

Identity Priming in English Is Compromised by Phonological Ambiguity

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If it takes longer to achieve a single phonological representation for inconsistent words (e.g., BOWL) than for consistent words (e.g., BENT), and if phonological coherence is pivotal to visual word recognition, then identity priming should depend on consistency. This hypothesis was evaluated in naming and lexical decision within a 4-field presentation sequence of mask–prime–mask–target. The prime–target stimulus onset asynchrony (SOA) was either 114 or 244 ms (with prime durations, respectively, of 43 and 129 ms). Four experiments compared identity primes such as BOWL and BENT, which were equated, on average, for total number of friendly and unfriendly neighbors, bigram frequency, and number of 1-letter-different neighbors. In both tasks, BENT primed itself better than BOWL primed itself, with the difference being larger at the shorter SOA. Word processing is constrained primarily by the rate of achieving a coherent phonological code.

Identity priming refers to the priming of a word by itself. Given that all of the representations (orthographic, phonological, semantic, and syntactic) activated by an identity prime are of immediate relevance to processing and recognizing the target, it seems self-evident that an identity prime is the ultimate prime. As counterintuitive as it seems, the theory that visual word recognition is based in phonological codes leads to a very different understanding—namely, that a word may not necessarily be the best prime for itself and that it may even fail to prime itself. These curious predictions are the outcomes of thinking in terms of the *phonological coherence hypothesis* (Van Orden & Goldinger, 1994; Van Orden, Pennington, & Stone, 1990). According to this hypothesis, the various processes that eventuate in a response indexing visual word recognition (e.g., naming, lexical decision, semantic category judgement) rely on the initial achievement of a coherent phonological code. If an identity prime took longer to achieve phonological coherence than a suitably selected nonword prime similarly homophonic with the target, then naming of the target might well be facilitated more by the nonword prime than by the target itself (the identity prime). This greater facilitation by a nonword homophone would be most pronounced at onset delays of the target relative to the prime sufficient for attaining phonological coherence by the nonword prime but not sufficient for attaining phonological coherence by the identity prime.

Recent experiments on identity priming with Serbo-Croatian materials and with participants who were skilled in

reading both Roman and Cyrillic scripts confirm the preceding conjecture (Lukatela, Savić, Urošević, & Turvey, 1997). Certain pseudohomophone primes were more effective than identity primes in naming and lexical decision tasks when the stimulus onset asynchrony (SOA) was brief. The nonword primes that proved to be superior to identity primes were made possible by Serbo-Croatian's two partially overlapping orthographies (Lukatela & Turvey, 1998). Whereas the majority of the letters in the Cyrillic and Roman alphabets are peculiar to one or the other alphabet (they are *phonologically unique*), the overlap is such that certain letters are pronounced the same way in the two alphabets (they are *common*) and other letters are pronounced differently depending on whether they are read as Roman or Cyrillic (they are *phonologically ambiguous*). Depending on how these characters are combined, letter strings can be fashioned that have one or more phonological interpretations. Moreover, the generation of phonological codes is automatic; it does not heed alphabet boundaries (e.g., Lukatela, Turvey, Feldman, Carello, & Katz, 1989). A word such as ROBOT (meaning "robot") supports the all-Roman word interpretation /robot/ as well as the mixed-alphabet nonword interpretation /rovot/ because B is pronounced differently in the two alphabets.

This automaticity can be exploited in the creation of pseudohomophones that rely on a mix of alphabets. For example, the nonword letter string POBOT supports the same two phonological interpretations as ROBOT plus two more—/pobot/ and /povot/—because the uniquely Roman R is replaced by a phonologically ambiguous P. The mixed-alphabet nonword ROBOT, in contrast, supports only one phonological interpretation, /robot/. At brief prime–target SOAs (e.g., 70 ms), only ROBOT was found to be an effective phonological prime of the target word *robot* (Lukatela et al., 1997). According to the phonological coherence hypothesis, because both ROBOT and POBOT generate competing phonological patterns, short SOAs do not allow enough time to achieve a suitably resolved phonological code to benefit the naming of *robot* or a decision about its lexical status. At

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SOA = 250 ms, in contrast, all three were successful phonological primes for *robot*, this time with ROBOT matching the effectiveness of ROBOT and with both of these being superior to POBOT (Lukatela et al., 1997). By argument, POBOT becomes effective at the longer SOA because one of the competing phonological codes it generates (the one that maps to a word in the lexicon) receives top-down activation via phonological-semantic connections. ROBOT's advantage over POBOT comes from interalphabet inhibition: The uniquely Roman R inhibits the Cyrillic interpretation of the ambiguous character В (Lukatela, Feldman, Turvey, Carello, & Katz, 1989; Lukatela, Turvey, et al., 1989; Lukatela, Turvey, & Todorović, 1991), resolving the noise at the phonemic level. Settling on a single phonological pattern allows the identity prime to achieve the same level of effectiveness as the phonologically unique pseudohomophone.

The striking aspect of Lukatela et al.'s (1997) results is that phonological constraints result in superiority for the mixed-alphabet nonword prime, which has never been seen by the reader of Serbo-Croatian, over the identity prime, which is a common word in the language. Subsequent experiments by Lukatela, Carello, Savić, Urošević, and Turvey (1998) extended the preceding superiority to associative priming. They found that the phonologically unambiguous nonword ROBOT primed an associate (*automat*) of *robot* better than ROBOT did. In agreement with the phonological coherence hypothesis, if the time to resolve a phonological representation dictates the time course of stabilizing the other codes relevant to word recognition, then the phonologically unambiguous ROBOT would have an advantage at short SOAs over the phonologically ambiguous ROBOT. That is, the achievement of a phonological code appropriate to activating the lexical representation *robot* and, in turn, *robot's* associates in lexical memory, such as *automat*, would be more probable at a short SOA with the nonword prime ROBOT than with either the appropriate word prime ROBOT or the phonologically ambiguous nonword prime POBOT. In experiments in which the prime-target SOA was prolonged (250 ms vs. 70 ms), the reliable associative priming by the phonologically unique nonword was no longer superior to the reliable associative priming by the appropriate prime.

An important issue is whether the details of the Serbo-Croatian results on identity priming generalize to English, which is less oriented to transcribing phonology than is Serbo-Croatian. Specifically, will identity priming in English prove to depend on the phonological purity of the words in question? Will words pronounceable in more than one way (e.g., BOWL) function less well as identity primes than words pronounceable in only one way (e.g., BENT)? Most research on identity priming in English involves manipulating the lag between foveated and spatially superposed prime and target (e.g., Evett & Humphreys, 1981; Feustel, Shiffrin, & Salasoo, 1983; Forster & Davis, 1984; Forster, Davis, Schoknecht, & Carter, 1987; Humphreys, Besner, & Quinlan, 1988; Humphreys, Evett, Quinlan, & Besner, 1987; Humphreys, Evett, & Taylor, 1982; Norris, 1984; Scarborough, Cortese, & Scarborough, 1977). This research has not yet distinguished priming with phonologi-

cally inconsistent words from priming with phonologically consistent words and is, therefore, mute on the question of whether English identity priming will be impaired at short SOAs when the identity primes are phonologically inconsistent. There is, however, a conceptually similar line of research—involving extrafoveal rather than foveal primes and saccade-determined SOAs rather than experimenter-controlled SOAs—that does speak to a variant of this question but that falls short of providing a conclusive answer.

The research on transsaccadic word recognition examines the benefit of an extrafoveal preview of a target word prior to fixation on and identification of that target word or one that has been substituted for it during the saccade. Typically, only information about the first few letters of the preview item is integrated across the saccade (Pollatsek & Rayner, 1989), implying that any observed differences in preview benefits should be tied in some way to the word-initial pattern. Henderson, Dixon, Petersen, Twilley, and Ferreira (1995) evaluated the hypothesis that preview benefits (or priming advantages) are based on the phonological code generated for the first few letters of the preview item. Specifically, they evaluated the hypothesis that extrafoveal processing of, say, either BUTTON or BUTANE would benefit the subsequently fixated *button* but not the subsequently fixated *butane*. The contrast in expected benefits was due to the fact that Henderson et al. assumed that, in preview, BUT would be given the more common phonological interpretation—an interpretation that is compatible with that of BUT in BUTTON but not with that of BUT in BUTANE. Expressed in full, the *partial phonological coding hypothesis* of Henderson et al. (1995) asserted that if (a) the more common phonological code was assigned to BUT in the extrafoveal preview regardless of the word containing BUT and (b) there was transsaccadic integration of phonology (Pollatsek, Lesch, Morris, & Rayner, 1992), then (c) processing of the foveated *button* (where BUT receives the more common code) should benefit more than processing of the foveated *butane* (where BUT receives the less common code). The hypothesis was only partially supported in an experiment in which participants made lexical decisions on the foveated target items (Henderson et al., 1995). BUTTON-*button* was alone among the preview-target pairs in producing significant preview benefits (faster identification of the target relative to a nonpreview control); BUTANE-*button* was functionally identical to BUTTON-*butane* in producing no benefits; and BUTANE-*butane* produced a small benefit that was only marginally significant (by items analysis alone). In addition, it was found that the preview effect did not differ between the preview-target word pairs and corresponding nonword pairs created by changing the final three letters of the words in each word pair. The implication of the latter finding is that the preview benefit, when it occurs, is most likely prelexical in origin (Henderson et al., 1995).

In response to the lack of support for the partial phonological hypothesis in the mismatch pairs (BUTANE-*button*, BUTTON-*butane*), Henderson et al. (1995) conjectured that there might have been interference from the detection of the change that occurred in the final trigram during the saccade.

They provided no account, however, of how this interference with phonological coding or with transsaccadic integration would arise. Other explanations for the failed partial phonological hypothesis are possible, particularly if the number of letters coded is greater than the initial three (which Henderson et al. conceded is most likely). Because *BUTTON* and *BUTANE* can each support two different phonological codes (given the two pronunciations of *BUT*), it can be expected that both codes will begin to evolve soon after the extrafoveal presentation of either of these words is initiated, with the more common code emerging sooner than the less common code (Kawamoto & Zemplidge, 1992; Van Orden & Goldinger, 1994). With a short lag, *BUTTON*–*button* should yield greater preview benefits than the other matched pair *BUTANE*–*butane*, given that the code befitting *BUTTON* will have had a better chance of being established prior to foveation than the code befitting *BUTANE*. For the mismatch pairs, however, the phonological code at hand when the target is foveated is at odds—more (in the case of *BUTANE*–*button*) or less (in the case of *BUTTON*–*butane*)—with the phonology of the foveated target word, making a preview benefit unlikely.

The results of Henderson et al. (1995) provide, therefore, useful hints that a word's ability to prime itself may well vary with the phonological consistency of the word and with the time available for processing it as a prime—as expected from the phonological coherence hypothesis. In order to evaluate these possibilities more directly, the number of phonological interpretations supportable by a word needs to be manipulated explicitly, as does the time between the onsets of the word as prime and the word as target. In the research of Henderson et al. (1995), the words were uniform in the number of phonological interpretations they could support, and onset interval was a variable saccade with a grand mean across participants of 200 ms. In the present research, the required explicit manipulations of phonological interpretations and prime–target SOAs were performed using foveated stimuli at the same spatial location, in common with the majority of studies on identity priming. Specifically, we performed the manipulations to evaluate the prediction that at short SOAs (<250 ms) between repetitions of a word, identity priming in both the naming and lexical decision tasks should be stronger for phonologically consistent words (those with no “unfriendly” neighbors) than for phonologically inconsistent words (those with one or more “unfriendly” neighbors), with the magnitude of this difference being inversely related to the magnitude of the onset asynchrony. The number of “unfriendly” neighbors is defined as the number of English words sharing the same orthographic rime (the same spelling) but differing in rime pronunciation (e.g., *bowl* and *fowl*; Pugh, Rexer, & Katz, 1994). Accordingly, if words with one or more unfriendly neighbors take longer than words with no unfriendly neighbors to achieve a single phonological representation, and if phonological coherence is the linchpin of visual word recognition (Van Orden & Goldinger, 1994), then identity priming of English words at short prime–target SOAs should depend on the number of unfriendly neighbors. In the present article, Experiment 1 (SOA = 244 ms, prime dura-

tion = 129 ms) and Experiment 2 (SOA = 114 ms, prime duration = 43 ms) were directed at the contrast between phonologically consistent and phonologically inconsistent identity primes in naming, and Experiment 3 (SOA = 244 ms, prime duration = 129 ms) and Experiment 4 (SOA = 114 ms, prime duration = 43 ms) were directed at this contrast in lexical decision.

Experiments 1 and 2: Naming

Consider the prime–target pairs *BOWL*–*bowl* and *BENT*–*bent* presented at two prime–target SOAs—one that approximates the upper limit on automatic processing (250 ms; e.g., Neely, 1991) and one that is considerably shorter. According to the phonological coherence hypothesis, the two prime types should prove to be similarly effective identity primes at the longer SOA but not necessarily at the shorter SOA. Because *BOWL* can support more than one phonological code, the dynamics resolving the single code corresponding to the prime's word interpretation will be prolonged relative to the dynamics resolving the single code for *BENT*. In the extreme, if the SOA is below the temporal limit on resolving /*bol*/ but above the temporal limit on resolving /*bent*/, then *BOWL* will not prime *bowl* but *BENT* will prime *bent*.

As in Lukatela et al. (1997), a patterned mask was inserted between the onsets of prime and target. Within the context of this four-field (mask–prime–mask–target) procedure, we raised three additional questions. The first question was whether priming could be influenced by the sameness of onsets. This question derives primarily from the investigations of Forster and Davis (1991) and Grainger and Ferrand (1996), which suggested that the initial phoneme may play an exceptional role in primed naming, with identity of initial phonemes producing Stroop-like facilitation and nonidentity of initial phonemes producing Stroop-like inhibition. The idea of Forster and Davis (1991) was that, in masked priming of naming responses, onset identity may be more important than overall phonological identity, providing facilitation of the initial phase of the articulatory program. As a check on the significance of onset identity relative to full phonological identity, we included in the experimental stimuli nonword–word pairs of the form *BAPH*–*bowl* and *BAPH*–*bend* together with their appropriate control pairs, *VAPH*–*bowl* and *VAPH*–*bend*, whose members do not share onsets. The second question we raised was whether a phonological encoding bias could be induced by an orthographically similar prime that takes the regular pronunciation of *_OWL*, such as *HOWL*. This question derives primarily from the seminal research of Meyer, Schvaneveldt, and Ruddy (1974) and from details of Van Orden and Goldinger's (1994) dynamical account of word recognition. Meyer et al. (1974) suggested that the phonological interpretation given to a prime like *HOWL* could retard the processing of a target like *bowl* (see Pugh et al., 1994). From the dynamical perspective, because of the regularity of *_OWL*'s pronunciation, *HOWL*'s proper phonological code should reach a higher degree of coherence in a short time span than either *BOWL*'s proper or improper phonological codes (which will be in competition). Consequently, in the present experi-

ments, HOWL might well exert a more significant priming effect (albeit negative) than might BOWL on *bowl*. In order to check on this latter possibility, and to control simultaneously for the onset effect, we included stimuli of the form HOWL-*bowl* and HALE-*bowl*. The final question we raised was whether prime identifiability would be a significant factor. In Experiment 1, the primes were identifiable; in Experiment 2, they were nonidentifiable. We expected on the basis of previous research in which the current four-field procedure was used (Lukatela et al., 1997; Lukatela & Turvey, 1994b) that the BOWL versus BENT contrast would be more important than the identifiability versus nonidentifiability contrast.

Method

Participants. Seventy-two undergraduates at the University of Connecticut participated in Experiment 1, and another 72 participated in Experiment 2, as part of the introductory psychology course requirement. In each experiment, a participant was assigned to one of two experiments and to one of eight groups, which resulted in a total of 9 participants per group.

Materials. There were eight sets of prime-target stimulus pairs, the first six of which (Sets 1-6) were directly relevant to the hypothesis about identity priming. Two auxiliary sets (Sets 7 and 8) were designed to address other priming phenomena in the current experimental setting. The eight stimulus sets are given in the Appendix. Set 1 (the base set) consisted of 96 identity word-word pairs, 48 of which were phonologically ambiguous (Set 1a; e.g., BOWL-*bowl*) and 48 of which were phonologically unique (Set 1b; e.g., BEND-*bend*).

The two types of targets in Sets 1a and 1b differed only with respect to the number of unfriendly neighbors (Pugh et al., 1994); the mean number was 1.85 for *bowl*-type targets and 0 for *bend*-type targets, $t(47) = 8.04, p < .0001$. The total numbers of neighbors (friendly and unfriendly) with the same body for the two types of targets (6.6 ± 3.0 for *bowl*-type targets and 7.3 ± 2.8 for *bend*-type targets) were not significantly different, $F(1, 94) = 1.28, p > .05$. The bigram frequencies for the two types were also not significantly different, $F(1, 94) < 1$ (171 ± 100 for *bowl*-type targets and 191 ± 130 for *bend*-type targets). With respect to the total number of neighbors that differed by just one letter (the *N* metric of Coltheart, Davelaar, Jonasson, & Besner, 1977), there was again no significant difference, $F(1, 94) = 2.06, p > .05$ (8.5 ± 3.9 for *bowl*-type targets and 9.8 ± 4.6 for *bend*-type targets). The primes from Sets 1a and 1b are referred to as *identity* word primes.

From Set 1 we generated seven additional sets of 96 pairs by preserving the target stimuli (*bowl*, *bend*) and replacing the prime stimuli only.

Set 2: Each prime from Set 1 was replaced by a word that was of the same length and of the same frequency as the target word. In addition, each prime in Set 2 shared its initial letter or letters with the target word (e.g., BEAM-*bowl* in Set 2a and BEAM-*bend* in Set 2b). Two-letter overlaps between the prime and the target were relatively rare, and they were randomly distributed over Set 2a and Set 2b. Primes from Set 2 are referred to as *shared-onset* word primes.

Set 3: Each prime from Set 1 was replaced by a word of the same length and of the same frequency as the target word. Prime and target never shared the initial letter or letters. These manipulations produced Set 3a (e.g., LIFT-*bowl*) and Set 3b (e.g., LIFT-*bend*). Primes from Set 3 are referred to as *non-shared-onset* word primes.

Set 4: Each prime from Set 1 was replaced by a row of Xs (e.g., XXXX-*bowl* in Set 4a and XXXX-*bend* in Set 4b). Primes from Set 4 are referred to as *neutral* primes.

Set 5: Each word prime from Set 1 was replaced by a nonword that shared its initial letter with the target word (e.g., BAPH-*bowl* in Set 5a and BAPH-*bend* in Set 5b). Primes from Set 5 are referred to as *shared-onset* nonword primes.

Set 6: The initial letter of each pseudoword prime in Set 5 (e.g., BAPH) was replaced by some different initial letter to produce *non-shared-onset* nonword primes (e.g., VAPH-*bowl* in Set 6a and VAPH-*bend* in Set 6b). Sets 5 and 6 were intended to evaluate onset-based effects (e.g., Forster & Davis, 1991) and the maximum-facilitation-by-shared-onset hypothesis recently advanced by Grainger and Ferrand (1996).

As noted above, two auxiliary sets of stimuli, Sets 7 and 8, were also created. Sets 7 and 8 addressed the phonological bias hypothesis initially advanced by Meyer et al. (1974).

Set 7: The initial letter in each base prime from Set 1a (e.g., BOWL) was replaced by a letter that created a word (e.g., HOWL) that was orthographically similar but phonologically dissimilar to the phonologically ambiguous target word (e.g., HOWL-*bowl* in Set 7a and HOWL-*bend* in Set 7b). These primes may be called *phonologically biased* primes.

Set 8: Each prime from Set 7 (e.g., HOWL) was replaced by a word of the same length, same frequency, and same initial letter (e.g., HALE) to produce *control* primes to Set 7 (e.g., HALE-*bowl* in Set 8a and HALE-*bend* in Set 8b).

Design. The major constraint on the design was that a given participant never encounter a given word or nonword more than once. Consider the stimuli in the first row of the Appendix and how they would be distributed across the eight groups of participants. In Group A, a participant shown BOWL-*bowl* would be shown BEND-*bend*; in Group B, the pairing would be BEAM-*bowl* and LIFT-*bend*; in Group C, it would be LIFT-*bowl* and BEAM-*bend*; in Group D, XXXX-*bowl* and XXXX-*bend*; in Group G, BAPH-*bowl* and VAPH-*bend*; in Group H, VAPH-*bowl* and BAPH-*bend*; in Group E, HOWL-*bowl* and HALE-*bend*; and in Group F, HALE-*bowl* and HOWL-*bend*. With respect to the next seven rows in the Appendix (Rows 2-7), the given participant in Group A would see BLOCK-*break* and FRAME-*brief* (Row 2), CLIP-*brow* and BUDS-*blot* (Row 3), XXXX-*bush* and XXXX-*bark* (Row 4), and so on. Considering all 48 rows, the given participant in Group A would see 6 stimulus pairs of each of the above 16 types for a total of 96 experimental pairs. Proceeding in the above manner for the participants in Groups B-F results in each participant's receiving 6 stimulus pairs of each of the above 16 types. In addition to the 96 experimental pairs, each participant saw a foil set of 24 phonologically related stimulus pairs and a foil set of 24 associatively related word-word pairs. Presentation of stimuli was divided into three parts, with a brief rest after each part. Stimulus types were ordered pseudorandomly within each participant. The experiment proper was preceded by a practice sequence of 32 different stimulus pairs.

Procedure. Participants, tested one at a time, sat in front of the monitor of a DIGITAL 466 computer in a well-lit room. The viewing distance was about 60 cm. The refresh rate of the VENTURIX monitor was 70 Hz, making a refresh cycle (i.e., a "tick") equal to 14.3 ms. The stimuli appeared on the screen as white characters on a dark background. Each trial consisted of a sequence of four visual events in the same location on the center of the screen. First, a pattern mask consisting of a row of seven number signs (#####) was presented for 38 ticks (557 ms); this was immediately followed by the prime stimulus for 9 ticks (129 ms) in Experiment 1 and for 3 ticks (43 ms) in Experiment 2. Immediately following the prime, an intervening mask consisting of a row of ampersands (four &s for four-letter primes and five &s

for five-letter primes) was presented for 8 ticks (115 ms) in Experiment 1 and for 5 ticks (71 ms) in Experiment 2. Finally, a target was presented for 38 ticks (557 ms). Because all interstimulus intervals were zero, the prime-target SOA was 17 ticks (244 ms) in Experiment 1, and 8 ticks (114 ms) in Experiment 2. Stimuli were presented and controlled with the DMASTR software developed at Monash University and the University of Arizona by K. I. Forster and J. C. Forster (1990).

Participants were told that on each trial there would be a sequence of two letter strings, with the first letter string in uppercase letters and the second letter string always a word in lowercase letters. The participants' task was to name the lowercase word out loud as quickly and accurately as possible while ignoring the uppercase letter string. After an experimental session, at debriefing, most of the participants in Experiment 1 (in which the prime exposure was 129 ms) reported having clearly seen the flashed primes. However, the overwhelming majority of participants in Experiment 2 (in which the prime exposure was 43 ms) were not able to recollect having seen any uppercase letter string. In all conditions, latencies from the onset of the target to the onset of the response were measured by a voice-operated trigger relay. Naming was considered erroneous when (a) the target word was mispronounced or preceded by any other sound, (b) the pronunciation was not smooth (i.e., the participant hesitated after beginning to name), or (c) the response was not loud enough to trigger the voice key. If the naming latency was longer than 1,400 ms, a warning message appeared on the screen for 500 ms followed by the next stimulus pair. For analyses, naming latencies were trimmed minimally by applying a 100-ms cutoff for fast responses and a 1,400-ms cutoff for slow responses. For the error analysis, these "latency" errors were combined with the "pronunciation" errors described in the preceding paragraph.

Results and Discussion

Tables 1 and 2 summarize the data of Experiments 1 and 2, respectively, and Figures 1 and 2 show the advantage of identity priming (Set 1) over the nonidentity priming of Sets 2-6. The common design of the two experiments encouraged combination of the data for an overall analysis. The analysis was restricted to Sets 1-6; Sets 7 and 8 are sensibly compared only in the case of phonologically inconsistent targets. For Sets 1-6, a 6 × 2 × 2 (Prime Type × Target Phonological Consistency × SOA) analysis of variance (ANOVA) was performed on the correct reaction times to word targets, with participants and stimuli as the error terms. Prime type (identity = 584 ms, shared-onset word = 596 ms, non-shared-onset word = 597 ms, neutral = 598 ms, shared-onset nonword = 596 ms, and non-shared-onset nonword = 599 ms) was significant by participants, $F_1(5, 710) = 8.05, p < .0001$, and by items, $F_2(5, 470) = 4.26, p < .0001$. Target phonological consistency (inconsistent = 601 ms; consistent = 589 ms) was significant by participants, $F_1(1, 142) = 61.55, p < .001$, but not by items, $F_2(1, 94) = 1.77, p > .05$. SOA (short = 585 ms; long = 605 ms) reached significance by participants, $F_1(1, 142) = 3.81, p < .05$, and by items, $F_2(1, 94) = 172.38, p < .0001$. Of the two-way interactions, only prime type by SOA was reliable, $F_1(5, 710) = 2.74, p < .05, F_2(5, 470) = 2.42, p < .05$. There was no three-way interaction, $F_1(5, 710) = 1.76, p > .05, F_2(5, 470) = 1.71, p > .05$. (In a corresponding ANOVA on errors, no reliable effects were found.)

Table 1
Mean Naming Latency (L; in Milliseconds) and Error Rate (ER; in %) for Inconsistent and Consistent Target Words in Sets 1-8 of Experiment 1

Statistic	Set 1 (identity)		Set 2 (shared-onset word)		Set 3 (non-shared-onset word)		Set 4 (neutral baseline)		Set 5 (shared-onset nonword)		Set 6 (non-shared-onset nonword)		Set 7 (phonological bias)		Set 8 (bias control)	
	L	ER	L	ER	L	ER	L	ER	L	ER	L	ER	L	ER	L	ER
	Inconsistent															
	(BOWL-bowl)															
M	594	2.11	609	2.58	611	2.36	619	3.04	613	2.09	620	2.83	622	4.65	606	2.81
SD _{subjects}	72	6.27	79	6.72	70	5.92	75	7.61	72	6.82	81	6.38	69	9.77	71	7.43
SD _{items}	56	6.17	58	7.33	55	6.27	60	7.89	56	8.11	53	7.92	49	10.07	49	8.81
	Consistent															
	(BEND-bend)															
M	586	1.18	600	2.36	600	1.65	600	2.33	606	2.56	607	1.87	596	1.89	595	1.65
SD _{subjects}	68	4.35	68	5.92	76	5.07	76	7.04	74	7.73	72	6.02	71	5.38	70	5.07
SD _{items}	46	4.06	61	6.25	49	5.39	58	7.66	54	7.82	62	7.08	57	5.21	53	5.75

Table 2
Mean Naming Latency (L; in Milliseconds) and Error Rate (ER; in %) for Inconsistent and Consistent Target Words in Sets 1–8 of Experiment 2

Statistic	Set 1 (identity)		Set 2 (shared-onset word)		Set 3 (non-shared-onset word)		Set 4 (neutral baseline)		Set 5 (shared-onset nonword)		Set 6 (non-shared-onset nonword)		Set 7 (phonological bias)		Set 8 (bias control)	
	L	ER	L	ER	L	ER	L	ER	L	ER	L	ER	L	ER	L	ER
<i>M</i>	Inconsistent															
	(BOWL– <i>bowl</i>)		(BEAM– <i>bowl</i>)		(LIFT– <i>bowl</i>)		(XXXX– <i>bowl</i>)		(BAPH– <i>bowl</i>)		(VAPH– <i>bowl</i>)		(HOWL– <i>bowl</i>)		(HALE– <i>bowl</i>)	
	589	1.64	596	2.11	594	1.18	589	2.57	589	1.87	592	2.12	608	3.97	593	1.64
<i>SD</i> _{subjects}	75	5.74	75	6.27	69	4.35	70	7.24	69	6.02	69	5.66	79	8.65	76	5.74
	47	6.95	49	7.71	48	5.46	41	8.54	56	8.61	53	6.99	56	9.87	53	6.95
<i>M</i>	Consistent															
	(BEND– <i>bend</i>)		(BEAM– <i>bend</i>)		(LIFT– <i>bend</i>)		(XXXX– <i>bend</i>)		(BAPH– <i>bend</i>)		(VAPH– <i>bend</i>)		(HOWL– <i>bend</i>)		(HALE– <i>bend</i>)	
	566	0.71	580	1.89	583	1.18	578	1.42	578	2.09	575	1.64	578	0.94	585	1.42
<i>SD</i> _{subjects}	58	3.42	67	5.38	70	4.35	75	4.73	65	6.82	60	5.74	60	3.92	74	4.73
	31	3.76	35	6.62	35	5.46	45	5.29	54	7.09	62	6.95	54	4.53	62	5.31

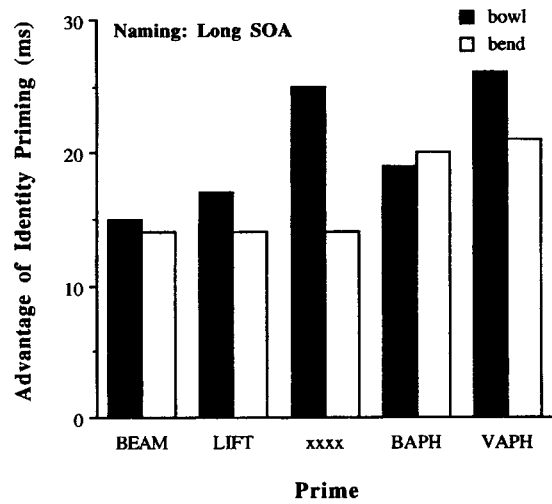


Figure 1. Advantage of priming a word by itself (e.g., *bowl* by BOWL and *bend* by BEND) relative to priming the word by a control prime (e.g., *bowl* and *bend* by BEAM, LIFT, XXXX, BAPH, and VAPH) in Experiment 1 with naming as the response. SOA = stimulus onset asynchrony.

Because most of the prime-type conditions in the preceding ANOVA were not expected to be effective, the ANOVA's evaluation of the target type effect as a function of SOA is overly conservative. A second ANOVA was conducted involving only Set 1 and Set 4 (the neutral baseline). Prime type, $F_1(1, 142) = 24.33, p < .0001, F_2(1, 94) = 12.48, p < .0001$, and target consistency, $F_1(1, 142) = 28.32, p < .0001, F_2(1, 94) = 39.29, p < .0001$, were significant, but SOA was not, $F_1(1, 142) = 2.61, p > .05, F_2(1, 94) = 1.89, p > .05$. The three-way interaction was significant, $F_1(1, 142) = 7.21, p < .01, F_2(1, 94) = 6.72, p < .01$. An

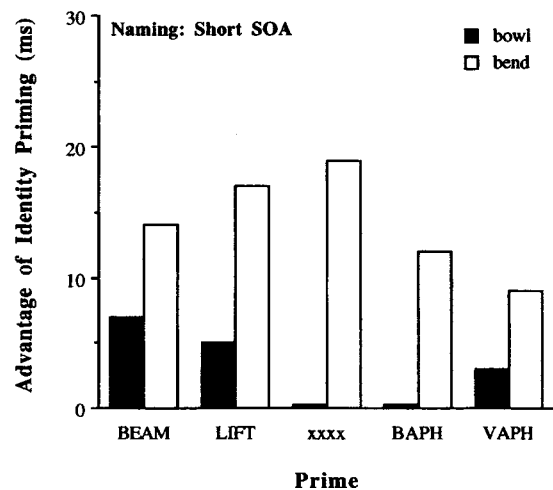


Figure 2. Advantage of priming a word by itself (e.g., *bowl* by BOWL and *bend* by BEND) relative to priming the word by a control prime (e.g., *bowl* and *bend* by BEAM, LIFT, XXXX, BAPH, and VAPH) in Experiment 2 with naming as the response. SOA = stimulus onset asynchrony.

inspection of means suggests that the three-way interaction was due to a stronger prime type by target consistency interaction for the shorter SOA (Experiment 2) than for the longer SOA (Experiment 1).

At the longer SOA of Experiment 1, identity priming occurred equivalently for both target types (see Figure 1); at the shorter SOA of Experiment 2, identity priming was considerably greater for the phonologically consistent target type (see Figure 2). With reference to the Experiment 1 data in Table 1 and Figure 1, planned comparisons within Sets 1–6 revealed the following: BOWL–*bowl* was faster than BEAM–*bowl*, $F_1(1, 71) = 6.54, p < .01, F_2(1, 47) = 4.14, p < .05$, LIFT–*bowl*, $F_1(1, 71) = 8.24, p < .01, F_2(1, 47) = 5.00, p < .05$, XXXX–*bowl*, $F_1(1, 71) = 18.99, p < .001, F_2(1, 47) = 11.99, p < .001$, BAPH–*bowl*, $F_1(1, 71) = 10.33, p < .001, F_2(1, 47) = 6.41, p < .01$, and VAPH–*bowl*, $F_1(1, 71) = 20.78, p < .001, F_2(1, 47) = 12.25, p < .001$. That is, at the long SOA of Experiment 1, phonologically inconsistent targets benefited substantially from identity priming. The same was true of the phonologically consistent targets. BEND–*bend* was faster than BEAM–*bend*, $F_1(1, 71) = 7.01, p < .01, F_2(1, 47) = 4.92, p < .05$, LIFT–*bend*, $F_1(1, 71) = 6.90, p < .01, F_2(1, 47) = 5.09, p < .05$, XXXX–*bend*, $F_1(1, 71) = 6.67, p < .01, F_2(1, 47) = 4.16, p < .05$, BAPH–*bend*, $F_1(1, 71) = 13.18, p < .001, F_2(1, 47) = 8.69, p < .01$, and VAPH–*bend*, $F_1(1, 71) = 14.99, p < .001, F_2(1, 47) = 10.78, p < .001$.

Similar planned comparisons were conducted for the data of Experiment 2 (see Table 2 and Figure 2). BOWL–*bowl* differed from neither BEAM–*bowl*, $F_1(1, 71) = 1.64, p > .05, F_2(1, 47) < 1$, LIFT–*bowl* ($F_s < 1$), XXXX–*bowl* ($F_s < 1$), BAPH–*bowl* ($F_s < 1$), nor VAPH–*bowl* ($F_s < 1$). Obviously, at the short SOA of Experiment 2, phonologically inconsistent targets benefited less from identity priming than from phonologically consistent priming. In contrast, planned comparisons that involved the phonologically consistent target words yielded mostly positive results. BEND–*bend* was faster than BEAM–*bend*, $F_1(1, 71) = 6.47, p < .01, F_2(1, 47) = 3.85, p < .05$, LIFT–*bend*, $F_1(1, 71) = 9.87, p < .001, F_2(1, 47) = 6.37, p < .01$, and XXXX–*bend*, $F_1(1, 71) = 11.58, p < .001, F_2(1, 47) = 9.03, p < .001$, was marginally faster than BAPH–*bend*, $F_1(1, 71) = 5.02, p < .001, F_2(1, 47) = 3.20, p = .07$, but was not faster than VAPH–*bend*, $F_1(1, 71) = 3.17, p > .05, F_2(1, 47) = 1.74, p > .05$.

The experiments permitted evaluation of the phonological bias hypothesis (Meyer et al., 1974) through the comparison of HOWL–*bowl* and HALE–*bowl*; support for the hypothesis would be indicated by a slower response to *bowl* following HOWL. In Experiment 1, HOWL–*bowl* was responded to 16 ms slower than was HALE–*bowl*, $F_1(1, 71) = 7.34, p < .01, F_2(1, 47) = 3.82, p < .05$, and in Experiment 2, HOWL–*bowl* was responded to 15 ms slower than was HALE–*bowl*, $F_1(1, 71) = 7.47, p < .01, F_2(1, 47) = 3.66, p < .05$. The theoretical importance of the check on phonological bias lies in the expected greater and more persistent slowing of responses to *bowl* induced by HOWL (a word with the regular pronunciation of *_OWL*) than by BOWL (a word with the irregular pronunciation of *_OWL*). An ANOVA with factors of SOA and prime (the contrast of HOWL and BOWL) revealed that

HOWL (614 ms) produced longer naming latencies than did BOWL (591 ms), $F_1(1, 142) = 35.09, p < .0001, F_2(1, 47) = 12.98, p < .01$, and that this difference was not dependent on SOA ($F_s < 1$).

In addition, the experiments permitted evaluation of the shared onset phenomena that have been observed in naming experiments. The evaluation involved the comparison of BAPH–*bowl* and VAPH–*bowl*; given the findings and arguments of Forster and Davis (1991) and Grainger and Ferrand (1996), shared onsets should lead to better priming. Contrary to expectation, BAPH–*bowl* was not faster than VAPH–*bowl* in either Experiment 1, $F_1(1, 71) = 1.81, p > .05, F_2(1, 47) < 1$, or Experiment 2 (both $F_s < 1$).

On the basis of the phonological coherence hypothesis (Van Orden & Goldinger, 1994) and previous research on naming Serbo-Croatian materials (Lukatela et al., 1997), we expected that identity priming of word naming in English would be compromised by phonological inconsistency. The nonsignificant identity priming in Experiment 2 of targets that were phonologically inconsistent confirms that expectation. Further, that identity priming was significant for phonologically consistent targets in Experiment 2 and that it was significant for both types of targets in Experiment 1 are strong corroborations of the phonological coherence hypothesis. The marked temporal limitations on prime processing that characterized Experiment 2 reduced the efficacy of identity priming only in the case where there were competing phonological codes (that is, *bowl*-type targets). When the temporal limitations on prime processing were less severe—the conditions that characterized Experiment 1—identity priming was indifferent to whether or not a word was phonologically consistent. The implication is that identity priming is constrained by the time evolution of a coherent phonological code. Achieving this coherency is prolonged in the case of a word whose letter pattern can support more than one phonological code. Accordingly, when the opportunity to process a phonologically inconsistent identity prime prior to the target is severely limited, its phonological code is unresolved by the time of target processing and its ability to act as a facilitator is thereby compromised.

Several ancillary observations deserve comment. First, the overall latency for consistent targets was less than that for inconsistent targets. This is the most typical finding of experiments in which unprimed low-frequency target words are named (e.g., Jared, McRae, & Seidenberg, 1990; Taraban & McClelland, 1987), and it has recently been extended to high-frequency words (Jared, 1997). It is important to underscore that the consistency effect in the present conditions of primed naming seems to have been indifferent to the primes; the two-way interaction of prime type and target consistency in the omnibus analysis was insignificant. A second observation is that, within the present four-field masking procedure, the mere sharing of onsets between prime and target was not sufficient to produce priming effects. The degrees of identity priming evident in Experiments 1 and 2 seem to have been due to the overall phonological forms of the respective primes. The importance of shared onsets shows up in procedures in which prime and target are not separated by a pattern mask (e.g.,

Forster & Davis, 1991); there is, to date, no evidence for shared onset effects in the mask–prime–mask–target procedure (Lukatela & Turvey, 1994a, 1994b, 1996; and see below).

A third ancillary observation concerns the hypothesis that HOWL's proper phonological code should reach a higher degree of coherence in a short time span than either BOWL's proper or improper phonological codes (which would be in competition). The results showed that HOWL exerted a significant negative priming effect on *bowl* at both prime–target SOAs. The fourth and final ancillary observation is that the identifiability or nonidentifiability of the prime seemed to be less significant than the consistency or inconsistency of the prime. In Experiment 1, the primes were identifiable; in Experiment 2, they were nonidentifiable. In both experiments, the consistent prime BENT exerted a reliable influence on the naming of *bent*.

Experiments 3 and 4: Lexical Decision

At issue is whether the lexical decision task will yield the same pattern of results found in Experiments 1 and 2 and lead, thereby, to the same conclusion concerning the phonological basis of identity priming. In a model of visual word recognition with a dual-route organization (Coltheart, Curtis, Atkins, & Haller, 1993; Coltheart & Rastle, 1994), naming the target stimuli would engage the phoneme system, which is activated both lexically and nonlexically. Accordingly, the observed priming effects favoring the phonologically consistent identity prime could be attributed to the ambiguity at the level of the phoneme system induced by the phonologically inconsistent identity prime. The identity prime BOWL would lead to one pattern of phoneme activation over the lexical route (*/bol/*) and to two patterns—one the same as that arrived at lexically (*/bol/*) and one different (*/baUl/*)—over the nonlexical route. In contrast, the phonologically consistent identity prime BEND, processed on the nonlexical route, would generate only a single pattern of phoneme activation, precisely that corresponding to the phonology of the target and perfectly suited, therefore, to the task of pronouncing the target. This beneficial effect of the phonologically consistent identity prime relative to the phonologically inconsistent identity prime would not occur, however, if the task was lexical decision. Via the lexical route, the letter patterns of words activate whole-word forms in an orthographic input lexicon and, in turn, whole-word forms in a phonological output lexicon. Over this lexical route, the letters of both identity primes, BOWL and BEND, match those of whole-word forms, thereby producing maximal priming of their targets. In the modern cascaded processing version of dual-route organization, the modules are interdependent so that the whole-word forms in the sublexicons can also be activated by the outputs of the nonlexical route (Coltheart et al., 1993; Coltheart & Rastle, 1994). Both primes processed over the nonlexical route could activate their targets' whole-word forms in the phonological output lexicon, but more slowly than over the lexical route.

From the perspective of the phonological coherence hypothesis, however, it must be the case that the pattern of results seen in Experiments 1 and 2 generalizes to lexical decision. According to this hypothesis, the visual processing of a prime proceeds at a rate scaled by the time it takes to resolve a unique and stable phonological code. Thus, the major constraint on an identity prime's ability to influence the decision on its target's lexical status is the same as the major constraint on its ability to influence the determination of the target's pronunciation. In both tasks, the success of priming depends on the time to achieve phonological coherence. Nonetheless, some differences between the tasks are expected. In the account of Van Orden and Goldinger (1994), coherence of visual and phonological subpatterns suffices for the specification of a target's name but not for the specification of a lexical decision on a target. The basis for distinguishing a word from a nonword is the degree of coherence (versus incoherence) among visual, phonological, and semantic subpatterns. To the extent that phonological coherence is delayed (as in the case of BOWL relative to BEND), the global visual-phonological-semantic coherence will be delayed.

Method

Participants. Seventy-two undergraduates at the University of Connecticut participated in Experiment 1, and another 72 participated in Experiment 2, as part of the introductory psychology course requirement. In each experiment, a participant was assigned to one of two experiments and to one of eight groups, which resulted in a total of 9 participants per group. None of the students had participated in Experiments 1 and 2.

Materials. Sets 1–8 from Experiments 1 and 2 were used in Experiments 3 and 4. Nonwords were constructed by replacing one letter, or sometimes two, in a set of words that were different from the words used in Sets 1–8.

Procedure. Stimulus presentation and timing relations were the same as in Experiments 1 and 2. The one change was the use of manual lexical decision (participants pressed one key for "yes" and another key for "no").

Design. The two experiments were designed similarly to Experiments 1 and 2. The simple addition was 72 nonwords used as foils. Each participant in each of the nine subgroups saw the same 72 nonwords.

Results and Discussion

Tables 3 and 4 summarize the data of Experiments 3 and 4, respectively, and Figures 3 and 4 show the advantage of identity priming (Set 1) over the nonidentity priming of Sets 2–6. Given the identical designs of the two experiments, initial analyses were conducted on the combined data. For Sets 1–6, a $6 \times 2 \times 2$ (Prime Type \times Target Phonological Consistency \times SOA) ANOVA was performed on the reaction times to word targets, with participants and stimuli as the error terms. Prime type (identity = 606 ms, shared-onset word = 634 ms, non-shared-onset word = 639 ms, neutral = 643 ms, shared-onset nonword = 639 ms, and non-shared-onset nonword = 634 ms) was significant, $F_{1(5)}$,

Table 3
Mean Decision Latency (*L*; in Milliseconds) and Error Rate (*ER*; in %) for Inconsistent and Consistent Target Words in Sets 1–8 of Experiment 3

Statistic	Set 1 (identity)		Set 2 (shared-onset word)		Set 3 (non-shared-onset word)		Set 4 (neutral baseline)		Set 5 (shared-onset nonword)		Set 6 (non-shared-onset nonword)		Set 7 (phonological bias)		Set 8 (bias control)	
	L	ER	L	ER	L	ER	L	ER	L	ER	L	ER	L	ER	L	ER
Inconsistent																
	(BOWL– <i>bowl</i>)		(BEAM– <i>bowl</i>)		(LIFT– <i>bowl</i>)		(XXXX– <i>bowl</i>)		(BAPH– <i>bowl</i>)		(VAPH– <i>bowl</i>)		(HOWL– <i>bowl</i>)		(HALE– <i>bowl</i>)	
<i>M</i>	594	3.52	621	3.75	622	5.17	631	3.29	639	4.68	623	6.08	623	6.07	626	3.06
<i>SD</i> _{subjects}	102	7.46	98	5.76	108	8.77	97	7.29	103	8.99	102	11.70	109	10.22	108	7.12
<i>SD</i> _{items}	61	7.65	63	10.24	75	10.24	81	9.12	71	9.68	67	11.69	71	10.23	67	7.84
Consistent																
	(BEND– <i>bend</i>)		(BEAM– <i>bend</i>)		(LIFT– <i>bend</i>)		(XXXX– <i>bend</i>)		(BAPH– <i>bend</i>)		(VAPH– <i>bend</i>)		(HOWL– <i>bend</i>)		(HALE– <i>bend</i>)	
<i>M</i>	593	3.75	644	7.51	642	7.24	666	6.31	653	8.17	645	7.90	643	6.56	646	5.35
<i>SD</i> _{subjects}	99	8.08	120	10.51	127	11.49	113	11.02	103	11.19	99	11.19	103	9.96	106	11.12
<i>SD</i> _{items}	62	9.26	104	15.94	81	9.01	86	11.19	91	13.31	92	13.31	66	10.45	73	12.34

Table 4
Mean Decision Latency (*L*; in Milliseconds) and Error Rate (*ER*; in %) for Inconsistent and Consistent Target Words in Sets 1–8 of Experiment 4

Statistic	Set 1 (identity)		Set 2 (shared-onset word)		Set 3 (non-shared-onset word)		Set 4 (neutral baseline)		Set 5 (shared-onset nonword)		Set 6 (non-shared-onset nonword)		Set 7 (phonological bias)		Set 8 (bias control)	
	L	ER	L	ER	L	ER	L	ER	L	ER	L	ER	L	ER	L	ER
Inconsistent																
	(BOWL– <i>bowl</i>)		(BEAM– <i>bowl</i>)		(LIFT– <i>bowl</i>)		(XXXX– <i>bowl</i>)		(BAPH– <i>bowl</i>)		(VAPH– <i>bowl</i>)		(HOWL– <i>bowl</i>)		(HALE– <i>bowl</i>)	
<i>M</i>	622	3.96	628	4.46	638	5.58	625	4.89	622	4.47	631	4.46	640	4.44	627	5.40
<i>SD</i> _{subjects}	91	9.06	93	8.46	97	9.65	80	9.86	81	8.02	104	9.35	87	9.73	89	8.85
<i>SD</i> _{items}	70	7.42	83	10.93	82	10.24	85	9.42	58	10.93	88	8.49	80	8.79	79	10.75
Consistent																
	(BEND– <i>bend</i>)		(BEAM– <i>bend</i>)		(LIFT– <i>bend</i>)		(XXXX– <i>bend</i>)		(BAPH– <i>bend</i>)		(VAPH– <i>bend</i>)		(HOWL– <i>bend</i>)		(HALE– <i>bend</i>)	
<i>M</i>	614	7.22	644	7.28	653	6.54	651	7.71	642	5.37	636	8.68	648	7.49	642	4.67
<i>SD</i> _{subjects}	88	11.89	97	9.70	93	10.32	98	10.83	89	9.65	88	10.90	88	11.19	88	9.39
<i>SD</i> _{items}	60	12.15	83	12.64	80	12.08	81	12.37	80	10.49	88	13.79	70	11.29	76	8.82

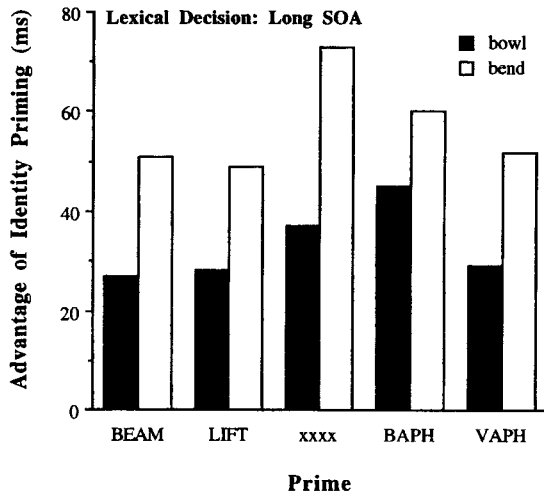


Figure 3. Advantage of priming a word by itself (e.g., *bowl* by BOWL and *bend* by BEND) relative to priming the word by a control prime (e.g., *bowl* and *bend* by BEAM, LIFT, XXXX, BAPH, and VAPH) in Experiment 3 with lexical decision as the response. SOA = stimulus onset asynchrony.

710) = 13.86, $p < .0001$, $F_2(5, 470) = 9.33$, $p < .0001$. Target consistency (inconsistent = 624 ms, consistent = 640 ms) was significant by participants, $F_1(1, 142) = 25.37$, $p < .0001$, but not by items, $F_2(1, 94) = 1.79$, $p > .05$. SOA (short = 634 ms, long = 631 ms) was not significant ($F < 1$). Of the interactions, only prime type by SOA was reliable, $F_1(5, 710) = 4.01$, $p < .001$, $F_2(5, 470) = 4.41$, $p < .001$. (In a corresponding ANOVA on errors, no reliable effects were found.)

A second ANOVA was conducted involving only Set 1 and Set 4 (the neutral baseline). Prime type was significant,

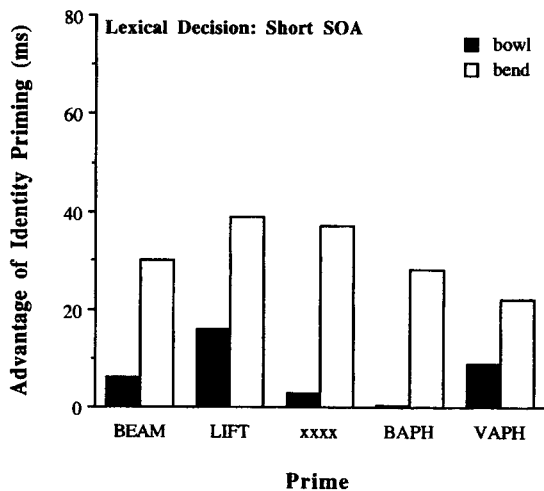


Figure 4. Advantage of priming a word by itself (e.g., *bowl* by BOWL and *bend* by BEND) relative to priming the word by a control prime (e.g., *bowl* and *bend* by BEAM, LIFT, XXXX, BAPH, and VAPH) in Experiment 4 with lexical decision as the response. SOA = stimulus onset asynchrony.

$F_1(1, 142) = 54.44$, $p < .0001$, $F_2(1, 94) = 35.27$, $p < .0001$, as was target consistency, $F_1(1, 142) = 6.61$, $p < .01$, $F_2(1, 94) = 39.29$, $p < .0001$. SOA was not significant, $F_1 < 1$, $F_2(1, 94) = 2.06$, $p > .05$. Two of the two-way interactions were significant, prime type by target consistency, $F_1(1, 142) = 12.54$, $p < .0001$, $F_2(1, 94) = 6.69$, $p < .01$, and prime type by SOA, $F_1(1, 142) = 11.99$, $p < .0001$, $F_2(1, 94) = 8.93$, $p < .01$. In contrast to the results of the corresponding ANOVA on the data of Experiments 1 and 2, the three-way interaction for the data of the present two lexical decision experiments was not significant (both $F_s < 1$), suggesting a less pronounced effect in lexical decision of SOA on the prime type by target type relation.

Figures 3 and 4 show the advantage of identity priming (Set 1) over the nonidentity priming of Sets 2–6. As can be seen, at the longer SOA of Experiment 3, identity priming occurred for both target types (see Figure 3); at the shorter SOA of Experiment 4, identity priming was limited to the phonologically consistent target type (see Figure 4). Confirmation was provided by planned comparisons. For the data of Figure 3, BOWL–*bowl* was different from BEAM–*bowl*, $F_1(1, 71) = 6.44$, $p < .01$, $F_2(1, 47) = 6.28$, $p < .01$, LIFT–*bowl*, $F_1(1, 71) = 6.86$, $p < .01$, $F_2(1, 47) = 4.72$, $p < .05$, XXXX–*bowl*, $F_1(1, 71) = 12.54$, $p < .001$, $F_2(1, 47) = 12.76$, $p < .001$, BAPH–*bowl*, $F_1(1, 71) = 18.13$, $p < .001$, $F_2(1, 47) = 18.27$, $p < .001$, and VAPH–*bowl*, $F_1(1, 71) = 7.60$, $p < .01$, $F_2(1, 47) = 9.09$, $p < .01$. Obviously, at the long SOA of Experiment 3, phonologically ambiguous targets benefited from identity priming. The same was true of the phonologically unique targets. BEND–*bend* was faster than BEAM–*bend*, $F_1(1, 71) = 24.41$, $p < .001$, $F_2(1, 47) = 18.92$, $p < .001$, LIFT–*bend*, $F_1(1, 71) = 22.12$, $p < .001$, $F_2(1, 47) = 14.87$, $p < .001$, XXXX–*bend*, $F_1(1, 71) = 49.66$, $p < .001$, $F_2(1, 47) = 32.29$, $p < .001$, BAPH–*bend*, $F_1(1, 71) = 33.21$, $p < .001$, $F_2(1, 47) = 25.72$, $p < .001$, and VAPH–*bend*, $F_1(1, 71) = 25.35$, $p < .001$, $F_2(1, 47) = 17.18$, $p < .001$.

For the data of Figure 4, BOWL–*bowl* was not different from either BEAM–*bowl* (both $F_s < 1$), LIFT–*bowl*, $F_1(1, 71) = 2.29$, $p > .05$, $F_2(1, 47) = 2.88$, $p > .05$, XXXX–*bowl* (both $F_s < 1$), BAPH–*bowl* (both $F_s < 1$), or VAPH–*bowl* (both $F_s < 1$). Clearly, at the short SOA of Experiment 4, phonologically ambiguous targets did not benefit from identity priming. In contrast, identity primes had a substantial effect on phonologically unique target words. BEND–*bend* was faster than BEAM–*bend*, $F_1(1, 71) = 8.56$, $p < .01$, $F_2(1, 47) = 8.18$, $p < .01$, LIFT–*bend*, $F_1(1, 71) = 15.14$, $p < .001$, $F_2(1, 47) = 12.08$, $p < .001$, XXXX–*bend*, $F_1(1, 71) = 13.09$, $p < .001$, $F_2(1, 47) = 9.84$, $p < .01$, BAPH–*bend*, $F_1(1, 71) = 7.66$, $p < .01$, $F_2(1, 47) = 6.52$, $p < .01$, and VAPH–*bend*, $F_1(1, 71) = 4.71$, $p < .05$, $F_2(1, 47) = 5.95$, $p < .05$.

Because there was no onset effect (639 ms for BAPH primes versus 634 ms for VAPH primes, $F_s < 1$), the phonological bias hypothesis (Meyer et al., 1974) could be evaluated with respect to several baselines. The originally planned evaluation through Sets 7a and 8a revealed that, in

Experiment 3, *HOWL-bowl* did not differ from *HALE-bowl* (both $F_s < 1$) and that, in Experiment 4, *HOWL-bowl* was responded to 13 ms slower than *HALE-bowl*. This latter magnitude was comparable to the degree of slowing induced in the naming task of Experiments 1 and 2, but it did not reach significance, $F_1(1, 71) = 1.56, p > .05, F_2(1, 94) < 1$. The suggested difference between the naming and lexical decision experiments is more apparent than real, however. When *XXXX* was taken as the baseline rather than *HALE*, an ANOVA found a task-independent interaction of SOA and prime, $F_1(1, 142) = 7.18, p < .01, F_2(1, 47) = 4.20, p < .05$, indicating a significant slowing of responses by *HOWL* at the short SOA for both naming (19 ms) and lexical decision (15 ms) and no effect of *HOWL* at the long SOA for either naming (3 ms) or lexical decision (-8 ms).

The theoretical importance of the check on phonological bias lies in the expected greater and more enduring slowing of responses to *bowl* induced by *HOWL* (a word with a regular pronunciation of *_OWL*) than by *BOWL* (a word with the irregular pronunciation of *_OWL*). Consistent with the results of the naming experiments, an ANOVA with factors of SOA and prime (*HOWL* vs. *BOWL*) revealed that *HOWL* (631 ms) produced slower lexical decisions on *bowl* than did *BOWL* (608 ms), $F_1(1, 142) = 12.47, p < .0001, F_2(1, 47) = 7.26, p < .01$, and that this difference was not dependent on SOA ($F_s < 1$).

The results of the two lexical decision experiments (Experiments 3 and 4) replicate the major findings of the two naming experiments (Experiments 1 and 2). When prime processing time was severely limited (Experiment 4), identity priming was significant only for phonologically consistent words. When the time for prime processing was extended (Experiment 3), priming for both phonologically consistent and phonologically inconsistent words improved markedly. One possibly important difference between the lexical decision experiments and the naming experiments was the continued superiority in lexical decision of phonologically consistent identity primes at the longer SOA. That is, although phonologically inconsistent identity primes were effective at the longer SOA of Experiment 3, they were still less effective than the phonologically consistent identity primes, as shown in Figure 3. In the naming experiments, the two types of identity primes were indistinguishable at the longer SOA. This difference between lexical decision and naming at the longer SOA was not found in the corresponding Serbo-Croatian research (Lukatela et al., 1997). In that research, in both lexical decision and naming, the inconsistent word prime equalled the consistent nonword prime in priming efficacy at the 250-ms SOA, in contrast to the inconsistent word prime's marked inferiority in both tasks at the 70-ms SOA. The odd result in the present research, from the perspective of Lukatela et al.'s (1997) experiments, is the prolonged advantage of the consistent prime in the present Experiment 3 with the longer SOA. The ANOVAs, together with inspection of Tables 3 and 4, suggest that an understanding of this odd result is tied to an unusual feature of the present lexical decision experiments—namely, an effect of target consistency. The observed target consistency effect is unusual for two reasons. First, a consistency effect has not

been found to date in an unprimed lexical decision task (e.g., Brown, 1987; Jared, 1997; Seidenberg, Waters, Barnes, & Tanenhaus, 1984). Second, the direction of the difference between the latencies to consistent and inconsistent targets in Experiments 3 and 4 was opposite to the finding that is typical of naming tasks and that was replicated in Experiments 1 and 2. In the lexical decision experiments, inconsistent targets were responded to faster than consistent targets.

The contrast between lexical decision and naming in the direction of the consistency effect is transparent in an ANOVA performed on the stimuli from Set 4 (*XXXX* as the prime) with factors of target consistency (*bowl* vs. *bend*), SOA, and task (Experiments 1 and 2 vs. Experiments 3 and 4). The two-way interaction between task and consistency, with *bowl* faster than *bend* in lexical decision (628 vs. 658 ms) and *bowl* slower than *bend* in naming (613 vs. 592 ms), was significant, $F_1(1, 284) = 38.29, p < .0001, F_2(1, 94) = 5.68, p < .02$. There were no interactions involving SOA. A fuller expression of the directional contrast was obtained by performing an ANOVA that used all primes but the identity primes. The consistency by task interaction was significant, $F_1(1, 285) = 107.85, p < .0001, F_2(1, 94) = 9.00, p < .01$, with consistent targets being faster in naming and inconsistent targets being faster in lexical decision. The consistency by prime type interaction, $F_1(6, 1710) = 1.42, p > .05, F_2(6, 564) < 1$, and the consistency by prime type by task interaction (both $F_s < 1$) were not significant. It is important to note that the preceding interaction of task and consistency found for the targets was not found for the primes, as was shown by an ANOVA restricted to Sets 1a and 1b. *BOWL-bowl* (600 ms) was slower than *BEND-bend* (589 ms) by the participants analysis, $F_1(1, 285) = 8.53, p < .01, F_2(1, 94) = 1.86, p > .05$, independently of task, $F_1(1, 285) = 2.18, p > .05, F_2 < 1$.

At first blush, the finding of longer lexical decisions in response to consistent targets would seem to contradict the phonological coherence hypothesis and the prediction of stronger priming at short SOAs by consistent primes. On closer consideration, however, the results of the preceding analyses suggest that there may be no real contradiction. The fact that the task dependency of the target consistency effect was constant over the (nonidentity) primes, including *XXXX*, suggests that the locus of the unusual consistency effect in lexical decision was not in the processes leading up to and including the activation of a target's representation. Presumably, a prime is successful to the degree that it enhances these latter processes. If the origin of the target consistency effect was within the same processes, then an interaction of prime and consistency would be expected. By default, the implication of the observed additivity (rather than interaction) is that the locus of the target consistency effect is in postlexical decision processes on the target. Further, the fact that there was, in contrast, no interaction of task with prime consistency suggests that the explicit processing of the targets *bowl* and *bend* was different from the implicit processing of the primes *BOWL* and *BEND* (analogous to conclusions drawn from recent studies of deep dyslexia that

contrasted primed and unprimed word identification, e.g., Buchanan, Hildebrandt, & MacKinnon, 1995, 1996).

A reasonable conjecture, therefore, is that consistent words, as either primes or targets, cohered faster than inconsistent words but that their speed advantage as targets in the lexical decision task was compromised by postlexical processes. The nonwords in Experiments 3 and 4 were generated from a set of words that were, in the majority, consistent. There may, therefore, have been dimensions of similarity that made the distinguishing of the consistent targets from the nonwords more difficult than the distinguishing of the inconsistent targets. It would seem that the continued superiority in lexical decision of consistent over inconsistent primes at the long SOA was due primarily to the fact that identity priming by consistent primes (e.g., *BEND–bend*) was evaluated against prime–target pairs in which decisions in response to the targets were uniformly slow regardless of the prime and SOA. Quite possibly, the continued differences between the priming effects of *BEND* and *BOWL* from the shorter (see Figure 4) to the longer (see Figure 3) SOA were more indicative of continued differences in decision processes on the targets than of continued differences between consistent and inconsistent primes. If so, a marked lengthening of SOA should not affect the dependence of target consistency on task.

We conducted an additional naming experiment replicating the conditions of Experiments 1 and 2 and an additional lexical decision experiment replicating the conditions of Experiments 3 and 4 with the prime–target SOA extended to 488 ms (prime and intervening mask durations of 244 ms). There were 64 participants in each of these two experiments. An ANOVA involving all primes but the identity primes found the same Consistency \times Task interaction; that is, *BEND* was faster than *BOWL* in naming (553 ms vs. 564 ms) and slower than *BOWL* in lexical decision (626 ms vs. 615 ms): $F_1(1, 126) = 20.19, p < .0001, F_2(1, 94) = 5.93, p < .02$. The effect of consistency was independent of prime type, $F_1(6, 564) = 1.54, p > .05, F_2(6, 756) = 2.02, p > .05$, and there was no interaction among consistency, task, and prime type (both $F_s < 1$). Confirmation that the Consistency \times Task interaction found for the targets did not extend to the primes was provided by an ANOVA restricted to Sets 1a and 1b (identity priming). Overall, *BOWL–bowl* (561 ms) was numerically slower than *BEND–bend* (547 ms), $F_1(1, 126) = 5.91, p < .05, F_2(1, 94) = 2.81, p > .05$, but there was no dependence of this numerical difference on task, $F_1(1, 126) = 2.97, p > .05, F_2(1, 94) = 1.21, p > .05$. In sum, the supplementary experiments reinforce the impression that the observed slowing of lexical decisions in response to consistent targets in Experiments 3 and 4 was of postlexical origin.

General Discussion

The present experiments were designed to test the prediction that whether an English word is an effective prime for itself depends on the speed with which the word's phonological code can be established. When a word has one or more

neighbors that are spelled similarly but pronounced differently, resolving the word's phonological code will take longer than it would if there were no such neighbors (other things being equal). It has generally been presumed that the comparatively slow pronunciation of inconsistent words is due to competition between alternative pronunciations (e.g., Norris, 1994; but see Brown, 1987). Consequently, if the amount of time available for determining the word's phonology is restricted prior to the word's repetition, then the word's phonological representation is likely to be incoherent at the time of the repetition. The present results suggest that in the absence of a coherent phonological representation, a word's ability to prime itself will be weakened despite the graphemic, semantic, and syntactic identity. This suggestion goes beyond the idea that phonological constraints on visual word recognition can develop rapidly to the idea that phonological constraints are foundational to the processes resulting in visual word recognition (Bosman & de Groot, 1996; Carello, Turvey, & Lukatela, 1992; Liberman, 1995; Lukatela & Turvey, 1994a, 1994b; Van Orden, 1991). A coherent phonological code serves to mediate—in the sense of *resolve*—the competing states of time-evolving visual-semantic and phonological-semantic interactions occurring at multiple grain sizes (Stone & Van Orden, 1994; Van Orden & Goldinger, 1994; Van Orden et al., 1990).

The phonological coherence hypothesis places the locus of successful and failed identity priming in the processes that establish a correspondence between a word's visual and phonological codes. In this respect, the hypothesis contrasts with lexically based accounts in which the theoretical emphasis is on the form-based activation of lexical representations and the agonistic–antagonistic influences of lexical neighbors sharing the same orthographic form (e.g., Forster et al., 1987). The related Serbo-Croatian data are not favorable to a form-based lexical account (Lukatela et al., 1997). For targets with two phonological interpretations, one corresponding to a word and one to a nonword, the effective primes at short SOAs were nonwords with a single phonological interpretation matching the word phonology of the target. These nonwords were unfamiliar in visual form, composed by mixing letters from the Roman and Cyrillic alphabets. They differed from the target by a single letter, thereby satisfying the conventional “form prime” criterion (e.g., Forster et al., 1987). The ineffective primes at short SOAs similarly satisfied the criteria of form primes—namely, words identical to the targets and mixed-alphabet nonwords that differed from the targets by a single letter (that is, nonwords satisfying the form-prime criterion). What made the ineffective primes different from the successful primes was the simple fact that they were phonologically interpretable in several ways. Aspects of the present results are similarly unfavorable to a form-based lexical account. Strong facilitatory effects of form primes are obtained only when the prime is unidentifiable (masked; e.g., Evett & Humphreys, 1981; Forster et al., 1987; but see Forster & Veres, 1998) and only when the words have few orthographic neighbors as measured by the N metric (Forster &

Davis, 1991). The influence of N applies equally to the lexical decision and naming tasks (Forster & Davis, 1991). In the present experiments, N was the same large value for both consistent and inconsistent targets; how these targets differed was solely with respect to the number of unfriendly neighbors (0 vs. ≈ 2 on the average, respectively). Form priming, therefore, was an unlikely contributor to the present identity priming given the large N . Reinforcing the preceding conclusion is the observation that when primes were nonidentifiable in Experiments 2 and 4, effective identity priming was restricted to consistent primes. Coupled with the successful priming by both identity primes in Experiments 1 and 3, in which primes were visible, it seems that consistency of primes rather than identifiability of primes was the crucial factor.

The phonological coherence hypothesis is closely tied to the principle of adaptive resonance (Grossberg, 1982; Grossberg & Stone, 1986; Stone & Van Orden, 1994). This principle can be brought to bear on the failed identity priming of Experiments 2 and 4. Assume three adaptive resonances: visual-phonological, visual-semantic, and phonological-semantic (Stone & Van Orden, 1994; Van Orden & Goldinger, 1994). In accordance with adaptive resonance theory, the layers in each of the preceding two-layer networks are fully interconnected with modifiable synaptic weights (Caudill & Butler, 1990). A letter string stimulates a pattern of activity in the input layer common to the visual-phonological and visual-semantic networks. This visual pattern is modified (in the typical weighted-sum fashion) in its transmission to the upper layers. The stimulated phonological pattern will initially include all phonological subpatterns associated with the visual pattern. Competitive-cooperative dynamics within the phonological layer change the initial phonological activity. They do so in the sense of contrast enhancement—tending to increase the activity of the more appropriate encodings and to decrease (but not fully eliminate) the activity of false encodings arising from cross-talk. The cleaned-up activity pattern at the phonological layer feeds activation back to the visual layer. This top-down activation can be viewed as an attempt by the higher phonological level to interpret the visual pattern (“What visual pattern could have produced this phonological pattern?”). If the activity pattern excited in the visual input layer is a close match to the pattern excited in the visual input layer by the letter string (i.e., the top-down interpretation was correct), then the system is said to be in adaptive resonance. If a match is not achieved, then the bottom-up, top-down cycle repeats, with the increased strength of the correct visual pattern providing stronger bottom-up support for the appropriate phonological pattern(s). For a word such as BEND, contrast enhancement and the resonance cycle will eventuate in the elimination of cross-talk and the achievement of equilibrium in the visual-phonological system. That is, processes within the visual-phonological system suffice for phonological coherence. The same cannot be the case, however, for a word such as BOWL. Resolution of the single (word-specific) phonological code for BOWL requires a contribution from the phonological-semantic system. Resonance in this latter system is hypoth-

esized to occur more slowly than in the visual-phonological system (Van Orden & Goldinger, 1994), and this longer time scale sets the lower temporal limit on the evolution of a phonologically coherent representation of BOWL. Consequently, in some range of SOA, processing of the target *bowl* will begin before phonological coherence of the prime is reached, lowering the probability of the target’s benefiting from the previously presented prime. Evidence for the important hypothesized difference between the resonance scales of the phonological-semantic and visual-phonological systems derives, in part, from experiments demonstrating that when there is more than one pronunciation of a letter string, incorrect but regular pronunciations can occur faster than correct but irregular pronunciations. Thus, it has been observed that PINT is misnamed to rhyme with MINT on 25% of the trials, with the latencies of these regularization errors being about 100 ms less than the latencies of the correct pronunciations (Kawamoto & Zemblidge, 1992). The implication is that correct naming of PINT must rely on constraints that arise later than the visual-phonological processes that initially evolve toward the more self-consistent phonological coding of _INT as rhyming with /mint/ (Van Orden & Goldinger, 1994).

In conclusion, the present results should be considered with respect to their relevance for understanding the naming and lexical decision tasks. Whether a participant had to name a word or determine its presence in the internal lexicon, the degree to which its phonological representation had been resolved beforehand mattered a great deal. Discussions of the relative merits of the naming and lexical decision tasks identify a number of distinctions between them. For example, when they are considered as measures of the associative processes between letter strings and their representations, naming latency is thought to be the purer measure given that it involves far fewer postaccess decision processes (e.g., Forster, 1990). Many discussions of the lexical decision task assume that participants could reach their decision about an item’s lexical status simply on the basis of their familiarity with the item’s form (either orthographic or phonological) without necessarily accessing its lexical representation (e.g., Balota & Chumbley, 1984; Gordon, 1983; Seidenberg, 1992; Seidenberg, Waters, Sanders, & Langer, 1984). In other discussions of the processing constraints ultimately brought to bear on responding in the two tasks, the pattern of activity in phonological units is thought to matter most for naming, and the pattern of activity in word units is thought to matter most for lexical decision (e.g., Coltheart & Rastle, 1994; Lukatela, Carello, & Turvey, 1990; Van Orden & Goldinger, 1994). What the present data suggest is that naming and lexical decision, regardless of their differences, may well be alike in a fundamental way: In both tasks, the lower limit on processing time is set by the time scale of phonological coherence.

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(Appendix follows)

Appendix

Stimulus Materials in Experiments 1–4

Each row identifies, in order, the phonologically inconsistent identity prime (which is also the inconsistent target word), the phonologically consistent identity prime (which is also the consistent target word), the shared-onset word prime, the non-shared-onset word prime, the neutral nonlinguistic prime, the shared-onset nonword prime, the non-shared-onset nonword prime, the phonologically biased prime, and the control for the phonologically biased prime.

1. BOWL, BEND, BEAM, LIFT, XXXX, BAPH, VAPH, HOWL, HALE
2. BREAK, BRIEF, BLOCK, FRAME, XXXXX, BAITH, MAITH, FREAK,
3. BROW, BLOT, BUDS, CLIP, XXXX, BLIT, PLIT, GROW, GOAL
4. BUSH, BARK, BITS, LEND, XXXX, BLEG, SLEG, RUSH, RENT
5. CLOWN, CLODS, CLUCK, SKULL, XXXXX, COAGS, DOAGS, BLOWN, BLESS
6. COMB, COCK, COIL, RAMP, XXXX, CAIG, MAIG, WOMB, WOLD
7. DEAF, DILL, DOTS, BUTT, XXXX, DOLK, POLK, LEAF, LIMP
8. DOOR, DARK, DEEP, HELD, XXXX, DAND, YAND, POOR, POOL
9. DOUGH, DOLLS, DITCH, BLADE, XXXXX, DAICK, NAICK, COUGH, CLING
10. DOVE, DIME, DOOM, BEEP, XXXX, DEST, HEST, STOVE, SEATS
11. FOOT, FAST, FORT, SONG, XXXX, FENK, KENK, BOOT, BUZZ
12. GONE, GIRL, GAME, SENT, XXXX, GEEB, NEEB, BONE, BENT
13. HOOD, HAZE, HERB, SOAK, XXXX, HOAG, ROAG, FOOD, FALL
14. LIVE, LATE, LOST, BILL, XXXX, LOFF, HOFF, DIVE, DECK
15. LOSE, LAKE, LUCK, TASK, XXXX, LUZZ, MUZZ, ROSE, RICH
16. MOVE, MEAN, MISS, COLD, XXXX, MING, VING, LOVE, LAND
17. NONE, NINE, NECK, MASS, XXXX, NASS, HASS, TONE, TEAM
18. PINT, PINE, PEAK, MAPS, XXXX, POOZ, FOOZ, HINT, HOSE
19. FLOW, PRAY, POPS, SAIL, XXXX, PIMS, MIMS, SLOW, SAFE
20. POUR, PEER, PORK, SUDS, XXXX, PERG, KERG, SOUR, SOBS
21. PROVE, PRIME, PLAIN, FIRMS, XXXXX, PENGE, YENGE, DROVE, DRESS
22. SAYS, SOON, SEEM, ROAD, XXXX, SELP, FELP, PAYS, PILL
23. SOUL, SOLD, SELF, MAIL, XXXX, SERG, NERG, FOUL, FLIP
24. SOWN, SASH, SANT, MALL, XXXX, SIPH, LIPH, TOWN, TALK
25. SWAMP, SWORN, SWELL, GROOM, XXXXX, SAIMS, ZAIMS, STAMP, STACK
26. SWAN, SWAM, SWAY, LINT, XXXX, SIGS, KIGS, SPAN, SLIP
27. SWAP, SWIG, SWUM, DINE, XXXX, SONT, JONT, SLAP, SEEP
28. SWORD, SOLES, STOOL, TAILS, XXXXX, SLAZE, FLAZE, SWARM, SWINE
29. TEAR, TOYS, TOSS, BAGS, XXXX, TASP, MASP, WEAR, WEAK
30. TOLL, TILE, TANK, SINS, XXXX, TINK, NINK, DOLL, DUSK
31. TOMB, TOPS, TIDE, DASH, XXXX, TITH, KITH, BOMB, BARS
32. TOUCH, TAKES, TRAIN, SPOKE, XXXXX, TLOKE, FLOKE, COUCH, CREST
33. TOUR, TOOL, TEND, PATH, XXXX, TATH, GATH, HOUR, HALL
34. WAND, WANE, WISP, PUFF, XXXX, WUTH, NUTH, SAND, SONS
35. WANT, WEST, WALL, TURN, XXXX, WEEM, NEEM, SCANT, SCOOP
36. WARD, WAKE, WITS, POND, XXXX, WECK, YECK, HARD, HOPE
37. WARM, WORE, WINE, DUST, XXXX, WESK, HESK, FARM, FEED
38. WARN, WINS, WEEP, SPIT, XXXX, WENK, NENK, BARN, BELT
39. WARP, WELD, WICK, MESH, XXXX, WERG, LERG, SHARP, SHIPS
40. WART, WEPT, WIPE, PUMP, XXXX, WEPH, YEPH, PART, POINT
41. WASH, WIRE, WISE, FOAM, XXXX, WOAM, POAM, CASH, CREW
42. WASP, WADE, WILT, HOGS, XXXX, WORG, GORG, RASP, REEL
43. WIND, WAGE, WOOD, SITE, XXXX, WEGS, DEGS, KIND, KEEP
44. WOLF, WINK, WHIG, TEEN, XXXX, WEEF, HEEF, GOLF, GIFT
45. WORD, WEEK, WIFE, FIVE, XXXX, WASK, FASK, LORD, LOSS
46. WORK, WELL, WENT, LONG, XXXX, WAMS, TAMS, FORK, FOND
47. WORM, WAIL, WELK, FINK, XXXX, WAPH, SAPH, DORM, DENT
48. WOUND, WOODS, WINGS, MARKS, XXXXX, WEATH, PEATH, FOUND, FACT