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Orthography Affects Second Language Speech: Double Letters and Geminate Production in English

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Keywords
Orthography; phonology; speech production; second language; grapheme–phoneme correspondences

Abstract

Second languages (L2s) are often learned through spoken and written input, and L2 orthographic forms (spellings) can lead to non-native-like pronunciation. The present study investigated whether orthography can lead experienced learners of English$_{L2}$ to make a phonological contrast in their speech production that does not exist in English. Double consonants represent geminate (long) consonants in Italian but not in English. In Experiment 1, native English speakers and English$_{L2}$ speakers (Italians) were asked to read aloud English words spelled with a single or double target consonant letter, and consonant duration was compared. The English$_{L2}$ speakers produced the same consonant as shorter when it was spelled with a single letter, and longer when spelled with a double letter. Spelling did not affect consonant duration in native English speakers. In Experiment 2, effects of orthographic input were investigated by comparing two groups of English$_{L2}$ speakers (Italians) performing a delayed word repetition task with or without orthographic input; the same orthographic effects were found in both groups. These results provide arguably the first evidence that L2 orthographic forms can lead experienced L2 speakers to make a contrast in their L2 production that does not exist in the language. The effect arises because L2 speakers are affected by the interaction between the L2 orthographic form (number of letters), and their native orthography–

phonology mappings, whereby double consonant letters represent geminate consonants. These results have important implications for future studies investigating the effects of orthography on native phonology and for L2 phonological development models.

1 Effects of Orthographic Forms on Second Language Speech Production

Learning the phonology of a second language (L2) is a difficult task. Importantly, second languages are often learned through both spoken and written input, and L2 orthographic forms (spellings) can interfere with the acquisition of L2 phonology. But could orthographic forms even lead L2 speakers to produce speech sounds that do not exist in the L2?

Recent research shows that L2 orthographic forms affect the perception and production of L2 speech sounds, and can lead to non-native-like pronunciation, especially in the early stages of L2 learning (Bassetti, 2008; Bassetti, Escudero, & Hayes-Harb, 2015). For instance, speakers of American English$_{L2}$ can produce the same target flap /ɾ/ as [t] when the spelling is <t> and as [d] when the spelling is <d>, as in *beauty* and *lady* (Vokic, 2011). Some substitutions are caused by incongruences between native language (L1) and L2 grapheme–phoneme correspondences (relationships between letters or letter clusters and sounds). This happens because speakers incorrectly assimilate an L2 phoneme with an L1 phoneme when they are represented by the same grapheme. For example, some English$_{L1}$ beginner learners of Spanish$_{L2}$ produce [v] in Spanish words spelled with a <v>, because this is what the grapheme <v> represents in their native English, whereas in Spanish it represents [b], and [v] does not exist (Zampini, 1994). Such effects of native grapheme–phoneme correspondences have been found repeatedly in language learners (Pytlyk, 2011), including advanced speakers learning L2 pseudowords (Escudero, Hayes-Harb, & Mitterer, 2008), even leading beginners to produce sounds that do not exist in the target language (Zampini, 1994).

The effect of orthography on L2 phonology must be understood for effective research into both L1 phonology and L2 phonological development. There is growing evidence that orthography affects L1 phonology (e.g., Rastle, McCormick, Bayliss, & Davis, 2011; but see e.g. Alario, Perre, Castel, & Ziegler, 2007). However, evidence from L2 speakers may be quantitatively and qualitatively different. Quantitatively, effects in L2 speakers may be stronger than in native speakers, because instructed L2 learners are usually exposed to orthographic input from the early stages of learning, and often in large amounts. Qualitatively, because L2 learners encounter L2 orthographic forms after becoming literate in a first language, they may decode the L2 orthographic forms using the mapping between the orthographic and phonological units of their first language. Such inter-orthographic effects cannot occur in monolingual native speakers. The current dominant models of L2 phonological development—the Speech Learning Model (Flege, 1995) and the Perceptual Assimilation Model (Best & Tyler, 2007)—do not address orthographic input. More data are needed for a meaningful theoretical debate of the effects of orthography on L2 phonology, and to allow L2 phonology studies to contribute to the understanding of native phonology.

2 The Present Study

In the Italian language, consonant length is contrastive, with singleton (short) and geminate (long) consonants distinguished by relative phonetic duration (Laver, 1994). This means that phonetically short and long consonants distinguish minimal word pairs—those differing in only one phoneme; for instance, a short /t/ and a long /tː/ distinguish the words /nɔte/ and

/nɔtːe/ (‘notes’ and ‘night’; Clark & Yallop, 1995). This phonological contrast is represented orthographically by single letters for singleton consonants and double letters for geminate consonants (<note> and <notte>). In the English language, consonants with different lengths are different realizations of the same phoneme (Laver, 1994), and double consonant letters do not represent consonantal length.

Language learners sometimes recode L2 spellings using L1 grapheme–phoneme correspondences. The aim of the present study was to determine whether L2 spellings can cause experienced learners of $English_{L2}$ to make a phonological contrast in their L2 speech production that does not exist in English; namely, whether they would distinguish two sounds where there should only be one.

To this end, $Italian_{L1}$ speakers of $English_{L2}$ were presented with English words spelled with a single or double consonant letter to determine whether they would produce geminates in the double-letter words; for example, producing a longer [t] in *kitty* than in *city*. If Italians systematically produced the same target English consonant as longer when spelled with a double letter, this would indicate that they have established a contrast between geminate and singleton consonants in their L2 English phonological system that does not exist in the language. This would happen because they are affected (a) by the number of consonant letters in an L2 word, and (b) by their L1 grapheme–phoneme correspondences (whereby double consonant letters represent geminates).

This is arguably the first study to test whether inter-orthographic effects result in experienced L2 speakers making a phonological contrast in their L2 production that does not exist in the target language. The characteristics of the study are described below.

First, the approach is experimental. A previous descriptive study reported anecdotal evidence of a long [pː] in the word *apple* produced by primary school learners of English in a reading aloud task (Browning, 2004). The present study tested this orthographic effect experimentally, by manipulating orthographic forms.

Second, participants were experienced L2 learners who had been studying the L2 for most of their lives, and the target words were real words. To date, research on L2 orthographic effects has focused on naïve and beginner learners (e.g., Pytlyk, 2011; Young-Scholten, 2002), or experienced speakers producing pseudowords (Escudero et al., 2008). Evidence from experienced L2 speakers producing real words is needed to understand the influence of orthography beyond the early stages of acquisition.

Third, the study investigated an orthography-induced phonological contrast that does not exist in the phonological system of the target language. Although there is evidence that beginner learners and naïve learners of novel languages may make phonological contrasts that do not exist in the target language (Zampini, 1994), there is arguably no experimental evidence of such a phenomenon in experienced L2 speakers. Vokic (2011) is the closest example, but the study showed that experienced L2 speakers produce the same sound as [t] or [d], a contrast that exists in the target language. Importantly, models of L2 phonological development focus on explaining how L2 contrasts are learned, particularly when the L1 has only one category corresponding to two categories in the L2. The present study instead investigates a contrast that does not exist in the L2, as the L2 has one category corresponding to two categories in the L1. If such a contrast is demonstrated beyond the early stages of acquisition, this finding will have implications for models of L2 phonological development.

3 Experiment 1

3.1 Method

3.1.1 Participants. Thirty Italian high-school learners of English (males = 83%; age: *M* = 17 years 2 months, *SD* = 8 months) and 30 native speakers of British English (males = 43%, age: *M* = 23 years 10 months, *SD* = 100 months) participated in the study. They reported no visual, reading or language difficulties. Italians were chosen because they are likely to be affected by L2 orthographic forms, owing to being native users of a writing system that has regular mappings between orthography and phonology (Erdener & Burnham, 2005). The Italian participants were native speakers of the Roman variety of standard Italian. This variety was chosen because its geminate consonants are phonetically about twice as long as corresponding singletons (Esposito & Di Benedetto, 1999), and are therefore more clearly distinguished from singletons than in other varieties of Italian.
The Italian participants were studying English as a compulsory school subject, with three hours a week of classes covering language and literature. Their textbooks and related audio and video files were in British English. Respondents (*n* = 28; two participants did not answer) had been studying English for an average of 11 years 6 months (*SD* = 34 months). The median length of study with native teachers was 33 months. Half of the respondents (54%) had never been in an English-speaking country; the other half had stayed in an English-speaking country for a median duration of 1 month. Respondents reported spending three times longer listening to English than reading it, including listening to pop songs and watching movies (*Mdn* = 6 versus 2 hr a week). Most respondents (86%) rated native-like pronunciation as 'important' or 'very important'.

3.1.2 Materials. Eighteen English words (nine word pairs), each containing a target voiceless stop consonant (see Appendix), were created by manipulating the number of consonant letters (singleton or double) and type of voiceless stop consonant ([p], [t], [k]). There were three word pairs for each of the three consonants.
Within each pair, the same target consonant appeared in both words in the same intervocalic context and with the same stress pattern, but in one word ('C-word') it was spelled with a single consonant letter and in the other ('CC-word') with a double consonant letter, e.g. [t] in *city* and *kitty*. Overall, the words were more frequent in written than spoken language (spoken/written frequency ratios: $Mdn_{\text{C-words}} = 0.43$; $Mdn_{\text{CC-words}} = 0.70$), and C-words were more frequent overall than CC-words (see Appendix). To obtain a representative sample of English words, the selection of words took into account variables that may affect consonant duration, as follows: (a) word length: seven word pairs were disyllabic, one trisyllabic, and one quadrisyllabic (segments may be shorter in longer words); (b) primary lexical stress position: target consonants occurred in post-tonic position in seven pairs, and in pre-tonic or stressed position in the other two (in Italian, closure durations tend to be longer in post-tonic positions); (c) L1–L2 orthographic congruence. The phonological form of an L1 word may affect the pronunciation of an L2 cognate, thus confounding the effects of orthography. For this reason, of the four CC-words that were loanwords or cognates, three were orthographically congruent (spelled with a double letter in both languages, e.g. *occupy*,

cognate of *occupare*), and one was orthographically incongruent (spelled with a double consonant letter in English but not in Italian: *pepper*, cognate of *pepe*).

3.1.3 Task and procedure. Participants received a printed list of target words, and produced each word orally three times within the carrier sentence *The word ___ is missing*. The carrier sentence placed the target word in the nuclear position within the intonational unit. The three repetitions were used to calculate a mean duration for each target consonant, as measures from single productions may be unreliable.
Participants were tested individually in a quiet, light room. They read the words in the same order. Responses were recorded using either a Boss Micro BR digital recorder with a Shure SM58 microphone, or a Zoom H4N Pro digital recorder with a Harman AKG HSD 171 microphone.
This project received ethical approval by the University of York Department of Education Ethics Committee.

3.2 Data analysis

The acoustic analysis of the target consonants was performed by measuring the duration of closures from the onset of silence to the point of release using Praat software (Boersma & Weenink, 2005). Closure duration was chosen because it is the primary phonetic clue to gemination in Italian (Pickett, Blumstein, & Burton, 1999). For each target consonant, the mean closure duration was obtained from measurements of the three repetitions of the word. Four percent of data could not be analyzed because the target word was pronounced incorrectly or because the recording was of insufficient quality for acoustic analysis due to sudden background noise such as a chair moving (total: 45/1080). Data were analyzed by one of two trained phoneticians, one of whom was blind to the hypothesis. The two phoneticians' intraclass correlation coefficient, based on the analysis of 13.3% of data from each group (n = 72 mean closure durations), was 0.91, 95% CI [0.86, 0.94], $F(71, 71) = 12.27$, $p < .001$

3.3 Results

Table 1 shows the mean closure duration of target consonants by first language and consonant spelling.

Table 1
Mean Consonant Closure Duration (in Milliseconds; Standard Deviation in Brackets) as a Function of Consonant Spelling (Single Letter or Double Letter) and First Language (English Native Speakers or Italian$_{L1}$ Speakers of English$_{L2}$)

	Consonant spelling	
First language	**Single letter**	**Double letter**
Native English speakers	75 (12)	72 (9)
Italian$_{L1}$ speakers of English$_{L2}$	60 (9)	94 (15)
All	67 (13)	83 (16)

Mean closure durations were analyzed using a multi-level ANOVA with first language as the

between-group factor (native English speakers, Italian$_{L1}$ speakers of English$_{L2}$) and consonant spelling as the within-group factor (single letter, double letter). There was no main effect of first language, $F_1(1, 58) = 1.44$, $p = .236$, $F_2(1, 16) < 1$. The main effect of consonant spelling, $F_1(1, 58) = 120.83$, $p < .001$, partial $\eta^2 = .68$, $F_2(1, 16) = 2.12$, $p = .165$, partial $\eta^2 = 0.12$, was qualified by the interaction, $F_1 (1, 58) = 180.01$, $p < .001$, partial $\eta^2 = .76$, $F_2 (1, 16) = 32.69$, $p < .001$, partial $\eta^2 = .67$. This showed that Italian$_{L1}$ speakers of English$_{L2}$ produced longer consonants when the target consonant was spelled with a double letter than when it was spelled with a single letter, whereas English native speakers' consonant duration was not affected by spelling.

For each participant, a mean geminate/singleton ratio was calculated by dividing the mean closure duration of the CC-consonant by the mean closure duration of the C-consonant within each pair. The mean ratio was 0.99 for the English group ($SD = 0.08$), and 1.66 for the Italian group ($SD = 0.31$).

To ensure that the Italians' gemination in English words was not due to gemination in cognate words in their native language, the geminate/singleton ratios in the three word pairs whose CC-word was an orthography-congruent cognate or a loanword were compared with the ratios of the other word pairs containing the same target consonant. The ratio was larger for the pair containing the loanword *floppy* than for the other /p/ word pairs ($M_{loanword} = 1.88$, $SD = 0.42$; $M_{other} = 1.58$, $SD = 0.39$, $t(29) = 4.11$, $p < .001$). No other differences were found.

3.4 Discussion

The results confirmed predictions that experienced Italian$_{L1}$ speakers of English$_{L2}$ make a phonological contrast between short and long consonants in their English$_{L2}$ production. Participants recoded L2 English double consonant letters according to L1 Italian grapheme–phoneme correspondences, where double consonant letters represent geminate consonants. This resulted in the target consonant being produced as a geminate even though English does not have a singleton–geminate contrast. Acoustic analysis confirmed that this contrast is unattested in native speaker production, as there was no difference in the closure duration of consonants spelled with one or two letters in the native speaker sample. Although long and short consonants are different realizations of the same phoneme to native English speakers, they appear to be different phonemes in the English$_{L2}$ phonological system of native Italian speakers, who produce the same target consonant as shorter or longer, depending on its spelling. As Table 1 shows, Italians' English$_{L2}$ production featured short consonants ($M_{C\text{-}consonant} = 60$ ms) and long consonants ($M_{CC\text{-}consonant} = 94$ ms), whereas native speakers' duration was in-between ($M_{C\text{-}consonant} = 75$ ms; $M_{CC\text{-}consonant} = 72$ ms).

The first experiment revealed orthographic effects in the production of consonants during a reading aloud task. The second experiment tested whether these orthographic effects were modulated by the presence or absence of orthographic input. In learners of novel languages (Young-Scholten, 2002), beginner L2 learners (Zampini, 1994) and experienced L2 speakers producing pseudowords (Rafat, 2016), orthographic effects are stronger if orthographic input is provided, compared with tasks with no orthographic input. However, it is not known whether the presence of orthographic input affects experienced L2 speakers producing real words. If orthographic effects in experienced L2 speakers are stronger—or indeed only appear—in the presence of orthographic input, such effects may be attributed to L1 influences on the online recoding of L2 orthographic forms. If, however, orthographic effects are the same with or without orthographic input, various explanations are possible: instructed L2 learners may have orthography-influenced phonological representations of L2 words, or they may activate orthographic representations when producing speech, or both. To test for

the effects of the presence or absence of orthographic forms, participants in this study produced the same target words in one of two delayed word repetition tasks: with only acoustic input, or with both acoustic and orthographic input.

4 Experiment 2

4.1 Method

4.1.1 Participants. Sixty Italian high-school learners of English (males = 57%; age: *M* = 17 years 0 months, *SD* = 8 months) were recruited from the same school as the participants in Experiment 1. They were randomly allocated to two groups (both *n* = 30): one group performed the delayed word repetition task without orthographic input, and one group performed it with orthographic input. The two groups did not differ in any of the biographical or language learning variables analyzed (all *p*s = ns), therefore these variables are reported here for all participants. Questionnaire respondents (*n* = 56; four did not answer) had been studying English for an average of 12 years 0 months (*SD* = 46 months). The median length of study with native teachers was 11 months, and the median length of stay in an English-speaking country was 2.5 months. Respondents reported spending more time listening to English than reading it (*Mdn* = 3 versus 2 hr per week). The majority (91%) rated native-like pronunciation as 'important' or 'very important'.

4.1.2 Materials. The same 18 words were used as in Experiment 1. Each target word was illustrated by an image and presented orally within a six-word phrase (see Appendix). Phrases were recorded by a male native speaker of Standard British English, whose closure durations did not differ in words spelled with singleton or double letters. For each phrase, a truncated version was obtained by deleting the target word and all words following it from the audio recording.

4.1.3 Tasks. Participants performed one of two delayed word repetition tasks, which varied in the type of input (acoustic only, or acoustic and orthographic). Figure 1 shows a graphical representation of the tasks.

Delayed word repetition without orthographic input. In this task, participants first repeated a phrase (or clause or sentence) containing a target word, and then produced the target word again in a carrier sentence. First, an image (e.g. a condiment set) appeared on screen, and remained there until the end of the trial. After clicking a button on the screen, participants heard a phrase through their headphones (e.g. *salt and pepper, oil and vinegar*). Participants counted backwards from seven to one in English and then repeated the phrase. Backwards counting was used to eliminate traces of the phonological input from memory. If needed, they could hear the phrase again up to two more times, by clicking the on-screen buttons. After repeating the phrase, they clicked another button, and heard the truncated version. Their task was to recall the first missing word and to produce it orally within the carrier sentence *The word ___ is missing* three times. For instance, after hearing and repeating *salt and pepper, oil and vinegar*, they heard *salt and* and produced *the word pepper is missing* three times.

Delayed word repetition with orthographic input. This task was the same as the previous one, except that the orthographic form of the phrase appeared on screen simultaneously with the acoustic input. The orthographic form of the complete phrase disappeared simultaneously with the end of the complete audio recording. The truncated version did not contain the target word.

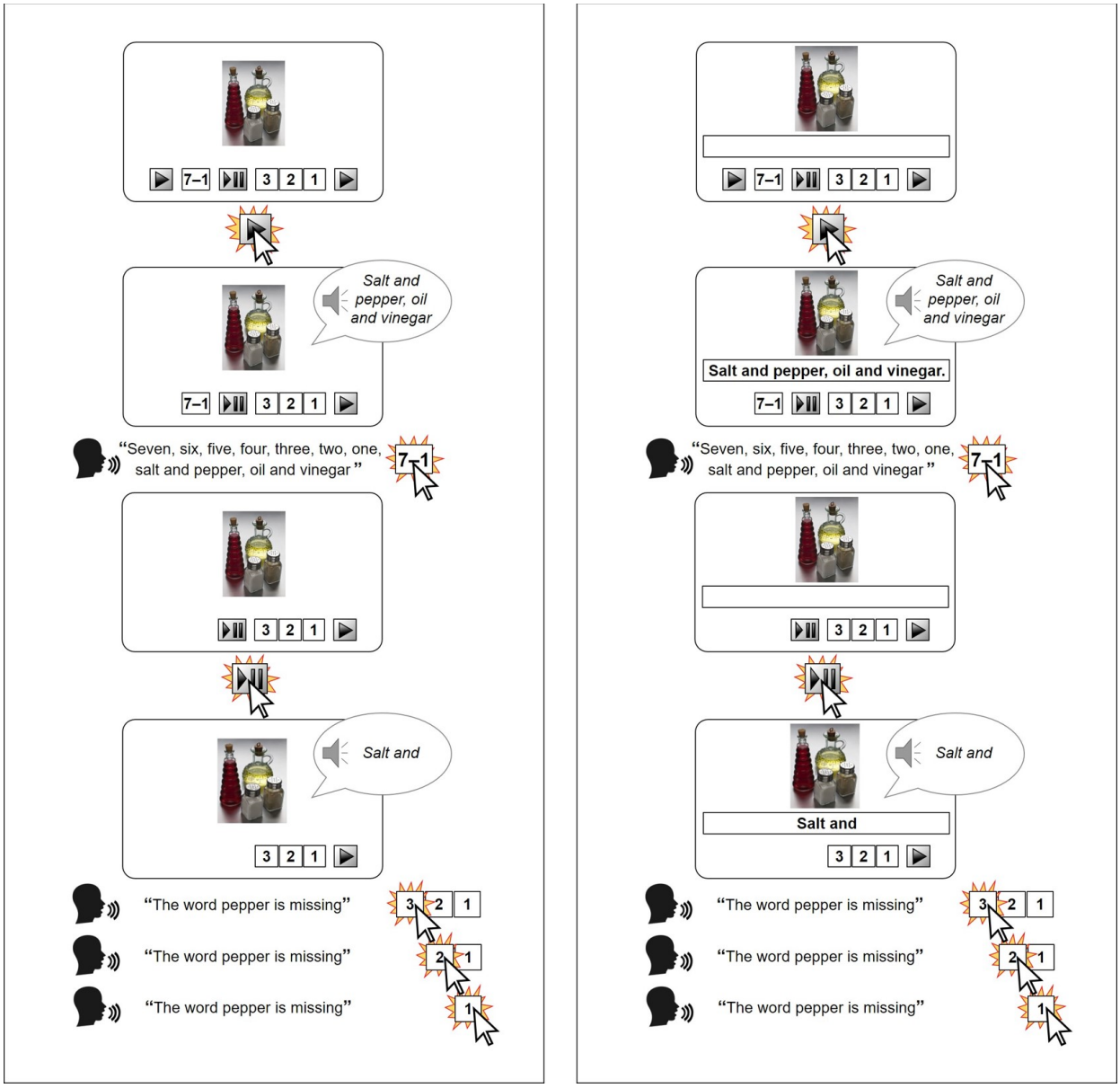

Figure 1. Schematic of the delayed word repetition tasks, without orthographic input (left) and with orthographic input (right).

Note. Photograph source: www.123rf.com

4.1.4 Procedure. Environmental conditions were the same as in Experiment 1. Before the task, participants received oral instructions and performed four practice trials, which were repeated if required. All participants completed the trials in the same order. Stimulus presentation was controlled using PsyScope X software (Cohen, MacWhinney, Flatt, & Provost, 1993). Participants interacted with a Macintosh PowerBook laptop computer using a mouse, and listened to recordings through headphones.

4.1.5 Data analysis. Nine percent of trials were eliminated from the analysis because the participant failed to produce the target word, or the recording was not of sufficient quality for acoustic analysis (total: 93/1080 responses). Target consonants were analyzed acoustically as in Experiment 1.

4.2 Results

The mean closure duration of the target consonants was analyzed using a multi-level ANOVA with delayed word repetition task as the between-group factor (without orthographic input, with orthographic input), and consonant spelling as the within-group factor (single letter, double letter). Table 2 shows the mean consonant closure durations by task and spelling.

Table 2
Mean Consonant Closure Duration (in Milliseconds; Standard Deviation in Brackets) as a Function of Delayed Word Repetition Task (without Orthographic Input, with Orthographic Input) and Consonant Spelling (Single Letter or Double Letter)

Delayed Word Repetition Task	Consonant Spelling	
	Single Letter	Double Letter
Without Orthographic Input	58 (9)	92 (13)
With Orthographic Input	56 (7)	91 (12)
All	57 (8)	91 (13)

There was a main effect of spelling, $F_1(1, 58) = 510.67$, $p < .001$, partial $\eta^2 = .90$, $F_2(1, 16) = 21.80$, $p < .001$, partial $\eta^2 = .58$. Although descriptively there was a small difference between the two groups, the group effect reached significance only in the item analysis, $F_2(1, 16) = 7.40$, $p = .015$, partial $\eta^2 = .32$. Crucially, there was no interaction between spelling and group, $F < 1$. This reflects the fact that both groups produced longer consonants in CC-words than in C-words. The mean geminate/singleton ratio was 1.70 in both groups ($SD_{\text{without orthographic input}} = 0.26$; $SD_{\text{orthographic input}} = 0.32$).
To ensure that gemination was not limited to cognate words or loanwords that contain a geminate in the native language, the geminate/singleton ratio was compared for orthographically congruent word pairs versus other pairs. No differences were found.

4.3 Discussion

Experiment 2 showed that Italian$_{L1}$ speakers produce geminate and singleton consonants in English$_{L2}$ both when exposed only to acoustic input and when exposed to acoustic and orthographic input. In learners of pseudowords or novel languages, and in beginner L2

learners, orthographic effects are stronger with orthographic input than without (Rafat, 2016; Zampini, 1994). However, in the present study, orthographic input had no effect on real words produced by L2 speakers who had been learning English for most of their lives. Acoustic analyses show that the same target consonant was on average 1.7 times as long when spelled with double letters than with a singleton letter in both groups. Finally, there were no differences in geminate/singleton ratios between word pairs containing a loanword or an orthographically congruent cognate and the other pairs, showing that gemination is not due to the effects of native phonological forms but to double letters in the orthographic form of English words.

5 General Discussion

The results of this study show that L2 orthographic forms, recoded according to L1 grapheme–phoneme correspondences, can lead experienced L2 speakers to make a phonological contrast in their L2 production that does not exist in the target language. Thus, $Italian_{L1}$ speakers of $English_{L2}$ pronounced the same English consonant in two different ways: shorter than native English speakers when the target consonant was spelled with a singleton letter, and longer when it was spelled with a double letter. Across the two experiments, the average closure duration for the Italians was 56–60 ms for C-consonants and 90–94 ms for CC-consonants, whereas native English speakers' average closure duration was 72–75 ms. This means that the Italians established two distinct categories, whereas the native English speakers had one category with a duration between that of the Italians' two categories.

$Italian_{L1}$ speakers' geminates were on average 1.7 times as long as their singletons. Although previous anecdotal evidence did indicate that a long consonant was produced in a single word by a small group of primary school children (Browning, 2004), the present study demonstrated such effects experimentally. Italian participants not only produced longer consonants than native English speakers in double-letter words, they also produced shorter consonants than the native speakers in single-letter words. This again confirms that the Italians established two phonological categories corresponding to one target category, and were producing a phonological contrast between singletons and geminates in L2 English. Crucially, these effects were found in L2 speakers with over ten years of L2 exposure.

Orthographic effects were not affected by the presence of orthographic input, as they appeared both in reading aloud and in delayed repetition of a native speaker's production. Furthermore, the phonological form of native cognates did not modulate the orthographic effect, as there were generally no differences in gemination when the native language had a cognate word or loanword. Although the loanword *floppy* appeared to differ from other /p/ words in Experiment 1, these effects disappeared in Experiment 2. Future studies should investigate variables that may modulate orthographic effects.

This study cannot explain the locus of orthographic effects, but it shows that orthographic effects differ between native and L2 speakers as follows. With regard to the locus of the effect, three explanations are possible: orthography affects phonological representations (Taft, 2006); phonological and orthographic representations are co-activated during speech production (Muneaux & Ziegler, 2004; Rastle et al., 2011); or both. If orthography affects phonological representations, the outcomes differ between native and L2 speakers, because only the latter recode L2 orthographic forms using L1 grapheme–phoneme correspondences. If orthographic effects are due to the co-activation of phonological and orthographic representations, the process must also differ between native and L2 speakers. In L2 speakers,

the effects occur because, when L2 orthographic representations are activated during L2 speech production, they are recoded using L1 grapheme–phoneme correspondences, rather than the correspondences of the language. Knowledge and activation of more than one set of grapheme–phoneme correspondence is only possible in L2 speakers.

6 Conclusion

This study extends the growing body of research into the effects of orthography on native speech phonology. The results show what happens when acoustic and orthographic input co-occur from the early stages of language acquisition, and what happens when speakers are affected not only by the orthographic forms of target words and sounds, but also by the interaction of two orthographies in one mind.

The present results also have important implications for models of L2 phonological acquisition, for two reasons. First, they indicate that L2 speakers make phonological contrasts based on orthographic input, which is not addressed in the current dominant models of L2 phonological development (e.g., the Perceptual Assimilation Model, Best & Tyler, 2007; Speech Learning Model, Flege, 1995). Second, they imply that models should also include situations where the L2 has only one category, which is mapped onto two different categories in the L2 speaker's L2 phonological system. This would extend the current models' focus on situations where two L2 categories map onto one category in the L1. The present results highlight the need for further specific research on orthographic effects in L2 phonology to obtain a complete picture of the role of orthography in phonology, and of L2 phonological development.

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Appendix

List of Materials

Word pairs

(target consonants are underlined)

No.	Target C	Form		Frequency	
		Spoken	Written	Spoken	Written
1	/k/	əˈkjuːt	a<u>c</u>ute	3.36	25.46
		əˈkjuːz	a<u>cc</u>use	1.83	3.73
2	/k/	ˈdɒkjumənt	do<u>c</u>ument	47.84	54.12
		ˈɒkjupaɪ	o<u>cc</u>upy	3.36	11.31
3	/k/	ˌnɪkəˈrægjuə	Ni<u>c</u>aragua	0.67	5.31
		ˌpɪkəˈdɪli	Pi<u>cc</u>adilly	0.77	3.31
4	/p/	ˈwepən	wea<u>p</u>on	8.93	20.99
		ˈpepə	pe<u>pp</u>er	2.79	10.57
5	/p/	ˈræpɪdli	ra<u>p</u>idly	12.87	49.45
		ˈhæpɪli	ha<u>pp</u>ily	7.69	18.58
6	/p/	ˈkɒpi	co<u>p</u>y	67.34	58.17
		ˈflɒpi	flo<u>pp</u>y	5.00	5.12
7	/t/	ˈlætɪn	La<u>t</u>in	4.71	30.35
		ˈtʃætɪŋ	cha<u>tt</u>ing	8.65	5.57
8	/t/	ˈsɪti	ci<u>t</u>y	142.75	242.64
		ˈkɪti	ki<u>tt</u>y	3.94	2.86
9	/t/	ˈvɪtəmɪnz	vi<u>t</u>amins	2.79	5.14
		ˈlɪtərɪŋ	li<u>tt</u>ering	0.29	0.44

Phrases

(target words are underlined)

1. Please look at this <u>document</u> here.
2. A group of <u>happily</u> married couples.
3. Salt and <u>pepper</u>, oil and vinegar.
4. No <u>littering</u>, take your litter home.
5. We both felt an <u>acute</u> pain.
6. Take a CD or a <u>floppy</u>.
7. How do you <u>occupy</u> your time?

8. Could I have a copy please?
9. They both work in the city.
10. This drink contains vitamins and sugar.
11. Nowadays the world is changing rapidly.
12. This is a very ancient weapon.
13. An expensive shop near Piccadilly Circus.
14. She studies Greek and Latin poetry.
15. I don't want to accuse anyone.
16. I have friends from Peru and Nicaragua.
17. My god, a Hello Kitty room.
18. She is chatting on the phone.