply read the letter string aloud as rapidly as possible. In both tasks, the time transpiring between onset of the stimulus and initiation of the response is measured. Visual and phonological characteristics of the letter strings are varied to ascertain what effect, if any, they have on the response latencies.

Effects on lexical decision time are taken to have implications for the nature of lexical access, models of which include linguistic processes (phonological recoding of letter strings), nonlinguistic processes (simple figural analyses), and combinations of both (dual processing). Effects on naming may be consistent with one or another lexical routes or may suggest, further, that the lexicon need not be accessed at all in order to pronounce a letter string. These implications rest on two logical underpinnings. First, if a letter string is phonologically ambiguous (i.e., can be pronounced in more than one way), then any phonological analysis (if it exists) ought to be hindered in comparison to such an analysis on phonologically unique letter strings. This would be true in both lexical decision and naming. If phonological ambiguity produces no effect, the case for phonological analysis is undermined. Second, while the three general models of word processing all suggest that words should be named faster than pseudowords, a phonologically analytic strategy ought to yield a fairly small difference that is relatively constant for ambiguous and unambiguous letter strings. An interaction between lexicality and phonological ambiguity, however, would seem to support one of the other models. These will be elaborated in Section 6.0.
 Obviously, a great deal hinges on the manipulation of phonological ambiguity. In English, two methods have been used. In one, pseudowords are constructed to be homophonic with words. While lexical rejection of pseudohomophones takes longer than rejection of pseudowords (Coltheart, Davelaar, Jonasson, & Besner, 1977), at least for good readers (Barron, 1978), interpretation of this fact is tricky because the appropriateness of pseudohomophones has been questioned on a number of grounds (Feldman, Lukatela, & Turvey, 1985; Martin, 1982). These include (i) the possibility that phonetic representations may be sensitive to orthographic differences between letter strings that sound alike when spoken aloud; (ii) the formal distinction, in English, between phonetic and morphophonological representations; and (iii) the suspicion that pseudohomophones are structurally odd.

The second way in which phonological ambiguity has been manipulated in English is through a comparison of words with regular and irregular (or exceptional) pronunciations. Whether or not differences are found, however, depends on how regularity is defined (Parkin, 1982). For example, words in which each graphemic unit receives the major phonemic correspondence (as detailed in Venezky’s [1970] rules) are considered regular while those that receive a minor correspondence may be treated as irregular (Coltheart, Besner, Jonasson, & Davelaar, 1979). A finer distinction reveals that words can be classified as regular and consistent (i.e., they and all words that are visually similar to them receive the major phonemic correspondences) or regular and inconsistent (i.e., they receive major correspondences but other exemplars receive minor correspondences and, thus, are irregular [Glushko, 1979]). Some irregular words might be considered especially exceptional, however, if only because lexicographers provide pronunciation guides for them (but not for all minor correspondence words [Parkin, 1982]). Moreover, a particular grapheme-phoneme correspondence will be considered minor and, therefore, exceptional because there are fewer instances of it when, in fact, those instances might occur with greater frequency than the so-called major grapheme-phoneme correspondences (Parkin, 1982). Lastly, phonologically irregular words may differ with respect to whether or not they are orthographically irregular as well (Parkin & Underwood, 1983). Depending on which of these characterizations of regularity is used, one will or will not find differences between regular and irregular words, either supporting or belying claims for phonological analysis.

As important as the phonological manipulation is to evaluating lexical properties, it is not clear that studies in English have been successful in providing unequivocal tests. The task is much more straightforward in Serbo-Croatian, however, where the unique properties of the orthography can be exploited. In the following review, we will focus on the bi-alphabetism of fluent readers.

5 Reading in Serbo-Croatian Is Phonologically Analytic

Because Serbo-Croatian is phonologically shallow, there are no minor phonemic correspondences, no irregular words nor inconsistent regular words, and no orthographically irregular words. Phonological ambiguity is manipulated by choosing words (or nonwords) that combine common letters with unique letters (unambiguous letter strings) or common letters with ambiguous letters (ambiguous letter strings). The lexical status of letter strings so chosen will depend on their phonemic interpretation—that is, in which alphabet they are read. For example, an ambiguous string could be a word in Cyrillic but a
pseudoword in Roman (or vice versa). Or it could be one word in Cyrillic but a different word in Roman (or pseudowords in both). An unambiguous string could be a word in one alphabet and impossible in the other (or a pseudoword in one and impossible in the other). Finally, if composed exclusively of common letters, a string would be the same word in both alphabets (or the same pseudoword).

In lexical decision tasks, comparisons of response times to the variety of letter string types reveals a phonological ambiguity effect—an ambiguous letter string takes longer to decide about than an unambiguous letter string. This is true when it is (i) a word in one reading and a pseudoword in the other; (ii) a word, though different, in both readings; and (iii) a pseudoword, though different, in both readings (Lukatela, Popadić, Ognjenović, & Turvey, 1980; Lukatela, Savić, Gligorijević, Ognjenović, & Turvey, 1978). The effect is more pronounced with words than pseudowords (Feldman & Turvey, 1983; Lukatela et al., 1978). The greater the number of ambiguous letters in the string, the longer lexical decision takes (Feldman, Kostić, Lukatela, & Turvey, 1983; Feldman & Turvey, 1983). While attempts to bias subjects toward a Roman reading by instructions or task (i.e., uniquely Cyrillic letters never appear) did not eliminate the effect, the presence of a single unique character did (Feldman et al., 1983; Lukatela et al., 1978). Finally, the effect is more pronounced in good readers than in poor readers (Feldman et al., 1985), suggesting that those who more effectively exploit the phonologically analytic strategy are harmed more by ambiguity.

It is important to note that the phonological ambiguity effect is not an artifact of the frequency of ambiguous letter strings. These occur regularly in the Serbo-Croatian language. But the point is underscored nicely by two experimental findings. First, in a comparison of two inflected forms of the same noun, frequency is (at one level) equal since they are the same word (e.g., RUKA and RUCI both mean hand). But the occurrence of the various grammatical cases differs such that nominative singulars (e.g., RUKA) are at least ten times more frequent than dative singulars (e.g., RUCI). When both forms are unique letter strings, the latency for nominatives is (about 80 ms) shorter. When the nominative singular is ambiguous and the dative singular is unambiguous (i.e., has one unique character), latency for datives is (about 185 ms) shorter (Feldman et al., 1983). Phonological ambiguity overrides the frequency advantage.

The second rejoinder to frequency arguments comes from a comparison of words that are ambiguous in one alphabetic transcription but unique in the other. For example, the Cyrillic version of "hawk"—Koëv— is unique (pronounceable only as /kobats/) while its Roman version—KOBAČ—is ambiguous (pronounced /kobats/ if read as Roman but /kovas/ if read as Cyrillic. With such pairs, a word can be used as its own control: Frequency, meaning, length, number of syllables are identical. Only the number of morphophonological representations is different but that is sufficient to produce a 350 ms difference in decision time (Feldman, 1981).

6 Word-pseudoword Comparisons

As indicated in Section 4.0, the three general models of word processing agree that words should be named faster than pseudowords. Their reasons are quite different, however, as are the particulars of how lexicality might interact with phonological ambiguity. A model of visual analysis suggests that
words and pseudowords are read aloud by a common analogical process. Very roughly, a word finds a perfect analogy in the lexicon, with a singularly defined code for pronunciation; a pseudoword finds several analogies in the lexicon, defining several alternative pronunciations. The competition among lexical entries induced in the case of pseudowords would account for their slower naming relative to words (e.g., Glushko, 1979; Kay & Marcel, 1981). The effects of such competition ought to be especially (perhaps exclusively) apparent in experiments that compare phonologically ambiguous letter strings.

A model of phonological analysis holds that words and pseudowords are read aloud by a common phonological strategy that uses spelling-to-sound rules (based on the same principle as, though not necessarily identical to, the grapheme-to-phoneme correspondences identified by Venezky [1970]). Very roughly, the more regular the letter string the more rapid the recoding. As a rule, pseudowords will be less phonologically regular than words, resulting in slower naming latencies (e.g., Parkin, 1982; Parkin & Underwood, 1983). This residual difference should not change when both types of letter strings are chosen to be purposely ambiguous.

Finally, a dual process view asserts that words are read aloud by a visually based look-up of a word's lexical representation where the word's pronunciation can be retrieved. In contrast, pseudowords are read aloud by assembling a pronunciation on the basis of grapheme-phoneme correspondences. It is hypothesized that visual access is faster than rule-based assembly; consequently, words are named more rapidly than pseudowords (e.g., Coltheart, 1978; Coltheart et al., 1979). Phonological ambiguity should affect only pseudowords since their names alone are derived phonologically.

In Serbo-Croatian, at least, it appears that the difference in naming latencies between words and pseudowords does not change when phonological ambiguity is manipulated (Feldman, 1981). Both are slowed by about 450 ms when the letter strings can be read in two ways, suggesting that phonological involvement is the same for words and pseudowords. Certainly, this strategy is encouraged by the fairly direct correspondence to speech that the Serbo-Croatian orthographies exhibit. One might expect a different pattern with English, where the correspondence between orthography and speech is abstract. While English and Serbo-Croatian have not been compared directly (i.e., in the same experiment with the same controls) on the lexicality-ambiguity interaction, the direct comparisons that have been performed reveal differences between the languages that are germane to this issue. Since these involve a manipulation—semantic priming—that we have not yet discussed, we'll take a moment to describe its logic before summarizing the results.

It is commonly found that lexical decision and naming are facilitated when the target word is preceded by a semantically related priming word (Becker & Killion, 1977; Massaro, Jones, Lipscomb, & Scholz, 1978; Meyer, Schvaneveldt, & Ruddy, 1975). The general assumption is that when the prime activates its own lexical representation, that activation spreads to semantically related items, thereby speeding their subsequent lexical processing. Tasks that are lexically mediated ought to be facilitated; tasks that are not facilitated are unlikely to be lexically mediated.

Semantic priming of lexical decision is, in fact, found in both English and Serbo-Croatian (Katz & Feldman, 1983). For naming, however, facilitation is found only for English, suggesting that naming in the phonologically shal-
low Serbo-Croatian orthography need not involve the lexicon. This point is underscored by the correlations between lexical decision and naming (which may be taken as an index of processing similarity). In English, performance on semantically primed lexical decision correlates with naming, whether the latter is semantically primed or not; lexical decision without semantic priming also correlates with naming, whether primed or not. In Serbo-Croatian, the only significant correlation occurred when neither task was semantically primed. "The similarity between tasks is strongest when there is least involvement of the internal lexicon" (Katz & Feldman, 1983, p. 163).

7 Conclusion

The case for phonological analysis as the primary, nonoptional reading strategy in Serbo-Croatian is quite strong. It is not yet clear, however, whether or not this strategy is peculiar to Serbo-Croatian (or writing systems with similar properties): Does phonological analysis result from experience with a shallow orthography (i.e., does orthography influence processing) or is it simply easier to demonstrate in the sorts of experiments that the Serbo-Croatian orthography allows?

As strongly as we argue for a phonologically analytic strategy in Serbo-Croatian, others have claimed that Chinese characters can only be read via the visual route. Indeed, lexical decision is slowed by a visual manipulation wherein the internal components of two-character words (and nonwords) are distorted disproportionately, for example, 含 becomes 且; 不 becomes 不 (Hung, Tzeng, Salzman, & Dreher, 1984). This parallels the result for mixing upper and lower case letters in English (e.g., Coltheart & Freeman, 1974) but is in contrast to mixing Cyrillic and Roman letters in Serbo-Croatian. The latter slows neither lexical decision nor naming (Feldman & Kostić, 1981; Katz & Feldman, 1981). Interestingly, however, visual distortion in both Chinese and English affects poor readers more than good readers (Hung et al., 1984). This is puzzling if one assumes that the manipulation interferes with the putatively optimal strategy on which better readers ought to be more reliant. Serbo-Croatian, at least, follows the expected logic for a phonologically analytic strategy—good readers are hurt more by phonological ambiguity (Feldman et al., 1985).

We do not know if fluent readers of Chinese rely on some strategy other than visual analysis or if they can resort to some other strategy if the visual route is hindered. We do know that there are hints of some phonological analysis of Chinese characters. Detection of graphemic components (e.g., 胎 /taɪ/ ) is more successful when the component carries a phonetic clue (as in 胎 /taɪ/ ) than when it does not (as in 含 /yi/ [Hung & Tzeng, 1981]). Inconsistent characters take longer to name than consistent characters (where consistency is defined by the ratio of exemplars pronounced the same as the target to the total number of characters with that phonetic, regardless of how they are pronounced [Fang & Horng, this volume]). And a comparison of Japanese kanji (the logographic script borrowed from Chinese) with kana (a syllabary that depicts the phonetic value of its characters) reveals that colors are named faster when written in kana even though color names appear more frequently in kanji in Japanese literature (Feldman & Turvey, 1980; cf. Salto, 1981). This last finding, especially, seems troublesome for those models that restrict the role of phonological analysis. Phonological involvement is demonstrated for words (not just pseudowords) and it appears to facilitate, rather than slow, naming. One might argue that if phonological
analysis is optional, then it is an option readily (eagerly?) exploited when available— even in writing systems that are biased, by design and practice, in favor of visual analysis (cf. Brooks, 1977).

References


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Footnotes

1This is akin to Klima's (1972) third convention.

2We find these parallels to be pedagogically useful but they may be idiosyncratic and should not be taken as representative of how linguistic demand is characterized typically. For example, Mattingly (1984) has recently revised his distinction of phonological maturity and linguistic awareness as entailing grammatical knowledge and access to such knowledge, respectively. We are less able to use this distinction for our present purpose of classifying orthographies.