

Relation Between Pronunciation and Recognition of Printed Words in Deep and Shallow Orthographies

Leonard Katz and Laurie B. Feldman

University of Connecticut and Haskins Laboratories, New Haven, Connecticut

The processes responsible for recognition and pronunciation of printed words were studied by means of lexical decision and naming experiments. Two languages were examined: English, which has a complex and deep correspondence between spelling and speech, and Serbo-Croatian, in which the correspondence is simple and direct. It was hypothesized that reliance on articulatory coding (instead of on mediation by the internal lexicon) would be greater for Serbo-Croatian because its shallow orthography would allow more efficient use of spelling-to-speech correspondences. Each target stimulus was preceded by a word that was either related or unrelated semantically. Semantic priming of target words facilitated performance in both lexical decision and naming for English, results suggesting an influence of the internal lexicon on both processes. In contrast, semantic priming facilitated only lexical decision for Serbo-Croatian, which suggests that naming, at least in that language, is not strongly influenced by the internal lexicon. Further, in Serbo-Croatian, lexical decision and naming latencies were correlated when both tasks were not semantically primed and were uncorrelated when either or both tasks received semantic priming. This suggested that articulatory coding is used in lexical decision, at least under conditions in which contextual semantic facilitation is absent. In contrast, in English, lexical decision and naming were correlated uniformly whether semantic facilitation was present or not, which, when considered with the effect of semantic facilitation on naming, suggested a stronger influence of the internal lexicon on both recognition and pronunciation.

The present study is concerned with the relation between word pronunciation and word recognition. The alphabet is, of course, the primary tool for specifying the pronunciation of words; children are instructed in its grapheme-to-phoneme correspondences when they are taught to read. Young readers demonstrate this knowledge by reading aloud and, particularly, by sounding out words that are new to them. Even so, skilled reading involves silent reading, and it is not clear to what extent articulatory coding still mediates word recognition for the skilled reader.

A related question concerns the pronunciation of familiar words. Does the skilled reader pronounce these words directly by means of spelling-to-speech correspondence rules (as the beginning reader might), or, instead, is the pronunciation accessed as a stored memory along with the meaning of the word? In effect, this question asks if pronunciation is mediated by the internal lexicon. This article explores these questions.

The correspondence between English orthography and speech is highly abstract (involving complex transformations) in that the orthography principally references the morphophonemic level of English (Chomsky & Halle, 1968). It has been argued, therefore, that faster word recognition will occur with a strategy that avoids articulatory mediation and, instead, uses some aspect of the visual information in the print. According to this argument, then, languages with different degrees of complexity in their spelling-to-speech correspondence should show appropriately different degrees of dependence on articula-

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Requests for reprints should be sent to Leonard Katz, Haskins Laboratories, 270 Crown Street, New Haven, Connecticut 06510.

tory coding. In particular, readers should use articulatory coding more often when reading an orthography that has a more direct correspondence to speech than does English. In addition, because articulatory coding may be produced more easily by readers of a more direct orthography, these readers may depend less on lexical mediation for the pronunciation of printed words. Instead, simplified spelling-to-speech correspondences may be more efficient (in terms of speed of access and storage space) than a lexically mediated system. We are suggesting, then, that a reader's use of articulatory coding for word recognition and pronunciation may depend, in part, on the nature of the relation between the orthography and the spoken language.

The present experiment tests these notions by comparing the processes of pronunciation and recognition between English (with its deep orthography) and Serbo-Croatian, a language whose shallow alphabetic orthography was deliberately designed on the principle "Spell it as it sounds; says it as it is written" (Lukatela & Turvey, 1980). The spelling-to-sound correspondence is so consistently simple that even minor dialectal variation in the speech is mirrored in the orthography.¹ Thus, we have a basis for assessing the notion that the complexity of the relation between orthography and phonology will determine a skilled reader's reliance on articulatory mediation.

Articulatory codes constitute one example of the class of linguistic codes that are available to the reader for mediating between print and word recognition. As examples of articulatory codes, we include not only speech and subarticulation but also unexpressed specification for articulation. A second class of linguistic codes consists of abstract phonological codes based on the alphabetic principle (e.g., abstract specifications for grapheme-to-phoneme correspondence), spelling patterns (e.g., syllable codes), and morphophonemes (Chomsky & Halle, 1968; Venezky, 1970). Abstract phonological information is insufficient, by itself, to specify a precise vocal gesture. However, its relation to an articulatory code can be discussed in terms of whether a past connection existed, for the reader, between articulation and phonological knowledge. One example of a his-

torical connection between articulatory and phonological coding is given by the beginning reader who uses grapheme-to-phoneme correspondence in order to pronounce (and then recognize) words but, later, with increasing skill, eliminates overt and covert articulation. The phonological coding of grapheme-to-phoneme may continue to be used for word recognition, but it is then divorced from a plan for articulation (cf. LaBerge & Samuels, 1974). On the other hand, it is possible that there never may have been any such historical connection between an individual's use of phonology and articulation; such a circumstance must occur for some congenitally deaf readers. (For both circumstances, that is, for the use of phonological information with and without a past connection to articulation, there is a problem of terminology. As McCusker, Hillinger, and Bias, 1981, pointed out in a recent review of phonological coding in reading, there is no widespread agreement on how far a code must be abstracted from articulation in order to be called phonological.) Finally, codes for lexical access may be non-linguistic (and therefore certainly not articulatory) in the sense that they are not based on a linguistic analysis of the word. Such codes may consist of visual information about letter features or word shape. They are nonlinguistic codes because their elements do not correspond to elements in the spoken language (cf. Katz & Feldman, 1981).

In the present experiment, the lexical decision and naming tasks are used to study word recognition and pronunciation, respectively. The experimental rationale is similar to that used by Forster and Chambers (1973) and consists of two parts. First, because the same words are presented in both lexical decision and naming, the relative reaction times to words can be compared between tasks; a positive correlation between tasks indicates a commonality of origin for lexical decisions and naming. Conversely, a zero correlation suggests that the lexical decision and naming processes are independent. If a positive correlation is found, an attempt can be made to

¹ For discussions and comparisons of the Serbo-Croatian and English orthographies, see Katz and Feldman (1981), Lukatela, Popadić, Ognjenović, and Turvey (1980), and Lukatela and Turvey (1980).

determine the causal direction of the variables in the correlation. A positive correlation could mean that naming mediates lexical decision, that lexical decision mediates naming, or that both are determined by a third factor. This ambiguity can potentially be resolved in the second part of the approach in which a variable is manipulated that affects lexical search but, putatively, should not affect any articulatory process that precedes lexical search.

Forster and Chambers (1973) found a moderate correlation between lexical decision and naming ($r = .55$). This suggested that the two tasks had substantial commonality. The investigators believed that word frequency indexed the underlying organization of the internal lexicon and, therefore, should affect only those processes that were dependent on lexical access. Because Forster and Chambers considered word frequency to be a principle of lexical organization exclusively, they interpreted a word frequency effect in the naming task (high-frequency words were named faster) as evidence that naming is lexically mediated. Lexical mediation for naming effectively precludes the first of the possibilities, described above, for articulatory coding in word recognition. That is to say, if lexical access precedes the articulation of a printed word, it is unlikely that the code a reader uses for input to the lexicon would be an articulatory code. Forster and Chambers's results suggested that the specification for pronunciation is stored in memory and is accessed along with a word's meaning. They report some internal experimental assessment of the assumption that word frequency is a variable that affects lexical access but not prelexical access.

In the present study, we chose semantic priming as a manipulation that should affect lexically mediated processing but should not affect prelexical processing. Other investigators have demonstrated, in English, a facilitating effect of semantic context on both lexical decision and naming (Becker & Killion, 1977; Massaro, Jones, Lipscomb, & Scholz, 1978; Meyer, Schvaneveldt, & Ruddy, 1975), which suggests that, for English, the naming task involves at least some mediation by the internal lexicon. However, because none of these investigators presented correlations be-

tween the two tasks, we do not know the extent of processing similarity. For Serbo-Croatian, no previous data exist that indicate semantic facilitation of either lexical decision or naming.

In summary, we tested two hypotheses concerning the role of articulatory coding in lexical decision. First, we examined the notion that articulatory coding precedes lexical access in word recognition by looking for (a) a positive correlation between lexical decision and naming and (b) the absence of semantic priming effects on naming.

Three other outcomes are possible. If the correlation between lexical decision and naming is positive but, in addition, there are effects of semantic priming on naming, it would suggest that naming is at least partly lexically determined and that articulatory coding plays a diminished role or no role in either naming or recognition. Another possible outcome is that lexical decision and naming do not correlate. In this case, if lexical decision is affected by semantic priming but naming is not, the results would doubly suggest that naming and lexical decision are processes with different origins. Finally, an anomalous outcome would be one in which there is no correlation between lexical decision and naming, coupled with a semantic priming effect on both tasks.

The second hypothesis that we assessed was the notion that a reader's reliance on articulatory recoding for lexical access is directly related to the simplicity of the correspondence between the orthography and phonology of the language. Thus, readers of Serbo-Croatian (a language that has a simple, shallow orthography) should depend more on articulatory coding than readers of English.

Method

Subjects

Fifty-six students from the Faculty of Philosophy at the University of Belgrade and 68 students from the University of Connecticut participated in the experiment in partial fulfillment of requirements for a course in introductory psychology. All Yugoslav subjects had participated previously in reaction time experiments, but the American subjects, in general, had not. All subjects were native speakers of their respective languages. There were 14 Yugoslav subjects in each of four experimental conditions. The number of English subjects in each group

varied between 16 and 18; 72 subjects were tested, but the data of 5 were deleted due to error rates exceeding 15%. No Yugoslav subjects approached this error rate, and none were deleted.

Stimuli

Target words were 59 nouns in English and 59 nouns in Serbo-Croatian, all judged to be familiar to college students. The two sets of nouns contained substantially similar words with regard to content. In both languages, the length of target words varied from four to nine letters. Fifty-nine English pseudowords and 59 Serbo-Croatian pseudowords were generated from the real words by changing two or three letters of each word. Vowels were substituted for vowels, and consonants were substituted for consonants. For each word, a semantically related prime was selected such that the prime represented either a synonym or a superordinate semantic class for the target word. Pseudowords were also paired with word primes that were not related to the pseudowords in any obvious way. Stimuli were typed in the Roman alphabet in the center of 35-mm Prima U Film slides.

Three experimental lists were composed for each language. One list (the semantically related condition) contained 59 prime-word target pairs, each of which was semantically related, and 59 prime-pseudoword target pairs. Also, two semantically unrelated lists were constructed. Both contained the same prime-pseudoword pairings as in the semantically related list but were composed of different pairings of prime and target word. The sequence of target words was constant for all three lists.

Procedure

Subjects received either a semantically related or a semantically unrelated list. In the semantically related prime condition, each prime word was presented for 300 msec in one channel of a three-channel Scientific Prototype Model GB tachistoscope. At its termination, a lighted blank field appeared for 300 msec, and then the target item was presented in another channel for 3,000 msec. In the neutral (semantically unrelated) condition, the same prime items were presented in a different order so that there was no obvious semantic association between target and prime. Target words and target pseudowords were randomly intermixed under the constraint that no more than three consecutive target items could be of one type. The experimental sequence was preceded by a sequence of 28 practice items, which was identical for all experimental groups. In practice, the relation of prime to target was semantically neutral.

In the lexical decision task, subjects had to decide whether the target was a word and indicate their response by pressing one of two telegraph keys. In the naming conditions, subjects were required to pronounce each target word or pseudoword as quickly and as distinctly as possible. Reaction time was measured from the onset of the target word by a voice-operated Schmitt trigger relay. Periodically, in order to ensure that subjects were reading the primes, they were asked by the experimenter to report the prime item. The verbal inquiry immediately followed the subject's response. Inquiries occurred quasi-randomly, with at least one inquiry within a run of 10

target items. Subjects were almost always able to report the word.

In summary, orthography (Serbo-Croatian/English), task (lexical decision/naming), and prime condition (semantically related/semantically unrelated) were between-subjects variables. All four groups in a given language received the same 59 words and 59 pseudowords as targets. In the semantically related condition, the word targets were preceded by semantically related prime words, and the pseudowords were preceded by (necessarily) unrelated prime words. In the unrelated condition, the same prime words were reordered randomly so that there was no obvious semantic relation between each target and its prime.

Results

Errors

Mean error percentages are presented in Table 1. In the lexical decision task, error rates are low in all experimental conditions but are slightly higher in English than in Serbo-Croatian. In the naming task, most errors were made in pronouncing English pseudowords. The error rates in the other conditions are low. Nearly all errors were mispronunciations and incomplete utterances (e.g., only the first syllable of a multisyllabic pseudoword). There were few omissions of an entire pseudoword. A liberal criterion was used by the experimenter in judging the acceptability of a pronunciation. If the pronunciation appeared to be based on an analogy with a real English word, or was otherwise reasonable according to common pronunciation rules, it was accepted. Furthermore, slight hesitations and slurring of sounds within the pseudoword were not counted as errors. Thus, most errors consisted of incorrect consonant substitutions. In cases of doubt, the experimenter transcribed the subject's response and consulted the first author.

Analyses of variance (ANOVAs) were performed for the two tasks by using the error percentage on words and pseudowords for each subject. For the lexical decision task, only the overall difference between English and Serbo-Croatian was significant, $F(1, 58) = 10.96$, $p < .01$, $MS_e = .0009$. The difference between the two languages was also significant in the ANOVA for the naming task, $F(1, 58) = 11.86$, $p < .01$, $MS_e = .002$, and, in addition, the difference between words and pseudowords was significant, $F(1, 58) = 47.79$,

Table 1
Mean Error Percentages for Word and Pseudoword Targets as a Function of Semantic Relation Between Prime and Target Words

Target item	Lexical decision		Naming	
	Unrelated	Related	Unrelated	Related
Serbo-Croatian				
Pseudoword	2	1	5	5
Word	1	1	3	4
English				
Pseudoword	4	3	10	12
Word	3	3	4	2

$p < .001$, $MS_e = .0014$. The three-way interaction between orthography (English vs. Serbo-Croatian), word-pseudoword, and semantic relatedness was marginally significant, $F(1, 58) = 4.34$, $p = .04$, $MS_e = .0014$, and reflects the presence of a slight simple interaction between semantic relatedness and word-pseudoword for English but not for Serbo-Croatian. Most important, the interaction between orthography and word-pseudoword was strongly significant, $F(1, 58) = 19.67$, $p < .001$, $MS_e = .0014$, which supports the suggestion made above that the highest error rate occurred for English pseudowords.

Reaction Times

Mean reaction times were calculated for correct responses on word trials and pseudoword trials. Figure 1 presents the mean reaction times for the lexical decision and naming tasks. Inspection of the figure suggests that for both English and Serbo-Croatian readers, lexical decisions to words were facilitated by semantically related priming. However, for the naming task, a different result obtains. For Serbo-Croatian readers, word naming is not facilitated by semantically related priming, whereas for English readers, the naming task results are similar to those of the lexical decision task. For pseudowords, a seemingly odd result was found. The pattern of results parallels that of the word trials: semantic facilitation for both English and Serbo-Croatian readers in lexical decision but semantic facilitation for only the English readers in naming. This apparent

anomaly—semantic facilitation for pseudowords—is discussed later.

Comparison of error rates from Table 1 with reaction times from Figure 1 does not suggest any systematic relation between the two measures. In particular, there is no evidence for a speed-accuracy trade-off.

The ANOVAS for the lexical decision and naming tasks were performed on the mean reaction time of correct responses both for each stimulus item averaged over subjects (stimulus analysis) and for each subject's word and pseudoword trials (subject analysis). For the lexical decision task, the only significant factors were (a) word versus pseudoword, $F'_{\min}(1, 127) = 57.88$, $p < .001$, and (b) semantically related versus semantically unrelated priming, $F'_{\min}(1, 59) = 4.69$, $p = .03$. For the naming task, the significant factors were (a) semantic relatedness, $F'_{\min}(1, 60) = 4.91$, $p = .03$, and, more important, (b) the interaction of semantic relatedness and orthography (English vs. Serbo-Croatian), $F'_{\min}(1, 60) = 6.092$, $p = .02$. In addition, the naming task analysis produced significant effects for (c) word versus pseudoword, $F'_{\min}(1, 167) = 108.71$, $p < .001$, and (d) the interaction of orthography and word-pseudoword, $F'_{\min}(1, 169) = 11.869$, $p < .001$. These results suggest that semantically related priming aids English readers in both word recognition (lexical decision) and word naming but, for Serbo-Croatian readers, semantically related priming aids only word recognition.

Correlations

The suggestion of a similarity between lexical decision and naming for English readers but not for Serbo-Croatian readers receives further support from correlations calculated between lexical decision and naming. Mean reaction times were calculated (averaged over subjects) for each of the 59 words and 59 pseudowords in each of the four experimental conditions in each language, that is, for the semantically related and semantically unrelated treatment conditions in the lexical decision and naming tasks. Table 2 presents these correlations. In addition to the correlations between conditions in each language, we have included correlations between En-

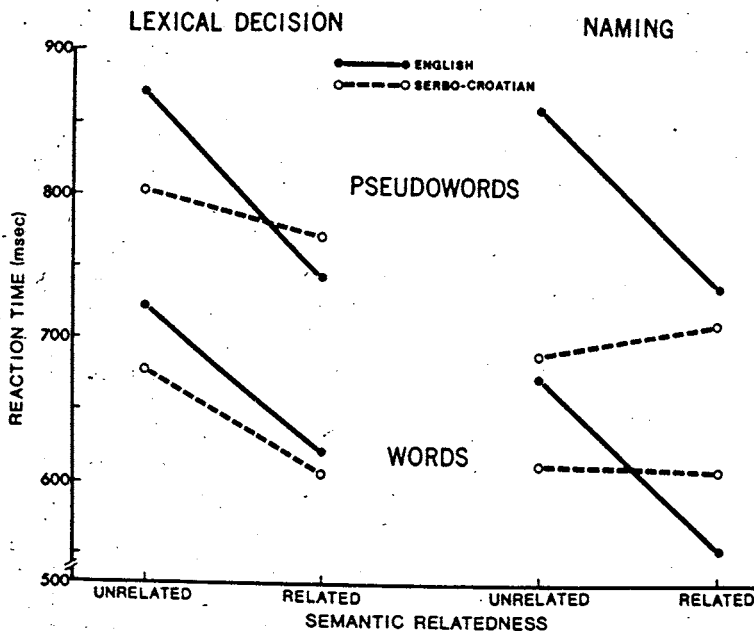


Figure 1. Reaction time to target stimuli in lexical decision and naming tasks for the English and Serbo-Croatian orthographies as a function of semantically related and semantically unrelated prime words.

English and Serbo-Croatian. These latter correlations are based on each item's ordinal position in the list of trials; that is, the first item on the English list was paired with the first item on the Serbo-Croatian list and so on. These correlations are included because they give an index of the covariation between conditions due to secondary sources such as practice and fatigue and, so, provide a baseline against which the other correlations can be evaluated. Correlations based on mean reaction time for each of 59 words in each of the eight experimental conditions are entered above the diagonal in the correlation matrix. Below the diagonal are the correlations based on the mean reaction time for each of the 59 pseudowords in each of the eight experimental conditions. All correlations have 57 *df*; correlations above .26 are significant ($p < .05$).

Pseudoword Correlations

For pseudowords, some strong correlations obtained. In both Serbo-Croatian and English, correlations between semantically related and semantically unrelated conditions were high for the naming task ($r = .82$ and $r = .83$, respectively). For the lexical decision

task, the same correlations were lower but still substantial ($r = .57$ and $r = .68$). These high correlations indicate, for both languages, a strong consistency within tasks in the processing of pseudowords. They indicate that reliability was sufficient to produce substantial correlations. Nevertheless, when the four between-tasks correlations for Serbo-Croatian were considered, it was apparent that they were all low. These correlations were nonsignificant, which suggests that there was little or no commonality between lexical decision and naming in the way pseudowords were processed. In contrast, two of the four between-tasks correlations were statistically significant for English. The correlation between the related prime conditions for lexical decision and naming was .34, and the correlation between related lexical decision and unrelated naming was .38. Their difference was not statistically significant. Nevertheless, only the larger was significantly different from its Serbo-Croatian counterpart ($r = .01$). Thus, there is strong evidence that pseudowords were processed similarly within tasks whether or not the experimental manipulation involved semantically related priming. In addition, there is no evidence to suggest processing similarities between tasks

for Serbo-Croatian. Finally, there is equivocal evidence suggesting some between-tasks commonality for English pseudowords.

Word Correlations

Of major interest are the four correlations between lexical decision and naming for words. For Serbo-Croatian readers, only one of these is significant: The correlation between the two conditions in which the prime was semantically unrelated to the target ($r = .32$). This correlation is as strong as that found by Feldman (Note 1) and is about as strong as the correlations within tasks (i.e., between semantically unrelated and semantically related priming for lexical decision, $r = .35$, and for naming, $r = .31$). Otherwise, the remaining correlations between tasks are nonsignificant. Thus, the commonality between lexical decision and naming changes as a function of the semantic relatedness between prime and targets. The similarity between tasks is strongest when there is least involvement of the internal lexicon, that is, when there is no semantically related priming.

A quite different pattern of correlations

was found for the English readers. Here, the lexical decision-naming correlations were all significant, although only of moderate size, ranging from .30 to .44. There are no statistically significant differences among them, nor do they differ statistically from the only significant Serbo-Croatian correlation between tasks ($r = .32$). Thus, in contrast to Serbo-Croatian, lexical decision and naming in English share a moderate amount of processing commonality among all experimental conditions. This commonality is not affected by the semantic relatedness between prime and target.

The differences between Serbo-Croatian and English in the size of the correlations did not appear to be due to artifacts related to differences in the variances of the contributing variables. Inspection of the standard deviations of the 16 variables whose correlations are given in Table 2 indicated general homogeneity. In addition, not all of the critical comparisons discussed above could be attributed to any heterogeneity that did exist. For example, the standard deviations for semantically related and unrelated word naming, respectively, were 49 msec and 95 msec for Serbo-Croatian and 54 msec and 52 msec

Table 2
Correlations of Mean Stimulus-Item Reaction Time Between Semantically Unrelated and Semantically Related Priming Conditions in Lexical Decision and Naming Tasks for Serbo-Croatian and English Readers

Task	Serbo-Croatian				English			
	Unrelated		Related		Unrelated		Related	
	LD	N	LD	N	LD	N	LD	N
Serbo-Croatian								
<i>Unrelated</i>								
LD		32	35	22	-11	-06	-16	03
N	09		06	31	-10	06	-04	21
<i>Related</i>								
LD	57	01		06	15	11	26	-15
N	11	82	04		-05	-10	-04	00
English								
<i>Unrelated</i>								
LD	28	-21	26	-16		44	71	36
N	-10	-19	-09	-10	20		37	68
<i>Related</i>								
LD	13	-20	-21	-08	68	38		30
N	00	-07	-15	-05	13	83	34	

Note. Correlations for words are entered above the diagonal; correlations for pseudowords are entered below the diagonal. LD = lexical decision; N = naming.

for English, but the correlation for English was by far the larger (.68 vs. .31) in spite of its having a smaller standard deviation for semantically unrelated naming.

Discussion

Word Naming

These results address, most directly, the question of the mechanism by which printed words are pronounced. For English, the word naming process appears to be mediated, at least in part, by the internal lexicon. The major evidence that supports this suggestion is the finding that word pronunciation was facilitated when the target word was preceded by a semantically related word. This result is direct evidence of lexical involvement because semantic relations between words are viewed as an exclusive property of the lexicon. Second, there is correlational evidence consistent with the hypothesis of lexical involvement in pronunciation; pronunciation latencies and lexical decision latencies were not uncorrelated. Because the lexical decision task requires subjects to access their internal lexicon, the absence of a positive correlation would have been inconsistent with the major finding.

The present results are in agreement with the results of Becker and Killion (1977) and Meyer et al. (1975), both of whom found semantic priming effects on word naming in English. In addition, the argument for lexical involvement in pronunciation is strengthened by the studies of Forster and Chambers (1973) and Frederiksen and Kroll (1976), who found word naming latencies to be affected by word frequency, a putative lexical factor. Nevertheless, none of the data we have discussed indicates that lexical mediation is the sole mechanism for pronouncing printed English words. It is obvious that pronunciation in English is not always accomplished solely by lexical look-up; application of some spelling-to-speech correspondences must be applied, at least, to new words. Further, Baron and Strawson (1976) presented data supporting the suggestion that pronunciation in English is accomplished, even by skilled readers, by using the two mechanisms of lexical mediation and spelling-to-speech correspondence rules. Recently, Navon and Shim-

ron (1981) demonstrated that grapheme-to-phoneme coding is typically used in naming, at least in part, by readers of Hebrew despite the Hebrew orthography whose design would seem to favor an alphabetic principle (i.e., grapheme-to-phoneme coding) even less and a lexical mechanism even more than the orthography of English.

In the present study, we compared the English orthography, which has a deep, complex correspondence to speech, with the Serbo-Croatian orthography, whose simple, direct correspondence to speech constitutes an extreme application of the alphabetic principle. The question of interest was whether the degree of lexical mediation found in English word naming would also be found in Serbo-Croatian or, instead, would lexical involvement be reduced in Serbo-Croatian because of the more efficient spelling-to-speech correspondence in that orthography. The data clearly support the latter alternative; semantic priming did not facilitate Serbo-Croatian word naming. Also, with one exception (discussed below), pronunciation latencies were uncorrelated with lexical decision latencies, a finding that further supports the notion that lexical mediation plays less of a role in naming in Serbo-Croatian than in English.

Lexical Decision

The major questions asked about word recognition were whether it is mediated, at least in part, by articulatory coding and, if so, whether the influence of articulatory coding is greater for the Serbo-Croatian orthography than for English. For English, there was no evidence in support of a mediating articulatory process. This is consistent with previous results that offer little support for the use of articulatory codes in skilled word recognition in English (see McCusker et al., 1981, for a review). However, for Serbo-Croatian, the results suggested that articulatory coding precedes word recognition, at least sometimes. Although a facilitating effect of semantic priming occurred for both English and Serbo-Croatian (and, therefore, indicated at least some involvement of the internal lexicon for both), the two orthographies differed importantly in the pattern of correlations between lexical decision and naming, a result suggesting some coding differences. For En-

lish, there were moderate-sized correlations between the two tasks, but the correlations did not vary as a function of the semantic relatedness between prime and target; that is, whether the prime had been related to the target or not, the relative reaction times to the target words remained fairly constant. This occurred in spite of an overall decrease in reaction time for all words when the prime was, in fact, semantically related to the target. Thus, for English, there was a general consistent commonality of processing between lexical decision and naming.

In contrast, for Serbo-Croatian, the two tasks were not correlated when either or both of the tasks had received semantic priming. Only when neither task was semantically primed did they correlate. It appears that there was a processing similarity between word recognition and naming only when there was no involvement of the internal lexicon. This suggests that when the lexical search process in lexical decision received no semantic priming, it used, to a degree, the same kind of informational code that the pronunciation process used when it received no semantic priming. Presumably, this was not a lexical code because semantic priming had no facilitating effect on naming. Further, because this pattern of correlations occurred for Serbo-Croatian and not for English, it is plausible to ascribe the difference to their differences in orthographic depth; for Serbo-Croatian, articulatory coding is more easily achieved and therefore more likely to be used for word recognition.

There is, however, one result that is superficially inconsistent with this interpretation: the failure of semantically primed naming to also correlate significantly with semantically unrelated lexical decision. If semantic priming truly had no effect on Serbo-Croatian naming, then both the semantically unrelated and the semantically related naming conditions should have correlated significantly with unrelated lexical decision. However, this failure is somewhat mitigated by a nonsignificant difference between the two correlations. A tentative explanation for the smaller correlation may be that (a) semantic priming did occasionally stimulate the use of a lexical route to pronunciation but (b) this route was not more efficient than the other. The occasional use

of the alternate semantic route could have been sufficient to weaken the correlation between semantically related naming and semantically unrelated lexical decision.

Pseudowords

The pseudoword error data support the argument that the use of articulatory coding in naming is more prevalent in Serbo-Croatian than in English. The English readers made many more errors in pronouncing pseudowords (10% and 12%) than did the Serbo-Croatian readers (5%), even though there was no such discrepancy in pronouncing real words (for which all error rates were in the range of 2%–4%). If it can be assumed that pseudowords in both languages were equally wordlike with regard to spelling pattern (no pseudowords were phonologically irregular), then these error data underline the relative difficulty in pronouncing unfamiliar English print whatever the pronunciation strategies are, whether a strict application of spelling-to-speech correspondence or a dependence on analogies to the pronunciations of familiar words (e.g., Glushko, 1981).

A second result that we found for pseudowords appears, at first glance, to be anomalous: the effect of semantic relatedness on pseudoword latency in all experimental groups except Serbo-Croatian naming (see Figure 1). However, a retrieval strategy effect may account for this result. Obviously, pseudowords could not have been helped by receiving priming cues that pointed to a semantically defined address in memory; pseudowords have no address in memory. However, subjects in the semantically related conditions may have depended on using the information in the primes to facilitate a memory search for the target and, accordingly, may have used this expectation to reduce their criterion time for converging on a true lexical entry; targets not found before the criterion limit would be classified as nonwords.

Other investigators have also observed semantic facilitation for pseudowords under certain conditions. Posner and Synder (1975), using a match-mismatch paradigm found that reaction times to mismatched target items were faster following a word or letter that did not predict the target than when fol-

lowing an asterisk that was equally unpredictable. In two studies, Neely (1976, 1977) found that reaction times to pseudowords that followed word primes were faster than those that followed a neutral string of Xs. Neely's (1977) explanation of these results suggested that subjects adopted a strategy of attempting to find common semantic features between the prime and the target, an explanation not incompatible with our own explanation for the results of the present experiment. According to Neely's approach, subjects in our semantically related conditions could have tried (more than other subjects) to use the semantic information that was in common between prime and target in order to decide on the lexical existence of a target item. The presence of common semantic features (as for word targets) or the absence of common semantic features (as for pseudoword targets) could have speeded up the time to make appropriate responses. Note that if this explanation is accurate, then the presence of semantic facilitation for pseudowords in a naming task is additional evidence that the naming process is at least partly mediated by the internal lexicon. In the present experiment, the pseudoword data contribute to the evidence that naming is lexically mediated in English but not in Serbo-Croatian. Unfortunately, any detailed explanation for the priming effect on pseudowords must wait for a future experiment; only ad hoc explanations can be proffered here. Nevertheless, it is an important question to pursue. The appearance of the phenomenon in several experiments attests to its robustness, and its explanation should shed light on the process of word recognition.

Reference Note

1. Feldman, L. B. *Word recognition in Serbo-Croatian is necessarily phonological* (Status Report on Speech Research, SR-66). New Haven, Connecticut, 1981.

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