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Sequential Effects in Naming: A Time-Criterion Account

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S. J. Lupker, P. Brown, and L. Colombo (1997) reported that target naming latencies are strongly affected by the difficulty of the other stimuli in a trial block, an effect they attributed to readers' strategic use of a time criterion to guide responding. In the present research, the authors asked whether there are also trial-by-trial ("sequential") effects by examining naming latency as a function of the difficulty of the preceding stimulus. In Experiment 1, both nonwords and high-frequency regular words were named more rapidly following a word than a nonword. Experiments 2, 3, and 4 were parallel experiments involving a variety of stimulus types (e.g., high- and low-frequency inconsistent words, easy and hard nonwords). In all cases, similar sequential effects were observed (i.e., all stimulus types had shorter latencies following an easier-to-name than a harder-to-name stimulus). In terms of the time-criterion account, criterion placement appears to be affected by the relative difficulty of the preceding stimulus in a way that is independent of stimulus type.

For a skilled reader, the reading process is quite rapid and automatic. The apparent simplicity with which reading is done by skilled readers, however, obscures the fact that reading is a multicomponent process requiring the integration of a number of different types of information. The ease and speed with which reading is accomplished also make it quite difficult for researchers to investigate this rather important and intriguing aspect of human behavior.

One prominent issue in the study of reading is whether readers have strategic control over its component processes. This issue has often been investigated by using the lexical-decision task (e.g., Davelaar, Coltheart, Besner, & Jonasson, 1978; Dorfman & Glanzer, 1988; Gibbs & Van Orden, 1998; Glanzer & Ehrenreich, 1979; Gordon, 1983; Pexman, Lupker, & Jared, 2001; Pugh, Rexer, & Katz, 1994; Stone & Van Orden, 1993). More recently, there has been a growing interest in strategy effects in other tasks, particularly naming tasks (Baluch & Besner, 1991; Buchanan & Besner, 1993; Coltheart & Rastle, 1994; Forster, 1981; Jared, 1997; Lupker, Brown, & Colombo, 1997; Monsell, Patterson, Graham, Hughes, & Milroy, 1992; Rastle & Coltheart, 1999; Tabossi & Laghi, 1992; Zevin & Balota, 2000).

Much of this research has been carried out within the framework of the dual-route model of naming (Coltheart, 1978; Coltheart, Curtis, Atkins, & Haller, 1993; Patterson & Morton, 1985). According to this model, there are two ways to produce a phonological code. One, referred to as the *nonlexical route,* involves deriving a pronunciation by applying the spelling-to-sound rules of the reader's language. This route always produces the "regularized" pronunciation of any letter string and is the only route that can produce a phonological code for nonwords. The second, referred to as the *lexical route,* involves accessing lexical memory and retrieving the word's phonological code in a more holistic fashion. This route is required for the successful naming of exception words. These two routes are assumed to act in parallel whenever readers are trying to name a word, and the resultant pronunciation is determined by some sort of interaction between the phonological codes produced by the two routes.

Within this theoretical framework, the idea is that readers may have strategic control over the relative contribution of each route to the naming process (i.e., a given route could be emphasized or de-emphasized). For example, nonwords may be added to the stimulus list with the idea that this manipulation will cause readers to put additional emphasis on the nonlexical route. The expected result is that the naming of words should then show a stronger influence of the nonlexical route. Alternatively, experimenters may add exception words to their stimulus lists to encourage readers to rely more heavily on the lexical route.

More concretely, Tabossi and Laghi (1992) demonstrated that when nonwords were included in the stimulus list, associative priming effects disappeared, at least in Italian. Because associative priming effects are assumed to be due to processing on the lexical route, this result was taken as evidence for decreased use of that route (see also Colombo & Tabossi, 1992). Similarly, Baluch and Besner (1991) demonstrated that frequency effects diminished when nonwords were included in the stimulus list, at least for certain types of Persian words. Again, because frequency effects are assumed to be due to processing on the lexical route, the implication of this result is that the inclusion of nonwords led to a decreased emphasis on this route (see Simpson & Kang, 1994, for a similar demonstration in Korean). Finally, Monsell et al. (1992) showed that naming latencies for high-frequency exception words

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were slowed when nonwords were included in the stimulus list. Again, this result is what one might expect if the inclusion of nonwords led to a lesser relative emphasis on the lexical route, because this route is the only route that can produce an accurate phonological code for exception words.

Although most of these results are reasonably consistent with this type of analysis, as Lupker et al. (1997) argued, they are also generally consistent with an alternate strategy based on the setting of a time criterion for responding. More specifically, Lupker et al. noted that a strong trend in these experiments, as well as their own, was that when stimuli that yield fast responding in a pure block (hereafter referred to as the "fast stimuli") were mixed with stimuli that yield slow responding in a pure block (hereafter referred to as the "slow stimuli"), naming latencies became more homogeneous. Typically, latencies for fast stimuli increased and latencies for slow stimuli decreased when the two were mixed (this effect is referred to as a "blocking" effect). Furthermore, in a number of Lupker et al.'s experiments, these patterns emerged even in situations in which a route-emphasis account would predict either null or opposing results. These patterns of results were explained in the following way.

Lupker et al. (1997) started with the assumption that the process of generating a viable phonological code is an incremental one (i.e., its buildup can be represented by a growth curve). As the quality of the phonological code grows, readers are presumably monitoring that growth process in an effort to obey the experimenter's instructions to "respond as rapidly as possible without making too many errors." Lupker et al. suggested that there are two strategies readers may use to decide that the phonological code is sufficiently developed and that it is time to move on to the next process in the production of a naming response (possibly that of turning the phonological code into an articulatory code). The first option is to monitor phonological code quality and to begin the subsequent process when the phonological code reaches a sufficient level (i.e., to set a quality criterion). The second option is to monitor the passage of time and, at the point at which an appropriate amount of time has passed, try to respond using whatever quality of phonological code is available (i.e., to set a time criterion).

In most of the theories of human performance in reaction time tasks, the implicit (and often explicit) assumption is that participants use some combination of quality and time information to follow the task instructions of responding as rapidly as possible without making too many errors (e.g., Link & Heath, 1975; Ratcliff, 1978, 1985). In contrast, most current models of naming tend to pay very little attention to how decision criteria and the decision-making process affect naming performance. Nonetheless, the assumption that readers use some sort of quality criterion in determining when to respond appears to be implicit in these models. In other words, in their attempt to follow the experimental instructions, readers are assumed to set some sort of criterion for when a phonological code will support an accurate pronunciation. When the code develops to that level, readers presumably respond as rapidly as they can. For example, it is often assumed that the time it takes for an attractor network to settle on a pronunciation is analogous to naming time (e.g., Plaut, McClelland, Seidenberg, & Patterson, 1996).

If individuals were indeed responding only when their phonological code had reached a sufficient quality, one would expect that requiring them to speed up their responses should produce a noticeable increase in errors. This expectation is in contrast to experimental results showing that, by using a deadline procedure, people can be made to name stimuli faster than they normally would with virtually no corresponding increase in error rates. For example, Colombo and Tabossi (1992) included a condition in their Experiment 2 in which speed was stressed in the instructions. In addition, if any participant's response time was longer than 600 ms, the participant was again asked to respond more rapidly. The instructions had a significant effect, with mean response times decreasing by more than 50 ms in the speed-emphasis condition when compared with mean response times in the condition in which speed was emphasized to a lesser extent. However, the error rates in the speed-emphasis condition were actually lower than those in the less speeded condition. Thus, if readers were using a quality criterion, it would appear that they were using it in a rather odd fashion and certainly not one that was consistent with the experimental instructions.

On the other hand, it also seems unlikely that the process of computing/retrieving a phonological code could be driven solely by a time criterion. If it were, the expectation would be that latencies would be fairly constant to all stimulus types in an experiment. Clearly, they are not. Thus, it is likely that decisions about when to begin articulatory processes are driven by some combination of quality and time criteria. Most importantly, it is likely that (as in other reaction time tasks) how these criteria are used by participants is largely under their strategic control.

Predictions: Quality Criterion Versus Time Criterion

Working under the assumption that blocking effects do indeed represent changes in criterion placement rather than changes in route emphasis, the main question that Lupker et al.'s (1997) data addressed was whether it is a time criterion or a quality criterion that plays the more central role. Lupker et al. used the same experimental setup used by Monsell et al. (1992). In this experimental design, fast and slow stimuli are presented, either in pure or mixed blocks. The incremental growth curves for the fast and slow stimuli are similar to those shown in Figures 1 and 2, with the phonological code quality increasing more slowly for slow stimuli.

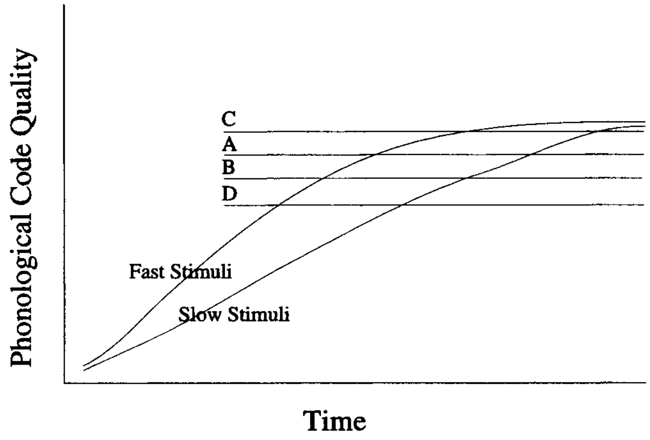

Figure 1. Quality criteria in the naming task.

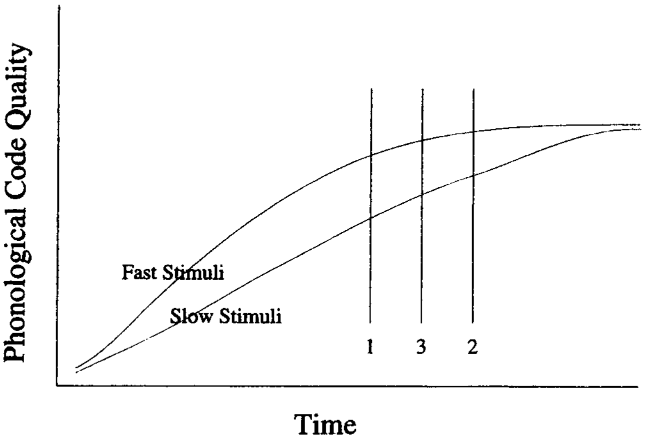

Figure 2. Time criteria in the naming task.

Example quality criteria are shown in Figure 1, and example time criteria are shown in Figure 2.

The use of a quality criterion can quite easily explain the difference in naming performance between fast and slow stimuli in pure blocks. Phonological code quality increases more slowly for the slow stimuli than for the fast stimuli; therefore, the quality criterion will be reached more slowly for the slow stimuli, meaning that these stimuli will take more time to name. Because more errors are made in a pure block of slow stimuli than in a pure block of fast stimuli, it seems logical to assume that, in a pure slow block, individuals use a less strict quality criterion than they do in a pure fast block. Thus, the pure block criterion for fast stimuli might be at Position A in Figure 1, whereas the pure block criterion for slow stimuli might be at Position B in Figure 1.

The difference in naming latencies and error rates between a pure fast block and a pure slow block can be explained equally plausibly in terms of a time criterion. Lupker et al. (1997) hypothesized that the position of the time criterion is determined principally by the perceived difficulty of the stimuli being named. When a block of stimuli is being named, individuals quickly determine the time at which they would prefer to begin articulation (when responses are acceptably fast and the error rate is acceptably low), and that is where they set their time criterion. When the stimuli are relatively homogeneous (as in the pure blocks), the criterion will be set at a position that is appropriate for most of the stimuli in the block. Again, because the phonological code quality for the slow stimuli increases more slowly than that for the fast stimuli, the time criterion will be set at a more lax position for the slow stimuli (e.g., Position 2 in Figure 2) than for the fast stimuli (e.g., Position 1); thus, slow stimuli will take more time to name and will be more prone to errors.

Although the use of a time criterion or a quality criterion can account equally well for performance in fast and slow pure blocks, the evidence for the importance of the time criterion emerges clearly in the mixed blocks. As Lupker et al. (1997) reported, the latencies to fast stimuli are longer in mixed blocks than in pure blocks. The implication is that the criterion in mixed blocks must be above that in pure fast blocks (e.g., Position C in Figure 1). However, if Criterion Position C were actually used in the mixed blocks, the prediction for the slow stimuli would be that their latencies would be longer and their error rates would be smaller than in pure blocks (i.e., contrast Position C with Position B). As noted, exactly the opposite pattern occurs. Alternatively, one can focus on the slow stimuli. Because latencies to them decrease in a mixed block, the implication is that the mixed block criterion must be below that in a pure slow block (e.g., Position D). If so, the mixed block prediction for the fast stimuli would be that their latencies should also decrease (i.e., contrast Position D with Position A). Again, the opposite pattern occurs.

Predictions based on the use of a time criterion are quite different. If the time criterion in a mixed block is simply moved to a place intermediate to those in the pure blocks (e.g., Position 3 in Figure 2), the predictions are that the latencies for fast stimuli will increase whereas those for slow stimuli will decrease (with the potential for an increase in errors). This, of course, is exactly what occurred in virtually all of Lupker et al.'s (1997) experiments. Thus, Lupker et al. argued that these results are most consistent with an account of naming in which a time criterion plays the major role.

The Present Research

A primary goal of the present research was to extend the aforementioned notions by obtaining a clearer understanding of the factors affecting criterion placement. Lupker et al. (1997) assumed that the criterion placement was set early in a block of trials (based on experience with the first few stimuli) and was then maintained throughout the block. If such a hypothesis were correct, the implication would be that after a certain number of trials in a block, response latencies would be entirely unaffected by what occurred on the immediately preceding trials. However, as Sanders (1998) noted when reviewing the performance literature, it is seldom the case that one finds data of this sort. Rather, one tends to find "sequential" effects in which the nature of the immediately preceding stimuli (and the processing involved) has a marked effect on the latency of the present stimulus.

In the context of the time-criterion model, this idea can be captured with the assumption that the criterion does not remain stationary throughout a trial block, but rather is adjusted on a trial-by-trial basis. As Lupker et al. (1997) showed, when trial block means are analyzed, stimulus difficulty is a prime determinant of the position of the time criterion. Thus, if the criterion were adjusted on a trial-by-trial basis, this same factor (i.e., the difficulty of naming the previous stimulus) would presumably be a prime determinant of how the criterion was adjusted. In turn, this criterion adjustment would affect the naming latency to the subsequent stimulus. Specifically, the expectation would be that a stimulus preceded by a fast stimulus would be named more quickly than when that same stimulus was preceded by a slow stimulus. On the other hand, if the position of the time criterion does remain stable after it is initially set, the difficulty of the preceding stimulus should be irrelevant.

As noted, sequential effects are pervasive in the human performance literature. However, most demonstrations of these effects have been in *n* choice tasks, tasks in which the set of stimuli and the set of responses were quite limited (Laming, 1973; Lupker & Theios, 1975; Remington, 1969; Treisman & Williams, 1984). Thus, in these types of situations, sequential effects were essentially repetition effects, involving the repetition of both the stimulus and the response (either immediately or after a short lag). As Treisman and Williams noted, attempts to explain these effects tended to place a lot of attention on the fact that the stimulus had been repeated.

More recently, sequential effects have been reported in tasks involving much larger sets of stimuli, although the number of possible responses was still quite restricted. Thus, only a repetition of responding was typically involved (e.g., Strayer & Kramer, 1994b, when examining performance in a memory search–visual search task; Lima & Huntsman, 1997, when examining performance in a lexical-decision task; although see Kiger & Glass, 1981). As such, the accounts offered by these authors tended to focus more on response criteria.

In the present circumstance, the question is whether we can carry this type of analysis one step further. Sequential effects in a naming task, if they do arise, would involve neither the repetition of a stimulus nor a response. Rather, what they would involve would be more generic changes in the nature of processing on a trial-by-trial basis.

Experiment 1

In Experiment 1, mixed and pure blocks of nonwords (the slow stimuli) and high-frequency regular words (the fast stimuli) were presented. Naming latency was examined as a function of the type of stimulus named on trial N (fast or slow); block type (pure or mixed); and, in the mixed blocks, which type of stimulus (slow or fast) had been presented on the two previous trials (trials $N - 1$ and $N - 2$).

Of principal interest was the comparison of performance in the mixed blocks when participants named a particular type of stimulus on trial N (fast or slow) as a function of whether it was preceded by fast stimuli versus slow stimuli on previous trials. If sequential effects are observed such that either type of stimulus is named more rapidly following high-frequency regular words (fast stimuli) than following nonwords (slow stimuli), the implication would be that the time criterion was being adjusted on a trial-by-trial basis. We also evaluated pure fast and pure slow block performance to determine if the blocking effect reported by Lupker et al. (1997) was replicated. In addition, performance in pure blocks was compared with performance in mixed blocks after consecutive presentations of the same stimulus type to determine whether (and how rapidly) mixed block performance approached pure block performance for that stimulus type (Strayer & Kramer, 1994b).

Method

Participants. Forty-eight undergraduate students were paid $5 for their participation in Experiment 1. Participants reported having normal or corrected-to-normal vision and being native speakers of English.

Apparatus. Stimuli were presented on a TTX Multiscan Monitor (Model No. 3435P), and presentation was controlled by an IBM-clone Trillium Computer Resources PC (Model No. 316S-80MS). A microphone (Model No. 5755; Shure, Inc.) attached to an electronic voice key relay (Model No. 800; Ralph Gebrands Co.) was triggered by vocal responses, and the response latencies were recorded. Participants were seated approximately 15 cm from the microphone and 45 cm from the computer screen. The letters presented to the participants were approximately 0.75 cm tall.

Stimuli. The stimuli in this experiment consisted of 160 high-frequency regular words (the fast stimuli) and 160 nonwords (the slow stimuli). All of the stimuli are presented in the Appendix.[1] The word list was divided into two lists of 80 words each, and the mean frequency and the mean word length of these two lists were closely matched. The mean frequency of the words in List A was 363, and the mean frequency of the words in List B was 367 (Kučera & Francis, 1967). In addition, the two word lists were matched in terms of initial phoneme. Two lists of 80 nonwords were created to match the word lists for first phoneme and letter string length. Nonwords were judged by Tamsen E. Taylor to be easily pronounceable, and most nonwords were created by changing one letter of an English word. Each word list was paired with a nonword list to form the two full lists (i.e., List A and List B). Each participant named all of the stimuli in both lists. Half of the participants received the List A stimuli in a mixed block, and the other half of the participants received the List B stimuli in a mixed block. The words and nonwords in the other list were presented separately in pure blocks.

Half of the participants received the mixed blocks first, and the other half of the participants received the pure blocks first. For the pure blocks, half of the participants received the pure nonword block first, and the other half of the participants received the pure word block first. Thus, the order of blocks was counterbalanced, with either the mixed block or pure blocks being presented first and either the nonwords or words being presented first in the pure blocks, creating four counterbalancing conditions (pure blocks were always presented consecutively). As noted, half the time List A was presented in the mixed block, and half the time List B was presented in the mixed block, increasing the number of counterbalancing conditions to eight. The order of presentation of the stimuli in the individual lists was randomized and different for each participant. At the beginning of each block, participants were presented with eight practice stimuli reflecting the nature of the stimuli contained in the block. For each block type, each participant received the same practice stimuli in the same order.

Procedure. Participants were tested individually, and all participants were asked to name two pure blocks and one mixed block (the mixed block contained twice as many stimuli as each pure block). Participants were informed that they were going to be presented with a series of letter strings and that they were to read them aloud as quickly and as accurately as possible. Participants were also told that they would be presented with stimuli that were not English words but that they should name those items as if they were unfamiliar English words and attempt to do so as quickly as possible. Participants were asked if they had any questions, and then they were presented with the eight practice trials. Participants were again asked if they had any questions, and then the experimental trials were presented. The experimenter was present during all trials and recorded any errors produced by the participants or as a result of equipment malfunction.

A fixation cross remained in the middle of the screen during the trials, and the stimuli were presented centered above the fixation point. An auditory cue was presented 1,000 ms before each stimulus presentation. The stimulus remained on the screen until the participant responded, and there was a 2,000-ms interval between the participant's response and the next auditory cue (for a total intertrial interval of 3,000 ms). A break was provided halfway through the mixed block. When the participants indicated they were ready to continue, the experimental trials were restarted by the experimenter.

Results

A trial was considered to be a participant error and was omitted from the latency analyses if the pronunciation of the word was not correct, if the pronunciation of the nonword did not conform to any spelling-sound correspondence rules of English (if the word body

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[1] After data collection was completed, we noticed that the word *car* was included as both an experimental item and a practice item. It was therefore eliminated from all analyses.

of the nonword was inconsistent, both pronunciations were accepted; for example, *gow* could have been pronounced to rhyme with *cow* or with *low*), if the participant stuttered, or if the participant did not complete the pronunciation of the stimulus. These errors accounted for 2.4% of the trials and were the only errors included in the error analyses. Other trials not used in the latency analyses included trials in which the voice key was not triggered by the participant's first response (2.4% of the trials) and naming latencies greater than 1,500 ms or less than 150 ms, which were considered to be outliers (<0.1% of the trials). In addition to not analyzing latencies for trials on which errors occurred, we removed from the latency analyses the latencies for the trials occurring immediately after mechanical and participant errors (4.4% of the trials). Finally, in this and all subsequent experiments, the first 4 trials in each block were considered warm-up trials and were not included in the reaction time analyses.

Condition means. We performed a 2 × 2 (mixed vs. pure blocks and high-frequency regular words vs. nonwords) repeated measures analysis of variance (ANOVA)[2] on the subject means in each condition. The mean naming latencies and error rates are presented in Table 1. There was a significant interaction between block type and stimulus type, $F_1(1, 47) = 46.36, p < .001, MSE = 644.21$, and $F_2(1, 314) = 191.17, p < .001, MSE = 499.38$. This interaction was due to the fact that mixing words and nonwords had a different effect on the two types of stimuli: The naming latency for words increased in the mixed block, but the naming latency for the nonwords decreased in the mixed block. In addition, there was a significant main effect of stimulus type, with words being named faster than nonwords, $F_1(1, 47) = 140.85, p < .001, MSE = 2{,}561.30$, and $F_2(1, 314) = 546.40, p < .001, MSE = 2{,}202.38$. The main effect of block type was nonsignificant in the subject analysis, $F_1 < 1$ and $F_2(1, 314) = 5.47, p < .05, MSE = 499.38$.

We performed planned comparisons on the aforementioned data to examine the simple main effects. High-frequency regular words were pronounced significantly faster in pure blocks than in mixed blocks, $t_1(47) = 4.37, p < .001$, one-tailed, and $t_2(158) = 14.44, p < .001$, one-tailed, whereas nonwords were pronounced significantly faster in mixed blocks than in pure blocks, $t_1(47) = 2.96, p < .005$, one-tailed, and $t_2(158) = 5.42, p < .001$, one-tailed. Words were named significantly faster than nonwords in mixed blocks, $t_1(47) = 11.44, p < .001$, one-tailed, and $t_2(316) = 14.89, p < .001$, one-tailed.

As with the latency data, we performed a 2 × 2 repeated measures ANOVA on the error data. The interaction between block type and stimulus type was nonsignificant (both *F*s < 1). The main effect of stimulus type was significant, $F_1(1, 47) = 66.95, p < .001, MSE = 3.56$, and $F_2(1, 314) = 28.27, p < .001, MSE = 27.89$. The main effect of block type was nonsignificant (both *F*s < 1).

Table 1

Mean Naming Latencies (Reaction Times [RT], in Milliseconds) and Error Percentages (ER) for Experiment 1 as a Function of Stimulus Type and Blocking Condition

	Blocking condition					
	Pure		Mixed		Effect	
Stimulus type	RT	ER	RT	ER	RT	ER
High-frequency regular words	519	0.6	548	0.7	+29	+0.1
Nonwords	631	2.9	610	2.9	−21	0.0

First-order sequential effects. We performed planned comparisons on the data to examine sequential effects in the mixed block. The stimuli presented in the mixed block were categorized according to whether the stimulus named in the immediately preceding trial (trial $N - 1$) was a word or a nonword. The mean latencies and error rates are reported in Table 2. Words were named significantly faster when immediately preceded by another word trial (fast → fast trials) than when a nonword was named on the previous trial (slow → fast trials), $t_1(47) = 5.41, p < .001$, one-tailed, and $t_2(158) = 4.99, p < .001$, one-tailed. Similarly, nonword trials had significantly shorter latencies when they were preceded by a word (fast → slow trials) than by a nonword (slow → slow trials), $t_1(47) = 3.95, p < .001$, one-tailed, and $t_2(158) = 1.77, p < .05$, one-tailed. When mixed block performance and pure block performance were compared, words following another word in the mixed block were still named more slowly than words appearing in the pure block, $t_1(47) = 2.97, p < .005$, one-tailed, and $t_2(158) = 7.19, p < .001$, one-tailed. Similarly, nonwords following another nonword in the mixed block were still named more rapidly than nonwords presented in the pure block, $t_1(47) = 1.76, p < .05$, one-tailed, and $t_2(158) = 3.10, p < .005$, one-tailed. There were no significant effects in the error analysis.

Second-order sequential effects. We also examined response times to words and nonwords in the mixed block as a function of the nature of the stimulus presented on trial $N - 2$. Mean latencies and error rates for these trials are also presented in Table 2. Naming latencies for word trials preceded by a word on trial $N - 1$ were shorter if the word was preceded by a word on trial $N - 2$ (fast → fast → fast trials) than if the word was preceded by a nonword on trial $N - 2$ (slow → fast → fast trials), $t_1(47) = 2.83, p < .005$, one-tailed, and $t_2(153) = 1.70, p < .05$, one-tailed. Naming latencies were also shorter to word trials preceded by a nonword on trial $N - 1$ if the nonword followed a word (fast → slow → fast trials) rather than another nonword (slow → slow → fast trials), $t_1(47) = 1.81, p < .05$, one-tailed, and $t_2(153) = 0.60$, *ns*. When mixed block performance and pure block performance were compared, latencies to words in the pure block were still faster than latencies to the third of three consecutive words presented in mixed blocks (fast → fast → fast trials), $t_1(47) = 2.24, p < .05$, one-tailed, and $t_2(156) = 3.75, p < .001$, one-tailed. In contrast, responses to nonwords, although sensitive to the nature of the stimulus presented on trial $N - 1$, were not sensitive to the nature of the stimulus presented on trial $N - 2$ (all *t*s < 1). Finally,

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[2] Because the same items appeared in the two different types of blocks (pure and mixed) for different participants, the error variance due to items contributed to the expected mean squares for the Subject × Block Type and the Subject × Block Type × Frequency error terms. Thus, any effects tested against those error terms in the conventional analysis were simultaneously being tested against both item and subject variability. As such, as in Lupker et al. (1997), it was unnecessary to run separate analyses using items as a single random factor. Nonetheless, for interested readers, the results of item analyses are reported; however, no conclusions are based on them.

Table 2

Mean Naming Latencies (Reaction Times, in Milliseconds) and Error Percentages (in Parentheses) in Experiment 1 as a Function of Stimulus Type, Blocking Condition, and Previous Stimulus Types (Total Number of Trials for Each Sequence, in Square Brackets)

Target stimulus (trial N)	Stimulus on trial $N - 1$	Stimulus on trial $N - 2$
Words 548 (0.7)	Word 539 (0.8) [1,687]	Word 535 (0.6) [804]
		Nonword 543 (1.0) [883]
	Nonword 556 (0.5) [1,761]	Word 553 (0.5) [905]
		Nonword 560 (0.5) [856]
Nonwords 610 (2.9)	Word 603 (2.6) [1,767]	Word 603 (3.1) [845]
		Nonword 604 (2.1) [922]
	Nonword 617 (3.1) [1,592]	Word 618 (2.9) [833]
		Nonword 617 (3.4) [759]

Note. Means for pure blocks: for words, 519 (0.6); for nonwords, 631 (2.9).

latencies to nonwords in the pure block were still slower than latencies to three consecutive nonwords presented in the mixed block (slow → slow → slow trials), $t_1(47) = 1.74$, $p < .05$, one-tailed, and $t_2(156) = 1.97$, $p < .05$, one-tailed. There were no significant effects in the error analysis.

Discussion

As we had anticipated, there was a highly significant word type by block type interaction in Experiment 1. Specifically, when fast and slow stimuli were presented in mixed blocks, latencies to the fast stimuli (high-frequency regular words in this case) increased, and latencies to the slow stimuli (nonwords) decreased. In other words, the homogenization of latencies observed by Lupker et al. (1997) was replicated in the present experiment.

More importantly, naming latencies were shorter to both high-frequency regular words and nonwords when they were preceded by fast stimuli (words) than when they were preceded by slow stimuli (nonwords). This finding provides evidence supporting Strayer and Kramer's (1994a, 1994b) ideas as applied to the actions of the time criterion. Strayer and Kramer's account states that there is a trial-by-trial adjustment of the response criterion (in this case, the time criterion), depending on the difficulty of the stimulus immediately preceding the target stimulus. This result does not support the idea that the time criterion stabilizes for a block of trials, as suggested by Lupker et al. (1997). It is important to draw attention to the fact that these sequential effects are as large as many other effects found in the naming literature (with fast → fast trials and slow → fast trials differing by 17 ms) and that, at least for word stimuli, there are second-order sequential effects (i.e., naming latencies are sensitive to the nature of the stimulus presented on trial $N - 2$).

Before proceeding, we should consider two possible artifactual accounts of these sequential effects. The first is based on a design feature that is common to all of the present experiments, that is, that the stimuli were presented randomly in all trial blocks including the mixed block, which was the block used to evaluate sequential effects. As a result, it is quite likely that different stimuli did contribute differentially to the different sequences. Thus, the possibility exists that the reason we observed sequential effects was not due to the effects of the preceding stimulus but rather to the fact that, for example, the fast → fast trials may have, just by chance, involved more of the easier-to-name target stimuli than the slow → fast trials.

Although the pervasiveness of these sequential effects across the experiments to be reported here would seem to rule out such an explanation, to provide an additional evaluation of this account, we undertook the following analysis. In this and all subsequent experiments, we calculated mean pure block latencies for each stimulus (averaged over all participants receiving that stimulus in the pure block). We then artificially reconstructed the mixed block data for every participant in that experiment in the following fashion. For each stimulus in each participant's mixed block, the mean pure block latency for that stimulus was substituted for the participant's actual latency for that stimulus. We then recalculated all of the sequential effects on the basis of the trial sequences in these reconstructed data sets. If it is the case that our sequential effects were actually due to having more easier-to-name stimuli in some sequences (e.g., fast → fast) than others (e.g., slow → fast), then these artificial data sets should also have shown sequential effects. In virtually every case, they did not. Almost every one of these artificial "sequential effects" was 0, 1, or 2 ms. Indeed, the largest "sequential effect" we found in these analyses was 6 ms (in Experiment 4), and this difference actually went in the opposite direction than the effect in the real data.

The second artifactual account would apply only to second-order sequential effects. Although data from stimuli appearing in a trial following an error were not used in these analyses, data from the subsequent trial were used. Thus, the means for the second-order sequential effects did involve trials from sequences begun with an error trial. Because there were more errors for slow stimuli than for fast stimuli in these experiments, it is undoubtedly the case that more of the second-order sequences beginning with a slow stimulus would have actually begun with an error trial in comparison to the second-order sequences beginning with a fast stimulus. Making an error often does cause participants to slow down and be more careful, and it is certainly possible that the effect of an error could carry over beyond the subsequent trial (Rabbitt, 1966). Thus, it is possible that any differences between second-order sequences beginning with a slow stimulus and second-order sequences beginning with a fast stimulus could have been produced by the greater number of sequences beginning with an error in the former case than in the latter.

To examine this issue, we calculated means for all second-order sequences only for sequences in which neither the $N - 1$st nor the $N - 2$nd stimulus produced an error. The result was that the new means were virtually the same as the old means (only one of the eight means in Table 2 changed by as much as 2 ms). Thus, there was no hint that either of the significant second-order sequential effects in Experiment 1 was produced as a result of errors on trial $N - 2$.

One other aspect of the results of Experiment 1 that should be noted is that there was a significant 16-ms advantage for responses to words in pure blocks in comparison to responses to the third of three consecutive word trials in mixed blocks. Similarly, there was a significant 14-ms advantage for responses to the third of three consecutive nonword trials in mixed blocks in comparison to responses to nonwords in pure blocks. It is possible that a longer string of the same type of stimulus (i.e., fast or slow) would produce latencies equal to those in the pure blocks. That is, perhaps the criterion in mixed blocks can be driven to its pure block position. Alternatively, it may be the case that the fact that a mixed block contains two (or more) different kinds of stimuli prevents the criterion from being pushed too far in one direction. This issue is revisited in the discussion of the results of subsequent experiments.

Experiment 2

The results of Experiment 1 provide strong evidence that naming latencies are affected by the nature of the preceding stimuli, suggesting that the position of the time criterion appears to change on a trial-by-trial basis (e.g., Strayer & Kramer, 1994b). However, one potential issue concerning Experiment 1 is that the two stimulus types used not only differed in terms of the speed with which they were named but also differed qualitatively (i.e., words were represented lexically whereas nonwords were not). Thus, one could argue that the observed effects may not have been due simply to a mixing of fast and slow stimuli but rather could have been due to the mixing of two qualitatively different types of stimuli.

If the time criterion truly is a time criterion in the sense that Lupker et al. (1997) suggested, its effects should be independent of the specific types of stimuli used. As long as one stimulus type is more difficult to name than the other, mixed blocks should produce both a homogenization of naming latencies and sequential effects, as demonstrated in Experiment 1. Experiment 2 was an attempt to address this issue. To accomplish this, Experiment 2 involved a direct replication of Experiment 1 using only words, specifically, high- and low-frequency inconsistent[3] words, instead of high-frequency regular words and nonwords.

Method

Participants. Seventy-two undergraduate students were paid $5 or were given partial course credit in an introductory psychology course for their participation in Experiment 2. Participants reported having normal or corrected-to-normal vision and being native speakers of English. None of the participants had participated in Experiment 1.

Apparatus, stimuli, and procedure. The stimuli in this experiment consisted of 116 high-frequency inconsistent words (the fast stimuli) and 116 low-frequency inconsistent words (the slow stimuli). These stimuli are presented in the Appendix. As in Experiment 1, both the fast and slow stimuli were divided into two equal lists of 58 words each and were matched as closely as possible for mean word frequency and mean word length. The mean word frequency of List A words was 260 for the high-frequency inconsistent words and 4 for the low-frequency inconsistent words. The mean word frequency of List B words was 287 for the high-frequency inconsistent words and 4 for the low-frequency inconsistent words (Kučera & Francis, 1967). The equipment, procedure, and experimental design were identical to those used in Experiment 1.

Results

As in Experiment 1, a trial was considered to be a participant error and was omitted from the latency analyses if the pronunciation of the word was not correct, if the participant stuttered, or if the participant did not complete the pronunciation of the word. These errors accounted for 7.7% of the trials and were the only errors included in the error analyses. Other trials not used in the latency analyses included trials in which the voice key was not triggered by the participant's first response (3.1% of the trials) and naming latencies greater than 1,500 ms or less than 150 ms, which were considered to be outliers (<0.1% of the trials). In addition to not analyzing latencies for trials on which errors occurred, we removed from the latency analyses the latencies for the trials occurring immediately after mechanical and participant errors (9.1% of the trials).

Condition means. We performed a 2 × 2 (mixed vs. pure blocks and high-frequency inconsistent words vs. low-frequency inconsistent words) repeated measures ANOVA on the subject means in each condition. The mean naming latencies and error rates are presented in Table 3. There was a significant interaction between block type and stimulus type, $F_1(1, 71) = 52.60$, $p < .001$, $MSE = 578.80$, and $F_2(1, 228) = 72.65$, $p < .001$, $MSE = 662.17$. This effect was due to the fact that mixing high- and low-frequency inconsistent words had a different effect on the two types of stimuli. As in Experiment 1, the latencies for the fast stimuli (high-frequency inconsistent words) increased in the mixed block, and the latencies for the slow stimuli (low-frequency inconsistent words) decreased in the mixed block. In addition, there was a significant main effect of stimulus type, with high-frequency inconsistent words being named faster than low-frequency inconsistent words, $F_1(1, 71) = 379.65$, $p < .001$, $MSE = 1{,}740.66$, and $F_2(1, 228) = 144.36$, $p < .001$, $MSE = 8{,}111.07$. The main effect of block type was nonsignificant in the subject analysis, $F_1(1, 71) = 1.86$, *ns*, and $F_2(1, 228) = 11.67$, $p < .005$, $MSE = 662.17$.

As in Experiment 1, we performed planned comparisons on the aforementioned data to examine the simple main effects. High-frequency inconsistent words were named significantly faster in pure blocks than in mixed blocks, $t_1(71) = 5.05$, $p < .001$, one-tailed, and $t_2(115) = 10.79$, $p < .001$, one-tailed, whereas low-frequency inconsistent words were named significantly faster

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[3] In fact, although the majority of the words used in Experiment 2 were inconsistent in the standard sense (other words with that word body are pronounced differently; e.g., *cow* and *low*), some would actually be better referred to as "strange" (no other one-syllable word contained the same word body and their pronunciation appeared to be irregular; e.g., *ache*).

Table 3

Mean Naming Latencies (Reaction Times [RT], in Milliseconds) and Error Percentages (ER) for Experiment 2 as a Function of Stimulus Type and Blocking Condition

	Blocking condition					
	Pure		Mixed		Effect	
Stimulus type	RT	ER	RT	ER	RT	ER
High-frequency inconsistent words	546	2.7	573	3.1	+27	+0.4
Low-frequency inconsistent words	662	11.7	648	13.1	−14	+1.4

in mixed blocks than in pure blocks, $t_1(71) = 2.61$, $p < .005$, one-tailed, and $t_2(115) = 2.95$, $p < .005$, one-tailed. High-frequency inconsistent words were named significantly faster than low-frequency inconsistent words in mixed blocks, $t_1(71) = 17.78$, $p < .001$, one-tailed, and $t_2(230) = 8.87$, $p < .001$, one-tailed.

As with the latency data, we performed a 2 × 2 repeated measures ANOVA on the error data. The interaction between block type and stimulus type was nonsignificant, $F_1(1, 71) = 1.92$, *ns*, and $F_2(1, 228) = 1.84$, *ns*. The main effects of both block type and stimulus type were significant. More errors were made to low-frequency words than to high-frequency words, $F_1(1, 71) = 254.71$, $p < .001$, $MSE = 25.61$, and $F_2(1, 228) = 36.42$, $p < .001$, $MSE = 288.60$, and more errors were made in mixed blocks than in pure blocks, $F_1(1, 71) = 4.94$, $p < .05$, $MSE = 11.13$, and $F_2(1, 228) = 6.44$, $p < .05$, $MSE = 13.75$.

First-order sequential effects. As in Experiment 1, we used planned comparisons to examine sequential effects in mixed blocks. These means are presented in Table 4. High-frequency words were named faster when a high-frequency word had been presented on trial $N - 1$ (fast → fast trials) than when a low-frequency word had been presented on trial $N - 1$ (slow → fast trials), $t_1(71) = 1.85$, $p < .05$, one-tailed, and $t_2(115) = 1.06$, *ns*. Similarly, low-frequency words were named faster when a high-frequency word had been presented on trial $N - 1$ (fast → slow trials) than when another low-frequency word had been presented on trial $N - 1$ (slow → slow trials), $t_1(71) = 1.93$, $p < .05$, one-tailed, and $t_2(115) = 2.83$, $p < .005$, one-tailed. When mixed block performance and pure block performance were compared, high-frequency words following another high-frequency word in mixed blocks were still named more slowly than high-frequency words appearing in pure blocks, $t_1(71) = 4.04$, $p < .001$, one-tailed, and $t_2(115) = 7.82$, $p < .001$, one-tailed. Low-frequency words following another low-frequency word in mixed blocks were named faster than low-frequency words in pure blocks; however, the difference was nonsignificant, $t_1(71) = 1.20$, *ns*, and $t_2(115) = 0.60$, *ns*. There were no significant effects in the error analysis.

Second-order sequential effects. Naming latencies to high- and low-frequency inconsistent words in mixed blocks were also examined in the context of the preceding two trials. Mean latencies and error rates are reported in Table 4. Naming latencies to high-frequency words were shorter if the word was immediately preceded by two high-frequency words (fast → fast → fast trials) than if a low-frequency word was presented on trial $N - 2$ and a high-frequency word was presented on trial $N - 1$ (slow → fast → fast trials), $t_1(71) = 2.36$, $p < .01$, one-tailed, and $t_2(115) = 0.46$, *ns*. Naming latencies were also shorter to high-frequency words that were immediately preceded by a low-frequency word (trial $N - 1$) if that low-frequency word followed a high-frequency word (fast → slow → fast trials) rather than another low-frequency word (slow → slow → fast trials), $t_1(71) = 1.72$, $p < .05$, one-tailed, and $t_2(115) = 1.11$, *ns*. Response times to high-frequency words in pure blocks were still faster than naming latencies to fast → fast → fast trials, $t_1(71) = 2.90$, $p < .005$, one-tailed, and $t_2(115) = 4.48$, $p < .001$, one-tailed.

Responses to low-frequency words preceded by high-frequency words on trial $N - 1$ did not appear to be affected by the type of stimulus presented on trial $N - 2$ (both *t*s < 1). However, latencies to low-frequency words that were immediately preceded by another low-frequency word did differ as a function of the nature of the stimulus on trial $N - 2$. Latencies were shorter if the stimulus on trial $N - 2$ was a high-frequency word (fast → slow → slow trials) than if it was a low-frequency word (slow → slow → slow

Table 4

Mean Naming Latencies (Reaction Times, in Milliseconds) and Error Percentages (in Parentheses) in Experiment 2 as a Function of Stimulus Type, Blocking Condition, and Previous Stimulus Types (Total Number of Trials for Each Sequence, in Square Brackets)

Target stimulus (trial *N*)	Stimulus on trial $N - 1$	Stimulus on trial $N - 2$
HF INC words 573 (3.1)	HF INC word 569 (2.8) [1,727]	HF INC word 564 (3.6) [861]
		LF INC word 575 (2.2) [866]
	LF INC word 576 (3.2) [1,642]	HF INC word 571 (3.5) [821]
		LF INC word 580 (3.1) [821]
LF INC words 648 (13.1)	HF INC word 643 (13.5) [1,612]	HF INC word 643 (13.3) [753]
		LF INC word 643 (13.1) [859]
	LF INC word 654 (12.5) [1,366]	HF INC word 648 (12.0) [704]
		LF INC word 665 (12.7) [662]

Note. HF INC and LF INC = high- and low-frequency inconsistent, respectively. Means for pure blocks: for HF INC words, 546 (2.7); for LF INC words, 662 (11.7).

trials), $t_1(71) = 1.84, p < .05$, one-tailed, and $t_2(114) = 0.67$, *ns*. Unlike in Experiment 1, the difference between the latencies to low-frequency words in pure blocks and slow → slow → slow trials was nonsignificant (both *t*s < 1). In fact, pure block trials were actually slightly faster than slow → slow → slow trials.

The error analysis did show one effect. In this sequential effect analysis, what was being examined was whether there was a tendency for error rates to go in the opposite direction to the latencies. That is, if a certain sequence produced faster latencies than the comparison sequence, did the former sequence also produce more errors? The only effect of this sort was that the fast → fast → fast trials tended to be more error prone than the slow → fast → fast trials, $t_1(71) = 1.86, p < .05$, one-tailed, and $t_2(115) = 1.73, p < .05$, one-tailed.

Discussion

In all important respects, the results of Experiment 2 replicated the basic findings of Experiment 1. There was a significant blocking effect, with shorter naming latencies to fast stimuli in pure blocks and shorter naming latencies to slow stimuli in mixed blocks. Although the first-order sequential effects were not as large as those in Experiment 1, shorter naming latencies when fast stimuli had most recently been named were found consistently across conditions. Thus, both the blocking effect and the sequential effect do appear to be independent of the type of stimulus named on the previous trial.

As in Experiment 1, there were significant second-order sequential effects for the fast targets. In addition, unlike in Experiment 1, there was one significant second-order effect for the slow targets. The question again emerges as to whether any of the observed second-order sequential effects might have been due to more errors on trial $N - 2$ for second-order sequences beginning with a slow stimulus than for second-order sequences beginning with a fast stimulus. Thus, as in Experiment 1, we recalculated means for the second-order sequences using only sequences in which there were no errors. For the fast targets, no mean changed by more than 1 ms. However, the one significant second-order sequential effect for the slow targets (i.e., the 17-ms difference between the fast → slow → slow trials and the slow → slow → slow trials) became nonsignificant (both *t*s < 1) due to the fact that the mean for the slow → slow → slow trials was reduced by 9 ms whereas the mean for the fast → slow → slow trials was unchanged. One must, of course, be a bit careful in interpreting these results because of the number of trials that were removed for this analysis. Nonetheless, on the basis of this analysis, it appears that, as in Experiment 1, second-order sequential effects tend to be restricted to fast targets.

One additional aspect of these data to note is that, although there was a latency difference between responses to high-frequency words in pure blocks and the third of three consecutive high-frequency words in mixed blocks (as in Experiment 1), there was no parallel difference for the low-frequency words (unlike in Experiment 1). In fact, the small (3-ms) difference that was observed went in the wrong direction (pure block latencies were faster). This pattern of a consistent difference for fast stimuli but no difference for slow stimuli repeated itself throughout the remainder of the present experiments. The implication of these results together with the general lack of second-order sequential effects for slow stimuli seems to be that movements of the criterion have a much greater impact on latencies for fast stimuli than on latencies for slow stimuli.

At an intuitive level, the notion that the time criterion plays a larger role for fast stimuli than for slow stimuli seems quite reasonable, because it is always possible to delay responding to fast stimuli, whereas it may be somewhat more difficult to hasten it to any great degree for slow stimuli. That is, presumably latencies for fast stimuli in mixed blocks are slower than they need to be, as evidenced by the fact that latencies for those same stimuli in pure blocks are much shorter. Thus, for fast stimuli in mixed blocks, it must be the case that participants have a viable phonological code for some time period before responding. Therefore, it is reasonable that response initiation can be very strongly controlled by the placement of the time criterion.

On the other hand, slow stimuli must have some limit as to how rapidly they can be responded to without producing error rates that participants deem too high. Thus, even though the criterion might be driven to a stricter level than usual as the result of a sequence of (fast) stimuli, it is not necessarily the case that latencies for slow stimuli would continue to follow. Rather, mixed block latencies for slow stimuli may be constrained within a limited range, a range just below their latency in pure blocks. Indeed, that entire range of movement may be traversed simply by whatever criterion movement is produced by having a fast stimulus on trial $N - 1$. Thus, second-order sequential effects would be difficult to observe. Furthermore, the general tendency in mixed blocks may be to keep the criterion reasonably close to where it is in pure slow blocks. Thus, often a slow stimulus on trial $N - 1$ may be sufficient to bring the criterion back to a position that is close to its pure slow block position.

Experiment 3

Experiment 2 (which involved the mixing of high- and low-frequency inconsistent words) was designed to examine the possibility that the results of Experiment 1 were due to the mixing of two qualitatively different types of stimuli (words and nonwords). The point can be made, however, that certain theoretical frameworks (e.g., Coltheart et al.'s [1993] dual-route cascaded model) would suggest that it is also the case that high- and low-frequency words are qualitatively different because their phonological codes are computed/retrieved in qualitatively different ways. That is, high-frequency words are assumed to be processed rapidly on the lexical route with little or no input from the nonlexical route, whereas low-frequency words generally have their phonology synthesized from the output of both routes, and especially in the case of low-frequency exception words, there may be some competition that needs to be resolved. Thus, one could still argue that the observed sequential effects could be due to factors other than simple speed differences. Experiments 3 and 4 were attempts to further investigate this issue.

In Experiment 3, the stimuli were two sets of nonwords, what we call fast nonwords and slow nonwords. On the basis of naming latencies in prior experiments, including Experiment 1, we were able to select two sets of nonwords that, within each set, had fairly homogeneous naming latencies, and yet the two sets themselves had quite different average naming latencies. Although one could argue that there is a qualitative difference between words and nonwords, or a qualitative processing difference between high- and low-frequency words, it is rather difficult to make a similar argument about two types of nonwords. Thus, if the nature of the sequential effect is primarily determined by the speed of naming the preceding stimuli, then the fast and slow nonwords should produce sequential effects similar to those found in the previous experiments. However, if a difference in the qualitative nature of the stimuli is producing the sequential effects observed in Experiments 1 and 2, one would not expect to find sequential effects in the mixed block in Experiment 3.[4]

Method

Participants. Seventy-two undergraduate students were given partial course credit in an introductory psychology course for their participation in Experiment 3. Participants reported having normal or corrected-to-normal vision and being native speakers of English. None of the participants had participated in Experiment 1 or 2.

Apparatus, stimuli, and procedure. The stimuli in this experiment consisted of 80 fast and 80 slow nonwords. These stimuli are presented in the Appendix. To find 80 relatively fast and 80 relatively slow nonwords, we examined the mean latencies for the nonword stimuli from Experiment 1. The nonwords that were named most rapidly and the nonwords that were named most slowly in Experiment 1 were selected for use in Experiment 3. The sets of 80 were completed by other nonwords by using data collected from other naming experiments. With the exception that this experiment consisted of fewer stimuli than in previous experiments, the equipment, procedure, and experimental design were identical to those used in Experiment 1.

Results

As in Experiment 1, a trial was considered to be a participant error and was omitted from the latency analyses if the pronunciation of the nonword did not conform to any spelling-sound correspondence rules of English, if the participant stuttered, or if the participant did not complete the pronunciation of the nonword. These were the only errors included in the error analyses and accounted for 4.5% of the trials. Mechanical errors were trials in which the voice key was not triggered by the participant's first response and were also not included in the latency analyses (1.8% of the trials), as were latencies greater than 1,500 ms or less than 150 ms, which were considered outliers (0.5% of the trials). In addition to removing trials on which mechanical and participant errors occurred, we removed from the latency analyses the trials occurring immediately after both types of errors (5.9% of the trials).

Condition means. We performed a 2 × 2 (mixed vs. pure blocks and fast vs. slow nonwords) repeated measures ANOVA on the subject means in each condition. The mean latencies and error rates are presented in Table 5. As we expected, the interaction between stimulus type and block type was significant, $F_1(1, 71) = 14.93, p < .001, MSE = 1{,}064.69$, and $F_2(1, 156) = 31.15, p < .001, MSE = 534.25$. There was also a significant main effect of stimulus type, with the fast nonwords being named more rapidly than the slow nonwords, $F_1(1, 71) = 286.02, p < .001, MSE = 3{,}456.74$, and $F_2(1, 156) = 491.43, p < .001, MSE = 2{,}158.94$. The main effect of block type was nonsignificant in the subject analysis, $F_1(1, 71) = 1.51$, *ns*, and $F_2(1, 156) = 7.25, p < .01, MSE = 534.25$.

As in the previous experiments, we performed planned comparisons to examine the simple main effects. Fast nonwords were pronounced faster in pure blocks than in mixed blocks, $t_1(71) = 4.87, p < .001$, one-tailed, and $t_2(79) = 6.79, p < .001$, one-tailed. Slow nonwords were pronounced faster in mixed blocks than in pure blocks, although the difference was nonsignificant, $t_1(71) = 1.16$, *ns*, and $t_2(79) = 1.60, p < .10$, one-tailed. Fast nonwords were named faster than slow nonwords in mixed blocks, $t_1(71) = 16.64, p < .001$, one-tailed, and $t_2(158) = 17.23, p < .001$, one-tailed.

Table 5
Mean Naming Latencies (Reaction Times [RT], in Milliseconds) and Error Percentages (ER) for Experiment 3 as a Function of Stimulus Type and Blocking Condition

	Blocking condition					
	Pure		Mixed		Effect	
Stimulus type	RT	ER	RT	ER	RT	ER
Fast nonwords	567	2.2	588	1.7	+21	−0.5
Slow nonwords	699	7.1	691	7.2	−8	+0.1

The same ANOVA was performed on the error data as on the latency data. The interaction between block type and stimulus type was nonsignificant (both *F*s < 1). There was a significant effect of stimulus type, resulting from the fact that more errors were made to slow nonwords than to fast nonwords, $F_1(1, 71) = 140.87, p < .001, MSE = 13.86$, and $F_2(1, 156) = 42.62, p < .001, MSE = 51.05$. The main effect of block type was nonsignificant (both *F*s < 1).

First-order sequential effects. Only first-order sequential effects were examined because only half as many stimuli of each type were used in Experiment 3 as in Experiment 1. As in the previous experiments, we performed planned comparisons to examine sequential effects in the mixed blocks. These means are presented in Table 6. Fast nonwords were named more quickly when a fast nonword was presented on trial $N - 1$ (fast → fast trials) than when a slow nonword was presented on trial $N - 1$ (slow → fast trials), $t_1(71) = 1.65, p < .05$, one-tailed, and $t_2(79) = 1.19$, *ns*. Similarly, slow nonwords were named more rapidly when a fast nonword was presented on trial $N - 1$ (fast → slow trials) than when a slow nonword was presented on trial $N - 1$ (slow → slow trials), $t(71) = 2.14, p < .05$, one-tailed, and $t_2(79) = 1.01$, *ns*. When performance in pure blocks was compared with performance in mixed blocks, fast nonwords were named

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[4] For our purposes, what is important here is that we were able to find two sets of nonwords that had noticeably different latencies. Interested readers may, nonetheless, wonder why the two sets of nonwords differed so much in latency. In a post hoc analysis, we were able to determine that the two sets of nonwords did differ on a number of important dimensions: length (3.8 letters for the fast nonwords vs. 4.6 letters for the slow nonwords), neighborhood size (Coltheart, Davelaar, Jonasson, & Besner, 1977; 7.8 for the fast nonwords vs. 4.0 for the slow nonwords), and number of whammies (Rastle & Coltheart, 1998; .39 per nonword for the fast nonwords vs. .96 per nonword for the slow nonwords). Indeed, in a multiple regression analysis of the naming latencies from the mixed block of Experiment 3, all three of these variables contributed significantly to the regression equation.

Table 6

Mean Naming Latencies (Reaction Times, in Milliseconds) and Error Percentages (in Parentheses) in Experiment 3 as a Function of Stimulus Type, Blocking Condition, and Previous Stimulus Type (Total Number of Trials for Each Sequence, in Square Brackets)

Target stimulus (trial N)	Stimulus on trial $N - 1$
Fast nonwords 588 (1.7)	Fast nonword 586 (1.8) [1,276]
	Slow nonword 591 (1.5) [1,210]
Slow nonwords 691 (7.2)	Fast nonword 684 (7.3) [1,190]
	Slow nonword 697 (7.0) [1,092]

Note. Means for pure blocks: for fast nonwords, 567 (2.2); for slow nonwords, 699 (7.1).

significantly faster in pure blocks than when they followed a fast nonword in mixed blocks (fast → fast trials), $t_1(71) = 3.98, p < .001$, one-tailed, and $t_2(79) = 4.42, p < .001$, one-tailed. For slow nonwords, there was no difference between latencies in pure blocks and latencies following another slow nonword in mixed blocks (slow → slow trials; both ts < 1). There were no significant effects in the error analysis.

Discussion

The results of Experiment 3 parallel those of Experiments 1 and 2. Fast stimuli were named more rapidly in pure blocks, and slow stimuli were named more rapidly in mixed blocks. Furthermore, all stimuli were named faster following a fast stimulus than following a slow stimulus. The implication is that it is the difficulty of naming the prior stimulus that is driving these changes in naming latency and not any qualitative differences between the two stimulus types.

Experiment 4

The results of Experiment 3 strongly support the claim that it is the speed with which stimuli are named that determines both the blocking effects (as argued by Lupker et al., 1997) and the nature of sequential effects. In Experiment 4, we examined this latter claim once again. In this experiment, high-frequency regular words were added to the nonwords from Experiment 3. If the speed with which the stimuli are named is indeed the key, one would expect that the two types of nonwords should have differential effects on words. That is, words following fast nonwords should be responded to more rapidly than words following slow nonwords. In general, an examination of sequential effects for all three types of stimuli should show the pattern of fastest responding following a word, the next fastest responding following a fast nonword, and the slowest responding following a slow nonword.

Method

Participants. Seventy-two undergraduate students were paid $5 or were given partial course credit in an introductory psychology course for their participation in Experiment 4. Participants reported having normal or corrected-to-normal vision and being native speakers of English. None of the participants had participated in Experiment 1, 2, or 3.

Apparatus, stimuli, and procedure. The stimuli in this experiment consisted of the 160 high-frequency regular words from Experiment 1 (the fast stimuli) and the 160 nonwords from Experiment 3 (the slow stimuli). In an attempt to keep the procedure as similar as possible to that used in the previous experiments, the fast and slow nonwords were presented together in one pure block. Thus, the pure block of nonwords was actually itself a mixed block, which allowed us to once again examine sequential effects when only nonwords were being named. The stimuli were divided into two equal lists, each consisting of 80 high-frequency regular words (the same as those used in Experiment 1) and 40 fast nonwords and 40 slow nonwords (the same as those used in Experiment 3). The equipment, procedure, and experimental design were otherwise identical to those used in Experiment 1.

Results

As in Experiment 1, a trial was considered to be a participant error and was omitted from the latency analyses if the pronunciation of the word was not correct, if the pronunciation of the nonword did not conform to any spelling-sound correspondence rules of English, if the participant stuttered, or if the participant did not complete the pronunciation of the word. These were the only errors included in the error analyses and accounted for 3.0% of the trials. Trials in which the voice key was not triggered by the participant's first response were also not included in the latency analyses (1.9% of the trials). Latencies greater than 1,500 ms or less than 150 ms were considered outliers and were also omitted from the latency analyses (0.5% of the trials). In addition to removing latencies for trials on which errors occurred, we removed from the latency analyses the latencies for the trials occurring immediately after mechanical and participant errors (4.5% of the trials).

Condition means. We performed a 2 × 3 (mixed vs. pure blocks and words vs. fast nonwords vs. slow nonwords) repeated measures ANOVA on the subject means in each condition. The mean response times and error rates are presented in Table 7. There was a significant interaction between block type and stimulus type, $F_1(2, 142) = 20.18, p < .001, MSE = 770.86$, and $F_2(2, 314) = 68.22, p < .001, MSE = 305.86$. Again, this effect was due

Table 7

Mean Naming Latencies (Reaction Times [RT], in Milliseconds) and Error Percentages (ER) for Experiment 4 as a Function of Stimulus Type and Blocking Condition

	Blocking condition					
	Pure		Mixed		Effect	
Stimulus type	RT	ER	RT	ER	RT	ER
High-frequency regular words	514	0.8	538	0.6	+24	−0.2
Fast nonwords	591	2.8	579	2.8	−12	0.0
Slow nonwords	703	7.2	690	8.1	−13	+0.9

to the fact that mixing fast and slow stimuli resulted in faster naming times for the slow stimuli and slower naming times for the fast stimuli in the mixed versus the pure block, with the fast nonwords behaving as slow stimuli. There was also a significant main effect of stimulus type, $F_1(2, 142) = 242.69$, $p < .001$, $MSE = 4{,}419.78$, and $F_2(2, 314) = 689.60$, $p < .001$, $MSE = 1{,}870.73$. The main effect of block type was nonsignificant (both Fs < 1).

The means of the three stimulus types differed as we expected. When mean latencies to the three types of stimuli were compared, words were named significantly faster than fast nonwords in both pure blocks, $t_1(71) = 11.57$, $p < .001$, one-tailed, and $t_2(238) = 19.38$, $p < .001$, one-tailed, and mixed blocks, $t_1(71) = 7.13$, $p < .001$, one-tailed, and $t_2(238) = 9.79$, $p < .001$, one-tailed. Words were also named significantly faster than slow nonwords in both pure blocks, $t_1(71) = 15.88$, $p < .001$, one-tailed, and $t_2(238) = 35.79$, $p < .001$, one-tailed, and mixed blocks, $t_1(71) = 13.81$, $p < .001$, one-tailed, and $t_2(238) = 29.36$, $p < .001$, one-tailed. Furthermore, fast nonwords were named significantly faster than slow nonwords in both pure blocks, $t_1(71) = 16.08$, $p < .001$, one-tailed, and $t_2(158) = 16.27$, $p < .001$, one-tailed, and mixed blocks, $t_1(71) = 16.43$, $p < .001$, one-tailed, and $t_2(158) = 17.00$, $p < .001$, one-tailed.

The interaction between block type and stimulus type was also as we expected. The high-frequency regular words were pronounced significantly faster in pure blocks than in mixed blocks, $t_1(71) = 6.88$, $p < .001$, one-tailed, and $t_2(159) = 12.64$, $p < .001$, one-tailed. The pure block of nonwords actually consisted of a mixed block of fast and slow nonwords. Both types of nonwords were pronounced faster when mixed with the words; however, only the difference for fast nonwords was significant, $t_1(71) = 1.80$, $p < .05$, one-tailed, and $t_2(79) = 2.79$, $p < .005$, one-tailed, whereas the difference for the slow nonwords was marginal, $t_1(71) = 1.60$, $p < .10$, one-tailed, and $t_2(79) = 3.32$, $p < .001$, one-tailed.

The error data were submitted to the same ANOVA as the latency data. The interaction between block and stimulus type was nonsignificant, $F_1(2, 142) = 1.40$, *ns*, and $F_2(2, 314) = 2.12$, *ns*, as was the effect of block (both Fs < 1). The main effect of stimulus type was significant, $F_1(2, 142) = 111.84$, $p < .001$, $MSE = 16.42$, and $F_2(2, 314) = 112.60$, $p < .001$, $MSE = 23.01$, with the error rates mirroring the latency data.

First-order sequential effects. Only the first-order sequential effects were examined because of the small number of observations per cell for second-order sequential effects when the nonwords were broken down into the two categories. In all cases, the directions of the sequential effects were as we predicted; that is, stimuli were named fastest when preceded by a word, next fastest when preceded by a fast nonword, and slowest when preceded by a slow nonword. These data are presented in Table 8.

Table 8

Mean Naming Latencies (Reaction Times, in Milliseconds) and Error Percentages (in Parentheses) in Experiment 4 as a Function of Stimulus Type, Blocking Condition, and Previous Stimulus Type (Total Number of Trials for Each Sequence, in Square Brackets)

Target stimulus (trial N)	Stimulus on trial $N - 1$		
Words 538 (0.6)	Word	531 (0.5)	[2,651]
	Fast nonword	542 (0.2)	[1,321]
	Slow nonword	549 (1.2)	[1,255]
Fast nonwords 579 (2.8)	Word	573 (2.3)	[1,322]
	Fast nonword	583 (3.0)	[629]
	Slow nonword	590 (3.7)	[597]
Slow nonwords 690 (8.1)	Word	681 (8.4)	[1,203]
	Fast nonword	689 (7.3)	[609]
	Slow nonword	711 (8.4)	[531]

Note. Means for pure blocks: for words, 514 (0.8); for fast nonwords, 591 (2.8); for slow nonwords, 703 (7.2).

Word targets. Words were named significantly faster when preceded by another word than when preceded by a fast nonword, $t_1(71) = 3.64$, $p < .001$, one-tailed, and $t_2(159) = 3.22$, $p < .001$, one-tailed, or when preceded by a slow nonword, $t_1(71) = 8.01$, $p < .001$, one-tailed, and $t_2(159) = 3.85$, $p < .001$, one-tailed. The difference between words preceded by a fast versus a slow nonword was also significant, $t_1(71) = 1.68$, $p < .05$, one-tailed, and $t_2(159) = 0.54$, *ns*. When words named in the pure block were compared with two consecutive word trials presented in the mixed block, words named in the pure block were named significantly faster, $t_1(71) = 4.57$, $p < .001$, one-tailed, and $t_2(159) = 6.60$, $p < .001$, one-tailed. There was one significant effect in the error analysis: Error rates were significantly lower when the previous trial was a fast nonword than when it was a word, $t_1(71) = 1.83$, $p < .05$, one-tailed, and $t_2(159) = 2.22$, $p < .05$, one-tailed.

Fast nonword targets. Fast nonwords were named significantly faster when preceded by a word than when preceded by a slow nonword, $t_1(71) = 3.24$, $p < .005$, one-tailed, and $t_2(79) = 2.43$, $p < .01$, one-tailed. However, the difference between fast nonwords preceded by a word and fast nonwords preceded by another fast nonword was only marginally significant, $t_1(71) = 1.63$, $p < .10$, one-tailed, and $t_2(79) = 1.15$, *ns*, and the difference between fast nonwords preceded by a fast nonword and fast nonwords preceded by a slow nonword was nonsignificant, $t_1(71) = 1.20$, *ns*, and $t_2(79) = 1.30$, *ns*. The second of two consecutive fast nonwords in the mixed block was named more quickly than fast nonwords in the pure block of nonwords; however, this difference was nonsignificant, $t_1(71) = 1.23$, *ns*, and $t_2(79) = 1.24$, *ns*. There were no significant effects in the error analysis.

Slow nonword targets. Slow nonword targets were named more quickly when preceded by a word than when preceded by a slow nonword, $t_1(71) = 3.39$, $p < .001$, one-tailed, and $t_2(79) = 2.12$, $p < .05$, one-tailed. Slow nonwords were also named significantly more quickly when preceded by a fast nonword than when preceded by a slow nonword, $t_1(71) = 2.00$, $p < .05$, one-tailed, and $t_2(79) = 2.15$, $p < .05$, one-tailed. However, the difference between slow nonwords preceded by words and slow nonwords preceded by fast nonwords was nonsignificant (both *t*s < 1). The second of two consecutive slow nonword trials was named more slowly in the mixed block than in the pure block; however, this difference was also nonsignificant (both *t*s < 1). There were no significant effects in the error analysis.

First-order sequential effects in the nonword pure block. Because the pure block of nonwords was actually a mixed block involving both fast and slow nonwords, it was also possible for us to examine sequential effects in that block. These results are presented in Table 9. As in the mixed blocks, both fast nonwords, $t_1(71) = 1.93$, $p < .05$, one-tailed, and $t_2(79) = 1.58$, $p < .10$, one-tailed, and slow nonwords, $t_1(71) = 2.25$, $p < .05$, one-tailed, and $t_2(79) = 1.66$, $p < .05$, one-tailed, were responded to faster when preceded by a fast nonword than a slow nonword. In the error analysis, more errors were made to fast nonwords when they were preceded by a fast nonword than when they were preceded by a slow nonword, $t_1(71) = 2.18$, $p < .05$, one-tailed, and $t_2(79) = 2.13$, $p < .05$, one-tailed. Such was not the case for slow nonword targets (both *t*s < 1).

Discussion

Although the effects were small and not always significant, the results of Experiment 4 were as we predicted. Fast nonwords, which were pronounced more quickly than the slow nonwords but more slowly than the words, produced sequential effects appropriate to their naming latencies. Specifically, the latencies for all three types of stimuli were fastest when the target stimulus was preceded by a word, intermediate when the target stimulus was preceded by a fast nonword, and slowest when the target stimulus was preceded by a slow nonword. Thus, the results of Experiment 4 provide strong support for the claim that the important factor driving sequential effects is the speed with which the preceding stimulus is named, and not the nature of the stimulus itself.

Experiment 4 also reinforces the notion that the time criterion in mixed blocks tends to gravitate toward its position in pure blocks with slow stimuli. Specifically, in this experiment, the slow → slow trials actually produced latencies slower than in the pure blocks of slow stimuli. Similar results were found in Experiments 2 and 3, in which latencies for a run of slow stimuli were usually quite similar to latencies for slow stimuli in pure blocks (although such was not the case in Experiment 1). However, for fast stimuli, there was always a difference between the pure block latency and the latency to the last of a series of fast stimuli in mixed blocks. Perhaps the knowledge that a difficult-to-name stimulus may be coming up in the mixed block puts a limit on the degree to which the position of the criterion will be different from the position it occupies in pure blocks of slow stimuli.

Table 9
Mean Naming Latencies (Reaction Times, in Milliseconds) and Error Percentages (in Parentheses) in the Pure Nonword Block of Experiment 4 as a Function of Stimulus Type, Blocking Condition, and Previous Stimulus Type (Total Number of Trials for Each Sequence, in Square Brackets)

Target stimulus (trial *N*)	Stimulus on trial *N* − 1
Fast nonwords 591 (2.8)	Fast nonword 588 (3.6) [1,224]
	Slow nonword 596 (2.1) [1,196]
Slow nonwords 703 (7.2)	Fast nonword 697 (6.7) [1,155]
	Slow nonword 711 (7.7) [1,071]

General Discussion

The present experiments were designed to determine whether sequential effects exist in naming tasks and, if so, whether those effects are based on the same principles as blocking effects (Lupker et al., 1997). The results in all of these experiments indicate that the naming latency for a stimulus of any type is faster if the previous stimulus was a fast stimulus than if it was a slow stimulus. There was also evidence that the nature of the stimulus on the trial before the previous trial (trial $N - 2$) affected response latency, although this seemed to be true only for the fast target stimuli. Finally, a run of three fast stimuli in mixed blocks did not produce latencies as short as the latencies in pure blocks of fast stimuli. However, for slow stimuli, there was typically very little difference between pure block latencies and latencies to the second of two consecutive slow stimuli in a pure block. These results clearly indicate that latencies in naming tasks, tasks that do not involve the repetition of either stimuli or responses, are the product of more than simply the difficulty of the stimulus being named.

Findings indicating that latencies are the product of more than simply the difficulty of the stimulus being processed are not at all rare. Indeed, a recurring theme in the psychological literature is that responding (in all tasks) is controlled by a decision criterion (e.g., Green & Swets, 1966; Tanner & Swets, 1954), with a subsidiary theme being that the placement of that criterion is affected by the context of the situation (Sperling & Dosher, 1986; Strayer & Kramer, 1994a, 1994b; Treisman & Williams, 1984). In this literature, it has inevitably been the case that the relevant data also show sequential effects, that is, that the placement of the criterion is affected by the nature of the previous trial. For example, sequential effects have been reported in unspeeded *n* choice decision tasks (see Treisman & Williams, 1984, for a summary of these results), in *n* choice reaction time tasks (Laming, 1973; Lupker & Theios, 1975; Remington, 1969), and even in tasks in which the processing requirements change dramatically from trial to trial (e.g., Kiger and Glass [1981] demonstrated that the time to make a semantic category judgment is affected by the difficulty of verifying a mathematical equality presented on the previous trial). This consistency of findings across tasks was noted by Kiger and Glass and led them to argue that these effects have essentially the same cause. It also led them to issue the following prediction:

> If we are correct, then the same context effect will continue to be rediscovered in many circumstances when an experimenter compares RTs [reaction times] from two blocks containing some common items in a reaction time task and will be mistakenly attributed to a multiplicity of causes. (Kiger & Glass, 1981, p. 697)

A commonality among the tasks in this literature, however, is that responding involves a selection from among a small set of possible responses. This has made it possible for researchers to propose many elegant mathematical treatments of these types of data (e.g., Link & Heath, 1975; Ratcliff, 1981). The naming task is somewhat different for a number of reasons, not the least of which is that the response set is virtually unconstrained (certainly when nonwords are used) and there is typically no repetition of responses. As a result, the use of a criterion in modeling naming data has been somewhat limited up to this point (e.g., the criterion involved is a stationary criterion set on a quality dimension). Lupker et al. (1997) extended these ideas by suggesting that the more relevant criterion is a time criterion and that it is clearly affected by context. The present results complete the parallel to the previous literature by showing that this criterion should also be thought of as changing on a trial-by-trial basis as a function of the difficulty of the previous stimulus.

More specifically, the ideas being put forward here are much like those proposed by Treisman and Williams (1984) and Strayer and Kramer (1994a, 1994b), with the focus being on the time dimension. Criterion setting is a two-component process. On the basis of the task instructions and any additional information the participant may receive before the trial block, a criterion is positioned on the time axis. Feedback from each trial then drives the criterion to either a more strict or a more lax position along the time axis. Specifically, when a rapid response is made to a stimulus on trial $N - 1$, the criterion is moved to a more strict position on the time axis in preparation for trial N. Similarly, when a slow response is made to a stimulus on trial $N - 1$, the criterion is moved to a more lax position on the time axis in preparation for trial N. The result is slightly faster responding (on average) on trial N in the former situation than in the latter.

To make this description of the actions of the time criterion more precise and, hence, to derive quantitative predictions, a number of modeling decisions would have to be made. Clearly, although the criterion placement guides responding, it does not dictate it. Thus, decisions must be made about how to model responding on trials in which the criterion placement mismatches processing speed. For example, if a response is ready prior to the criterion, is there an upper limit on how long responding will be delayed? If delaying the response until that upper limit is reached would still lead to responding prior to the criterion, will the participant wait or respond immediately? If a response is not yet ready by the criterion, how much will a participant compromise (i.e., begin responding before all the phonemes are determined and, therefore, risk an error) so as to respond close to the criterion? Will that decision be affected more by the state of readiness of the first phoneme than by the state of readiness of all the phonemes (Kawamoto, Kello, Jones, & Bame, 1998)? Presumably, these are questions that can be addressed empirically. As such, subsequent research should provide information about how best to model these decision operations.

The present data do suggest some general principles for thinking about the actions of the time criterion. For example, it appears that the position of the criterion in mixed blocks is often considerably closer to the position in pure slow blocks than the position in pure fast blocks. This conclusion is based on the asymmetry in the size of the blocking effects for fast and slow stimuli. That is, as shown in the present experiments and in Lupker et al. (1997), it is typically the case that the latencies for fast stimuli slow down more in mixed blocks than the latencies for slow stimuli speed up. Additional evidence is provided by the fact that a single slow stimulus on trial $N - 1$ in a mixed block is often sufficient to produce a latency to a slow stimulus on trial N equal to that in the pure block of slow stimuli. In contrast, two fast stimuli in a row in a mixed block do not push the latency for another fast stimulus to the level of the latency of fast stimuli in pure blocks. In fact, use of the criterion in this fashion makes sense. It is always possible to slow down responding to fast stimuli, whereas it is not always possible to speed up responding to slow stimuli (at least not without a noticeable penalty in terms of increased error rates). Thus, presumably, participants would not be willing to maintain a criterion placement in the mixed block that was too far from the pure block placement for slow stimuli.

We should also note that the change in the criterion position between pure slow blocks and mixed blocks (which produces significant blocking effects in the latency data) never seems to lead to more than a very minor increase in error rate (see also Colombo & Tabossi, 1992). Apparently, the function representing the development of the phonological code over time must be relatively flat at the point at which most naming responses are made. That is, assuming that the function in Figure 3 represents the general relationship between phonological code quality and time, it appears that time criteria in naming tasks are typically placed to the right of Position 2 (e.g., at Position 3). One implication of this is that participants could respond even faster than they do without a corresponding increase in errors. That is, moving the time criterion from Position 3 to Position 2 would produce a decrease in latency, but it would likely not produce an observable increase in errors. A second implication is that one cannot simply assume that because there is no evidence of a speed–accuracy trade-off in the error data, that no trade-off has occurred. That is, as just noted, it is quite possible to observe no differences in error rates even though there was a speed–accuracy trade-off, for example, a trade-off involving the movement of the time criterion from Position 3 to Position 2. In contrast, other movements of the time criterion (e.g., a change from Position 2 to Position 1) would likely produce both a decrease in latency and an increase in errors, clearly indicating that a speed–accuracy trade-off had occurred. Needless to say, these

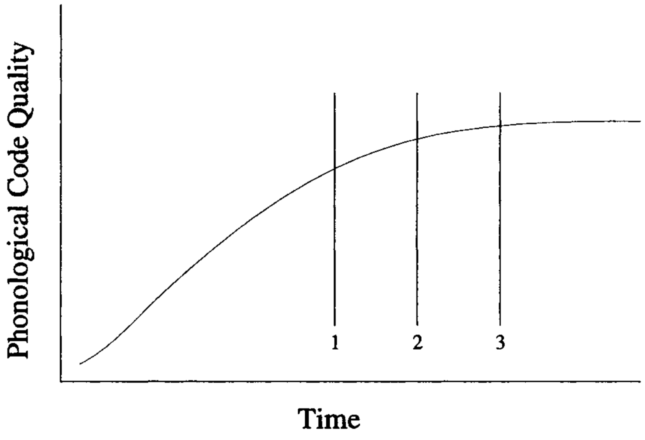

Figure 3. Differential effects of criteria on error rates in the naming task.

problems can severely complicate the interpretation of latency data from naming tasks.

Other tasks could avoid this problem to the extent that participants could be encouraged to place their criterion at a position near the point of inflection (i.e., the point at which the steep slope ends and the shallow slope begins) on the speed–accuracy trade-off function. However, Kiger and Glass's (1981) data in a sentence verification task tend to show the same general pattern as shown here (i.e., noticeable latency changes with little changes in the error rate). Thus, it may be the case that this problem is actually one that is common to many speeded tasks.

Kiger and Glass's (1981) data are interesting from another perspective as well. Their task was a sentence verification task, and it involved verification of both class inclusion statements (e.g., *All robins are gems.*) and mathematical equalities (e.g., *Eight and eight are three.*), with the mathematical equalities being either easy or difficult. Their results suggest that latencies for verifying both types of sentences were driven by "decision criteria operating at a more general level" (Kiger & Glass, 1981, p. 692). This raises the following question: How general are these criteria? Would the mixing of any two speeded tasks produce the types of effects seen here and reported by Kiger and Glass, because both tasks would be driven by these general-level decision criteria? Obviously, this is an empirical question: however, there is currently no evidence that the generality of blocking effects is limited.

Finally, as noted by Lupker et al. (1997), however this process is ultimately modeled, the existence of a time-criterion-based decision process would be quite neutral with respect to which model of naming should be regarded as superior (e.g., Coltheart et al., 1993; Plaut et al., 1996). Any model that conceptualizes the phonological code as being built up over time rather than as an "all-or-none" process can have a time-criterion decision process mapped onto it.

Evidence for Other Strategies

As we noted earlier, there recently has been considerable research trying to establish the existence of strategies in naming. Much of it has been couched within the framework of the classic dual-route model (e.g., Coltheart et al., 1993) and has focused on the idea that participants can emphasize or de-emphasize one or the other route. As we also noted, much of this evidence can be explained equally well in terms of strategic adjustments of the time criterion. Furthermore, because the action of the time criterion seems to have such a clear impact, we would argue on the basis of parsimony that any effect that can be explained in terms of a strategic adjustment of the time criterion is best explained that way.

Rastle and Coltheart (1999), for example, demonstrated that both nonwords and low-frequency regular words were named more slowly in a block of irregular words in which the irregularity was in the first position than in a block of irregular words in which the irregularity was in the third position. This result was predicted on the basis of the idea that in the former case, the nonlexical route would be de-emphasized, whereas in the latter case, it would not be. However, the first-position irregular words were also substantially slower to name than the third-position irregular words. Thus, the time criterion would have been set later in the former block than in the latter block. Indeed, the effect sizes that were observed are quite consistent with what one would expect according to a time-criterion account. As such, we would argue that the time-criterion account would seem to provide a much more parsimonious account of those data.

The point does need to be made that we are not claiming that adjusting a time criterion is the only strategic adjustment possible in naming tasks. In fact, there would seem to be ample evidence for other types of strategic adjustments, some of it coming from our own lab. For example, in Experiment 1 of Lupker et al. (1997), it appeared that participants were engaging in a strategy of lexical checking when naming low-frequency exception words and nonwords. Similarly, Colombo and Lupker (2000) have reported evidence suggesting that, under certain conditions, participants can be induced to strategically assign stress to multisyllabic words (see also Colombo & Tabossi, 1992).

The more central issue in this literature is the issue of whether there is evidence for the strategic adjustment of route emphasis in a dual-route sense (e.g., Coltheart et al., 1993). The idea is that the relative emphasis on the two routes can be changed by including either exception words (to increase the relative emphasis on the lexical route) or nonwords (to increase the relative emphasis on the nonlexical route). As we noted earlier, there is some evidence that the inclusion of nonwords reduces associative priming effects (i.e., Baluch & Besner, 1991; Colombo & Tabossi, 1992; Tabossi & Laghi, 1992), effects that are typically attributed to lexical processing. Note that in two of these experiments, adding the nonwords also reduced the percentage of related pairs, a manipulation that also has been shown to reduce priming effects in naming (Keefe & Neely, 1990).[5] Furthermore, we should note that parallel reductions in the associative priming effect when nonword targets are included have yet to be found in English (Keefe & Neely, 1990; Tabossi & Laghi, 1992, Experiment 3; West & Stanovich, 1982).

An alternative source of evidence for the route-emphasis strategy comes from experiments showing that the inclusion of nonwords appears to reduce frequency effects in naming (Baluch & Besner, 1991; Simpson & Kang, 1994; Zevin & Balota, 2000). Frequency effects are also effects that are typically attributed to the lexical route and, hence, should be reduced in size whenever the nonlexical route receives greater emphasis. For example, Zevin and Balota were able to reduce the frequency effect for regular words by presenting them after a series of nonwords as opposed to after a series of exception words. Specifically, the nonword series caused a 10-ms decrease in the size of the frequency effect, resulting from a 16-ms decrease in latencies for low-frequency words and a 6-ms decrease in latencies for high-frequency words (a similar result was reported by Decker, Simpson, Yates, & Adamopoulos, 1999).

From a dual-route perspective, however, the specifics of these results are a bit odd. Because high-frequency words are supposedly named by the lexical route, the expected effect of presenting nonwords (and, hence, increasing emphasis on the nonlexical route) would be to slow down high-frequency words, not to speed them up. In addition, because both routes contribute heavily to the naming of low-frequency regular words, it is unclear why their naming latencies would be altered at all by any shift in route

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[5] We thank Debra Jared for calling this fact to our attention.

emphasis. Thus, although Zevin and Balota's (2000) results clearly suggest a strategic effect of some sort, they also appear to pose a bit of a challenge for a standard dual-route account.

Alternatively, one can attempt to demonstrate changes in route emphasis by considering changes in the processing of low-frequency exception words. The pronunciation of these words is presumed to be slowed by the activities of the nonlexical route because that route provides an incorrect, regularized pronunciation that competes with the correct pronunciation derived by the lexical route. Thus, these words would seem to be the most likely to show effects of a shifting of emphasis from the nonlexical route to the lexical route. Yet, Monsell et al. (1992), Zevin and Balota (2000), and Lupker et al. (1997) were not able to demonstrate any latency advantages for low-frequency exception words when nonwords were removed (although Paap and Noel [1991, Experiment 2] were able to show a latency advantage for exception words of unspecified frequency when regular words were removed). Furthermore, neither Coltheart and Rastle (1994) nor Jared (1997) was able to show any changes in the size of the regularity effect when nonwords were removed.

What is possible when one is considering low-frequency exception words, of course, is that a shift in route emphasis may manifest itself not in a change in latency but in a change in the proportion of regularization errors. As Lupker et al. (1997) pointed out, however, neither their own data nor Monsell et al.'s (1992) data from the directly relevant experiment (Experiment 2) provide any evidence that the proportion of regularization errors increases when the nonlexical route supposedly has more emphasis.

Indeed, the only exception word data providing any evidence for a route-emphasis account are those reported by Zevin and Balota (2000). Zevin and Balota observed both a decrease in the size of the regularity effect and an increase in the proportion of regularization errors following a series of nonwords, as would be predicted from such an account. As with the frequency effect, however, the size of the regularity effect increased not because latencies for exception words increased but because latencies for the low-frequency regular words decreased. Furthermore, the increase in regularization errors, although significant, was quite small, amounting to less than one error per participant. Nonetheless, these data do provide at least some evidence for the existence of a strategy based on the shifting of route emphasis.

To be fair to Zevin and Balota (2000), they did recognize the weakness of their data in support of the standard dual-route account (i.e., Coltheart et al., 1993). Thus, their discussion of shifting of route emphasis also focuses on whether what they may be observing is a shift in the degree to which semantic information plays a role in naming in a parallel-distributed-processing type model (e.g., Plaut et al., 1996). Although this discussion is not repeated here, their data may indeed be more consistent with this type of "route-shifting" conceptualization than with one framed within the standard dual-route account.

Alternative Conceptualizations

Recently, Kello and Plaut (2000) suggested that blocking effects (and, presumably, sequential effects) are not due to a time criterion but to alterations in the speed at which phonological codes are generated. For example, Kello and Plaut could argue that instead of the time criterion being made more strict following a fast stimulus, participants turn up a "gain" parameter so that the phonological code is generated more rapidly on the next trial.

Kello and Plaut's (2000) proposal is an interesting one, and on the basis of the available data, it does not appear to be possible to distinguish between their proposal and the time-criterion proposal. Nonetheless, Kello and Plaut argued that their proposal should be regarded as the superior one on the basis of their finding that when participants are made to respond faster through an artificially imposed deadline, not only do participants do so by attempting to respond on deadline, but they also complete their response more quickly. Indeed, the time-criterion notion is mute on the question of how quickly the response will be completed, whereas Kello and Plaut's account would predict that, because of the increase in gain, all processes should finish faster.

What is not clear, however, is whether the more rapid completion of responses actually accompanies effects of the sort we observed here (i.e., blocking and sequential effects) or whether it is observed only in Kello and Plaut's (2000) deadline task. For example, Kinoshita and Woollams (2000) found results that were exactly the opposite of those of Kello and Plaut in a standard blocking experiment (i.e., as latencies decreased, durations increased). In contrast, Monsell et al. (1992) did find a slight trend for the latency and duration data to go in the same direction. However, the duration effects were nonsignificant, and when analyzing these trends at the individual item level, Monsell et al. reported no correlation between the sizes of the blocking effects on latency and duration. Thus, at this point, it is unclear whether what Kello and Plaut regarded as the key datum favoring their interpretation over the time-criterion account actually characterizes tasks of the sort used here.

Taylor (1997) proposed a second, slightly different conceptualization. Certainly, for participants to make a response using a time criterion, not only must they have their criterion set at a particular point, but they must also be monitoring (i.e., estimating) the passage of time. Thus, there is the possibility that both blocking and sequential effects are produced not by adjusting the criterion but by changes in a participant's subjective estimation of the passage of time. In fact, there is evidence to suggest that context does affect the accuracy of subjective time estimations. For example, when participants are attempting to estimate the passage of time while performing another task, their time estimations are affected by the difficulty of the second (nontemporal) task. The usual pattern of results is that the perceived duration of an interval is inversely related to the cognitive difficulty of the second task. This effect has been examined by using many different cognitive tasks. For example, Chastain and Ferraro (1997) and Warm and McCray (1969) asked participants to judge the presentation duration of high-frequency and low-frequency words that were actually presented for the same duration. In both studies, participants judged the presentation duration of high-frequency words as being longer than the presentation duration of low-frequency words. Other researchers have found similar results using different secondary tasks, different methods of measuring time perception, or both (e.g., Brown, 1985; Casini & Macar, 1997; Chaston & Kingstone, 1998; McClain, 1983).

These results do not directly address the issue of whether time estimations are affected by a priori events. However, if processing on trial $N - 1$ did affect time estimates on trial N, in theory, such changes in time perception could produce blocking and sequential effects like those found in the present experiments without there being any changes in the position of the time criterion. That is, if participants' perception of time were being affected on a trial-by-trial basis, one would expect to see both blocking and sequential effects even if the criterion placement was not changing. To account for the data reported here, it would have to be the case that the perceived passage of time was slower after a difficult (slow) stimulus than after an easy (fast) stimulus. If so, then participants would respond more quickly after an easy stimulus than after a difficult stimulus, because in the former case they would perceive that they had reached the criterion sooner. As with Kello and Plaut's (2000) gain hypothesis, there do not appear to be any data currently available to distinguish this time perception hypothesis from the hypothesis that blocking and sequential effects are due to participants strategically adjusting the position of the time criterion.

Conclusion

The purpose of the present set of studies was to examine whether the time it takes to name a letter string is a function of the speed with which the immediately preceding letter strings were named, independent of the qualitative nature of those letter strings. The present results fully support this proposal. These results are quite consistent with the idea that naming performance is strongly dependent on a time criterion that changes position on a trial-by-trial basis. Thus, it is important that models of naming performance include a mechanism like a time criterion if they wish to truly describe naming performance. As suggested, such a mechanism can be reasonably easily incorporated into most current models of naming.

References

Baluch, B., & Besner, D. (1991). Visual word recognition: Evidence for strategic control of lexical and nonlexical routines in oral reading. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 17,* 644–652.

Brown, S. W. (1985). Time perception and attention: The effects of prospective versus retrospective paradigms and task demands on perceived duration. *Perception & Psychophysics, 38,* 115–124.

Buchanan, L., & Besner, D. (1993). Reading aloud: Evidence for the use of a whole word nonsemantic pathway. *Canadian Journal of Experimental Psychology, 47,* 133–152.

Casini, L., & Macar, F. (1997). Effects of attention manipulation on judgments of duration and of intensity in the visual modality. *Memory & Cognition, 25,* 812–818.

Chastain, G., & Ferraro, F. R. (1997). Duration ratings as an index of processing resources required for cognitive tasks. *Journal of General Psychology, 124,* 49–76.

Chaston, A., & Kingstone, A. (1998, June). *Time estimation and attention.* Poster session presented at the meeting of the Canadian Society for Brain, Behaviour, and Cognitive Science, Ottawa, Ontario, Canada.

Colombo, L., & Lupker, S. J. (2000). *Strategic shifts in processing in naming Italian words.* Manuscript submitted for publication.

Colombo, L., & Tabossi, P. (1992). Strategies and stress assignment: Evidence from a shallow orthography. In R. Frost & L. Katz (Eds.), *Orthography, phonology, morphology, and meaning* (pp. 319–340). Amsterdam: Elsevier.

Coltheart, M. (1978). Lexical access in simple reading tasks. In G. Underwood (Ed.), *Strategies of information processing* (pp. 112–174). New York: Academic Press.

Coltheart, M., Curtis, B., Atkins, P., & Haller, M. (1993). Models of reading aloud: Dual-route and parallel-distributed-processing approaches. *Psychological Review, 100,* 589–608.

Coltheart, M., Davelaar, E., Jonasson, J. T., & Besner, D. (1977). Access to the internal lexicon. In S. Dornic (Ed.), *Attention and performance VI* (pp. 535–555). New York: Academic Press.

Coltheart, M., & Rastle, K. (1994). Serial processing in reading aloud: Evidence for dual-route models of reading. *Journal of Experimental Psychology: Human Perception and Performance, 20,* 1197–1211.

Davelaar, E., Coltheart, M., Besner, D., & Jonasson, J. T. (1978). Phonological recoding and lexical access. *Memory & Cognition, 6,* 391–402.

Decker, G., Simpson, G. B., Yates, M., & Adamopoulos, A. C. (1999, November). *Flexible use of lexical and phonological information in word recognition.* Poster session presented at the meeting of the Psychonomic Society, Los Angeles.

Dorfman, D., & Glanzer, M. (1988). List composition effects in lexical decision and recognition memory. *Journal of Memory and Language, 27,* 633–648.

Forster, K. I. (1981). Frequency blocking and lexical access: One mental lexicon or two? *Journal of Verbal Learning and Verbal Behavior, 20,* 190–203.

Gibbs, P., & Van Orden, G. C. (1998). Pathway selection's utility for control of word recognition. *Journal of Experimental Psychology: Human Perception and Performance, 24,* 1162–1187.

Glanzer, M., & Ehrenreich, S. L. (1979). Structure and search of the internal lexicon. *Journal of Verbal Learning and Verbal Behavior, 18,* 381–398.

Gordon, B. (1983). Lexical access and lexical decision: Mechanisms of frequency sensitivity. *Journal of Verbal Learning and Verbal Behavior, 22,* 24–44.

Green, D. M., & Swets, J. A. (1966). *Signal detection theory and psychophysics.* New York: Wiley.

Jared, D. (1997). Evidence that strategy effects in word naming reflect changes in output timing rather than changes in processing route. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 23,* 1424–1438.

Kawamoto, A. H., Kello, C. T., Jones, R., & Bame, K. (1998). Initial phoneme versus whole-word criterion to initiate pronunciation: Evidence based on response latency and initial phoneme duration. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 24,* 862–885.

Keefe, D. E., & Neely, J. H. (1990). Semantic priming in the pronunciation task: The role of prospective prime-generated expectancies. *Memory & Cognition, 18,* 289–298.

Kello, C. T., & Plaut, D. C. (2000). Strategic control in word reading: Evidence from speeded responding in the tempo-naming task. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 26,* 719–750.

Kiger, J. I., & Glass, A. L. (1981). Context effects in sentence verification. *Journal of Experimental Psychology: Human Perception and Performance, 3,* 688–700.

Kinoshita, S., & Woollams, A. (2000). *The left-to-right regularity effect and strategy effects in naming.* Manuscript submitted for publication.

Kučera, H., & Francis, W. (1967). *Computational analysis of present-day American English.* Providence, RI: Brown University Press.

Laming, D. (1973). *Mathematical psychology.* New York: Academic Press.

Lima, S. D., & Huntsman, L. A. (1997). Sequential dependencies in the lexical decision task. *Psychological Research/Psychologische Forschung, 60,* 264–269.

Link, S. W., & Heath, R. A. (1975). A sequential theory of psychological discrimination. *Psychometrika, 40,* 77–105.

Lupker, S. J., Brown, P., & Colombo, L. (1997). Strategic control in a naming task: Changing routes or changing deadlines? *Journal of Experimental Psychology: Learning, Memory, and Cognition,* 23, 570–590.

Lupker, S. J., & Theios, J. (1975). Tests of two classes of models for choice reaction times. *Journal of Experimental Psychology: Human Perception and Performance, 104,* 137–146.

McClain, L. (1983). Interval estimation: Effect of processing demands on prospective and retrospective reports. *Perception & Psychophysics, 34,* 185–189.

Monsell, S., Patterson, K. E., Graham, A., Hughes, C. H., & Milroy, R. (1992). Lexical and sublexical translation of spelling to sound: Strategic anticipation of lexical status. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18,* 452–467.

Paap, K. R., & Noel, R. W. (1991). Dual-route models of print to sound: Still a good horse race. *Psychological Research/Psychologische Forschung, 53,* 13–24.

Patterson, K. E., & Morton, J. (1985). From orthography to phonology: An attempt at an old interpretation. In K. E. Patterson, J. C. Marshall, & M. Coltheart (Eds.), *Surface dyslexia: Neuropsychological and cognitive studies of phonological reading* (pp. 131–181). Oxford, England: Oxford University Press.

Pexman, P. M., Lupker, S. J., & Jared, D. (2001). Homophone effects in lexical decision. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 27,* 139–157.

Plaut, D. C., McClelland, J. L., Seidenberg, M. S., & Patterson, K. E. (1996). Understanding normal and impaired word reading: Computational principles in quasi-regular domains. *Psychological Review, 103,* 56–115.

Pugh, K. R., Rexer, K., & Katz, L. (1994). Evidence of flexible coding in visual word recognition. *Journal of Experimental Psychology: Human Perception and Performance, 20,* 807–825.

Rabbitt, P. M. A. (1966). Errors and error correction in choice response tasks. *Journal of Experimental Psychology, 71,* 264–272.

Rastle, K., & Coltheart, M. (1998). Whammies and double whammies: The effect of length on nonword reading. *Psychonomic Bulletin & Review, 5,* 277–282.

Rastle, K., & Coltheart, M. (1999). Serial and strategic effects in reading aloud. *Journal of Experimental Psychology: Human Perception and Performance, 25,* 482–503.

Ratcliff, R. (1978). A theory of memory retrieval. *Psychological Review, 85,* 59–108.

Ratcliff, R. (1981). A theory of order relations in perceptual matching. *Psychological Review, 88,* 552–572.

Ratcliff, R. (1985). Theoretical interpretations of speed and accuracy of positive and negative responses. *Psychological Review, 92,* 212–225.

Remington, R. J. (1969). Analysis of sequential effects in choice reaction times. *Journal of Experimental Psychology, 82,* 250–257.

Sanders, A. F. (1998). *Elements of human performance: Reaction processes and attention in human skill.* Mahwah, NJ: Erlbaum.

Simpson, G. B., & Kang, H. (1994). The flexible use of phonological information in word recognition in Korean. *Journal of Memory and Language, 33,* 319–331.

Sperling, G., & Dosher, B. (1986). Strategy and optimization in human information processing. In K. Boff, L. Kaufman, & J. Thomas (Eds.), *Handbook of perception and human performance* (Vol. 1, pp. 2-1–2-65). New York: Wiley.

Stone, G. O., & Van Orden, G. C. (1993). Strategic control of processing in word recognition. *Journal of Experimental Psychology: Human Perception and Performance, 19,* 744–774.

Strayer, D. L., & Kramer, A. F. (1994a). Strategies and automaticity: I. Basic findings and conceptual framework. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 20,* 318–341.

Strayer, D. L., & Kramer, A. F. (1994b). Strategies and automaticity: II. Dynamic aspects of strategy adjustment. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 20,* 342–365.

Tabossi, P., & Laghi, L. (1992). Semantic priming in the pronunciation of words in two writing systems: Italian and English. *Memory & Cognition, 20,* 303–313.

Tanner, W. P., & Swets, J. A. (1954). A decision making theory of visual detection. *Psychological Review, 61,* 401–409.

Taylor, T. E. (1997). *Strategic effects in naming: Effects of the time criterion.* Unpublished master's thesis, University of Western Ontario, London, Ontario, Canada.

Treisman, M., & Williams, T. C. (1984). A theory of criterion setting with an application to sequential dependencies. *Psychological Review, 91,* 68–111.

Warm, J. S., & McCray, R. E. (1969). Influence of word frequency and length on the apparent duration of tachistoscopic presentations. *Journal of Experimental Psychology, 79,* 56–58.

West, R. F., & Stanovich, K. E. (1982). Source of inhibition in experiments on the effect of sentence context on word recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 8,* 385–399.

Zevin, J. D., & Balota, D. A. (2000). Priming and attentional control of lexical and sublexical pathways during naming. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 26,* 121–135.

Appendix

Experimental and Practice Stimuli

List A	List B
Fast experimental items (high-frequency regular words): Experiments 1 and 4	
ACT	ADD
AID	AIR
ARM	ART
BAD	BACK
BALL	BANK
BRIGHT	BRING
CALL	CAUSE
CAN	CAR
CARE	CASE
CHANCE	CHARGE
CHECK	CHURCH
CLAIM	CLASS
CLUB	CLEAR
DANCE	DARK
EACH	EAST
FACE	FACT
FAITH	FALL
FAR	FARM
FEAR	FEED
FEEL	FEET
FELL	FELT
FORCE	FORM
FREE	FRENCH
GROUND	GROWTH
HAIR	HALL
HARD	HAND
HEAT	HERE
HELD	HELL
HIM	HIT
HOLD	HOME
HORSE	HOUSE
KEEP	KEY
LACK	LAND
LAW	LAY
LEAST	LEAVE
LED	LEG
LESS	LET
LIFE	LIKE
LINE	LIGHT
LONG	LORD
LOSS	LOST
MADE	MAIN
MAKE	MASS
MAN	MAY
ME	MEET
MEAN	MEANS
MEN	MET
MIND	MIGHT
NEAR	NEED
NOTE	NORTH
OIL	OLD
PAGE	PAY
PAID	PAIN
PARK	PART
PASS	PAST
PLACE	PLANE
PLAN	PLANT
RAN	RAW
REACH	REAL
RED	REST
RIGHT	RISE
ROAD	ROLE

List A	List B
Fast experimental items (high-frequency regular words): Experiments 1 and 4 (*continued*)	
SAME	SAY
SENSE	SENT
SHORT	SHOT
SIDE	SIZE
SIT	SIX
SOUND	SOUTH
STEP	STOP
TEACH	TEETH
TELL	TEN
THIN	THIRD
TRADE	TRAIN
WAGE	WAIT
WAVE	WAY
WE	WELL
WHILE	WHITE
WIDE	WIFE
WISH	WITH
Slow experimental items (nonwords): Experiment 1	
AIF	AIN
ARB	ARP
ATH	AFF
BAME	BAPE
BAMP	BASP
BRIST	BRICH
CABE	CATH
CAF	CAG
CARM	CADE
CHAND	CHASK
CHEAB	CHURD
CLAIL	CLACH
CLEMP	CLUM
DAND	DARL
EATH	EASK
FAMP	FAIT
FAP	FARK
FASP	FALM
FEAP	FEEK
FEEB	FEEM
FEMP	FELD
FORP	FORN
FREEP	FRENT
GROACH	GROUNT
HAIP	HALD
HARB	HANE
HEAK	HEAB
HELT	HELF
HIB	HIG
HOKE	HODE
HORCH	HOSP
KEEM	KEET
LAPE	LASP
LAS	LAR
LEAMP	LEASP
LEB	LEN
LEV	LEP
LIBE	LIGE
LIPE	LISK
LOSK	LOSH
LOTE	LOSP
MAB	MAZ

(*Appendix continues*)

Appendix (*continued*)

Slow experimental items (nonwords): Experiment 1 (*continued*)

List A	List B
MABE	MAPE
MASP	MAFE
MEAP	MEAM
MEK	MEB
MEP	MEG
MISP	MISH
NEEB	NEEK
NOTH	NOST
OPE	OSH
PAF	PAPE
PAIP	PAIF
PASH	PARD
PASP	PASK
PLAMP	PLAND
PLANG	PLAT
RAB	RAK
REAT	REAST
RELL	RET
RISH	RISP
ROAT	RONE
SAB	SAN
SEMP	SERT
SHORK	SHOFE
SIBE	SILE
SIG	SIM
SOUSH	SOUCH
STAM	STAP
TEASP	TEASH
TEP	TELF
THIM	THIRP
TRAND	TRAIP
WAME	WALP
WAPE	WAIM
WELB	WEMP
WEP	WEM
WHIVE	WHIGE
WIBE	WIKE
WIGE	WINT

Fast experimental items (high-frequency inconsistent words): Experiment 2

List A	List B
BEAR	AGE
BLIND	ARC
BOOK	BLOOD
BOTH	BREAK
BREAD	BROAD
BREATH	BROWN
CHILD	BUILT
CHOOSE	CHRIST
COME	COURT
COULD	DOOR
COURSE	DOUBT
DEAD	DRAWN
DO	FOOT
DOES	FOUR
DONE	GOOD
DOWN	GREAT
EARTH	GROWN
EIGHT	GUARD
FRIEND	GUESS
FRONT	GUY
GIVE	HEAD
GONE	HEARD
GROSS	HOUR

Fast experimental items (high-frequency inconsistent words): Experiment 2 (*continued*)

List A	List B
GROUP	KNOW
GROW	KNOWN
GROWTH	LOSE
HALF	MOST
HEALTH	MOVE
HEART	NONE
HOUSE	ONCE
LEARN	PULL
LOVE	ROOF
MEANT	ROUGH
MIND	SAYS
MONTH	SCENE
OUGHT	SCHOOL
OUR	SEARCH
PHASE	SHALL
POOR	SMOOTH
POST	SON
PROVE	SOUL
PUT	SPREAD
RARE	THOUGH
SHARE	THROUGH
SHOOK	TOUCH
SHOW	TOWN
SIGN	TWO
SOUTH	VIEW
SURE	WALK
THREAT	WANT
TOUR	WAR
WATCH	WARM
WEIGHT	WHOLE
WHOSE	WHOM
WON	WOOD
WORK	WORD
WORSE	WORLD
YOUR	WORTH

Slow experimental items (low-frequency inconsistent words): Experiment 2

List A	List B
BLOWN	ACHE
BROW	AISLE
BURNT	APE
CHOIR	AXE
CHORD	BATHE
CLOTHE	BREADTH
CLOVE	BROOCH
CLOWN	CHALK
CORPSE	CHIC
CROW	CHUTE
CRYPT	COMB
CYST	COUGH
CZAR	CREPE
DISC	DWARF
DREAD	FEUD
FLOWN	FIEND
FREAK	FIERCE
FROST	FOLD
GEL	FUSE
GHOUL	GAUZE
GIST	GLOVE
GUILD	GNAW
HEARSE	GNOME
HEIR	GYM
HINGE	HEARTH
ISLE	HERB

Appendix (*continued*)

List A	List B
Slow experimental items (low-frequency inconsistent words): Experiment 2	
LEAPT	HIND
LEWD	HOOD
LURE	KELP
MOW	LYNCH
MUSE	MAUVE
NICHE	MULE
NYMPH	OATH
PEAR	OUNCE
PLAGUE	PIER
PLEAD	PLAID
PLUME	PROW
PSALM	PROWL
QUART	ROUGE
REIGN	SCALP
SALVE	SCARCE
SEW	SCENT
SIEVE	SHEIK
SMEAR	SHOVE
SOOT	SOWN
SPOOK	SPONGE
SPRAWL	SPOUSE
SWAY	STEAD
SWORD	SWAMP
THRONG	SWAP
TREAD	THWART
TROUPE	TROUGH
TWINGE	TRYST
WAND	VEIL
WARP	WALTZ
WISP	WASP
WOMB	YACHT
WORM	YEARN
Fast nonwords: Experiments 3 and 4	
ARN	ARB
CADE	ARP
CATH	CAF
CLUM	DAP
DARL	DAPE
DEXT	DARR
DOAD	DOKE
GLIM	GARK
GOSP	HELT
JITE	HIG
LASP	LAS
LEB	LEN
LEV	LEP
LOAST	LISK
LOSH	LOAK
LOSP	LOSK
LOTE	LUND
MAB	MABE
MAPE	MASP
MECK	MEAP
MEG	MEP
MISH	MISP
MISK	MUNT
MURF	MURT
NEEK	NAFT
NEEM	NEEB
NILT	NURCH
OSH	OSK
PASK	PASH
RISH	RAME
Fast nonwords: Experiments 3 and 4 (*continued*)	
SERT	RISP
TISP	TICE
TIVE	TUND
WELB	WEMP
WEM	WEP
WINT	WIKE
WOPE	WUCK
WUFF	WUP
WUNG	YAKE
YEAM	YETCH
Slow nonwords: Experiments 3 and 4	
BAPE	BAME
BRUVE	BRICH
CHEAB	CAG
CHED	CHASK
CLAIL	CHURD
EAF	CLACH
EASK	EATH
FACK	FAMP
FEAP	FEACE
FERSE	FIPE
FREEP	FOAF
FRENT	FREET
FROAR	FROPE
FRUNK	GICE
GROACH	GLEST
GRULP	GROUNT
HAIP	HEAB
LEAMP	KECK
LIGE	NAICK
NONK	NOST
PAIP	PAIF
PASP	PAPE
PEASH	PHOAD
POURSE	PLAMP
PRORE	PRUCH
RAK	REAST
SEFT	RENGTH
SHET	SHOFE
SKAL	SIM
SOINT	SOUSH
SOUCH	SPAIL
TAIGE	TEASP
TEASH	TEP
THAYL	THARK
THIM	THIRP
THIPE	THRAG
TROAR	TRAIP
TRUNG	VILTH
WHIGE	WHIVE
WOIF	YOWND

Fast block	Slow block	Mixed block
Practice items: Experiment 1		
NIGHT	GOW	ELD
MARCH	DELT	LATE
GUN	WUFF	CAR
TIME	MIM	GUP
SIGHT	WUNK	BEST
WHEEL	BREEK	SKAL
BORN	DEVE	TEST
NAME	STANG	YEAT

(*Appendix continues*)

Appendix (*continued*)

Fast block	Slow block	Mixed block	Fast block	Slow block	Mixed block
Practice items: Experiment 2			Practice items: Experiment 4		
SOME	PEARL	THIGH	NIGHT	FALM	ELD
WHAT	POUR	SAID	MARCH	ATH	LATE
ALL	DOLL	BEEN	GUN	STEACH	STILL
WERE	STEAK	SWEAR	TIME	FASP	GUP
ARE	WOOL	ONE	SIGHT	LAR	BEST
WAS	BRONZE	WEIRD	WHEEL	GOW	SKAL
HAVE	HYMN	CALF	BORN	DELT	TEST
TOOK	REINS	THROW	NAME	STANG	YEAT
Practice items: Experiment 3					
LAR	FALM	YEAT			
DELT	STEACH	SOOK			
FASP	CHUR	GOW			
NEAF	MAMP	STANG			
RALL	PLOOR	VEAK			
GUP	QUEEL	DRAP			
BLAR	KITCH	TRAN			
HAP	STRUP	ATH			

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New Editors Appointed, 2002–2007

The Publications and Communications Board of the American Psychological Association announces the appointment of five new editors for 6-year terms beginning in 2002.

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Manuscript submission patterns make the precise date of completion of the 2001 volumes uncertain. Current editors, Michela Gallagher, PhD; Raymond S. Nickerson, PhD; Nora S. Newcombe, PhD; Patricia B. Sutker, PhD; and Mark I. Appelbaum, PhD, respectively, will receive and consider manuscripts through December 31, 2000. Should 2001 volumes be completed before that date, manuscripts will be redirected to the new editors for consideration in 2002 volumes.