

Lexical Effects in Naming Pseudowords in Shallow Orthographies: Further Empirical Data

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Pseudoword reading in Italian, a language with a regular but context-sensitive mapping from orthography to phonology, was investigated. Pairs of pseudowords were derived from words by changing the vowel following a target letter. In 1 of the pseudowords, pronunciation of the target grapheme was the same as in the original word (consistent), whereas in the other it was different (inconsistent). In Experiment 1, pseudowords were mixed with words. In the other 2 experiments, only pseudowords were presented. Consistency effects in naming the pseudowords emerged in Experiment 1 but disappeared in Experiments 2 and 3. The pattern of results constrains the functional architecture of reading models because the list composition effect is compatible with a dual-route model but is difficult to reconcile with a single-route framework.

In this article we report on data on pseudoword reading in Italian. The aim of the article is twofold. On the one hand, the data reported constitute new empirical evidence for the consistency effect in reading pseudowords in shallow orthographies and thus complement and constrain those reported by Sebastián-Gallés (1991) for Spanish. On the other hand, the pattern of consistency effects obtained across experiments allows us to compare predictions derived from alternative models of word reading.

The consistency effect considered here refers to the fact that the pronunciation of pseudowords is affected by the pronunciation of existing words (e.g., Andrews, 1982; Glushko, 1979). Consider an example from English. The multiletter sequence *-ean* in the final word position is always pronounced /i:n/ (cf. *clean*), whereas the sequence *-eat* in the same position has different pronunciation in different words (*treat* vs. *threat*). Pseudowords derived from words with inconsistent endings (e.g., *breat*) take longer to be named than do pseudowords derived from words with a consistent ending (e.g., *hean*).

In the past, the consistency effect has been considered evidence in favor of single-route models (but see Paap & Noel, 1991, for a contrasting view). Such models postulate a single mechanism for converting print into sound for both words and pseudowords, and therefore such an architecture

predicts that pseudoword reading should be affected by the orthographic and phonological features of known words. The specific mechanism by which this should be accomplished varies greatly, from reading by analogy (Glushko, 1979) to adjusting connection weights in parallel distributed processing models (see Seidenberg & McClelland, 1989; Seidenberg, Plaut, Petersen, McClelland, & McRae, 1994), but the shared assumption is that the set of learned words determines the pronunciation of novel pseudowords. Recently, however, Coltheart, Curtis, Atkins, and Haller (1993) developed a computational version of a dual-route model—one that postulates both a lexical and a nonlexical route for converting print into sound—that can account for the consistency effect. The two routes share an initial stage of letter identification that feeds the visual word-recognition stage of the lexical route and the grapheme-phoneme conversion stage of the nonlexical route. The two routes also share a final processing stage of phonemic representation. The processing stages of each route operate in cascade and pass on information to adjacent levels continuously rather than wait until processing in one level is completed. Thus, when an orthographic string is presented, there is activation at the phonemic level from both the lexical and the nonlexical route, and if the two yield conflicting information, reading time is slowed.

Single- and dual-route models¹ make different predictions concerning how words and nonwords might be read in context created by the differential composition of lists of stimuli or from task requirements (see, e.g., Monsell, Patterson, Graham, Hughes, & Milroy, 1992; Pugh, Rexer, & Katz, 1994; Stone & Van Orden, 1993). Such context

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¹ Both so called single- and dual-route models postulate that the phonological form of a word can be retrieved by first retrieving the word meaning, and thus both assume a semantic route in addition to the nonsemantic route(s). For a discussion of this issue, see Besner, Twilley, McCann, and Seergobin (1990), Seidenberg and McClelland (1989), Coltheart et al. (1993), and Plaut, McClelland, Seidenberg, and Patterson (1996).

effects have been documented by, among others, studies showing that semantic effects, which are thought to be diagnostic of lexical involvement, arise in naming tasks only when the experimental list contains irregular words (Stanhope & Parkin, 1987), irregularly stressed words (Tabossi & Laghi, 1992), or opaque words (Baluch & Besner, 1991) and by studies using concurrent tasks on the assumption that the two routes require different attentional demands (e.g., Bernstein & Carr, 1996; Paap & Noel, 1991).

Single-route models postulate that a single mechanism is responsible for reading both words and pseudowords and that the information used to generate pseudoword pronunciation is derived from exposure to actual words. Given that the procedure used to derive a pronunciation to pseudowords is based on a single source of information, such models cannot account for both the presence and the absence of, for example, semantic effects in different lists. According to dual-route models, however, pseudowords and regular words can be read successfully by using the rules of the language that mediate grapheme-to-phoneme associations, whereas access to the mental lexicon is required in order to recover the pronunciation of irregular words (e.g., Coltheart, 1987; Patterson & Morton, 1985). Context effects follow naturally from this type of architecture, because access to the lexical system is required to produce semantic effects. Therefore, assuming that reliance on the two routes can be tuned by task and list demands, context effects are to be expected in the framework of dual-route models (Coltheart & Rastle, 1994).

Using the consistency effect in reading pseudowords may provide a good method to test the two classes of models because of the possibility that the lexical route may be disabled under specific task demands (e.g., Paap, Noel, & Johansen, 1992).

In this study we exploited the fact that most languages have context-sensitive rules for mapping print into sound. In particular, we considered the pronunciation of the letters *c* and *g* that, in Italian as in many other languages, depends on the letter(s) following them. It has already been shown that reading of pseudowords containing these letters is influenced by lexical knowledge, both in languages with a shallow orthography (see Sebastián-Gallés, 1991, for Spanish) and those with a deep orthography (see Peereman, 1991, for French). One of the Spanish experiments may be used to illustrate this phenomenon. In her Experiment 1, Sebastián-Gallés constructed two kinds of pseudowords by changing the vowel following the letter *g* or *c* of existing words. For example, from the word *encogido* /enko'xido/ she derived the pseudoword *encogedo* /enko'xedo/, in which the letter *g* has the same pronunciation as in the original word (we call this the consistent condition). From the word *arrugado* /arru'gado/ she derived the pseudoword *arrugedo* /arru'xedo/, in which the letter *g* has the alternative pronunciation than in the original word (we call this inconsistent condition). In a naming task participants made more errors reading inconsistent pseudowords than reading consistent pseudowords. Errors mainly involved the critical letters *c* and *g*. The pattern reported for French by Peereman is quite similar.

We contend that there is a possible confounding factor in both the Spanish and the French studies: The consistent and the inconsistent pseudowords were derived from two different sets of words, and thus the consistency effect reported could be a byproduct of differences in the two sets. This is particularly troublesome for the Spanish study, for which the two sets were not matched for frequency and other relevant dimensions, such as neighborhood size. In addition—and more relevant to the present study—pseudowords were always presented mixed with words; the only exception was Experiment 2 by Content and Peereman (1992), which we discuss shortly. Thus, no adequate empirical data are available for the evaluation of the list-composition issue.

The Present Study

To clarify these issues we devised three experiments in Italian, a language similar to Spanish in terms of the highly regular spelling-to-sound correspondence.²

In the first experiment, we tried to replicate the results of Sebastián-Gallés (1991) by presenting words and pseudowords in a mixed list. However, unlike in her study, in ours both the consistent and the inconsistent pseudowords were derived from the same words. In Experiments 2 and 3 we manipulated list composition and presented participants with a list containing only pseudowords.

Experiment 1

Method

Materials. On the basis of a frequency count of Italian words (Bortolini, Tagliavini, & Zampolli, 1972), we selected 18 high-frequency ($M = 37.66$) and 18 low-frequency ($M < 1.78$) words. Each word included one of the following graphemes: *g*, *c*, or *sc* (see Appendix A). In Italian the pronunciation of these graphemes is governed by context-sensitive rules in that it depends on the following vowel or consonant. When followed by *a*, *o*, or *u* (or by a consonant), they are pronounced /g/, /k/ and /sk/,³ respectively; when followed by *e* or *i* they are pronounced /dʒ/, /tʃ/, and /ʃ/. From each of the words, we derived two pseudowords by changing the vowel following the target grapheme. In one of the two pseudowords the pronunciation of the target grapheme is the same as in the original word (consistent pseudoword), whereas the other has the alternative pronunciation (inconsistent pseudoword). To illustrate, from the word *delicato* (delicate) /delikato/, we derived the consistent pseudoword *delicoto* /delikoto/ and the inconsistent pseudoword *deliceto* /delitʃeto/. All the pseudowords thus constructed were legal and easily pronounceable. From the 72 pseudowords, we constructed two lists in such a way that each participant

² Unlike in Spanish, in Italian words are marked for stress only when the stressed syllable is the final one. As a consequence, stress is unambiguous for mono- and bisyllabic words, but it is lexically based for words with three or more syllables. For multisyllabic words there is a tendency, though, for the penultimate syllable to be the stressed one.

³ Strictly speaking, the letter cluster *sc* in this case comprises two graphemes.

saw only one pseudoword from each pair. In addition to the 36 experimental pseudowords, each list contained 10 filler pseudowords not containing the graphemes *c*, *g*, or *sc*, and 46 words. Of these, half were high-frequency words ($M = 101.10$) and half were low-frequency words ($M = 1.78$).

Participants and procedure. Forty-eight students from the University of Padova took part in the experiment. Each participant was randomly assigned to one of the two experimental lists and was instructed to read aloud each letter string. The experimental session was preceded by a short training session in which 10 words and 10 pseudowords were presented. These pseudowords did not contain the critical graphemes but presented other graphemes with context-sensitive pronunciation.

We used a Macintosh SE computer with a Telema voice key attached to the keyboard to present all stimuli and to record all responses. A microphone was attached to the voice key to record naming times, and a separate microphone was attached to a tape recorder to record the session. The presentation of the stimuli and the response recording were controlled by the PsychLab program (Version 0.85).

The stimuli appeared in capital letters in the center of the computer screen, preceded by a fixation point. They disappeared as soon as the participants started their vocal response.

Results

Two of the researchers (Francesca Peressotti and Remo Job) independently classified responses to the experimental items into four categories: correct responses, errors, lexicalizations, and hesitations, which we define below.

Following the procedure of Sebastián-Gallés (1991), we classified errors as critical if they occurred on the target graphemes (*c*, *g* and *sc*), irrespective of whether some of the other graphemes were misread as well; when only one or some of the nontarget graphemes were incorrectly read, the errors were classified as not critical.

A response was considered a lexicalization if a word was produced. They were considered a separate class, because they may reflect guessing strategies rather than reading failures.

Finally, a response was considered a hesitation when participants paused during the pronunciation of a given item. Such responses were not considered in the analyses on reaction times (RTs), but they were considered in the analyses on errors only when the final pronunciation was incorrect.

Mean reading times to correctly named pseudowords are reported in Table 1.

Table 1
Mean Reaction Times (in Milliseconds) for Reading Aloud in Experiment 1

Frequency	Pseudoword		Difference	Word
	Consistent	Inconsistent		
High	618	637	-19	518
Low	616	639	-23	566
Difference	2	-2		-48

Note. For pseudowords, frequency refers to original word frequency.

Table 2
Percentages of Errors to Pseudoword Stimuli in Experiment 1

Error type	Pseudoword	
	Consistent	Inconsistent
Critical	0.94	2.81
Noncritical	3.89	5.14
Lexicalizations	0.94	1.51
Total	5.78	9.46

Two analyses of variance (ANOVAs) were performed, one with participants ($F1$) and one with items ($F2$) as a random variable. An alpha level of .05 was chosen for this and all subsequent analyses. The variables considered were (a) consistency of the pseudowords and (b) frequency of the original words. Consistent pseudowords were named faster than inconsistent pseudowords: $F1(1, 47) = 7.49$, $MSE = 2,828.46$; $F2(1, 34) = 4.27$, $MSE = 1,315.23$. Neither the frequency of the original words from which pseudowords were derived (both $F1$ and $F2 < 1$) nor the interaction (both $F1$ and $F2 < 1$) was significant.⁴

Accuracy scores are reported in Table 2. The error rate was quite low if compared with that reported by Sebastián-Gallés (1991) or by Peereman (1991). An ANOVA by items on the arcsin transformed error proportions was performed with consistency and frequency as variables. The effect of consistency was marginally significant, $F(1, 34) = 2.93$, $MSE = 0.13$, $p = .093$. No other effects were significant (all other $F_s < 1$). More errors were made to consistent than to inconsistent items. It was not possible to further analyze errors with parametric statistical analyses because of the low occurrence of errors in some of the cells. However, sign tests on consistent versus inconsistent critical errors proved not to be significant.

Reading times to the word stimuli (see rightmost column of Table 1) were also submitted to an analysis with frequency as the only variable. High-frequency words were named more quickly than low-frequency words: $F1(1, 47) = 91.83$, $MSE = 590.66$; $F2(1, 44) = 26.18$, $MSE = 1,004.51$. Only one error was made to the word stimuli.

Naming inconsistent pseudowords took longer than naming consistent pseudowords. The pattern of RT results thus

⁴ The lack of the frequency effect for pseudowords might be due to a weak manipulation of the frequency of the original words from which the pseudowords were derived. To control for this, the 36 original words and 36 newly formed pseudowords derived by changing one vowel from real words were presented to 16 students to name. Presentation conditions were the same as those of Experiments 1 and 2. The high-frequency words were named significantly faster than the low-frequency words (574 vs. 596 ms): $F1(1, 15) = 15.39$, $MSE = 233.34$; $F2(1, 34) = 5.62$, $MSE = 766.63$.

replicates the consistency effect that Sebastián-Gallés (1991) and Peereman (1991) found for errors. Unlike those experiments, the present study had a low error rate, but the trend was the same in that more errors were made to inconsistent than to consistent items. Because each pair of consistent–inconsistent pseudowords was derived from a single word, preserving the initial phoneme, we can rule out the possibility that the consistency effect could be due to differences between the sets of words from which the experimental items were derived.

The most straightforward explanation of this result is that there is a lexical contribution to pseudoword reading also in shallow orthographies. As already pointed out, both single- and dual-route models of reading can explain the results. However, according to single-route models, lexical influence in reading pseudowords is an inevitable outcome of the pronunciation of known and novel letter strings being based on stored lexical instances. On the contrary, according to dual-route models, the involvement of the lexical and nonlexical route may differ as a function of list composition: The presence of words in the experimental lists may favor the use of the lexical route to a greater extent than when no words are present in the lists, thus enhancing the probability of lexical effects; the absence of words in the experimental list may favor the use of the nonlexical route, thus lowering the possibility of lexical effects.

In the next experiment we examined this issue by presenting the same set of pseudowords in a list in which words are not present. According to dual-route models, in this condition participants would rely more on the nonlexical route, and lexical effects should be attenuated or should disappear. However, single-route models would predict no relevant difference in the consistency effect because the information used to derive pseudoword pronunciation would be the same, independent of the stimulus list.

Experiment 2

Method

Materials. We used the same experimental pseudowords as in Experiment 1 but added 36 filler, novel pseudowords. The added pseudowords were derived by changing one letter from real words that do not contain the graphemes *c*, *g*, and *sc*, and they were matched for length to the experimental pseudowords. We constructed two experimental lists, each containing 36 experimental items (18 consistent and 18 inconsistent pseudowords) and 36 filler pseudowords, and a training list, consisting of 20 pseudowords, some of which contained graphemes with context-sensitive pronunciation other than *c*, *g*, and *sc*.

Participants and procedure. Forty-nine students from the University of Padova took part in the experiment, but one was excluded because she was mistakenly presented with the training list of Experiment 1. None had participated in Experiment 1. Each participant was randomly assigned to one of the two experimental lists. The procedure and the other details of the method are the same as in the previous experiment.

Results

Responses were classified and analyzed as in Experiment 1. Reading times to correctly named experimental items are

Table 3
Mean Reaction Times (in Milliseconds) for Reading Aloud in Experiment 2 (Pseudowords Only)

Frequency	Consistent	Inconsistent	Difference
High	560	559	1
Low	572	574	-2
Difference	-12	-15	

Note. Frequency refers to original word frequency.

reported in Table 3. No effect was significant; all $F_s < 1$ except for frequency, for which $F(1, 47) = 3.37$.

Errors are reported in Table 4. As in the previous experiment, an ANOVA was performed with consistency and frequency as the main variables. No effect reached significance: for consistency, $F(1, 34) = 2.29$; for frequency, $F < 1$; for the interaction, $F(1, 34) = 2.09$. Errors classified as not critical were approximately the same in terms of the inconsistent and consistent items. By contrast, more critical errors were made to inconsistent than to consistent items. It was not possible to test for this latter difference with parametric statistical analyses because of the low occurrence of errors in some of the cells. However, sign tests proved not to be significant.

No consistency effect is present in the RT data: Inconsistent items are named as fast as consistent items. Also no statistically significant consistency effects are present in the error data, although the trend is for inconsistent items to give rise to more errors than consistent items.

Ad Interim Considerations

The pattern of results stemming from the two Experiments can be summarized as follows.

1. A consistency effect in reading time is found when pseudowords are mixed with words but not when they are presented alone.
2. Inconsistent items tend to generate more errors than consistent items in the mixed list and less so in the “pure” list, but the two lists present a similar distribution of critical and noncritical errors.
3. The RTs to stimuli in the mixed list appear to be longer than RTs to stimuli in the pure list.
4. In the mixed list there is a strong effect of frequency for the word stimuli.
5. The frequency of the original words from which the pseudowords were derived does not affect naming times.

Table 4
Percentage of Errors to Experimental Items in Experiment 2 (Pseudowords Only)

Error type	Consistent	Inconsistent
Critical	0.59	3.18
Non-critical	4.07	4.01
Lexicalizations	0.48	0.24
Total	5.14	7.43

The present results can be interpreted as showing that in the pure list, pseudowords can be read independent of the pronunciation of known words. However, in the mixed list, lexical information activated by the orthographic representation interferes with pseudoword reading. Both the frequency effect reported in Number 4 in the above list and the increase in RTs reported in 3 can be considered evidence for the activation of lexical information. In particular, the latter effect can be thought of as the result of two possible outputs, one from the lexical route and the other from the nonlexical route, competing for the response (on this point see Monsell et al., 1992). As shown by the analogous pattern of the pseudowords derived from high- and low-frequency words, reported in 5, the interference produced by the lexical route is not modulated by the frequency of the potentially interfering words. The phonological form of such words, however, does exert an effect.

The fact that the consistency effect disappears in the pure list is explained by dual-route models by assuming that when only pseudowords are presented, participants can strategically rely to a larger extent on the nonlexical route. Because the involvement of the lexical route is decreased, no lexical interference occurs. However, current single-route models, which assume a unique pathway from print to sound, seem unable to account for these context effects.

One result that could be seen as inconsistent with the claim of a differential processing of pseudowords in the two experiments is the similar pattern of critical errors in both Experiments 1 and 2. It is thus relevant to assess the overall coherence of the pattern obtained. To this end we performed (a) a comparison between Experiments 1 and 2 and (b) an experiment in which we tried to increase the occurrences of errors in order to look more closely at the error distribution.

Comparing Experiments 1 and 2

The main difference between Experiment 1 and 2 is that a consistency effect in reading time is found only in the former, in which RTs are also longer than in the latter. To test for the reliability of such differences, we performed an ANOVA, with Experiments 1 and 2 as a between-subjects variable. The other two variables were consistency of the pseudowords and frequency of the original words. The effect of the experiment was significant, $F(1, 94) = 6.71$, $MSE = 54,199.52$. Participants took 62 ms longer to name the pseudowords when they were presented in Experiment 1 (mixed list) than when they were presented in Experiment 2 (pure list). Also, the consistency effect was significant, $F(1, 94) = 4.78$, $MSE = 2,244.40$. This effect was qualified by the Experiment \times Consistency interaction, $F(1, 94) = 4.67$, $MSE = 2,244.40$, which reflected the fact that the consistency effect was present only in Experiment 1. No other effect or interaction was significant. A further analysis was conducted with items as the random variable. The Experiment \times Consistency interaction was not significant, $F(1, 34) = 1.63$, $MSE = 916.41$, $p = .21$. However, planned comparisons among the means showed that consistent and inconsistent items differed in Experiment 1, $F(1, 34) = 6.13$,

$MSE = 916.41$, but not in Experiment 2, $F(1, 34) = 0.44$, $MSE = 916.41$.

The analyses support our interpretation of the pattern of RTs in the two experiments. A consistency effect arises only when pseudowords are mixed with words.

Experiment 3

In this experiment we further investigated the pattern of errors when the stimulus list contained only pseudowords. In Experiment 2, contrary to what happens for RTs, the error pattern was in the direction of a consistency effect nearly of the same size as in Experiment 1. However, the rate of errors was too low to draw definite conclusions. The global error rates obtained in Experiments 1 and 2 are 7.6% and 6.3%, respectively. This is what is generally found in most naming experiments, but it is much lower than the rate of about 30% reported by Sebastián-Gallés (1991) and by Peereman (1991). Although we find such a rate somewhat surprising for the unlimited viewing condition they used, in Experiment 3 we tried to increase error rate by shortening the presentation time of the stimuli and by masking them.

Furthermore, to generalize the results obtained in Experiment 2, we created a new set of experimental pseudowords, which are listed in Appendix B. The creation of this new set was based on the following criteria. First, all the original words from which pseudowords were derived were trisyllabic words with the stress on the penultimate syllable. Second, the letter sequence following the critical letter in the consistent and inconsistent items occurred with approximately equal frequency in trisyllabic Italian words. For example, for the pair *pagilla*–*pagolla*, the letter sequences *-illa* and *-olla* occur in final position in 13 and 8 words, respectively. Third, for each consistent and inconsistent pseudoword, there is at least one Italian word that begins with the same letter sequence up to the critical letter. For example, no pseudowords derived from the word *bancario* /bankario/ (bank employee) were used, because no Italian word begins with the sequence /bantf-/. Fourth, none of the pseudowords had neighbors except for the word from which they were derived.⁵

Method

Materials. Sixteen high-frequency ($M = 37.69$) and 16 low-frequency ($M = 0.59$) words were selected (see Appendix B). Six of them were also used in the previous experiments. These were *figura*, *licenza*, *laguna*, *fucile*, and *pagella*. All words were trisyllabic, with the stress on the penultimate syllable. Half of them contained the critical grapheme *c* and half of them contained the critical grapheme *g*.⁶ Consistent and inconsistent pseudowords were derived from these words in the same way as in Experiments 1 and 2. All the pseudowords were legal and easily pronounceable. Two lists were constructed from the 64 pseudowords, and each

⁵ There was an exception for the pseudoword pair *rigure*–*rigere*, which had one more neighbor (*rigare*, to rule).

⁶ Because it was impossible to find words containing the letter cluster *sc*, which responded to the selection criteria, no words containing such clusters were used.

participant saw only 1 pseudoword from each pair. In addition to the 32 experimental pseudowords, each list contained 32 filler pseudowords, matched for length with the experimental pseudowords, derived by changing one letter to words that did not contain the grapheme *c* or *g*.

Participants and procedure. Thirty-six students from the University of Padova took part in the experiment. None of them had participated in the previous experiments. They were told in advance that only pseudowords would be presented. They were then exposed to a training list consisting of 20 pseudowords not included in the experimental material, and after that they were randomly assigned to one of the two experimental lists. Each of these had two different fixed random orders of item presentation.

Each trial consisted of the following events. A fixation point at the center of the screen was first displayed for 400 ms. The stimulus to be named followed at the same location for 200 ms, and it was replaced by a mask, which remained on the screen until response. The mask was a line of nine hash marks that covered a region of space slightly larger than the stimuli. The other details of the method were the same as those in the previous experiments.

Results

Responses were classified as in Experiments 1 and 2. The RTs and errors scores are reported in Tables 5 and 6, respectively.

No difference to consistent and inconsistent items was found for both RTs and errors. An ANOVA on RTs with consistency and frequency as within-subject variables confirmed this claim ($F_s < 1$ in both ANOVAs by item and by participants). No analysis was performed on errors given that error rate was the same for consistent and inconsistent stimuli.

Shortening the stimulus presentation time and masking the stimuli increased error rate, which now reached 17.53% of total responses. However, such an increase did not affect consistent and inconsistent items differently. Thus, these results nicely complement those of Experiment 2 by showing no consistency effect in reading pseudowords when the experimental list does not contain words.

Data inconsistent with the present ones have been reported by Content and Peereman (1992, Experiment 2), who found lexical effects in naming pseudowords even when only pseudowords were included in the stimulus set. There are three aspects of their work that should be emphasized. First, the language they used was French, a language with a highly irregular print-to-sound mapping. So, even if they did consider a rule-based aspect (the pronunciation of the letter *g*), it may still be possible that in deep-orthography languages, reliance on lexical knowledge is stronger (Katz &

Table 6
Percentage of Errors to Experimental Items in Experiment 3 (Pseudowords Only)

Error type	Consistent	Inconsistent
Critical	1.04	1.57
Non-critical	13.71	14.24
Lexicalizations	3.12	2.08
Total	17.87	17.89

Feldman, 1981; Katz & Frost, 1992). Second, as the authors themselves pointed out, the consistency effect obtained is weaker than the effect obtained when similar pseudowords are presented with words (Peereman, 1991). Finally, the comparison between their study and ours should be made with caution because of differences in the control condition. In our study the consistent and the inconsistent items control for each other because they are derived from the same lexical item. The control condition in Content and Peereman's study is instead given by pseudowords that differ from the critical pseudoword for some of the noncritical letters (e.g., *ganéloque* vs. *ganétique* for *génétique*), and thus no data on consistent items are available.

General Discussion

When participants are asked to read Italian pseudowords containing letters with a context-dependent pronunciation, they are affected by the pronunciation of similar words if the experimental list contains both pseudowords and words. This consistency effect is significant both in naming latencies, with longer latencies to inconsistent items, and in the error distribution, with more errors associated with the inconsistent items. When the same set of pseudowords is presented in a list in which only pseudowords are included, consistency does not affect either naming latencies (Experiment 2) or error rates (Experiment 3).

These results replicate and extend the findings of both Sebastián-Gallés (1991) and Peereman (1991) in two ways. On the one hand, keeping performance to a high level of accuracy, we found the consistency effect for letters having rule-based but alternative pronunciations also to affect naming latencies. On the other hand, having derived from a single word both the inconsistent and the consistent pseudowords, we are confident that the effect obtained is not to be ascribed to some uncontrolled properties of the original words. The important qualification that our experiments add to such an effect in shallow orthographies is that it is obtained only under some experimental conditions, namely, those that require processing of both pseudowords and words in the same list.

The present results show that lexical information is *directly* activated during reading in shallow orthographies. Such an activation is automatic, is driven by the orthographic representation (but see Lukatela & Turvey, 1991, Perfetti & Bell, 1991, and Van Orden, Johnston, & Hale, 1988, for different views), and is responsible for the

Table 5
Mean Reaction Times (in Milliseconds) for Reading Aloud in Experiment 3 (Pseudowords Only)

Frequency	Consistent	Inconsistent	Difference
High	452	458	-6
Low	467	462	5
Difference	-15	-4	

Note. Frequency refers to original word frequency.

interference of lexical information on pseudoword reading. The frequency effect for words in the mixed list supports the hypothesis of lexical involvement in shallow orthographies. However, the lack of interference in the pure list suggests that this is not the only means by which a phonological form may be obtained and that reading pseudowords may be accomplished independent of known words through the phonological translation of the orthographic subcomponents of the letter strings.

Evidence for the availability of different routes in reading aloud has been provided in languages such as Persian and Italian. Baluch and Besner (1991) have exploited a peculiarity of the Persian language in which words can include or omit vowels in their spelling, resulting in phonologically transparent words and phonologically opaque words, respectively. In a naming task, semantic priming effects and frequency effects were obtained for both types of stimuli when the list to be read included only words, suggesting a lexically based reading procedure for all the stimuli. However, when pseudowords were also included, semantic priming and frequency effects were obtained only for the opaque words, thus indicating that transparent words and pseudowords were read by means of a nonlexical procedure. Furthermore, although there was no frequency effect for the words when they were mixed with pseudowords, indicating that participants relied on the nonlexical route for reading both types of stimuli, a frequency effect was obtained when transparent words were presented alone. This latter result may be seen as inconsistent with our claim that in Experiment 1, where words and pseudowords were mixed, our participants relied on the lexical route for reading words. However, the discrepancy is only apparent. In fact, as reported in Footnote 2, for words with three or more syllables, stress assignment is lexically based in Italian. In our study, most stimuli were three-syllabic words, so that correct pronunciation of these stimuli required lexical knowledge. It is worth noting that there were no stress-assignment errors to the word stimuli in Experiment 1.

The switch from nonlexical to lexical reading in Italian has also been shown by Tabossi and Laghi (1992), who used a semantic priming paradigm. In their study, when a few of the to-be-named words required stress assignment to be lexically based, priming effects were obtained. Instead, when only regularly stressed bisyllabic words were used, the priming effects disappeared.

The pattern of results reported here is consistent with at least two versions of a dual-route model of reading. According to the first, a letter string is processed in a horse-race fashion by both the lexical and the nonlexical route. For some classes of stimuli (i.e., pseudowords and exception words), only one of the two routes produces a result, whereas for other classes of stimuli (i.e., regular words), both routes can accomplish the task, with the fastest of the two providing the final result (Baluch & Besner, 1991; Coltheart, 1987; Paap et al., 1992). The two routes work independently, but at some point the two procedures share a processing stage, and this may cause interference effects. Specifically, these interference effects can be brought about

by a pseudoword causing, on some proportion of trials, either the activation of a unit in the semantic system (i.e., Rosson, 1983), or the activation of entries in the phonological output lexicon by the orthographic input lexicon (i.e., Paap & Noel, 1991). In the former case, a word similar to the pseudoword stimulus may be erroneously activated in the semantic system, which in turn activates an entry in the phonological output system. In the latter case, the activation of an addressed phonological form would be accomplished directly from the orthographic input lexicon, through a direct connection postulated to account for reading without comprehension (e.g., Schwartz, Saffran, & Marin, 1980). In both cases, the information derived from the nonlexical route and the information available through the phonological output lexicon interfere, and either an error or a delay in naming should be expected.

In the literature, two candidates have been proposed as the stage common to the lexical and the nonlexical routes and hence as the locus of possible interference effects: The phonological output buffer (Patterson & Morton, 1985) and the phonological output lexicon (Hillis & Caramazza, 1991). The present data appear inconsistent with Hillis and Caramazza's proposal because their proposal cannot explain why the effect is absent in pure lists. According to their architecture, pseudowords should *always* activate similar words represented in the phonological output lexicon, thus producing a consistency effect independent of list composition. The pattern we obtained is instead compatible with Patterson and Morton's proposal. In their view, the phonological output buffer temporarily stores segmented phonological units to allow for the actual pronunciation of the stimuli. Therefore, it is involved in reading both words and pseudowords. In our study, when consistent pseudowords are presented, the nonlexical route and the lexical route—if activated—feed the response buffer with the same code for the pronunciation of the critical grapheme, and thus the response can be given without delay; however, with inconsistent pseudowords the two routes feed the response buffer with different codes for the pronunciation of the critical grapheme, and the resulting conflict causes a response delay. This conflict is quite frequent when the lexical and the nonlexical routes are both necessary to carry out the task (Experiment 1, mixed list), but it decreases if participants may rely exclusively on the nonlexical route (Experiments 2 & 3, pure list).

According to the second version of dual-route models, recently argued for by Coltheart et al. (1993), the interference effect is instead the result of the system working in a cascade fashion (McClelland, 1979). In Coltheart et al.'s computational model, it is assumed that pseudowords partially activate recognition word units of visually similar words and these, in turn, activate the corresponding phonological word units. At this point, in the phonological buffer common to both the lexical and the nonlexical routes, there is some activation due to the lexical system, in addition to the activation derived from the nonlexical procedure. In case of competing pronunciations from the two routes, there is interference between the two outputs and a delay in naming. The architecture of the model predicts that the locus of the

interference is at the level of the phoneme system, which corresponds to the phonological buffer in Patterson and Morton's (1985) terminology. Therefore, the horse-race and the cascade models make the same predictions as to the locus of the consistency effect.

In conclusion, our pattern of data is better accounted for within a dual-route framework. Although the computational nature of the cascade model makes it more appealing, the horse-race model is more in keeping with the original version. Our results do not allow us to choose between the two, and future research is needed to determine the range of empirical data that can be explained by each of them.

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Appendix A

Experimental Pseudowords Grouped by Frequency of Original Word and by Pronunciation of Target Grapheme(s)

Frequency	Original word	Pseudoword		Frequency	Original word	Pseudoword	
		Consistent	Inconsistent			Consistent	Inconsistent
	/k/	/k/	/tʃ/		/dʒ/	/dʒ/	/g/
High	<i>delicato</i> <i>mercato</i> <i>pecora</i>	DELICOTO MERCOTO PECARA	DELICETO MERCETO PECIRA	High	<i>legittimo</i> <i>logica</i> <i>oggetto</i>	LEGETTIMO LOGECA OGGITO	LEGUTTIMO LOGACA OGGOTTO
Low	<i>binocolo</i> <i>macula</i> <i>locanda</i>	BINOCALO MACALA LOCUNDA	BINOCILO MACILA LOCENDA	Low	<i>pagella</i> <i>flagello</i> <i>turgido</i>	PAGILLA FLAGILLO TURGEDO	PAGOLLA FLAGOLLO TURGADO
	/tʃ/	/tʃ/	/k/		/sk/	/sk/	/ʃ/
High	<i>fulcile</i> <i>principe</i> <i>licenza</i>	FUCELE PRINCEPE LICINZA	FUCOLE PRINCOPE LICANZA	High	<i>biscotto</i> <i>motoscafo</i> <i>discorso</i>	BISCUTTO MOTOSCOFO DISCURSO	BISCITTO MOTOSCEFO DISCERSO
Low	<i>sfacelo</i> <i>facezia</i> <i>tricipite</i>	SFACILO FACIZIA TRICEPITE	SFACALO FACOZIA TRICUPITE	Low	<i>microscopio</i> <i>moscato</i> <i>discorde</i>	MICROSCAPIO MOSCOTO DISCARDE	MICROSCIPIO MOSCITO DISCERDE
	/g/	/g/	/dʒ/		/ʃ/	/ʃ/	/sk/
High	<i>figura</i> <i>negozio</i> <i>drogato</i>	FIGORA NEGUZIO DROGOTO	FIGERA NEGEZIO DROGITO	High	<i>disciplina</i> <i>miscela</i> <i>nascita</i>	DISCEPLINA MISCILA NASCETA	DISCAPLINA MISCOLA NASCUTA
Low	<i>laguna</i> <i>canguro</i> <i>sagoma</i>	LAGANA CANGARO SAGUMA	LAGENA CANGERO SAGIMA	Low	<i>mascella</i> <i>proscenio</i> <i>viscido</i>	MASCILLA PROSCINIO VISCEDO	MASCALLA PROSCONIO VISCADO

Appendix B

Experimental Pseudowords Grouped by Frequency of Original Word and by Pronunciation of Target Grapheme(s)

Frequency	Original word	Pseudoword		Frequency	Original word	Pseudoword	
		Consistent	Inconsistent			Consistent	Inconsistent
	/k/	/k/	/tʃ/		/g/	/g/	/dʒ/
High	<i>sicuro</i> <i>balcone</i> <i>vacanza</i> <i>incontro</i>	SICORO BALCUNE VACONZA INCUNTRO	SICIRO BALCENE VACINZA INCINTRO	High	<i>agosto</i> <i>ragazzo</i> <i>rigore</i> <i>figura</i>	AGASTO RAGOZZO RIGURE FIGORA	AGESTO RAGEZZO RIGERE FIGIRA
Low	<i>mucosa</i> <i>falcata</i> <i>sarcasmo</i> <i>tucano</i>	MUCASA FALCOTA SARCUSMO TUCUNO	MUCISA FALCETA SARCESMO TUCINO	Low	<i>dogana</i> <i>fagotto</i> <i>inganno</i> <i>laguna</i>	DOGONA FAGUTTO INGUNNO LAGONA	DOGENA FAGITTO INGINNO LAGENA
	/tʃ/	/tʃ/	/k/		/dʒ/	/dʒ/	/g/
High	<i>fulcile</i> <i>preciso</i> <i>sincero</i> <i>licenza</i>	FUCELE PRECESO SINCIRO LICINZA	FUCOLE PRECASO SINCARO LICANZA	High	<i>regina</i> <i>argento</i> <i>agente</i> <i>vigilia</i>	REGENA ARGINTO AGINTE VIGELIA	REGUNA ARGONTO AGUNTE VIGALIA
Low	<i>marcita</i> <i>lucerna</i> <i>forcina</i> <i>nocivo</i>	MARCETA LUCIRNA FORCENA NOCEVO	MARCOTA LUCURNA FORCANA NOCOVO	Low	<i>angina</i> <i>degenza</i> <i>sigillo</i> <i>pagella</i>	ANGENA DEGINZA SIGELLO PAGILLA	ANGUNA DEGANZA SIGOLLO PAGOLLA