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Effects of Phonological Ambiguity on Beginning Readers of Serbo-Croatian

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Third- and fifth-grade Yugoslavian children rapidly named familiar words and unfamiliar pseudowords that were written either in the Roman alphabet or in the Cyrillic alphabet and that were either phonologically ambiguous or not. Phonological ambiguity was produced by using letter strings that, when transcribed in Roman or when transcribed in Cyrillic, contained one or more ambiguous characters. Ambiguous characters are those letters shared by the two alphabets that receive different phonemic interpretations in the two alphabets. The controls for phonologically ambiguous words were the same words in their alternative, nonambiguous alphabetic transcription. Consistent with previous experiments on adults, the phonologically ambiguous form of a word or pseudoword was named much more slowly than the phonologically unambiguous form. For children who were equally proficient in both Roman and Cyrillic, the effect of phonological ambiguity was greater as children named letter strings faster. If it can be assumed that reading fluency correlates with naming latency, then it can be argued that the better beginning reader is more phonologically analytic.

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The present paper reports an experiment on the rapid naming of printed letter strings by Yugoslavian children. These children are taught two alphabets: a Roman alphabet (the characters of which would be fairly familiar to the reader of English) and a Cyrillic alphabet (the characters of which are similar to but not identical with Russian script). Ordinarily, Yugoslav children learn both alphabets by the end of the second grade and are reasonably proficient in both by the fifth grade. In Belgrade, where most of the children in the present experiment were educated, the Cyrillic alphabet is taught first. Unlike the English writing system, the two writing systems of the Serbo-Croatian language maintain strict grapheme–phoneme correspondences; the phonemic interpretation of a letter does not vary with context and there are no letters made silent by context. Nevertheless, a source of confusion similar to that experienced by the beginning reader of English is experienced by the beginning reader of Serbo-Croatian (Mann, Liberman, & Shankweiler, 1980).

As noted above, the Serbo-Croatian language is written in two different alphabets, Roman and Cyrillic. The two alphabets transcribe one language and their graphemes map simply and directly 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 Fig. 1). Whatever their category, the individual letters of the two alphabets have phonemic interpretations (classically defined) that are virtually invariant over letter contexts. (This reflects the phonologically shallow nature of the Serbo-Croatian orthography.) 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.

The present experiment exploits this limited but explicit ambiguity in the Serbo-Croatian writing system. It does so to address the question of whether or not beginning readers who have learned both the Roman and Cyrillic alphabets can be distinguished by their sensitivity to phonological ambiguity: In rapidly naming letter strings, is the better beginning reader more hampered by the presence of phonologically ambiguous characters than the poorer beginning reader? The question takes this latter form for two reasons. First, accessing the name of a letter string may entail a phonologically analytic strategy, especially when the orthography is as regular as the Serbo-Croatian orthography (Turvey, Feldman, & Lukatela, 1984). Second, facility with a phonologically analytic strategy for naming (and, more generally, for accessing the internal lexicon)

TABLE 1
ROMAN AND CYRILLIC LETTERS AND THEIR PHONEMIC INTERPRETATION

Roman		Cyrillic		Letter name in IPA
Uppercase	Lowercase	Uppercase	Lowercase	
A	a	А	а	a
B	b	Б	б	bə
C	c	Ц	ц	tsə
Č	č	Ч	ч	tʃə
Ć	ć	Ћ	ћ	tʃjə
D	d	Д	д	də
Đ	đ	Ђ	ђ	dʒjə
DŽ	dž	Џ	џ	dʒə
E	e	Е	е	e
F	f	Ф	ф	fə
G	g	Г	г	gə
H	h	Х	х	xə
I	i	И	и	i
J	j	Ј	ј	jə
K	k	К	к	kə
L	l	Л	л	lə
LJ	lj	Љ	љ	ljə
M	m	М	м	mə
N	n	Н	н	nə
NJ	nj	Њ	њ	njə
O	o	О	о	ɔ
P	p	П	п	pə
R	r	Р	р	rə
S	s	С	с	sə
Š	š	Ш	ш	ʃə
T	t	Т	т	tə
U	u	У	у	u
V	v	В	в	və
Z	z	З	з	zə
Ž	ž	Ж	ж	ʒə

may be one way to distinguish the more skilled reader from the less skilled reader.[1] Consequently, on the basis of these two reasons, it may be supposed that in Serbo-Croatian the more skilled the beginning reader the greater is his or her vulnerability to phonologically ambiguous letter strings.

[1] This analytic style may be specific to language or it may be more general, embracing both linguistic and nonlinguistic perception (see Wolford & Fowler, 1984).

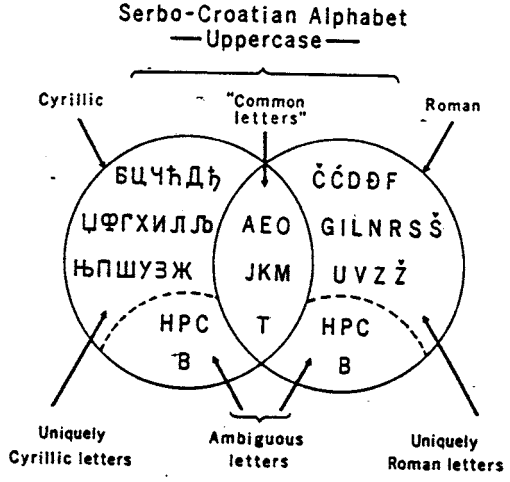

FIG. 1. The Roman and Cyrillic alphabet sets.

A similar strategy has been pursued by Liberman, Shankweiler, and their colleagues with regard to distinguishing good and poor readers of English by their ability to use phonetic coding in the short-term retention of linguistic materials presented visually or auditorily. The general result obtained by these investigators is that good readers perform proportionately worse than poor readers when the to-be-remembered stimuli are phonetically similar compared to when they are phonetically dissimilar (Mann et al., 1980; Shankweiler, Liberman, Mark, Fowler, & Fischer, 1979). That is, although good readers tend to do better in short-term memory tests than poor readers, the scores of good readers are deflated more by phonetic similarity.[2]

Outside of the short-term memory task, however, evidence for a difference between good and poor readers of English that is based on a difference in sensitivity to the linguistic underpinnings of the orthography is both sparse and equivocal. For example, Barron (1978) showed that visually presented pseudohomophones (e.g., BRANE, WERD) lengthened the lexical decision latencies of good readers but not of poor readers. It is difficult, however, to draw conclusions about linguistic contributions to visual word processing on the basis of pseudohomophone effects for the following reasons. First, there is the possibility that the phonetic

[2] In one failure to replicate these results (Hall, Humphreys, Tinzmann, & Bowyer, 1983), a criterion for selecting good and poor readers was the math achievement test score from the Woodcock–Johnson battery (Woodcock, 1973). This test includes a subtest where word problems are presented orally so that successful performance on that test must involve short-term memory abilities. By constraining selection procedures in this way, all children with short-term memory problems were effectively eliminated from the Hall et al. (1983) study.

interpretations assigned to pseudohomophones (e.g., BRANE) and to their related words (e.g., BRAIN) may be sensitive to the orthographic differences between them. Second, even if a pseudohomophone and its related word were assigned identical phonetic interpretations, it does not mean that they would be assigned identical phonological interpretations. (In formal linguistics, the phonetic and phonological representations of an English word are distinct.) Third, it is frequently the case that the pseudohomophones used in experiments are visually less similar to English words (i.e., orthographically less well structured) than are the control pseudowords (Martin, 1982).

Speaking more generally, reliable demonstrations of a linguistic contribution (e.g., phonological) to visual lexical access with English materials have proven hard to come by, regardless of the age and fluency of the reader. This fact has been interpreted to mean that accessing the lexical representation or name of printed English words is ordinarily a linguistically nonanalytic process, often termed visual (e.g., Coltheart, 1978). Alternatively, it could be interpreted to mean that, within the confines of the experimental procedure for studying lexical access and naming, it is difficult to find a manipulation of English stimulus materials that consistently reveals a linguistic contribution.

Results of research on lexical access and naming with the Serbo-Croatian language contrast sharply with the results of research with English. It has been shown repeatedly that in tasks where the lexical status of a letter string has to be provided rapidly, the presence of ambiguous characters has a retarding effect. A phonological contribution is consistently implicated (Feldman, 1983). The basic experimental procedure has been to compare two kinds of letter strings: (1) unambiguous letter strings composed of letters unique to an alphabet as well as letters shared by the two alphabets (see Fig. 1) and (2) ambiguous letter strings composed solely of letters shared by the two alphabets and always including one or more ambiguous letters. The first kind of letter string can be read in only one way and has a single morphophonological representation. In contrast, the second kind of letter string can be read in two ways because it is written in the letters shared by the two alphabets, some of which are phonemically bivalent; a letter string of this kind has two distinct morphophonological representations.[3] If lexical access and naming proceed with reference to the phonology, then a phonologically ambiguous letter string might be expected to extend response time relative to a letter

[3] For example, EKCEP can be interpreted as either /ekser/, which means *nail*, or as /ektsep/, which is meaningless. The former form is based on a Cyrillic reading of EKCEP and the latter on a Roman reading. By contrast, EKSER can only be interpreted in Roman, i.e., /ekser/. Therefore, EKCEP is phonologically ambiguous and EKSER is phonologically unique. The phonological representation associated with lexical access is sometimes termed morphophonological.

string that receives a unique morphophonological representation. This hypothesis has been evaluated in two ways: via a comparison of *different* letter strings (Lukatela, Popadić, Ognjenović, & Turvey, 1980; Lukatela, Savić, Gligorijević, Ognjenović, & Turvey, 1978) and via a comparison of different versions (Roman and Cyrillic) of the *same* letter string (Feldman, 1981; Feldman, Kostić, Lukatela, & Turvey, 1983; Feldman & Turvey, 1983).

When different words are compared, problems arise of matching the words on frequency of occurrence in the language, richness of meaning, length, number of syllables, etc. These problems can be virtually eliminated by taking advantage of the fact that some Serbo-Croatian words can be transcribed in the Roman and Cyrillic alphabets such that in one alphabet the reading is phonologically ambiguous, whereas in the other alphabet the reading is phonologically unique. To evaluate the phonological contribution to lexical access and naming, the bialphabetical nature of Serbo-Croatian permits a comparison of a written word with itself.

Consider the Serbo-Croatian word meaning *savanna*. This word is phonologically ambiguous when transcribed in Cyrillic (CABAHA, where C, B, and H are ambiguous) and phonologically unequivocal when transcribed in Roman (SAVANA). The expectations that lexical decisions on, and the naming of, letter strings like CABAHA should be significantly slower than the same responses to letter strings like SAVANA has been confirmed experimentally (Feldman, 1981; Feldman et al., 1983; Feldman & Turvey, 1983). To reiterate, the letter strings exemplified by CABAHA and SAVANA are the same word and, therefore, identical in all respects but one, namely, the number of morphophonological representations. It is, therefore, a noteworthy empirical observation that their associated latencies should differ by hundreds of milliseconds.

The design employed in the present experiment with children was modeled after that used in the experiments with adults by Feldman and her colleagues (see above). Because mastery of both the Roman and Cyrillic alphabets is an essential prerequisite for the appreciation of bivalence, children were tested at two levels of alphabetic proficiency, that is, 6 months and 30 months after they had learned the second alphabet. All children were presented words and pseudowords that were phonologically ambiguous when transcribed in one of the two alphabets. The children's naming latencies and erroneous responses to these ambiguously transcribed letter strings and to their unambiguously transcribed controls were compared. In the experiment, the question about phonological ambiguity and beginning readers of Serbo-Croatian posed above took the following form: With alphabetic proficiency controlled, is the latency (and/or error) difference between naming ambiguous and unambiguous versions of the same word (that is, the effect of phonological ambiguity) larger for the child whose reading skills are superior?

METHOD

Subjects

In order to include a range of reading ability at two levels of alphabetic proficiency, third- and fifth-grade students from the Svetozar Miletić School in Zemun, a suburb of Belgrade, participated in the study. The sample consisted of two complete classes at each grade level. As is the practice in Yugoslavia, these classes were not grouped by ability. Based on their own accounts, 85% of the children had learned the Cyrillic alphabet in the first grade and the Roman alphabet in the second. For the remaining 15%, the order of acquisition was reversed. When asked to write out their name, 95% of third graders and 73% of fifth graders chose to write in Cyrillic. Initially, 40 third graders and 37 fifth graders were tested. Three students were eliminated from the study because they often hesitated and triggered the voice key before actually initiating articulation. Two students were eliminated due to a preponderance of technical errors. Another four students were randomly eliminated in order to yield an equal number of subjects in each condition. Data from 34 students at each grade level were included in the analysis.

Materials

Two sets of letter strings were presented to each child. These included a pretest composed of 20 orthographically regular pseudowords all written in Cyrillic. After a brief pause, this was followed by a mixed test list. The test included 40 words and 40 pseudowords. Half of the letter strings were ambiguous and half were unambiguous. Among the ambiguous words, half were words by their Roman reading (and pseudowords by their Cyrillic reading), e.g., BATAK, and half were words by their Cyrillic reading (and pseudowords by their Roman reading), e.g., EKCEP. Among the ambiguous pseudowords, both alphabet readings were phonologically acceptable but meaningless.

Stimulus items were constructed so that each word and pseudoword could be written in two forms: a phonologically ambiguous form and the unique alphabet transcription of that same word. For the ambiguous words, half of the unique alphabet transcriptions were in Roman and half in Cyrillic. Analogously for the ambiguous pseudowords, half of the unique alphabet transcriptions were in Roman and half in Cyrillic. For the ambiguous pseudowords, however, the unique alphabet transcription was arbitrarily designated because there was no preferred phonological interpretation based on lexicality to which it need correspond.[4] In summary,

[4] For example, the possible unique alphabet transcriptions of BOPAM were БОПАМ (in Cyrillic) and VORAM (in Roman) where neither option was lexical. Therefore, alphabet designation for the unique alphabet transcription of ambiguous pseudowords was randomly assigned and balanced over items.

there were four types of words (ambiguous/pure × Roman/Cyrillic) and three types of pseudowords (ambiguous/pure Roman/pure Cyrillic). Each child viewed words and pseudowords of each type and different forms of the same item were presented to different groups of children.

All letter strings had between three and five letters and the proportion of items with three, four, and five letters was balanced across words and pseudowords in the test list. All letter strings in the pseudoword pretest contained four or five letters. All words in the test list were familiar to third- as well as fifth-grade students as judged by their teachers' assessment and by a frequency count based on children's texts in Serbo-Croatian (Lukić, 1970).

Procedure

The children performed a naming task on two lists of items, a pretest and a test. As each word appeared, they read it aloud. Words were projected onto a screen situated about 1 m in front of the child. Reaction time was measured from stimulus onset by a voice key. One experimenter recorded latencies and marked errors while a second experimenter noted the errors in more detail. In the pretest, children were instructed to read each letter string as accurately as possible. They were told that all items were pseudowords, composed of four or five letters, printed in Cyrillic. After the pretest, instructions were modified so that speed as well as accuracy was stressed. In addition, children were informed that the subsequent list would be composed of both meaningful words and of letter strings that had no meaning. Further, they were clued that some of these would be printed in Cyrillic and some in Roman. Finally, they were instructed at the outset and prompted through the course of the test list to read ambiguous words by their word reading when one existed, i.e., to read BATAK as /batak/ meaning *drumstick,* not as /vatak/ which is meaningless. (Only the word readings were treated as correct responses.) In summary, the ambiguous and unique forms of each word were distributed across two groups of subjects so that no subject saw two forms of the same word but all subjects saw 10 ambiguous forms and 10 unique forms in each alphabet. Pseudowords were designed in an analogous manner although there was no real distinction between the two alphabets for ambiguous pseudowords. Examples of the 40 words and 40 pseudowords and their distribution across groups is summarized in Table 2. Finally, practice items occurred at the beginning of both the pretest and the test list.

RESULTS

All correct reaction times were included in the analysis of variance. Because there was a high proportion of slow latencies, some as long as 4000 ms, median times were entered into the analysis of variance on

TABLE 2
EXAMPLES OF AMBIGUOUS AND UNIQUE LETTER STRINGS AND THEIR DISTRIBUTION ACROSS GROUPS OF SUBJECTS

Lexicality	Alphabet	Phonology	Form group 1	Form group 2
Word	Roman	Ambiguous	BATAK drumstick	KOBAC hawk
		Unique	EKSER nail	VETAR wind
	Cyrillic	Ambiguous	BETAP wind	EKCEP nail
		Unique	КОБАЧ hawk	БАТАК drumstick
Pseudoword	Roman	Ambiguous	BOPAM[a]	HABOT[a]
		Unique	ROJOS	SEMON
	Cyrillic	Ambiguous	CEMOH[a]	POJOC[a]
		Unique	ХАБОТ	БОпАМ

[a] Classification of these letter strings distinguish only in the randomly assigned alphabet of their unique alphabet transcription (see text).

reaction times. Separate analyses were performed on the word and pseudoword data. In order to capture any pattern revealed by the extended latencies, a second set of error analyses was performed including incorrect responses and correct responses that were slower than 2500 ms. For both the median and the error data on words, analyses based on subject variability and on item variability (in parentheses) are reported.

The analysis of median reaction times for words revealed significant main effects for three variables: grade, alphabet, and phonology. Inspection of the means in Fig. 2 shows a significant effect of grade—that is, third graders were slower than fifth graders, $F(1, 66) = 5.58$, $MS_e = 281{,}883.0$, $p < .05$ ($F(1, 38) = 44.60$, $MS_e = 15{,}329.8$, $p < .001$). In addition, there was a significant effect of alphabet—Cyrillic words were faster than Roman words, $F(1, 66) = 6.04$, $MS_e = 13{,}753.0$, $p < .05$ ($F(1, 38) = 0.74$, $MS_e = 492{,}078.0$, $p < .60$). Most important, there was a significant

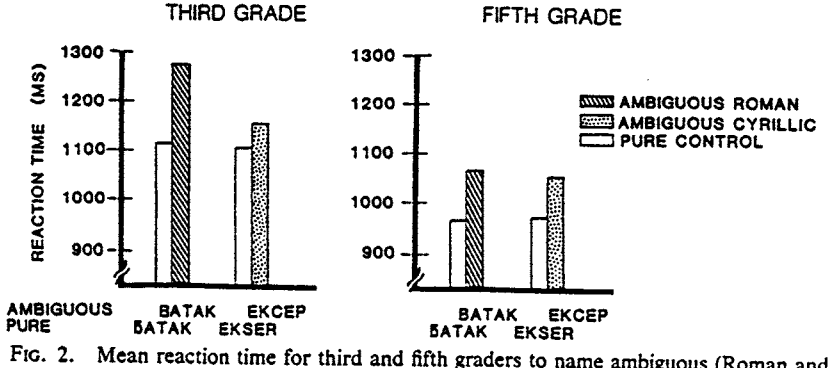

FIG. 2. Mean reaction time for third and fifth graders to name ambiguous (Roman and Cyrillic) words and the unambiguous alphabet transcription of the same words.

effect of phonology—ambiguous words were slower than the unique alphabet transcription of the same word, $F(1, 66) = 38.56$, $MS_e = 16{,}175.9$, $p < .001$ ($F(1, 38) = 13.03$, $MS_e = 35{,}081.2$, $p < .001$). Two 2-way interactions approached significance in the subjects analysis (but not in the items analysis): The interaction of phonology × alphabet suggested that, overall, the effect of ambiguous phonology might have been more robust in Roman than in Cyrillic, $F(1, 66) = 3.37$, $MS_e = 20{,}080.2$, $p < .06$. And means for the interaction of grade × alphabet indicated that third graders were slower on all Roman print than on all Cyrillic but that fifth graders read aloud comparably in both, $F(1, 66) = 3.84$, $MS_e = 13{,}753.8$, $p < .05$. The three-way interaction of alphabet × phonology × grade missed significance, however.

The analysis of variance on incorrect and slow responses to words provided a pattern similar to that for reaction time. Third graders performed less well than fifth graders, $F(1, 66) = 7.90$, $MS_e = 2.0879$, $p < .01$ ($F(1, 38) = 6.40$, $MS_e = 0.9993$, $p < .05$). Ambiguous words were more likely to elicit incorrect responses than unambiguous words, $F(1, 66) = 234.75$, $MS_e = 0.9247$, $p < .001$ ($F(1, 38) = 52.05$, $MS_e = 4.9967$, $p < .001$). There was, however, no main effect of alphabet. In the analysis of errors, the difference between third and fifth graders was larger for ambiguous words than for pure words as the interaction of phonology by grade indicated, $F(1, 66) = 12.03$, $MS_e = 0.9247$, $p < .001$ ($F(1, 38) = 4.22$, $MS_e = 1.1598$, $p < .05$). Moreover, as indicated by the interaction of alphabet × grade, third graders had a tendency to perform more poorly in Roman than in Cyrillic while fifth graders showed the opposite pattern, $F(1, 66) = 4.47$, $MS_e = 1.2523$, $p < .05$ ($F(1, 38) = 5.63$, $MS_e = 0.9993$, $p < .05$). Finally, the three-way interaction of phonology × grade × alphabet was nearly significant, $F(1, 66) = 3.47$, $MS_e = 1.6133$, $p < .06$ ($F(1, 38) = 7.78$, $MS_e = 1.1598$, $p < .01$). The mean number of errors for each condition and grade are reported in Table 3.

TABLE 3

MEAN NUMBER OF ERRORS AND STANDARD DEVIATION OF RESPONSE LATENCIES FOR AMBIGUOUS AND UNIQUE FORMS OF WORDS IN EACH ALPHABET

	Cyrillic ambiguous (EKCEP)	Unique control (EKSER)	Difference	Roman ambiguous (BATAK)	Unique control (БATAK)	Difference
Third grade	2.32[a] (361)[b]	0.47 (293)	1.85	2.94 (410)	0.41 (368)	2.53
Fifth grade	2.00 (213)	0.38 (151)	1.62	1.47 (201)	0.32 (183)	1.15

[a] Errors.

[b] Standard deviation of latencies.

The analysis of median pseudoword latencies including three types of pseudowords (ambiguous, unique Cyrillic, unique Roman) indicated a significant main effect of phonology, $F(2, 132) = 27.06$, $MS_e = 44{,}990.8$, $p < .001$, and a marginally significant effect of grade whereby third graders were slower than fifth graders, $F(1, 66) = 3.59$, $MS_e = 465{,}152.0$, $p < .06$. Mean pseudoword naming times for third graders were 1308 ms for Cyrillic, 1286 ms for Roman, and 1574 ms for ambiguous letter strings; corresponding times for fifth graders were 1204, 1097, 1324 ms, respectively. Post hoc tests indicated that unique Roman and unique Cyrillic forms did not differ for third graders, $F(1, 66) = .12$, but that unique Roman forms were significantly faster than unique Cyrillic forms for fifth graders, $F(1, 66) = 7.14$, $p < .009$.

Several analyses of variance suggested that alphabetic proficiency as indexed by interactions of alphabet × grade figured prominently in the pattern of results. In general, performance of fifth graders was comparable with Roman and Cyrillic print while third graders displayed weaker performance with Roman than with Cyrillic. In the analyses that follow, proficiency with each of the two alphabets was not confounded with measures of reading skill; the relation between reading skill and sensitivity to phonological ambiguity (which depends on the ability to derive *two* phonological interpretations for a letter string—one in *each* alphabet) was addressed separately at two levels of bialphabetic proficiency.

The Relation of Ambiguity to Decoding Speed and Error

For each subject, the difference in naming time for ambiguous and unique words was computed separately for Roman words, for Cyrillic words, and for their combined effect. These provided indices of the effect of phonological ambiguity. In addition, the median latency on the pretest with unambiguous Cyrillic pseudowords was computed for each child. Given that naming time for individual letters and pseudowords has been shown to correlate with reading skill (Jackson, 1980; Jackson & McClelland, 1979; Perfetti & Hogaboam, 1975), the median pretest latency can serve as an index of reading proficiency. The ambiguity scores were then correlated with the pretest latencies for 33 third graders and 34 fifth graders. (A reading skill measure was missing for 1 third grader.) Correlations were computed separately for each grade, as grade provided an index of bialphabetic proficiency. Moreover, separate correlations ensured against a correlation produced by sampling from two extreme groups, because third graders were generally slower than fifth graders. The correlation between the degree to which naming was slowed down by ambiguity and reading skill (as indexed by the pseudoword naming task) was significant for Cyrillic words alone for third graders, $r = -.430$, $p < .05$, and nearly significant for fifth graders, $r = -.297$, $p < .10$. The correlation between ambiguity and reading skill for Roman words

alone was nonexistent for third graders and nearly significant for fifth graders, $r = -.274$, $p < .20$. Finally, the correlation between ambiguity averaged over alphabets and reading skill was not significant for third graders but was significant for fifth graders, $r = -.378$, $p < .05$. These results are summarized in Table 4. The negative correlations indicate that, in general, the faster reader is more impaired by phonological ambiguity and, overall, the effect is strongest in the Cyrillic alphabet, that is, the alphabet learned first.

Classification of errors showed that, overall, third and fifth graders did not distinguish on the types of errors they made, although third graders tended to make more errors generally. Three types of errors were identified: (1) reading an ambiguous word in the wrong alphabet, for instance, giving BATAK a meaningless Cyrillic reading when it means "drumstick" read as Roman; (it is important to note that these errors can occur only with words); (2) mixing alphabets within a word, e.g., reading one ambiguous character in Roman and the following character in Cyrillic; (3) hesitating, or reversing or substituting a different phoneme for the one that is specified. In classifying errors, a given word for a given subject was never entered into two categories. Where an error was classifiable in more than one way, wrong-alphabet and mixed-alphabet designations took priority over substitutions and hesitations, but unique word errors were necessarily of the latter variety. The error data reported below are restricted to words, both ambiguous and unique, and are summarized in Table 5.

Pure words were excluded from subsequent analyses and separate analyses of variance were performed for wrong-alphabet and mixed-alphabet errors on ambiguous words. Inspection of mixed-alphabet means in Table 6 and the results of the analysis indicate no significant main effects or interactions. In the wrong-alphabet error analysis, there was a significant interaction of alphabet × grade, $F(1, 66) = 4.94$, $MS_e = 1.520$, $p < .05$ ($F(1, 38) = 3.09$, $MS_e = 1.620$, $p < .05$). Consistent with

TABLE 4
CORRELATION OF READING SKILL WITH DETRIMENT DUE TO AMBIGUITY

Ambiguous transcription	Third grade	Fifth grade	Combined
Cyrillic	−.430**	−.297+	−.398***
Roman	−.04	−.274+	−.011
Combined	−.28+	−.378*	−.286*
	$N = 33$	$N = 34$	$N = 67$

*$p < .05$.
**$p < .02$.
***$p < .01$.
+$p < .20$.
++$p < .10$.

TABLE 5
PROPORTION OF WRONG-ALPHABET, MIXED-ALPHABET, AND SUBSTITUTION/HESITATION ERRORS FOR ALL WORDS BY THIRD AND FIFTH GRADERS

Grade	Error		
	Wrong alphabet	Mixed alphabet	Substitution/ hesitations
Third	12.95[a]	3.75	3.28
Fifth	10.8	3.05	2.18

[a] Percentage.

the latency data on alphabetic proficiency described above, third graders found the Roman ambiguous words more difficult than the Cyrillic ambiguous words, while fifth graders found them equivalent.

In order to ascertain whether type of error varied with reading skill, each type of error was correlated with scores on the pretest. From the pretest, two indices of reading skill were developed: median pretest naming time and the number of pretest errors—substitution, hesitation, or reversals. As above, correlations were computed separately for each level of alphabet proficiency, i.e., grade. In this case, number of mixed-alphabet errors correlated significantly with reading skill. Results are summarized in Table 7. The positive correlations indicate that for readers who are equally proficient in both alphabets, less skilled decoders were more likely to mix alphabets within a word (Roman or Cyrillic) than were more skilled decoders.

DISCUSSION

If a reader named words strictly on the basis of their familiar figural aspects, then naming a printed familiar word transcribed with one or more ambiguous characters (e.g., BATAK) should not be any different from naming the same familiar word transcribed with no ambiguous characters (e.g., ѢATAK). It is evident, however, that phonologically ambiguous letter strings were named, in general, more slowly than were

TABLE 6
MEAN NUMBER OF WRONG-ALPHABET AND MIXED-ALPHABET ERRORS (AND STANDARD DEVIATION) FOR AMBIGUOUS ROMAN AND CYRILLIC WORDS

Ambiguous transcription	Third grade		Fifth grade	
	Wrong alphabet	Mixed alphabet	Wrong alphabet	Mixed alphabet
Cyrillic	0.91 (1.23)	0.44 (0.61)	1.22 (0.91)	0.44 (0.76)
Roman	1.63 (1.36)	0.34 (0.60)	0.97 (1.09)	0.19 (0.29)

TABLE 7
MEDIAN OF DECODING LATENCIES AND DECODING ERRORS (STANDARD DEVIATIONS) AND THEIR CORRELATION WITH MIXED-ALPHABET ERRORS

Measure	Third grade	Fifth grade	Third/fifth
Decoding Latency (*SD*)	969 (270)	878 (154)	924 (223)
	.182	.365*	.250*
Decoding errors (*SD*)	2.65 (1.99)	2.16 (2.19)	2.40 (2.09)
	.466***	.355*	.413***
	$N = 33$	$N = 34$	$N = 67$

* $p < .05$.
*** $p < .01$.

their phonologically unambiguous controls. Evidently, the readers in the present experiment did not treat words as holistic figural patterns. To the contrary, the data suggest that the beginning reader in the experiment noticed (more or less) the phonological aspects of a printed word that were specified in the details of its orthographic structure. In this latter respect the present data replicate with children the observations made previously with adults.

When bialphabetic adult readers of Serbo-Croatian performed a lexical decision task, letter strings composed of ambiguous and common characters incurred longer latencies than the unique alphabet transcription of the same word (Feldman & Turvey, 1983), and, in an analogous naming task, the same pattern of results occurred (Feldman, 1981). In the adult experiments, words were selected so as to include a varied distribution in the number and position of the ambiguous characters within the letter string. Results indicated that all letter strings that could be assigned both a Roman and a Cyrillic reading incurred longer latencies than the unique alphabet transcription of the same word and that the magnitude of the difference between the ambiguous form of a word and its unique alphabet control depended on the number and distribution of ambiguous characters in the ambiguous letter string. These results with phonologically bivalent letter strings were interpreted as evidence that both lexical decision and naming in Serbo-Croatian necessarily involve an analysis that is sensitive to phonology and component orthographic structure. Moreover, in an earlier study, words and pseudowords composed entirely of common letters (with no ambiguous or unique letters) were accepted and rejected, respectively, no more slowly than letter strings that included common and unique letters. Because the distinction between common letters and ambiguous letters was based on their phonemic interpretation, this result suggested that it was *phonological* bivalence rather than a figure-based

alphabetic bivalence that governed the effect (see Lukatela, Savić, Gligorijević, et al., 1978; Lukatela et al., 1980, for a complete discussion). In summary, the adult studies suggested that processes of word recognition were both *analytic* and *phonological* in nature.

The major question of interest in the present study was whether the magnitude of the difference between the ambiguous forms and their unique alphabet controls was larger for the more fluent beginning readers: Were the better beginning readers caused to respond proportionately more slowly (and/or to commit proportionately more errors) by phonological ambiguity than the poorer beginning readers? In the present experiment, the measure of reading skill was the speed with which a reader named unfamiliar, nonsense letter strings. This speed should be faster, on the average, the better are the reader's decoding skills. The answer to the ambiguity question was not independent of another more general question, however, viz., the relative proficiency in Roman and Cyrillic. Sensitivity to phonological ambiguity necessarily entails the ability to (automatically) assign phonological interpretations in *two* alphabets (see Turvey et al., 1984)—an ability that requires approximately equal familiarity with both alphabets.

The analysis of variance on median reaction times indicated that third graders named letters strings more slowly and less accurately than fifth graders. The analysis also revealed that the performance of all children—third and fifth graders—deteriorated on ambiguous letter strings relative to their unique alphabet controls. The major question of interest, however, was whether the more skilled beginning reader was more impaired by phonological ambiguity than the less skilled beginning reader, independent of general proficiency with each alphabet. Although the interactions of phonology × grade or of phonology × grade × alphabet were not significant, the relation between phonological ambiguity and reading skill was evaluated separately for each level of alphabetic proficiency for several reasons. First, inspection of the means in Fig. 2 indicated that for fifth graders the effect of phonological ambiguity was constant over alphabet, whereas for third graders the effect was more exaggerated for those letter strings that were ambiguous in the Roman alphabet. (A comparison of the variances across groups of words in Table 3 suggests the same thing.) Second, although neither of the two-way interactions was significant by the items analysis, by the subjects analysis, one (alphabet × phonology) was almost significant ($p < .06$), and the other (alphabet × grade) was significant ($p < .05$). Generally, the chances of obtaining higher order interactions with the dichotomous grade variable were further reduced by the magnitude of the variability in the latency data of the third-grade children. Third, the third-grade children's error data suggested that their facility with Roman letter strings in general was not as good

as their facility with Cyrillic letter strings in general, whereas no such bias was evident in the fifth-grade data.

Apparently, third graders were less proficient in the newly acquired Roman alphabet and they found it difficult to suppress the unwanted Cyrillic reading of an ambiguous Roman letter string. For third graders the first-learned and more familiar (Cyrillic) alphabet tended to dominate their naming responses. Because a Cyrillic bias would exaggerate the effect of ambiguous characters in Roman words and reduce the effect of ambiguous characters in Cyrillic words, it counters any true phonological ambiguity effect. It appears that the dominance of the first-learned alphabet has waned considerably by the fifth grade, however. The analysis on wrong-alphabet errors (Table 6) supports this interpretation. It should be remarked, however, that there is some evidence to suggest an asymmetry between the first- and second-learned alphabets—with a continued dominance of the first-learned—that persists, in more difficult tasks, through adulthood (Lukatela, Savić, Ognjenović, & Turvey, 1978). The literature on interference patterns between languages using the Stroop and dichotic listening tasks (Magiste, 1984) provides evidence for a similar asymmetry. The detrimental influence of the second-learned language on the first-learned language and the influence of the first-learned language on the second-learned language is *symmetric* when proficiency in both languages is balanced, but *asymmetric* when one language is dominant. As proposed elsewhere, in terms of the interaction of two symbol systems bialphabetism may be a limited case of bilingualism (Feldman, 1983; Lukatela, Savić, Ognjenović, & Turvey, 1978).

As discussed above, speed of naming nonsense letter strings was taken as the measure of a child's reading skill. Speed of naming nonsense items was then correlated with the ambiguous–unambiguous latency difference. Larger differences were associated with faster naming times (Table 4). That is, faster decoders were slowed proportionately more by phonological ambiguity than slower decoders. Examination of the subcorrelations revealed that this significant correlation was carried in largest part by the difference between words that were phonologically ambiguous in Cyrillic and their unique alphabet controls. The difference between words transcribed ambiguously in Roman and their unambiguous controls did not correlate significantly with the decoding speeds of third graders (see Table 4). However, as noted above, there was considerable variance in individual ambiguity scores for Roman materials, suggesting an inconsistency in the ability of some third graders to handle letter strings in the newly acquired alphabet. This suggestion is buttressed by the lack of a correlation between third-grade ambiguity scores in Roman and in Cyrillic. Apparently, for third graders the basis for the ambiguity effect in the two alphabets was not the same.

There are two possible reasons for the slower responses to ambiguous

letter strings, in particular to the ambiguous *Roman* letter strings. One possible reason, anticipated when selecting children at two grade levels, is an overall Cyrillic bias when interpreting letter strings that is due to unequal proficiency with the two alphabets. This bias was restricted to ambiguous letter strings, however. Those letter strings that included unique letters were no slower in Roman than in Cyrillic at either level of alphabet proficiency. Moreover, the latency scores for the third graders who learned the Roman alphabet first revealed the same pattern. Nevertheless, a Cyrillic bias is suggested by the latency data on ambiguous words for third graders and is further supported by the alphabet × grade interaction in the analysis of variance on wrong-alphabet errors. The other possible reason is an effect of two phonological analyses (where permitted) when proficiency with the two alphabets is equated. This possibility assumes equivalent performance with Roman and Cyrillic letter strings. The suggestion, therefore, is that, for some third graders, a large ambiguity effect on Roman letter strings occurred not because they were proficient decoders but, rather, because they were unfamiliar with the Roman alphabet. Put differently, the ambiguity effect with Roman materials that was manifested by third graders could have originated from one of two factors, where the two factors relate the opposite ways to reading skill. By contrast, fifth graders performed equivalently with ambiguous forms and unique alphabet controls in both the Roman and Cyrillic alphabets. As such, the fifth-grade data indicate a relation between reading skills and sensitivity to phonological ambiguity when the assumption of proficiency in the two alphabets is met.

Finally one other difference between the skilled and less skilled beginning reader should be noted, namely, that the less skilled beginning reader of Serbo-Croatian is less respectful of the fact that the characters of the Roman and Cyrillic alphabets belong to independent symbol systems. Table 7 reports the correlation of decoding speed with the tendency to mix alphabets in interpeting an ambiguous word. The less skilled decoder who has mastered both alphabets equally is more apt to ignore the independence of the two alphabets and to construct part of a word's name on the basis of a Roman alphabet reading and part on the basis of a Cyrillic alphabet reading.

In summary, the sequential acquisition of two alphabets in the process of learning to read, in conjunction with some special properties of the Serbo-Croatian language, permitted an investigation of the facility of beginning readers with a special variety of phonological analysis. It was demonstrated with children in the third and fifth grades that naming is slower and less accurate when a letter string can be assigned two phonological interpretations than when it can be assigned only one. This effect of ambiguity was assessed on two forms of the same word and it replicates

prior results with adults (Feldman, 1981; Feldman et al., 1983; Feldman & Turvey, 1983).

Two levels of bialphabetic proficiency were examined. The asymmetry of the effect of phonological bivalence for ambiguous words in Roman as compared with Cyrillic was reduced as proficiency in each alphabet became equal and this suggested an analogy with the interaction of the two linguistic codes of the bilingual. For third graders, evidence of a Cyrillic bias when analyzing ambiguous letter strings made assessment of the relation between reading skill and sensitivity to phonological ambiguity equivocal. For fifth graders who are almost equally proficient in the two alphabets, however, there was evidence that the more skilled beginning reader was *more* impaired by phonological ambiguity than the less skilled beginning reader. In conclusion, the beginning reader who names letter strings more rapidly is more analytic in his or her style of reading.

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