

Context Effects in Bi-alphabetical Word Perception

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The Serbo-Croatian language is transcribed in two partially overlapping alphabets. Some of the shared letters are pronounced differently in the two alphabets. Consequently, when the alphabet is not specified, some letter strings are phonologically ambiguous. Lexical decision and naming are much slower for such letter strings relative to appropriately controlled, phonologically unambiguous letter strings. Lexical decision and rapid naming experiments are reported, directed at contextually reducing this phonological ambiguity effect. For words, the phonological ambiguity effect was reduced by alphabetically related contexts in both tasks. Associatively related contexts also contributed to the effect's reduction in the rapid naming of words. For pseudowords, alphabet specification reduced the effect in lexical decision but not naming. Results were discussed in terms of their implications for an account of Serbo-Croatian word recognition. © 1989 Academic Press, Inc.

The Serbo-Croatian language is written with two partially overlapping script systems, Roman and Cyrillic. Seven upper case letters are shared. Of these common letters, four are ambiguous in the sense that they refer to different phonemes. For example, in IPA notation, H is read in Roman as /xə/ and in Cyrillic as /nə/. Other letters

are shared by both alphabets but receive the same phonemic interpretation in each. For example, the letter M occurs in both alphabets but is unambiguous because it is interpreted the same way in each. Some words in the language are written only in the shared unambiguous letters. Such words are *alphabetically* ambiguous. This form of ambiguity, however, is immaterial to the reading process. In contrast, where one or more of the letters in a word written in shared letters is ambiguous, the word in question can be read in more than one way. We refer to such words as *phonologically* ambiguous. For example, the Cyrillic letter string BETAP can be pronounced /vetar/ (its

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Cyrillic reading) or /betap/ (its Roman reading). Although both of these are phonotactically acceptable, only one of the two pronunciations is a real word. (The Cyrillic pronunciation means "wind," as in the phrase "wind storm"). When native speakers/hearers of Serbo-Croatian are presented phonologically ambiguous letter strings in either the rapid lexical decision or naming tasks their response latencies are slowed markedly relative to their response latencies for phonologically unambiguous letter strings (Feldman, 1981; Feldman & Turvey, 1983; Feldman, Kostić, Lukatela, & Turvey, 1983; Lukatela, Savić, Gligorijević, Ognjenović, & Turvey, 1978, Lukatela, Popadić, Ognjenović, & Turvey, 1980). Letter strings of the latter type include minimally one unique character, that is, a character that appears in only one of the two script systems and which, by definition, has only a single phonemic reading.

To get an impression of the degree to which phonological ambiguity can retard responding consider some numbers from Feldman and Turvey (1983). These investigators took advantage of the fact that a small set of Serbo-Croatian words are phonologically ambiguous when written in one alphabet (say, Cyrillic) and phonologically unambiguous when written in the other alphabet (Roman). An example is the Serbo-Croatian translation of the English word CARAVAN. In Cyrillic this word is written KAPABAH with three ambiguous characters (underlined). If read aloud as Roman it would sound like /kapabax/. In Roman, the word is written KARAVAN with no ambiguous letters. KARAVAN cannot be read as Cyrillic because R, V, and N are uniquely Roman characters—they do not appear in the Cyrillic alphabet. When lexical decision times to these two versions of the same word were compared the mean difference was 392 ms (KAPABAH 1038 ms, KARAVAN 646 ms).

Our intuition is that in the ordinary reading of connected text (like a story in a newspaper), phonologically ambiguous words

pose no special problem. In connected text the words are written in only one of the two alphabets. The text, apparently, renders phonologically ambiguous words unambiguous. How it might do so, however, is an open question. Lukatela, Savić, Gligorijević et al.'s (1978) experiments, by their design and by the instructions given to the subjects, directed the individual subject to treat the presented letter strings in the Roman alphabet "mode." Unique Cyrillic characters never appeared and subjects were told to identify letter strings as words by their Roman reading. The situation, in short, was closely analogous to reading connected text. For present purposes the important outcome of the Lukatela, Savić, Gligorijević et al. (1978) experiments was that the establishment of an alphabet mode through design/instruction did not eliminate the retarding effects of phonological ambiguity. The failure of these large-scale, long-term biases (they were defined over the experimental conditions and persisted throughout the course of the experiment) suggests that if phonologically ambiguous words are disambiguated in ordinary reading situations then the disambiguation is brought about by very local influences such as, for example, the immediately preceding word or words. Regarding a phonologically ambiguous word as a target and an immediately preceding unambiguous word as its (immediate) context we can ask what it is about the context that renders the target univocal.

The experiments reported focus on two aspects of the context word: the alphabet in which it is written and its associative relation to the target. The experimental tasks are rapid lexical decision and rapid naming. The results from the two simple contextual manipulations, conducted within the two simple experimental tasks, provide insights into the mechanisms underlying the bi-alphabetism of the Serbo-Croatian reader, extending, thereby, our previous investigations of this topic. With respect to more general issues in the theory of printed word

perception, the present series of experiments bears on the claim that, for Serbo-Croat, the lexical access code relates more closely to a word's phonemic structure than to its orthographic structure. For English, it is more commonly argued that orthographic structure controls access (Humphreys & Evett, 1985).

EXPERIMENT 1

On each trial the subject was presented two successive stimuli. The context stimulus was either a row of asterisks or a word. The target stimulus was either a word or a pseudoword. The subject had to decide as rapidly as possible whether the target stimulus was a real word or not. Targets were evenly divided into words and pseudowords and evenly divided into phonologically ambiguous and phonologically unambiguous letter strings. Contexts were evenly divided into asterisks and words. Target words were chosen in the fashion of Feldman and Turvey (1983). As noted above, Feldman and Turvey (1983) used words that could be written legitimately in Roman and legitimately in Cyrillic and were phonologically ambiguous in one of the two written forms. Using target words of this kind eliminates differences in visual familiarity (cf., Gernsbacher, 1984), number of letters, and richness of meaning (cf., Whalen, 1979) in the phonologically ambiguous/phonologically unambiguous comparison. In this first experiment, where word targets followed word contexts (as opposed to asterisks), (a) the alphabet of the target and the alphabet of the context were the same, and (b) the target was an associate of the context.

The major question of interest was whether a phonologically ambiguous item could be rendered effectively unambiguous by the conjunction of these two constraints on the context-target relation. It was expected that, consistent with previous observations (Feldman & Turvey, 1983), there would be a large ambiguous/unambiguous difference in a context that was neutral with

regard to the target word's alphabet and identity. In the context of a word associate written in the same alphabet, however, the ambiguous/unambiguous difference might be substantially reduced or eliminated.

Method

Subjects. Forty-eight high school students from Belgrade were paid to participate in the experiment. All were naive with respect to the questions under investigation although all had participated previously in reaction time experiments. Subjects were assigned randomly to one of four experimental groups according to their order of appearance for testing.

Materials. A basic set of 28 phonologically ambiguous Cyrillic and 28 phonologically ambiguous Roman words was selected. These are defined as letter strings that contain one or more ambiguous letters and no unique letters. A phonologically ambiguous Cyrillic word (e.g., BETAP) is a word by its Cyrillic reading (/vɛtar/ = "the wind") and a nonword by its Roman reading (/betap/). A phonologically ambiguous-Roman word (e.g., PAJAC) is a word by its Roman reading (/pajats/ = "clown") but a nonword by its Cyrillic reading (/rajas/). All words were of the consonant-consonant-vowel- or vowel-consonant-vowel-consonant-type. As such, all letter strings were orthographically and phonologically legal by both readings and easily pronounced in both readings. Most of the words (80%) were 4-5 letters and bisyllabic. The remainder were mono- or trisyllabic.

For the set of words chosen, each phonologically ambiguous word can be transcribed into the other alphabet to produce corresponding phonologically unique words. That is, the Roman transcription of the phonologically ambiguous Cyrillic word, BETAP, is the same word (VETAR = "the wind") in a phonologically unique Roman version. Similarly, the Cyrillic transcription of the phonologically ambiguous Roman word, PAJAC, is ПАЈАЦ

("clown"), a phonologically unique Cyrillic version.

The requirements that the letter strings be phonologically ambiguous words by one reading, nonwords by the other reading, and that each word have a phonologically unique transcription in the other alphabet resulted in the entire frequency range being represented. Average frequencies (according to Lukić, 1983) of phonologically ambiguous Cyrillic/phonologically unique Roman and phonologically ambiguous Roman/phonologically unique Cyrillic words were 116 and 63, respectively. All experimental manipulations compared a given word to itself, however, so that frequency was effectively controlled.

A corresponding set of 56 pseudowords was created by changing one consonant in each of the 56 phonologically unique and 56 phonologically ambiguous words. Ambiguous letters were substituted for ambiguous letters and unique letters were substituted for unique letters. This ensured that the same pseudoword appeared in both a unique and an ambiguous form. (For some letter strings, a single letter replacement of the required sort always resulted in another word. In those cases, a single letter common to the two alphabets was added to produce a pseudoword.) All letter strings were orthographically and phonetically legal.

Associative norms do not exist for the Serbo-Croatian language. In order to obtain associates, therefore, a test list was prepared with the basic word set transcribed as 28 phonologically unique Roman forms and 28 phonologically unique Cyrillic forms. The list was presented to 53 students sampled from the same population as the experiments (i.e., 25 from the Department of Psychology, University of Belgrade and 28 from the Fifth Belgrade Gymnasium). For each word in the list, students were asked to write the first five words that came to mind. Of the 168 (first-, second-, and third-order) associates so produced, 84 phonologically unique Roman forms and 84 phonologically unique Cyrillic forms were pre-

sent to another group of 32 subjects from the same population who again were asked to write the first five words that came to mind. Response sheets from both tasks were inspected for symmetrical associates regardless of rank differences (e.g., first-order and third-order, third-order and second-order, etc.) and these were used as associatively related contexts. For 7 of the original 56 target words, no reliable associates were produced. In those cases, related contexts were chosen to be semantically related (e.g., VRSTA = "species" paired with RASA = "race").

Target words and pseudowords were preceded by a row of three astericks on half of the trials and a real word context on the other half of the trials. Word contexts for target words were associates; word contexts for target pseudowords were associated with the source word from which that pseudoword had been derived. Context words always contained at least one unique letter and so were in the same alphabet as the word reading of the phonologically ambiguous Cyrillic forms and phonologically ambiguous Roman forms. For example, BETAP ("wind") was preceded by OJYJA ("storm") in which JI and Y are unique to the Cyrillic alphabet. Twenty-four unique word and 24 unique pseudoword fillers (half Roman and half Cyrillic) were always preceded by the neutral *** context. These fillers were not included in subsequent analyses. All words (contexts and targets, experimental and filler) were nominative singular nouns. They were not restricted with respect to gender (feminine, masculine, or neuter).

Design. On half of the trials, target words and pseudowords were phonologically ambiguous and on the other half they were phonologically unique. Half of each type were preceded by a word context and half were preceded by ***. Therefore, four experimental conditions were defined by the presence or absence of a context word and by the phonological ambiguity (equal numbers of phonologically ambiguous Cyrillic

forms and phonologically ambiguous Roman forms) or uniqueness (equal numbers of phonologically unique Roman forms and phonologically unique Cyrillic forms) of the target. In order that every word and pseudoword target appeared in every condition, and that no subject saw any context or target more than once, four experimental lists were created. Each contained the four experimental conditions defined above, but a given word was in a different condition in each list. The four lists are illustrated in Table 1. Each subject viewed one list. The order of items within a list was random with three exceptions. First, a source word and

its derived pseudoword were separated, on average, by 80 items (one half of the list). Second, whether the source word or the derived pseudoword was seen first was counterbalanced. And third, the ordering of experimental conditions within the four lists was identical, although the particular items differed. For example, the first item in every list was an associatively primed phonologically ambiguous Cyrillic word; the second item was an unprimed phonologically unique Roman pseudoword; and so on.

Procedure. Subjects performed a lexical decision task. As each target word appeared, they had to hit a telegraph key with

TABLE 1
ILLUSTRATION OF DESIGN OF EXPERIMENT 1 USING FOUR GROUPS OF SUBJECTS FOR FOUR EXPERIMENTAL CONDITIONS

Transcription	Context	Experimental group			
		1	2	3	4
<i>Words</i>					
PUR ^a	Associate	OLUJA-VETAR storm-wind	SLAMA-SENO straw-hay	ČEŠALJ-KOSA comb-hair	DREMEŽ-SAN drowsiness-sleep
	XXX	XXX-KOSA XXX-hair	XXX-SAN XXX-sleep	XXX-VETAR XXX-wind	XXX-SENO XXX-hay
PUC ^b	Associate	ЦИРКУС-ПАЈАЦ circus-clown	РАЗУМ-ПАМЕТ reason-mind	ЦУЦЈА-БЕБА pacifier-baby	ЖУБОР-ПОТОК ripple-brook
	XXX	XXX-БЕБА XXX-baby	XXX-ПОТОК XXX-brook	XXX-ПАЈАЦ XXX-clown	XXX-ПАМЕТ XXX-mind
PAC ^c	Associate	ДРЕМЕЖ-САН drowsiness-sleep	ОЛУЈА-БЕТАР storm-wind	СЛАМА-СЕНО straw-hay	ЧЕШАЈЉ-КОСА comb-hair
	XXX	XXX-СЕНО XXX-hay	XXX-КОСА XXX-hair	XXX-САН XXX-sleep	XXX-БЕТАР XXXX-wind
PAR ^d	Associate	ЖУБОР-ПОТОК ripple-brook	ЦИРКУС-ПАЈАЦ circus-clown	РАЗУМ-ПАМЕТ reason-mind	СУЛА-БЕБА pacifier-baby
	XXX	XXX-ПАМЕТ XXX-mind	XXX-БЕБА XXX-baby	XXX-ПОТОК XXX-brook	XXX-ПАЈАЦ XXX-clown
<i>Pseudowords</i>					
PUR	Associate	ČEŠALJ-TOSA comb-	DREMEŽ-SON drowsiness-	OLUJA-VEVAR storm-	SLAMA-SANO straw-
	XXX	XXX-VEVAR	XXX-SANO	XXX-TOSA	XXX-SON
PUC	Associate	ЦУЦЈА-БЕБАМ pacifier-	ЖУБОР-ПОТЕК ripple-	ЦИРКУС-ПЕЈАЦ circus-	РАЗУМ-ПАМОТ reason-
	XXX	XXX-ПЕЈАЦ	XXX-ПАМОТ	XXX-БЕБАМ	XXX-ПОТЕК
PAC	Associate	СЛАМА-САНО straw-	ЧЕШАЈЉ-ТОСА comb-	ДРЕМЕЖ-СОН drowsiness-	ОЛУЈА-ВЕВАР storm-
	XXX	XXX-СОН	XXX-ВЕВАР	XXX-САНО	XXX-ТОСА
PAR	Associate	РАЗУМ-ПАМОТ reason-	СУЛА-БЕБАМ pacifier-	ЖУБОР-ПОТЕК ripple-	ЦИРКУС-ПЕЈАЦ circus-
	XXX	XXX-ПОТЕК	XXX-ПЕЈАЦ	XXX-ПАМОТ	XXX-БЕБАМ

^a PUR = phonologically unambiguous Roman letter string.

^b PUC = phonologically unambiguous Cyrillic letter string.

^c PAC = phonologically ambiguous Cyrillic letter string.

^d PAR = phonologically ambiguous Roman letter string.

both hands to indicate whether or not it was a word. They hit the further key with the forefingers to indicate that it was a word and the closer key with the thumbs to indicate that it was not. All letter strings were printed in upper case characters and displayed on the monitor of an Apple IIe.

On each experimental trial a subject heard a brief warning signal and saw a fixation point. Then the fixation point disappeared to be replaced by a context—a word or a row of three asterisks—that appeared for 700 ms, slightly above the fixation point. After the context word ended, a delay of 100 ms was interposed before the target stimulus appeared, located slightly below the fixation point. The target stimulus—a word or a pseudoword—was displayed for 1400 ms. Decision latency was measured from the onset of the target. If a response was slower than 1500 ms or incorrect (e.g., the subject responded “word” when the target was a pseudoword) then a message appeared informing the subject of his or her slowness or incorrectness. The interval between trials was 2500 ms. On the average of once every 20 trials, the subject was asked, through a visual prompt, to report orally both of the presented stimuli.

Results and Discussion

In all the experiments to be reported the upper limit on acceptable latencies—those to be included in the analysis—was defined as the longest latency above which further increases in the latency cutoff did not result in a significant decrease in the “total error” (sum of incorrect responses and responses slower than the cutoff value). Using this definition meant that total error approached the true error, that is, the number of wrong decisions. The upper latency cutoff was standardized at 1500 ms for similar experiments. If the data, on inspection, did not fit this limit, then the limit was adjusted. The lower limit was standardized at 400 ms.

Figure 1 presents the mean latencies as a function of condition (left axis) and the

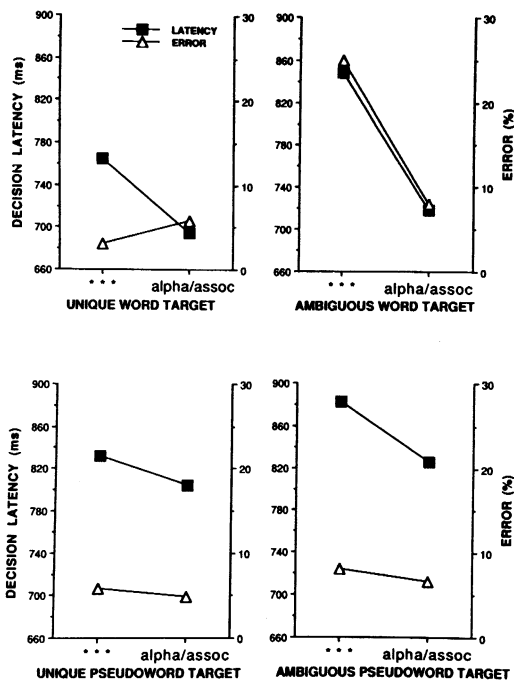


FIG. 1. Lexical decision latency and error as a function of context (asterisk vs. same alphabet/associate) and target type in Experiment 1.

mean error percentages as a function of condition (right axis). Analyses were conducted with subjects and items as random effect variables and on the word targets and pseudoword targets separately. Throughout this article the major comparisons are (a) between words processed under different conditions and (b) between pseudowords processed under different conditions. No major arguments are based on word-pseudoword differences as such.

The data on word targets are considered first. For the latency measure, the main effect of context (asterisks = 806 ms vs. same alphabet/associate = 706 ms) was significant, $\min F'(1,93) = 37.72, p < .001$, as was the main effect of ambiguity (nonambiguous = 730 ms vs. ambiguous = 783 ms), $\min F'(1,102) = 20.66, p < .001$. The interaction between these two variables (difference for asterisks = 83 ms vs. difference for same alphabet/associate = 23 ms) also proved significant: $\min F'(1,97) = 8.96, p < .01$. Both main effects were sig-

nificant for the error measure—context (asterisks = 14.0% vs. alphabet/associate = 6.9%, $\min F'(1,99) = 9.24, p < .01$; ambiguity (nonambiguous = 4.4% vs. ambiguous = 16.5%), $\min F'(1,102) = 39.72, p < .001$ —as was the interaction between them (difference for asterisks = 22.0% vs. difference for same alphabet/associate = 2.2%), $\min F'(1,95) = 24.41, p < .001$.

Decision latencies for pseudoword targets were affected by both context and ambiguity. With respect to context (asterisks = 857 ms vs. same alphabet/associate = 815 ms), $\min F'(1,79) = 10.34, p < .01$; with respect to ambiguity (unique = 818 ms vs. ambiguous = 854 ms), $\min F'(1,87) = 5.81, p < .05$. There was, however, no significant interaction (difference for other alphabet = 51 ms vs. difference for same alphabet = 22 ms), $\min F'(1,97) = 1.68, p > .05$. Unlike the analysis of the latency measure, the analysis of the error measures showed no effects of either independent variable.

The first experiment replicates the frequently observed phonological ambiguity effect. In the asterisks context the positive response latency to a phonologically ambiguous version of a word was, on the average, 83 ms longer than the latency to its phonologically unambiguous version. For pseudowords, the ambiguous–unambiguous latency difference was 51 ms. With respect to errors, 22% more errors were committed on a phonologically ambiguous version of a word in the asterisks context than on its phonologically unambiguous version. There was no effect of ambiguity on pseudoword error production. A numerically and often statistically larger phonological ambiguity effect for words is the rule (Feldman & Turvey, 1983; Lukatela et al., 1980; Lukatela, Savić, Gligorijević et al., 1978).

The main observation of this first experiment is that the phonological ambiguity of a target letter string is reduced substantially by a contextual word that is (a) associatively related to the target letter string and (b) written in the same alphabet as the tar-

get letter string. The significant Context \times Ambiguity interactions in the latency and error data point to the fact that the effect of a same alphabet/associative context was more pronounced for the phonologically ambiguous words. Ambiguous words were rendered more like their unambiguous counterparts (in terms of the latency and error measures) by a same alphabet/associative context (see Fig. 1). As an aside, this observation counters arguments that the slowed lexical decision for ambiguous words in a neutral context is because ambiguous words are less frequent, or because the subjects making the responses to this particular set of words are basically slower subjects (cf. Seidenberg, Waters, Barnes, & Tannenhaus, 1984). In the next two experiments we examined the separate contributions of an alphabet match and an associative relation to attenuating the phonological ambiguity effect.

EXPERIMENT 2

The second experiment focuses on the alphabetical aspect of the word context. All targets, words and pseudowords, are preceded by words. When the targets are words, their contexts are always associates. On only half of the context word/target word trials, however, is the context word printed in the same alphabet as the target. In short, the experiment holds the associative relation between context word and target word constant and manipulates the alphabetical relation.

Method

Subjects. Sixty high school students from Belgrade were paid to participate in the experiment. All were naive to the experiment's purpose. Most had participated previously in reaction time experiments. Subjects were assigned randomly to one of four experimental groups according to their order of appearance for testing.

Materials. The word context—word target pairs (i.e., associates) from Experiment 1 were used again. The same derived

pseudowords were also used, but the contexts for these pseudowords were words that were not associatively related to the pseudowords' source words. (One consequence of the latter restriction was that no word context was repeated for a given subject.) All context words were phonologically unique, containing on average two unique letters. One half of the contexts were in the same alphabet as the targets, and one half of the contexts were in the other alphabet. For pseudowords, the designations "same alphabet" and "other alphabet" refer to the context's alphabetic relation to the pseudoword's source word. The associative relation between context and target was not manipulated. To repeat, for words the relation was always associative; for pseudowords the relation was always nonassociative, as defined. There were no asterisks contexts.

Design. The design was the same as Experiment 1 with the exception that the asterisks/same-alphabet-and-associate contrast was replaced by a same alphabet/other alphabet contrast between the context and the target. Four experimental conditions were again produced, this time defined by the same alphabet or other alphabet relation of the context to the target and by the phonological ambiguity or unambiguity of the target. With the appropriate substitutions, the remainder of the design paralleled Experiment 1 and is illustrated in Table 2.

Procedure. Stimulus durations and manner of presentation were the same as in Experiment 1.

Results and Discussion

The means for the decision latencies and errors in each of the four conditions are presented in Fig. 2. Considering the latencies

TABLE 2
ILLUSTRATION OF DESIGN OF EXPERIMENT 2

Transcription of target	Alphabet of context	Experimental group			
		1	2	3	4
<i>Words</i>					
PUR	R (same)	OLUJA-VETAR	SLAMA-SENO	ČEŠALJ-KOSA	DREMEŽ-SAN
	C (different)	ЧЕШАЉ-KOSA	ДРЕМЕЖ-SAN	ОЛУЈА-VETAR	СЛАМА-SENO
PUC	R (different)	CIRKUS-PAJAC	RAZUM-PAMET	CUCLA-BEBA	ŽUBOR-POTOK
	C (same)	ЦУЦЛА-BEBA	ЖУБОР-POTOK	ЦИРКУС-ПАЈАЦ	РАЗУМ-PAMET
PAC	R (different)	DREMEŽ-SAN	OLUJA-BETAR	SLAMA-SENO	ČEŠALJ-KOSA
	C (same)	СЛАМА-СЕНО	ЧЕШАЉ-KOSA	ДРЕМЕЖ-SAN	ОЛУЈА-BETAR
PAR	R (same)	ŽUBOR-POTOK	CIRKUS-PAJAC	RAZUM-PAMET	CUCLA-BEBA
	C (different)	РАЗУМ-PAMET	ЦУЦЛА-BEBA	ЖУБОР-POTOK	ЦИРКУС-ПАЈАЦ
<i>Pseudowords</i>					
PUR	R (same)	VIHOR-TOSA	MIŠ-SON	TETREB-VEMAR	PLIMA-SANO
	C (different)	ТЕТРЕБ-ВЕМАР grouse-	ПЛИМА-SANO high tide-	ВИХОР-TOSA whirlwind-	МИШ-SON mouse-
PUC	R (different)	GUSAR-BEBAM	OGLEDALO-POTEK	SLAVUJ-PEJAC	GOVEĆE-PAMOT
	C (same)	СЛАВУЈ-ПЕЈАЦ nightingale-	МИРОР- ГОВЕЧЕ-PAMOT cattle-	ГУСАР-BEBAM pirate-	ОГЛЕДАЛО-POTEK mirror-
PAC	R (different)	PLIMA-SANO	VIHOR-TOCA	MIŠ-SON	TETREB-VEMAR
	C (same)	МИШ-СОН mouse-	ВИХОР-ТОСА whirlwind- ТЕТРЕБ-ВЕМАР grouse-	ПЛИМА-SANO high tide-	ГОВЕЧЕ-PAMOT whirlwind-
PAR	R (same)	GOVEĆE-PAMOT	GUSAR-BEBAM	OGLEDALO-POTEK	SLAVUJ-PEJAC
	C (different)	ОГЛЕДАЛО-POTEK mirror-	СЛАВУЈ-ПЕЈАЦ nightingale-	МИРОР- ГОВЕЧЕ-PAMOT cattle-	ГУСАР-BEBAM pirate-

Note. R - Roman and C - Cyrillic. For other acronyms, see Table 1.

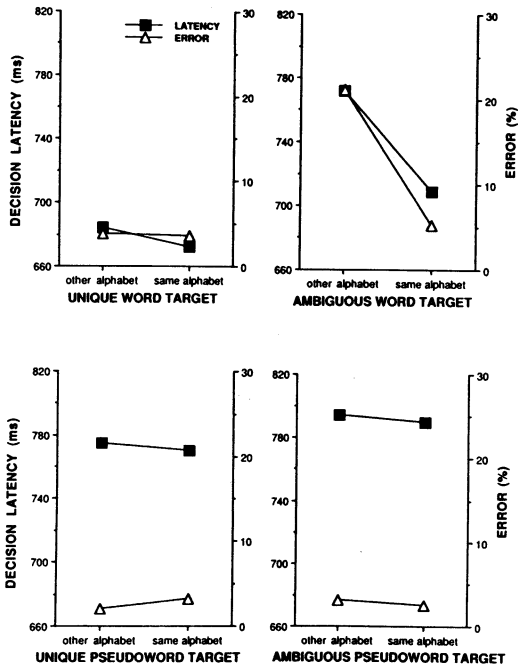


FIG. 2. Lexical decision latency and error as a function of alphabet relation between context and target (other alphabet vs. same alphabet), and target type in Experiment 2.

for words first, both context (other alphabet = 728 ms vs. same alphabet = 690 ms) and ambiguity (unique = 678 ms vs. ambiguous = 740 ms) were significant as was the interaction between them (difference for other alphabet = 82 ms vs. difference for same alphabet = 37 ms): $\min F'(1,108) = 10.4, p < .01$, $\min F'(1,101) = 38.91, p < .001$, and $\min F'(1,106) = 7.66 = 7.66, p < .01$, respectively. With respect to the errors for words, both main effects (other alphabet = 12.45% vs. same alphabet = 4.4%), (unique = 3.7% vs. ambiguous = 13.15%), and the interaction (difference for other alphabet = 17.3% vs. difference for same alphabet = 1.6%) were again significant: $\min F'(1,106) = 17.21, p < .001$, $\min F'(1,99) = 24.13, p < .001$, and $\min F'(1,108) = 20.53, p < .001$, respectively.

In considering the latency measure for the pseudowords, only the main effect of ambiguity (unique = 772 ms vs. ambiguous pseudowords = 792 ms) was significant.

The overall analysis was not significant, $\min F'(1,104) = 3.2, p < .07$, but the separate items and subjects analyses of the ambiguity variable were significant: $F(1,59) = 8.87, p < .01$, $F(1,55) = 5.0, p < .05$, respectively. There were no significant effects of context and ambiguity on errors on pseudowords ($\min F's < 1$).

It is evident from Fig. 2, and from the analyses, that the alphabet manipulation attenuated dramatically the phonological ambiguity effect for words as measured by the latency difference (from 772 ms for other-alphabet context to 709 ms for same-alphabet context) and the error difference (from 21.1% for other-alphabet context to 5.2% for same-alphabet context). Given that all contexts were associates of the target words, it would appear that association of itself does not make a large contribution to attenuating the phonological ambiguity effect. When the associated context was in the other alphabet, phonologically ambiguous words were responded to (in comparison to their unique counterparts) 88 ms slower and with 17.3% more errors.

As with the first experiment, an alphabetical/associative context was not sufficient to eliminate fully the ambiguity effect. In the same alphabet/associative context of the present experiment, phonologically ambiguous words were responded to 37 ms slower than their unique counterparts; in the first experiment the difference was 23 ms. We can infer from this residual, and from other aspects of the data, that alphabet biasing by an immediately preceding context is not a discrete operation—such as switching on Roman grapheme-phoneme correspondence rules (GPCs) and switching off Cyrillic GPCs. If the alphabet of the context word engaged automatically one set of GPCs to the complete exclusion of the other set then, under the condition of an alphabet mismatch, BETAP would receive a single phonological coding (/betap/) for which there is no lexical entry. With alphabet mismatch, words like BETAP should be responded to negatively (“nonword”). The

data for the ambiguous words reveal, however, that when the context was in the other alphabet the result was not a full-scale rejection; positive responses (79%) far outweighed negative responses. Moreover, the percentage of positive responses in the present experiment was of the same magnitude as that in the asterisks (that is, no alphabet) context of the first experiment. The high proportion of positive responses to BETAP-type words in other-alphabet contexts suggests that all GPCs are activated, not just those specified by the alphabet of the context.

The alphabet manipulation did not affect pseudowords but it would be wrong to conclude from this that there was no alphabet priming for pseudowords. Looking at Fig. 2, it can be seen that the ambiguous-unique difference for pseudowords is 19 ms in the other alphabet context and 20 ms in the same alphabet context. For pseudowords, which are generated by replacing and/or adding a letter in corresponding "source" words, the designations "other alphabet" and "same alphabet" describe the alphabetical relation between the context word and the target's source word. It is reasonable to assume that we are witnessing, in both contexts, a compression of the phonological ambiguity effect. Returning to Experiment 1, without alphabet specification (that is, with asterisks as context) the size of the phonological ambiguity effect for pseudowords was 51 ms. With alphabet specification (that is, with a same alphabet/associated words as context) the ambiguous-unique difference was 22 ms, which is comparable to the 19 ms and 20 ms difference observed in the other alphabet and same alphabet (nonassociative) contexts, respectively, of the present experiment.

EXPERIMENT 3

The third experiment manipulates the associative relation between context and target while holding the alphabet relation constant. The context is always a word in the same alphabet as the target.

Method

Subjects. Fifty-six high school students from Belgrade were paid to participate in the experiment. All were naive to the experiment's purpose. Most had participated previously in reaction time experiments. Subjects were assigned randomly to one of four experimental groups according to their order of appearance for testing.

Materials. The same 56 phonologically ambiguous words used in Experiment 1 were used in this third experiment. Also used were the same 28 associated context words. A new set of 28 words were selected as nonassociated context words. These were additionally restricted by the requirements that each contained at least two unique letters and each was of the same length as the target to which it was attached. The pseudowords of the present experiment were not the pseudowords of Experiment 1. The 56 pseudowords in the present experiment were generated from a different set of 28 phonologically ambiguous Cyrillic forms and 28 phonologically ambiguous Roman forms by changing one letter. For these 56 pseudowords, sets of 56 associated and 56 nonassociated context words were assembled. Here, "associated" and "nonassociated" refer to the associative relation between the context word and the pseudoword's *source* word.

Design. The design was the same as Experiment 1 with the exception that asterisk context/target pairs became word context/target pairs, where the word context was a nonassociated word written in the same alphabet. Four experimental conditions were again produced, this time defined by the associative relation of the context to the target and by the phonological ambiguity or unambiguity of the target.

Procedure. The stimulus durations and manner of presentation were the same as Experiment 1.

Results

The mean latencies and errors are pre-

sented in Fig. 3. Considering the latencies for word targets, both the effects of context (nonassociate = 891 ms vs. associate = 798 ms) and ambiguity (unique = 828 ms vs. ambiguous = 861 ms) were significant: min $F'(1,82) = 32.43$, $p < .001$, min $F'(1,100) = 9.17$, $p < .01$, respectively. The interaction between the two independent variables (difference for nonassociate = 35 ms vs. difference for associate = 32 ms) was not significant; the min F' , the F for the subjects analysis, and the F for the items analysis, were all less than 1. Both main effects were found to be significant for the errors committed on words. For context (nonassociate = 17.02% vs. associate = 6.25%), min $F'(1,94) = 16.2$, $p < .001$; for ambiguity (unique = 7.84% vs. ambiguous = 15.43%), min $F'(1,97) = 12.18$, $p < .001$. The interaction (difference for nonassociate = 10.59% vs. difference for associate = 4.6%) was not significant by the overall analysis, min $F'(1,90) = 2.05$, $p > .05$.

(Separate subjects and items analyses revealed significance only by subjects.)

Turning to the pseudoword results, latencies proved to be affected by context (nonassociate = 869 ms vs. associate = 904 ms), min $F'(1,98) = 16.69$, $p < .001$. (The slower responses for the associate context suggests that a pseudoword's source word was primed, thereby making the rejection of the pseudoword more difficult.) Ambiguity and the interaction were not significant. Errors on the pseudowords were affected by neither independent variable. Only the context (nonassociate = 2.23% vs. associate = 4.02%) min $F'(1,99)$ exceeded 1, namely, 2.44, which failed to reach significance at the .05 level.

Discussion

The main observation of this third experiment is that the associative relation between context and target and the ambiguity of the target did not interact. Associativeness had exactly the same effect on both phonologically ambiguous and phonologically unambiguous words. Given that the context words were always alphabetically consonant with the targets, all targets were alphabetically primed. In the associative contexts the difference between the mean latencies for ambiguous and unambiguous versions of the same words was 32 ms; in the nonassociative contexts the difference was 35 ms. These small differences confirm the presence of alphabetic priming. In Experiment 2 the ambiguous-unambiguous differences for the same alphabet/associative context was 37 ms. For the other alphabet/associative context it was 88 ms. We may conclude, therefore, from the absence of an interaction between context and ambiguity in the present experiment, that in lexical decision alphabetic priming and associative priming are largely independent of one another.

The experimental results obtained thus far can be conceptualized as follows. A phonologically ambiguous letter string such as BETAP activates all the phonemic inter-

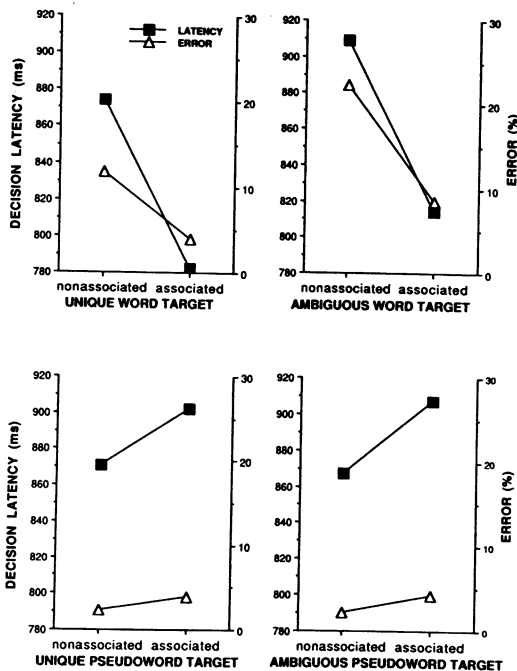


FIG. 3. Lexical decision latency and error as a function of associative relation between context and target (nonassociated vs. associated), and target type in Experiment 3.

pretations that its letter structure allows, namely, /və/ and /bə/ in the 1st position, /ɛ/ in the 2nd, /tə/ in the 3rd, /a/ in the 4th, and /rə/ and /pə/ in the 5th position. Any immediately preceding string whose structure uniquely specifies the alphabet (Cyrillic) in which BETAP has a lexical entry, disposes the word processing system to /və/ in the 1st position more than to /bə/, and to /rə/ in the 5th position more than to /pə/. As a result, the lexical entry for "wind" is accessed sooner than when BETAP is presented (a) without an immediate context of any kind and (b) after a letter string in the other alphabet. If the same-alphabet context letter string is also a word that is an associate of BETAP, such as the word "storm," then "wind" is accessed even faster. These two contextual influences on BETAP, the alphabetic and the associative, do not appear to be related. The effect of one contextual influence is exerted independently of the other, suggesting that they occur at different levels of the word processing system.

EXPERIMENT 4

Rapidly naming letter strings presents a different situation from rapidly deciding on their lexical status (Forster, 1981; Seidenberg et al., 1984). We will try to fashion a distinction between these two tasks for Serbo-Croatian materials in the following terms: Lexical decision is based on the states of entities that represent words; naming is based on the states of entities that represent phonemes. The former are the functional elements of the internal lexicon; the latter are not. Thus comparisons between the lexical decision and naming tasks can aid us in determining the mechanisms behind phonological ambiguity effects by providing information about the locus of processing. Although we cannot address in detail how a name is generated from the perceptual processing of a letter string, it seems safe to assume that the assembling of a pronunciation code is tied closely to the

activation of phoneme representations or processing units. For any Serbo-Croatian letter string, the precise letter-to-phoneme connections—the phonologically shallow nature of the Serbo-Croatian orthography (Frost, Katz, & Benton, 1987; Lukatela & Turvey, 1980)—will define the phonemes from which the letter string's name can be assembled. In principle, no lexical access is required to specify the segmental phonemes of a Serbo-Croatian word or non-word, which means that, in principle, the assembling of names could proceed solely under the constraints of the phoneme level. In practice, however, the Serbo-Croatian reader's lexicon (the level of word representations or word processing units) must be referred to in order to converge on a single pronunciation for a phonologically ambiguous word (and to determine the stress quality of words in general).

For example, a word such as BETAP will activate strongly seven phoneme units. From these, four different pronunciation codes could be assembled. Given that only one code is realized, namely, that of the word meaning "wind" (with phoneme constituents /və/, /ɛ/, /tə/, /a/, /rə/), then a selective operation must preface the utterance. The lexicon would be the source of this operation. The activation levels of the units at the phoneme level are modulated, in top down fashion, by the activation levels at the word level—themselves brought into play by the states of the phoneme units. Iteration of top-down and bottom-up activity produces an interaction between levels that results in a dominance of one specific pattern of phoneme level activation. In the case of BETAP it will be characterized by highest activation levels in the units /və/, /ɛ/, /tə/, /a/, and /rə/. It should be reasonably evident that the preceding theoretical framework is closely similar to parallel interactive models of English word recognition (e.g., McClelland & Rumelhart, 1981; Seidenberg, 1985; Rumelhart & McClelland, 1982).

If this word level contribution to naming

is automatic, then it must also apply to phonologically unique words. The benefits of a word level contribution to naming, however, cannot be as great in the latter case (after all, such words have unique pronunciations) but they should, nonetheless, be observable. It is expected, therefore, that for both phonologically ambiguous and phonologically unambiguous words, naming latencies in a context-target situation ought to be affected by the associative relation between context and target, with the effect, however, much more pronounced for the phonologically ambiguous words.

In conventional terms, the argument just fashioned promotes an automatic grapheme-phoneme correspondence (GPC) mechanism for generating names and an automatic lexical look-up to confirm them. By this argument, evidence for a lexical contribution to naming is not at the same time evidence against a GPC process of name generation, as is commonly implied (see Rosson, 1985, for a discussion of this issue). Similarly, by this argument, longer latencies for naming pseudowords as compared to naming words do not constitute *prima facie* evidence against a GPC process of name generation, as is also commonly implied (e.g., Seidenberg, 1985).

We are now claiming that what distinguishes the rapid naming task is that it is constrained primarily by the states of the phoneme units. Alphabet priming predisposes the relations at the phoneme level, possibly by a mechanism in which unique letters in the context inhibit the GPCs of the other alphabet. Effects of alphabet priming on naming are then to be expected. If BETAP is preceded by a phonologically unambiguous word in the Cyrillic alphabet, then the competing phoneme units /bə/ (with /və/) and /pə/ (with /rə/) will not become strongly activated due to the inhibition induced by the preceding unique character(s). Naming BETAP in a matching alphabetic context will, therefore, be speeded up relative to naming BETAP in a context in which neither alphabet is specified (e.g.,

***), or the other (Roman) alphabet is specified. By the same token, however, the naming of a phonologically unambiguous word should be relatively immune to the alphabetic aspect of word contexts. The mechanism of alphabetic priming is automatically at work, without context, in the processing of a phonologically unambiguous word composed of shared unambiguous, ambiguous, and unique letters. (The unique letters function to inhibit the other alphabet interpretation of the ambiguous letters.) And it is automatically at work, without context, in the processing of a word that contains no ambiguous characters, such as VETAR, though its implications for the processing of VETAR-type words must be minimal.

Let us now turn to the naming of pseudowords, beginning with unambiguous pseudowords. A phonologically unambiguous pseudoword such as BEZAP (B and P are common ambiguous, E and A are common unambiguous, and Z is unique Roman) will produce a pattern of phoneme-unit activation levels dominated by just five phonemes. It is very close to at least one word (BETAP) and has phonemes in locations consistent with the structure of many word units. Nonetheless, little word level influence on BEZAP's name is to be expected. Turning to a phonologically ambiguous pseudoword, such as BEMAP, letter unit-phoneme unit connections will activate highly seven phoneme units. These in turn will activate many word units to varying levels depending on the degree to which they and BEMAP overlap in segmental phonology. How might a single utterance for BEMAP be reached? If one phoneme unit in the 1st position, say /bə/, receives, from the word unit level, more excitatory feedback than the other, /və/, then /bə/ will come to be activated more than /və/. Within such a dynamical process, one can envisage the gradual emergence of five highly active phoneme units rather than seven, and hence the emergence of a unique utterance for BEMAP. Would the emergence of a

unique utterance be facilitated also by an alphabetic context? From the arguments laid out above, the answer must be yes.

In Experiment 4 we examine how naming is affected by the alphabetic relation between the context and the named target. The associative relation is held constant; the context is always an associate of the target (or an associate of the source word in the case of pseudoword targets). The experiment, therefore, is a naming replication of Experiment 2.

Method

Subjects. Forty eight high school students from Belgrade were paid to participate in the experiment. All were naive to the experiment's purpose. Most had participated previously in reaction time experiments. Subjects were assigned randomly to one of four experimental groups according to their order of appearance for testing.

Materials. The word context–word target pairs and word context–pseudoword target pairs described in the materials section of Experiment 2 were used. Contexts and targets were always associatively related; only the context–target alphabet relation was manipulated. There were no asterisks contexts.

Design. The design was the same as Experiment 2 and illustrated in Table 2.

Procedure. Stimulus presentation was the same as in Experiment 2. The response was naming the target letter string aloud. In all conditions, latencies from the onset of the target to onset of the responses were measured by means of a voice operated trigger relay. The duration of the context was 600 ms, the interval was 100 ms, and the duration of the target was 300 ms.

Errors in pseudoword naming deserve a comment. Given the phonetic precision of the Serbo-Croatian script system, the pronunciation of an unambiguous pseudoword is well defined. This is also true, of course, for an ambiguous pseudoword, although the absence of a unique character allows options. The naming of either kind of

pseudoword was considered to be erroneous when the pronunciation included a phoneme not specified by the characters in the letter string or when the pronunciation was not smooth, that is, when the subject hesitated after beginning the name. Added to these types of errors is the standard type of not initiating the response within the cutoff latency.

Results and Discussion

The mean latency and the mean error for each condition are presented in Fig. 4. Looking at the word latencies, context (other alphabet = 600 ms, same alphabet = 567.5 ms) was significant, $\min F'(1,93) = 13.46, p < .001$, as was ambiguity (unique = 564 ms, ambiguous = 603.5 ms), $\min F'(1,101) = 27.35, p < .001$. The interaction between the two independent variables (difference for other-alphabet = 64 ms, difference for same-alphabet = 15 ms) was also significant, $\min F'(1,96) = 10.24, p <$

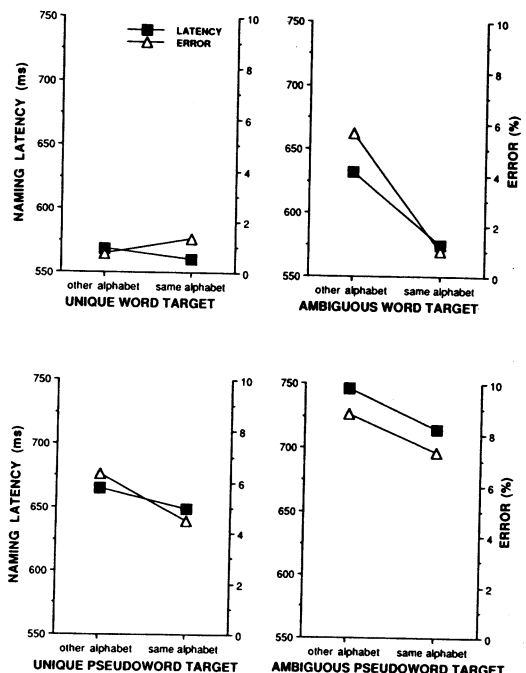


FIG. 4. Naming latency and error as a function of alphabet relation between context and target (other alphabet vs. same alphabet), and target type in Experiment 4.

.01. For the pseudoword latencies, both main effects were significant: min $F'(1,96) = 5.04$, $p < .05$, for context (other alphabet = 705.5 ms, same alphabet = 681.5 ms), and min $F'(1,102) = 32.46$, $p < .001$, for ambiguity (unique = 657 ms, ambiguous = 730 ms). The interaction, however, was insignificant (min $F' < 1$). With regard to context, it will be recalled that the alphabet match-alphabet mismatch contrast was not significant in the lexical decision data for pseudowords (Experiment 2).

The error analysis was largely, but not completely, consistent with the latency analysis. For words, context (other alphabet = 2.9%, same alphabet = 1.19%) was not significant by the min F' test—min $F'(1,97) = 3.72$, $p < .06$ —but was significant by both subjects analysis, $F(1,47) = 10.8$, $p < .01$, and items analysis, $F(1,55) = 5.67$, $p < .05$. Ambiguity (unique = 1.04%, ambiguous = 3.05%) was significant, min $F'(1,100) = 5.43$, $p < .05$, as was the Context \times Ambiguity interaction (difference for other-alphabet = 4.32%, difference for same-alphabet = 0.3%), min $F'(1,99) = 6.79$, $p < .01$. For pseudowords, only ambiguity (unique = 5.36%, ambiguous = 8.04%) reached significance, but not by the min F' test—min $F'(1,102) = 2.84$, $p < .09$; it was significant by the subjects analysis, $F(1,47) = 5.74$, $p < .05$, and by the items analysis, $F(1,55) = 5.61$, $p < .05$.

Naming phonologically unique words such as VETAR, that contain no ambiguous characters, can derive little benefit from a preceding alphabet specification. In the present data, naming was 8 ms faster in the same alphabet condition compared to the other alphabet condition. Small differences in this direction were seen similarly in the lexical decision experiments. Collectively they suggest a very small, but possibly reliable, contribution of alphabet context to the processing of unambiguous words of the VETAR type. Phonologically ambiguous words more clearly benefitted from the alphabetic manipulation; naming was 57 ms faster in the same alphabet condition.

Although the phonological ambiguity effect was reduced substantially by the alphabet manipulation it did not disappear completely. Ambiguous words were named 15 ms slower than unambiguous words in the same alphabet condition, a difference that was statistically significant. The continuation of the phonological ambiguity effect in the face of the alphabetic and associative priming is attributable, we think, to a reduction in inhibition over time so that a target following a context at some delay is processed against a backdrop in which competing GPCs are more active than if the lag was zero. It is also probable that the failure to eliminate fully the phonological ambiguity effect is due, in smaller part, to the weakening of associative priming with target delay.

The pseudoword data are more complicated to deal with. In part this is because the context labels do not apply straightforwardly to the pseudoword stimuli. Let us address first the observation that latencies were shorter in the same alphabet context (681.5 ms vs. 705.5 ms). For pseudowords the designation "same alphabet" refers to the match between the alphabet of the context word and the alphabet of the source word from which the pseudoword was derived. In Tables 3a and 3b we report how the phonologically ambiguous words (Table 3a) and phonologically ambiguous pseudowords (Table 3b) were named in the two contexts. All responses had been tape recorded and the percentages in Tables 3a and 3b are based on those recordings. Looking first at Table 3a, it can be seen

TABLE 3a
ALPHABET OF NAMING RESPONSE AS A FUNCTION
OF ALPHABET OF CONTEXT WORD AND ALPHABET
OF TARGET WORD IN EXPERIMENT 4

Context's alphabet	Target's alphabet	Response's alphabet		
		Cyrillic	Roman	Mixed
Cyrillic	Cyrillic	92.9	2.9	2.1
	Roman	9.8	86.5	1.1
Roman	Cyrillic	63.0	25.1	7.1
	Roman	1.3	97.6	0.5

TABLE 3b
ALPHABET OF NAMING RESPONSE AS A FUNCTION
OF ALPHABET OF CONTEXT WORD AND ALPHABET
OF TARGET PSEUDOWORD'S SOURCE WORD IN
EXPERIMENT 4

Context's alphabet	Target's alphabet	Response's alphabet		
		Cyrillic	Roman	Mixed
Cyrillic	Cyrillic	64.5	17.2	9.8
	Roman	53.4	37.1	4.2
Roman	Cyrillic	24.9	51.6	14.0
	Roman	9.8	82.6	2.6

that, when context words and target words were in different alphabets, naming responses tended to be in the alphabet of the target. That the alphabet of the context is, however, playing a significant role in forming the name of the target word can be seen in the fact that for Cyrillic target words in a Roman context, 25.1% were named in the Roman alphabet and 7.1% were named in a mix of the two alphabets. Turning to the pseudoword data in Table 3b, it can be seen that when the alphabet of the context and the alphabet of the target (precisely, of the target's source word) did not concur, naming was governed by both the alphabet of the context and by the alphabet of the target, with the former's contribution greater. For the Cyrillic-Roman pairs, 53.4% of the responses were Cyrillic, 41.3% were Roman and mixed. For the Roman-Cyrillic pairs, 51.6% were Roman, 38.9% were Cyrillic and mixed.

We can now attempt a rationalization of the significant alphabet effect (naming latencies to both unique and ambiguous targets were shorter in same alphabet than in the other alphabet) in the pseudoword data. The pattern of activation levels defined over the phoneme units were shaped by alphabetic priming and by feedback from the word level (the source word activated by the target pseudoword influenced the name of the pseudoword). The patternings imposed upon the phoneme level by alphabetic priming and word level feedback were at odds in the other-alphabet condition and in agreement in the same-alphabet condi-

tion. It is this contrast that might be responsible for the same-alphabet condition's shorter naming latencies (see Fig. 4). Alternatively, the advantage of a same-alphabet context might be understood in terms of the fact that the reader is biased, thereby, toward more probable phoneme combinations. We presume that words represent—much more so than pseudowords and non-words—the frequent sound patterns of the language. Consequently, to be directed toward the letter-phoneme correspondencies befitting the word that the pseudoword is like, should aid pseudoword pronunciation. The latter rationalization of an alphabet main effect on naming pseudowords might make understandable the contrasting observation for lexical decision, namely, *no* effect of the other alphabet-same alphabet contrast (Fig. 2).

A potentially puzzling aspect of the pseudoword data is the persistence of a pronounced phonological ambiguity effect. Alphabet specification by context did not appear to reduce the latency difference between ambiguous and unique pseudoword transcriptions. In the comparable lexical decision experiment, Experiment 2, ambiguity with respect to pseudoword latencies was a significant but numerically small effect (mean difference = 20 ms). Here, in the naming data of Experiment 4, the ambiguous-unique difference and, therefore, the phonological ambiguity effect, was numerically large: 81 ms in the other-alphabet context and 65 ms in the same-alphabet context. Further, the interaction between context and ambiguity failed to reach significance, indicating that the alphabet context (whether or not the context's alphabet matched that of the pseudoword's source word) did not affect the difference between phonologically ambiguous and phonologically unambiguous pseudowords.

Failure to find convincing evidence for a contextually induced reduction in the phonological ambiguity effect in pseudowords suggests that *the mechanism of alphabetic priming has been compromised*. We have

already raised the hypothesis that the inhibition underwriting alphabetic priming relaxes in time. The longer the delay between context and target the weaker should be the inhibition. If competitive processes at the word level play out more slowly with pseudoword stimuli, and if the resultant state of the phoneme level depends on those word level processes, then there would be time for a further weakening of the inhibition.

Along similar lines, alphabet biasing of the phoneme level may be weak in the absence of amplification of activity in the selected phoneme units by excitation from highly active word units. When the word BETAP is presented, preceded by a same-alphabet context, the word level excitation fed back to the phoneme level will enhance the bias toward /və/ over /bə/ in first position and /rə/ over /pə/ in fifth position. When the pseudoword BEMAP is presented, preceded by a Cyrillic context, there will be no word unit matching the dominant pattern of phoneme unit activity. As a consequence, the biases toward /və/ and /rə/ at the phoneme level will not be reinforced. The point is that, in the absence of marked word level feedback, the /və/-/bə/ difference and the /rə/-/pə/ difference may be insufficient to dominate the process of assembling a name.

EXPERIMENT 5

As noted, a puzzling feature of Experiment 4 was that alphabet specification did not reduce the effect of phonological ambiguity on the naming of pseudowords. This feature is the focal concern of Experiment 5. One goal of the experiment is to provide data on naming pseudowords that can be compared with the data on lexically deciding on pseudowords that was obtained in Experiments 1 and 2. A further goal of the experiment is to provide data on the alphabetic compositions of pronunciations when the context bears no associative relation to the target. Table 3b presented data on pronunciation composition when each context

was an associate of the target's source word. The question posed here is whether the alphabet of the target's source word will contribute significantly to a pseudoword's pronunciation in the absence of associative priming.

Method

Subjects. The subjects were 52 high school students who were paid to participate. All had experience in reaction time experiments, none had participated in the previous four experiments. Each subject was assigned to one of four conditions by order of appearance at the laboratory.

Materials and design. The phonologically ambiguous pseudoword conditions of Experiment 2 (contexts are other alphabet and same alphabet, with no implicit associative relation) and the phonologically unique pseudoword conditions of Experiment 1 (contexts are asterisks and same alphabet/associate) are reproduced with the one exception of more unique letters in the context words of the present experiment. The word contexts in Experiment 5 contain minimally three unique letters and on the average four unique letters. In Experiments 1 and 2 there were, on the average, two unique letters in the word contexts. Although the experiment's focus is pseudowords, the design requires word targets; the requirement is met through the use of the word conditions of Experiment 3 (contexts are same alphabet/nonassociate and same alphabet/associate).

Procedure. Stimulus durations, manner of presentation, and response were the same as in Experiment 4.

Results and Discussion

To repeat, unique pseudoword targets were presented in asterisk and same alphabet/associate contexts; ambiguous pseudowords were presented in other-alphabet and same-alphabet contexts that bore no implicit associative relation to the targets. For the unambiguous pseudowords, the mean latencies (and errors) in

the asterisk and same alphabet-associate contexts were 672 ms (4.3%) and 647 ms (5.5%), respectively. For the ambiguous pseudowords, the mean latencies (and errors) in the other alphabet and same alphabet contexts were 743 ms (8.9%) and 739 ms (10.2%), respectively. If alphabet specification reduced the phonological ambiguity effect substantially, then the third and fourth sets of numbers should have been comparable to the first set. Clearly, they are not. Unique pseudowords in an asterisk context are named 69 ms faster (on the average) and with 5.25% fewer errors (on the average) than ambiguous pseudowords in a highly alphabetic context. This persistence of a pronounced phonological ambiguity effect in naming pseudowords in the presence of alphabet specification—for latencies, $F'(1,99) = 39.68, p < .001$, for errors, $F'(1,105) = 7.17, p < .01$ —concur with the results of Experiment 4.

The phonologically ambiguous pseudowords can be divided into those for which the context was in the alphabet of the pseudoword's source word and those for which the context was in the opposite alphabet. In Table 4 the composition of the utterances for these two classes of pseudowords are given. The response composition pattern evident in Table 3b is reproduced almost exactly in Table 4. (The one notable exception is in the cell for Cyrillic responses when context and target were Cyrillic. In Table 4 the number in that cell is 81.9%; in Table 3b the number is 64.5%) In considering the similarities be-

tween Tables 3b and 4, it is worth bearing in mind the experimental differences: no implicit associative relation in the present experiment and a larger number of unique letters in the contexts of the present experiment. It is evident from Table 4 that, in producing a name for a phonologically ambiguous pseudoword, the subjects were influenced by both the alphabet of the context and the alphabet of the target. As in Experiment 4, we can see that the influence of the context's alphabet tended to exceed that of the target's (source word's) alphabet. That tendency, however, does not seem to have been affected by removing the associative relation and by including more unique letters in the context. In the present experiment, when the alphabets of context and of target disagreed, responses were in the context's alphabet 53.6% of the time, in the target's alphabet 32.1% of the time, and in a mixture of both alphabets 6.4% of the time. In Experiment 4, when the alphabets of context and target disagreed, responses were in the context's alphabet 52.5% of the time, in the target's alphabet 31.0% of the time, and in a mixture of both alphabets 9.1% of the time.

The conclusion to be drawn from Experiment 5 is that the pronunciation latency and error differences between ambiguous and unique pseudowords remain large despite alphabet specification through context. It is noteworthy that a same-alphabet context (context's alphabet agrees with that of the pseudoword's source word) removes the ambiguity from the composition of an ambiguous pseudoword's pronunciation (Table 4). It does so, however, without making that pronunciation (a) as fast and as errorfree as the pronunciation of the pseudoword's ambiguous version and (b) necessarily faster or more errorfree than pronunciation in the other-alphabet context.

EXPERIMENT 6

In Experiment 3, using the lexical decision task, we examined the change in the

TABLE 4
ALPHABET OF NAMING RESPONSE AS A FUNCTION
OF ALPHABET OF CONTEXT WORD AND ALPHABET
OF TARGET PSEUDOWORD'S SOURCE WORD IN
EXPERIMENT 5

Context's alphabet	Target's alphabet	Response's alphabet		
		Cyrillic	Roman	Mixed
Cyrillic	Cyrillic	81.9	8.4	3.8
	Roman	52.3	39.0	1.6
Roman	Cyrillic	25.2	54.9	11.2
	Roman	8.9	81.4	2.6

phonological ambiguity effect for words solely as a function of the associativeness of the context to the target. In that experiment, contexts were always alphabetically matched to the word targets (and to the source words of the pseudoword targets). With respect to decision latency, an effect of association was found that was of the same magnitude for both unique and ambiguous words and of the same magnitude for both unique and ambiguous pseudowords.

In the present experiment we pursue this issue of the phonological ambiguity effect as a function of associativeness but now with respect to rapid naming. To anticipate, the results of these experiments provide evidence of a notable word level contribution, corroborating, therefore, the analysis of naming errors in Experiments 4 and 5.

Method

Subjects. Fifty-two students from the Department of Psychology at the University of Belgrade participated in the experiment as part of a course requirement. Many had participated previously in reaction time experiments. Each was assigned by order of appearance at the laboratory to one of four conditions.

Materials and design. The context/target pairs and the design were as described in Experiment 3.

Procedure. The naming response and conditions of stimulus presentation were as described in Experiment 4.

Results

The mean latencies and the mean errors for each condition are presented in Fig. 5. For word latencies, context (nonassociate = 636 ms, associate = 609 ms) was significant, $\min F'(1,94) = 17.35$, $p < .001$, as was ambiguity (unique = 611.5 ms, ambiguous = 633.5 ms). The interaction (difference for nonassociated context = 37 ms, difference for associate context = 17 ms) failed to reach significance by the $\min F'$ test, $\min F'(1,101) = 3.01$, $p < .09$, but satisfied the significance requirements of

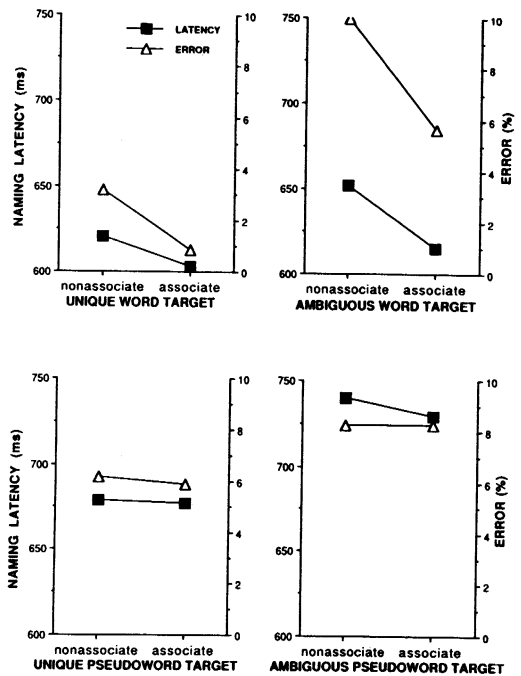


FIG. 5. Naming latency and error as a function of associative relation between context and target (nonassociated vs. associated), and target type in Experiment 6.

the subjects and items analyses conducted separately, $F(1,51) = 8.09$, $p < .01$, and $F(1,55) = 4.8$, $p < .05$. With the exception of the interaction ($\min F' < 1$), the errors on words replicated the statistical results for latencies: context (nonassociate = 6.53%, associate = 3.09%), $\min F'(1,101) = 7.36$, $p < .01$, ambiguity (unique = 1.99%, ambiguous = 7.63%), $\min F'(1,98) = 19.38$, $p < .001$. Analyses of latencies and errors for pseudowords produced only one significant effect which was ambiguity with respect to the latency data (unique = 678 ms, ambiguous = 734.5 ms), $\min F'(1,99) = 32.64$, $p < .001$. Ambiguity with respect to the error data (unique = 6.04%, ambiguous = 8.24%), yielded $\min F'(1,104) = 2.19$, $p > .05$, for all other effects $\min F'$ was less than 1. Recalling the lexical decision results (Experiment 3), there the nonassociative-associative contrast was significant; that is, association affected lexical decision on

pseudowords but not the rapid naming of pseudowords.

Discussion

The demonstration of an associative effect on naming Serbo-Croatian words corroborates the experimental results of Carello, Lukatela, and Turvey (1988) and contrasts with the conclusion of an earlier experiment of Katz and Feldman (1983) that naming is not affected lexically. In the latter experiment—and a subsequent one using the same stimuli (Frost, Katz, & Bentin, 1987)—contexts were semantic categories and subcategories. Lupker (1984) has shown that, for English language materials, semantic contexts that bear little associative relationship to target words produce minimal or insignificant effects on naming. Our impression is that the two previous failures to demonstrate a lexical contribution to naming Serbo-Croatian words were probably due to the fact that the semantic contexts in question were nonassociative.

Although the Context \times Ambiguity interaction for word stimuli failed to reach significance by the min F' it was significant by both the subjects and items analyses, suggesting an influence of word level on phoneme-level activity. To further our appreciation of the interaction between word and phoneme levels, we compare, across experiments, associative differences in context with alphabetic differences in context. It was suggested above that associative influences originate at the word unit level, whereas alphabetic influences originate at lower levels comprising letter and phoneme processing units. Looking first at the lexical decision experiments of relevance, Experiments 2 and 3, it appears that the effect of phonological ambiguity is more sensitive to the alphabet manipulation than the associative manipulation. In Experiment 2, which held the associative relation constant and manipulated alphabetic congruency, the min F' for the Context \times Ambiguity interaction was significant at the .0007 level (the size of the phonological ambiguity effect

was reduced by 51 ms). In Experiment 3, in which the context always matched the target alphabetically and the associative relation varied, the min F' for the Context \times Ambiguity interaction was insignificant (the size of the phonological ambiguity effect was reduced by 3 ms). Looking now at the naming experiments, Experiments 4 and 5, we see a similar pattern. The alphabetic manipulation of Experiment 4 resulted in a min F' that was significant at the .002 level for the Context \times Ambiguity interaction (the size of the phonological ambiguity effect was reduced by 49 ms) whereas the associative manipulation of Experiment 5 resulted in a nonsignificant min F' (the size of the phonological ambiguity effect was reduced by 20 ms, which was significant by less conservative statistics, as noted).

This common pattern for lexical decision and naming—in which phonological ambiguity is reduced more by alphabet match than by association—has implications for the modeling of alphabetic and associative context effects in Serbo-Croatian. Consider an underlying network of connections among processing units and consider this network in the situation in which an associative relation holds between a context word and a phonologically ambiguous target that are not written in the same alphabet, for example, OLUJA–BETAP. We can suppose that the Roman context OLUJA (“storm”) does two things: (a) it raises the activation level of the word meaning “wind” and (b) it inhibits the Cyrillic letter units (that is, the unique letters and their corresponding phoneme units together with the ambiguous letters and their corresponding “Cyrillic” phoneme units). Therefore, at the time that BETAP is presented, the phoneme units for /və/ and /rə/ will be inhibited. The word units beginning with /bə/ and ending in /pə/ will be activated more strongly by phoneme-level to word-level connections than those beginning with /və/ and ending in /rə/. In contrast, because of the word-level activation of /vetar/ (“wind”), phoneme units /və/ and /rə/ will

be more strongly activated by word-level to phoneme-level connections than the units /bə/ and /pə/. As a result, the interactive dynamic into which BETAP is inserted is one in which, with respect to the network's processing of BETAP, the phoneme-level to word-level activation runs counter to the word-level to phoneme-level activation. For the alphabetically matched and associated pair ОЈУЈА–BETAP (in which "storm" is written in Cyrillic), the bottom-up and the top-down activations will be compatible.

Consider now a situation in which a context word and a phonologically ambiguous target are alphabetically matched but not associated, for example, ФИЈАТЕЈИЈА–BETAP ("stamp collection"–"wind"). Here, the word unit for "wind" will be inactive prior to BETAP's presentation. But the Roman letter units will be inhibited, meaning that word units beginning with /və/ and ending with /rə/ (including the word unit for "wind") will be activated strongly by the phoneme level and those beginning with /bə/ and ending with /pə/ will be activated weakly. Now, what we have learned is that the disambiguating effect of ОЈУЈА on BETAP is (a) much greater than the disambiguating effect of ОЛУЈА on BETAP and (b) not much greater, if at all, than the disambiguating effect of ФИЈАТЕЈИЈА on BETAP. With respect to ОЛУЈА–BETAP, it appears that ОЛУЈА's word units' connections do not raise the activation at the word level high enough to overcome the phoneme activation pattern induced by ОЛУЈА's letter units' connections.

Turning to the pseudoword data, no main effect of Association was found, which contrasts, as noted above, with the lexical decision data (Experiment 3) in which the associative context slowed lexical decision on pseudowords. Two differences, therefore, have now been noted between rapid naming and lexical decision with regard to pseudowords: The other alphabet–same alphabet contrast affected naming but not lexical decision (Experiment 4 vs. Experi-

ment 2); the nonassociate–associate contrast affected lexical decision but not rapid naming (Experiment 3 vs. Experiment 5). Another naming–lexical decision contrast is noteworthy. In the present and preceding experiments (that is, Experiments 5 and 4, respectively) there was a pronounced phonological ambiguity effect even though the phonologically ambiguous pseudowords were preceded by contexts that specified alphabet. In the corresponding lexical decision experiment, the phonological ambiguity effect was eliminated.

CONCLUSIONS

When native speakers/hearers of Serbo-Croatian are presented phonologically ambiguous letter strings in either the rapid lexical decision or naming tasks their response latencies are slowed markedly relative to their response latencies for phonologically unambiguous letter strings. In the present series of experiments we have investigated the contextual manipulation of this phonological ambiguity effect. The main results of the experiments are as follows:

(1) The phonological ambiguity effect (e.g., BETAP responded to slower than VETAR) can be largely eliminated by an immediately preceding word that specifies the alphabet (Cyrillic) of the ambiguous word (BETAP). This result holds for both rapid lexical decision and rapid naming.

(2) If the context word is associatively related to the ambiguous target word, then it may make a contribution to disambiguation that adds to the contribution made by alphabet. The disambiguation due to association is notably smaller, however, than the disambiguation due to alphabet. Furthermore, in the two tasks, lexical decision and naming, the disambiguating effect due to association appears to be limited to that of naming.

(3) Naming is affected by an associative context. This associative effect is larger for phonologically ambiguous words than pho-

nologically unique words. Although Serbo-Croatian scripts are orthographically shallow, the process of naming engages the lexicon. A lexical contribution is needed to resolve the pronunciation ambiguity of BE-TAP-type words. Other evidence of a word level contribution to naming is provided by the contribution of a pseudoword's source word to the phonemic content of a pseudoword's utterance.

(4) With respect to pseudowords, the phonological ambiguity effect is attenuated in lexical decision by contexts specifying one or the other alphabet. Alphabet specification, however, does not affect the phonological ambiguity effect in naming.

Analyses of the phenomena in the foregoing inventory suggest certain requirements for the construction of a model of Serbo-Croatian word recognition: (a) three layers of processing units beyond the layer of feature processing units, namely, letter processing units, phoneme processing units, and word processing units, in that order; (b) inhibitory connections in both directions between Cyrillic and Roman letter processing units; (c) phoneme processing units as the major activators of word processing units (making phoneme based codes the major access codes for lexical information); and (d) activation of word processing units leading to modifications in the states of phoneme processing units. A model incorporating these requirements is presented in Lukatela, Turvey, Feldman, Carello, and Katz (1989).

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