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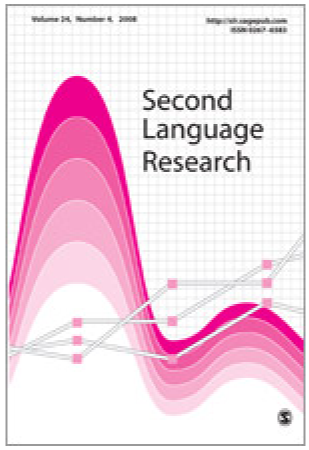

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Abstract

Previous studies have demonstrated the existence of non-native gemination in the speech of native (L1) Italian learners of a second language (L2), corresponding to double letters. We present the results of a bimodal truncated word-matching experiment testing phonological expectations for 30 L1 Italian learners of L2 French, and 30 L1 French control speakers. Manipulated consonantal durations affected responses and response times for learners, but not for native speakers: stimuli with lengthened consonants corresponding to single-letter spelling resulted in lower accuracy and higher response times; stimuli with short consonants corresponding to double-letter spelling resulted in high accuracy, but response times increased. We argue that exposure to native French in the classroom and during stays abroad has promoted the development of fuzzy L2 phonological representations, so that learners correctly process words spelled with double letters but cannot turn off their perceptual sensitivity to consonant duration, which remains modulated by orthography.

1. INTRODUCTION

1.1 Theoretical background

A growing body of literature has documented the effects of orthography on second language (henceforth L2) phonology acquisition (see Hayes-Harb and Barrios 2021 for a review). Several studies have revealed the effects of exposure to the written form of words while learning new vocabulary and/or a new phonemic contrast that is systematically reflected by spelling. Most relevant for our study are those that focused on learning new phonemic contrasts: for example, Escudero et al. (2008) famously showed that the availability of spelling reflecting the contrastive nature of confusable sounds /æ/ - /ɛ/ helped L1 Dutch learners of L2 English form lexical contrasts for novel L2 words. This finding is reflected by the study of Nimz and Khattab (2019), showing that L2 German long vowels are more consistently realised as such by L1 English learners when length is indicated in spelling by a lengthening h (e.g., in *fahren* vs *Tafel*). Similarly, Showalter and Hayes-Harb (2013) showed that tone marks supported tone learning for L1 English learners of L2 Mandarin, suggesting that even novel orthographic features may support L2 phonology learning. In contrast, other studies found no effects (Simon et al. 2010), or effects of exposure to the written form of words resulting in non-target-like pronunciations. Not only the production and discrimination of L2 sounds can be affected by the written form of words, but also L2 learners' phonological awareness and phonological representations, as revealed in syllable or phoneme counting tasks by Bassetti (2006), Detey and Nespolous (2008), Pytlyk (2017). Additionally, a series of studies on L1 Finnish learners of L2 French by Veivo, Järvikivi and colleagues revealed that L1 and L2 orthographic information is activated during L2 spoken word recognition and auditory processing, though the resulting effects seem to be modulated by proficiency (Veivo and Järvikivi 2013 and following).

The effects of spelling have been traditionally classified as facilitative (or supportive) or as negative, if resulting in non-target-like realisations. Negative effects have usually been associated to opaque spelling and L1-L2 differences in grapheme-phoneme conversion rules: for example, L1 English learners of L2 German produce a voicing distinction for final obstruents driven by spelling (e.g., for *Rat* and *rad*, which are both voiceless in German, see Young-Scholten & Langer 2015), and L1 American English learners often fail to produce flaps in L2 Spanish for <r> due to different L1-L2 grapheme-phoneme rules (flaps being associated to <t>, <tt>, <d>, <dd> in American English, Vokic 2011). Bürki et al. (2019) found that L1 French learners were more successful at learning L2 English words if supported by orthography, and this led to vowels that were less dispersed in the formant space (i.e., more consistently realised) but less native-like (e.g., *mib* being pronounced with a vowel closer to French [i] than [ɪ]). In an effort to reconcile the variable and sometimes contradictory effects of exposure to orthography, Welby et al. (2022) propose that experience with orthography contributes to the formulation of L2 phonological targets, which are then used by learners to generate subsequent pronunciations. These phonological targets can sometimes correspond to L1 or L2 categories, or even to sounds that do not exist in either language. Without access to orthography, L2 phonological targets are formulated on the basis of auditory input, while access to orthography interacts with this process.

In this article, we look at how L2 targets formulated on the basis of spelling can affect auditory processing by experience learners. We focus on a specific orthographic effect involving increased consonantal durations corresponding to double letters in L2s where consonant gemination is not contrastive. This phenomenon has been revealed and studied for L1 Italian learners of L2 English, initially in production (Bassetti 2017; Bassetti et al. 2018). Further investigations revealed the effect of double letters on the phonological awareness (Bassetti et al. 2020) and perception (Bassetti et al. 2021) of L2 English. Here we expand on this body of work by exploring the analogous effect for another language (L2 French) in L2 auditory processing.

1.2 Consonant gemination

In Italian, consonantal length has a lexically contrastive role; for instance, the words *fatto* /ˈfatːo/ 'done' - *fato* /ˈfato/ 'fate' are distinguished by the presence of a geminate (long) vs. singleton (short) consonant. The same is true for languages such as Japanese and Finnish, but in many others, such as English and French, consonantal length is not lexically contrastive. In Standard Italian, consonant gemination has a high functional load, and is even used within the inflectional system, e.g. *mangiamo* /manˈdʒamo/ 'we eat' - *mangiammo* /manˈdʒamːo/ 'we ate'. Contrastive gemination is consistently marked by orthography, with short consonants graphically represented with single letters (e.g., <t> in *fato*), and geminate consonants represented with double letters (e.g., <tt> in *fatto*). There is consensus that the main acoustic and perceptual cue of gemination in Italian is consonant duration, with reported geminate:singleton ratios of approximately 2:1 (Farnetani and Kori 1986; Esposito and Di Benedetto 1999; Pickett et al. 1999; Payne 2005; Di Benedetto and De Nardis 2021a, 2021b). A compensatory shortening of the preceding vowel has been reported as a secondary cue of gemination, but this applies only in nuclear position (Bertinetto 1981; Pickett et al. 1999; Bertinetto et al. 2008) and seems to be negligible as a perceptual cue for native speakers (Bertinetto and Vivalda 1978; Krull et al. 2006).

The acquisition of geminate consonants in an L2 is considered as marked with respect to simple consonants. Although it is difficult to determine the exact proportion of the world's languages having contrastive geminates, it is a fact that all languages have short consonants, but only a few have a phonological contrast between short and long consonants (see Blevins 2005). As such, geminate consonants are considered difficult to acquire when the L1 only has singletons (see Markedness Differential Hypothesis, Eckman 2008). They may be assimilated to the closest L1 equivalent (see Speech Learning Model original and revised, Flege 1995; Flege and Bohn 2021) which, for learners whose L1 does not use duration contrastively, is the corresponding non-geminate consonant. Many studies have examined the acquisition of geminate consonants in L2 Italian, both in production (Kabak et al. 2011; Sorianello 2014; De Clercq et al. 2014; Cordero et al. 2017; D'Apolito and Gili Fivela 2019; Feng and Busà 2022) and perception (De Clercq et al. 2014; Feng and Busà 2022; Altmann, Berger and Braun 2012), converging on the finding that learners of L2 Italian have difficulty in producing the exact timing patterns for geminate consonants, and auditorily discriminating/identifying singleton vs. geminate consonants.

1.3 Non-native gemination as an orthographic effect

Presently, L2 phonology models address cases where two L2 phonemes may correspond (with different degrees of goodness) to one L1 phoneme (e.g., PAM, Best and Tyler 2007, and SLM-r, Flege and Bohn 2021). However, the opposite case in which two L1 phonemes correspond (with varying degrees of goodness-of-fit) to an L2 category may need to be addressed too. Considering the case of learners of a non-geminating L2 and having an L1 with contrastive gemination, the basic assumption may be that such learners possess a phonological contrast in their L1 which simply turns out to be unexploited in the L2, so that L2 consonants are assimilated to L1 singleton equivalents. Similarly, L2 phonology models based on markedness (see Eckman 2008) would not predict specific difficulties for L1 Italian learners of L2 English or L2 French in terms of consonantal length, since what they have in their L1 is more marked than what they should learn in their L2.

However, some complications may arise. Firstly, L2 words acquired under emphasis or uttered with specific emotions may be erroneously analysed as containing a geminate consonant by learners whose L1 has contrastive gemination. Alternatively, an L2 phoneme that is natively pronounced with durations half-way between singletons and geminates may be erroneously assimilated to a singleton or to a geminate and produced as such without attending to how it differs from a geminate or singleton (see also findings that L1 English learners of L2 French pronounce /u/ farther from the native target than /y/, because the former is simply assimilated to the English equivalent sound and produced as such, Levy & Law 2010). Furthermore, recent studies have shown that a phonological contrast involving consonant gemination can be imported from the L1 (Italian or Japanese) to an L2 (English or French) via spelling (see Bassetti 2017), even if it does not exist in the L2: we refer to this as *non-native gemination*.

Evidence of non-native gemination comes directly from L2 speech, but is also found in English loanwords spelled with double letters (such as *killer*), reported as pronounced with geminate consonants by Canepari (1999) (see Hamann and Colombo 2017, for a discussion about the pronunciation of double letters in English loanwords in Italian). As for L2 speech, Bassetti et al. (2018) found that L1 Italian adult learners and late bilinguals of L2 English with several years of naturalistic exposure to English produced acoustically longer consonants for *Finnish* vs. *finish* and other minimal pairs, creating a phonological contrast which does not exist in native English speech. To a smaller extent, the same participants even pronounced slightly longer consonants for *add* vs. *ad* and similar pairs, where geminate consonants are not licensed by Italian phonotactics. Similar results involving a contrast of short vs. long consonants have also been found in L2 English speech produced by L1 Japanese learners (Sokolović-Perović et al. 2020), as well as in L2 French speech produced by L1 Italian (Mairano et al. 2018) and L1 Arabic (Nawafleh 2022) learners. Conversely, Mitterer (2021) did not find a quantity distinction of long vs. short consonants in L2 English productions by L1 Maltese speakers, and argued that the presence of geminate consonants in the L2 English produced by L1 Italian learners as an effect of spelling may be the product of focus on orthography in formal education.

Other studies looked at the phenomenon in perception and phonological awareness: Bassetti et al. (2020) showed that L1 Italian learners of L2 English tended to reject rhyming words spelled with single *vs.* double letters in a rhyming judgment task. Bassetti et al. (2021) revealed a perceptual illusion induced by double letters: L1 Italian learners rate the homophones such as *finish* vs. *Finnish* as different when they hear them and see their spelling form, but not when they only hear them. In an AX auditory discrimination task, we showed that L1 Italian learners of L2 French tended to rate French stimuli as different words if a geminable consonant is artificially lengthened by 60% or more (i.e., if it sounds like a geminate) (Mairano and Santiago 2023). These results converge towards the conclusion that consonant gemination is a real phonological feature in the L2 English and L2 French of L1 Italian learners (at least at some acquisitional stages, but also after long naturalistic exposure), and is imported from the L1 to the L2 via spelling.

1.4 Non-native gemination and perceptual adaptation

In the present study, we expand on previous work on non-native consonant gemination, and turn to the processing of L2 French speech by L1 Italian instructed learners. Since instructed learning in Italy focuses on written language (Bassetti 2017; Mitterer 2021), such learners have been heavily exposed to the written form of L2 French words and may have stored them in their mental lexicon. Based on the findings discussed in 1.3, it is likely that words with double consonants (such as *opposer*, 'to oppose') are interpreted as having a geminate consonant by learners by virtue of L1 grapheme-phoneme correspondences, and that geminate consonants have a distinctive function in the mind of L1 Italian learners (Bassetti et al. 2020; Mairano and Santiago 2023). In other words, experience with orthography may have led learners to generate phonological representations including geminate consonants for words spelled with double consonants in French. Given such phonological representations, and given that L1 and L2 orthographic information is activated during auditory processing (Veivo and Järvikivi 2013 and following), the absence of long consonants in L1 French speech may interfere with the auditory processing of French native speech by learners. The presence of gemination as a phonological feature in learners' mind may generate the expectation that words spelled with a double consonant be pronounced with a long sound in native speech, and that words with a singleton consonant be pronounced with a short sound. For known words, this expectation simply matches the phonological representation in learners' mind; for unknown words presented auditorily, an expected orthographic representation may be generated on the basis of the expectation that short sounds should be spelled with a short consonant and long sounds should be spelled with a long consonant; for unknown words presented orthographically, an expected phonological representation may be generated on the basis of the expectation that double letters should correspond to a long sound and singleton letters should correspond to a short sound. However, since consonants spelled with double letters are not realised with lengthened durations by native speakers of French, this is likely to result in delayed, or even inaccurate, lexical activation during auditory processing. If so, the recognition of words such as *opposer* as pronounced by L1 French speakers may have a higher processing cost, or may even fail, since the actual realisation comes with a short instead of long [p].

However, learners are also variably exposed to oral input in French, and this may have had an effect on the way they expect such consonants to be pronounced. It is in the listeners' best interest to stay perceptually flexible (Welby et al. 2022), and the literature suggests that they adopt perceptual strategies to cope with the huge amount of variation found in speech. Norris et al. (2003) found that native listeners can deploy lexical knowledge to cope with ambiguities at the phonetic level: after being exposed to an acoustically ambiguous fricative sound within a context that would favour its interpretation as /s/ (e.g., within 'horse') or /f/ (e.g., within 'giraffe'), two groups of participants were found to categorise ambiguous stimuli at the middle of the /f/ - /s/ continuum depending on the conditioning they had received. Similarly, Kraljic and Samuel (2006) found that L1 English speakers recalibrated their categorisation of plosives after exposure to unusual realisations in a lexical decision task. The perceptual recalibration of /f/ and /s/ categories has been observed for L1 German learners of L2 Dutch (Reinisch et al. 2010), and other cases of perceptual adaptation in L2 contexts have been described (see Cutler et al. 2010 for a review). Additionally, L1 English and Dutch speakers could recognise '*trick*' pronounced with /ɪ/ instead of /iː/ by L1 Italian speakers of L2 English (Weber et al. 2014), and Southern French listeners recognise Northern pronunciations that do not exist in their own variety (e.g., /mov/ instead of /mɔv/ for '*mauve*') with no extra processing time (Dufour et al. 2019). These results suggest that listeners relax their phonemic categorisation criteria to adapt to other speakers' or other accents' patterns. Therefore, it may be that prolonged exposure to native French in the classroom or during stays abroad can promote adaptations that can help learners more efficiently process native French speech. After being exposed to short <CC> consonants as pronounced by native French speakers, L1 Italian learners may be led to one of the following: (a) modify their phonological representations for <CC> words to (native-like) singleton consonants, (b) modify their phonological representations for <CC> words to consonants with underspecified duration, (c) become flexible in the interpretation of acoustic cues for gemination, so that short realisations can match mental representations with geminate consonants and vice versa. In this article, we look at the interaction between these two forces: the effect of an orthography-driven phenomenon (non-native gemination) and the effect of perceptual adaptation.

1.5 Goal of our study and predictions

We examine the lexical activation patterns by L1 Italian learners for what they may perceive as a spelling-sound incongruence with respect to short and long consonants. We are interested not only in whether the auditory processing of words like *opposer* is costlier (in terms of time and accuracy) for L1 Italian learners if pronounced with a short [p], but also if the same applies for words like *reposer* ('to rest') pronounced with a long [p].

In order to test the lexical activation patterns of L1 Italian learners of L2 French for short vs. long consonants, we adopted a bimodal truncated word-matching paradigm. This involves presenting participants with truncated auditory stimuli with manipulated consonantal durations and asking them to judge if they correspond to the word displayed orthographically on the screen. Lower accuracy and slower response times would point to difficulties posed by what learners perceive as a sound-spelling incongruence (e.g., *reposer* with a long [p], and *opposer* with a short [p]), whereas high accuracy and faster response times would indicate that participants have successfully learned to cope with mismatching cues in consonantal length. The test was performed by an experimental group of L1 Italian learners of L2 French and a control group of L1 French speakers. On the basis of the orthographic effect described for L1 Italian learners, we make the following predictions (illustrated in Figure 1):

- L1 French participants should not be affected by spelling condition (<C> vs. <CC>) or by manipulated consonant durations. Speakers of non-geminating languages have been shown to be less sensitive to consonantal length, so their accuracy should be at ceiling level and response times short, irrespective of consonant duration. We do not exclude a potential effect of consonant duration on response times, since consonants with unusual duration are deviant from the expected pronunciation, but this should remain limited.

- L1 Italian participants should be affected by spelling condition, as well as consonantal duration. In the <C> condition (e.g., *reposer*), we expect lower accuracy and longer response times for long consonant durations, since the participants are presented with what they may perceive as an incongruence between spelling and audio. For the same reasons, in the <CC> condition (e.g., *opposer*), we expect lower accuracy and longer response times for short consonant durations.

Although we expect an effect of consonant duration on accuracy and response time for Italian participants, we do not necessarily predict it to be linear: the identification of singleton vs. geminate consonants in L1 Italian has been shown to be categorical rather than gradual, meaning that consonant duration may affect L1 Italian listeners mainly after a given threshold, resulting in an effect that is closer to quadratic.

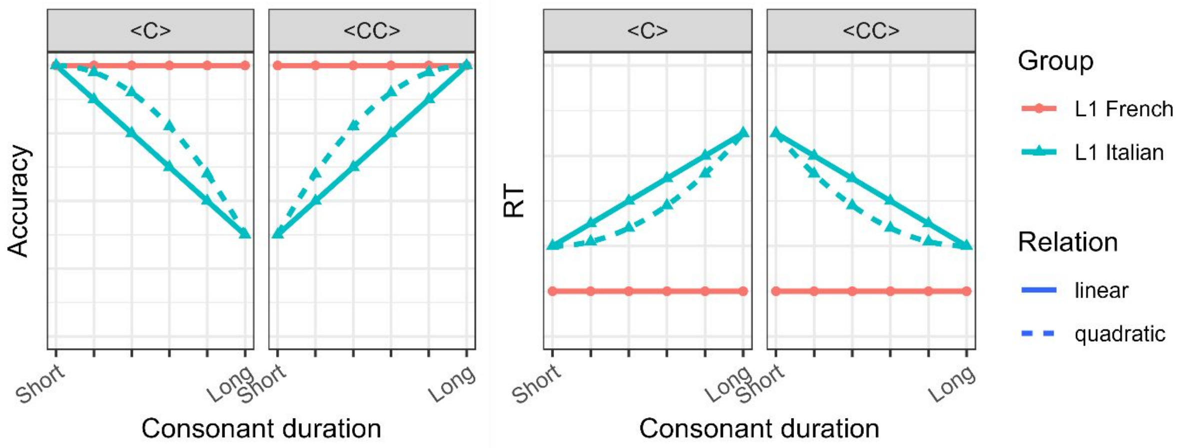

Figure 1. Predicted results of our experiment.

2. DATA AND METHODS

2.1 Stimuli

In order to develop our bimodal truncated word-matching task (see 2.3), we selected 160 French target words including single (N = 80) vs. double (N = 80) consonants in matching phonological contexts (e.g., *rescaper* – *échapper*, in which the target consonant is preceded by /a/ and followed by /e/ in both words). All words were at least trisyllabic (131 had three syllables, 28 had four syllables, and one had 5 syllables). According to the literature on French prosody, the last syllable of any group formed by a lexical word and its preceding clitics carries an obligatory final prosodic accent marking the prosodic boundary of the accentual phrase (Di Cristo 2016, Jun and Fougeron 2002, among others). In our study, isolated words used in our stimuli are potential accentual phrases with final accents. In order to control for potential effects due to final accent, the target consonant was at the onset of the second syllable for half of the stimuli (i.e., non-accented position, *capacité* [ka.**p**a.si.te], *apparat* [a.**p**a.ʁa]). In the other half, the target consonant was at the onset of the last syllable (i.e., accented position, *proclamer* [pʁo.kla.**m**e], *programmer* [pʁo.gʁa.**m**e]). The target consonant was a plosive (/p/ or /t/) for half of the stimuli, and a continuant (/l, m, n/) for the other half. It was not easy to find words that would fulfil all conditions and that would still be familiar to non-native speakers. Within every pair of words, lemma frequency was verified in the Lexique3 corpus (New et al. 2005) in an effort to balance it within every pair, and more broadly, across conditions. Although some stimuli are relatively infrequent, most of them (n = 144) have cognate words in Italian and are, therefore, recognisable and comprehensible to L1 Italian learners. Of these 144 cognate words, 66 are spelled <C> in both languages, 71 are spelled <CC> in both languages, and 7 have an incongruous spelling (5 have <C> in French and <CC> in Italian, e.g. *pélican* vs. *pellicano*, while 2 have the opposite pattern, e.g. *attiédir* vs. *intiepidire*). The full list of stimuli and cognates is reported in Appendix 1.

Additionally, 80 French words were selected to be used as distractors. They were formally similar to experimental stimuli, in that they consisted of three or more syllables (e.g., *Canada*, *japonais*, *satisfait*). None of them contained double consonants in their non-truncated part (see 2.2).

All experimental stimuli and distractors were recorded by a native Parisian male speaker in a sound-proof booth on the premises of the University of Paris 3. The speaker was an experienced phonetician at the beginning of his thirties, and care was taken to utter every word in isolation with a constant declarative tone, a constant speech rate, and avoiding list intonation and other artefacts of list reading. For distractors, one phoneme was systematically substituted: for example, *Canada* was read as [konada] instead of [kanada], *japonais* was read as [ʒabone] instead of [ʒapone], *satisfait* was read as [sadisfɛ] instead of [satisfɛ]. This was meant to ensure that listeners would identify these recordings as non-correspondent with respect to the written stimulus. Experimental stimuli and distractors were recorded with an XLR microphone and a portable wav recorder with +48 Volt phantom power at a sample rate of 44.1 Hz and 16-bit resolution.

2.2 Stimuli truncation and duration manipulation

All recorded words (experimental stimuli and distractors) were truncated by deleting syllables except the one before and the one after the target consonant. For example, *proposer* [pʀopose] and *supposer* [sypose] (with a target consonant at the onset of the second syllable) were truncated by keeping the first and second syllable (i.e., respectively before and after the target consonant) and removing the third syllable, giving respectively [pʀopo] and [sypo]. Similarly, *hôpital* [opital] and *sagittal* [saʒital] (with a target consonant at the onset of the last syllable) were truncated by keeping the penultimate and final syllable, and removing the first syllable, giving respectively [pital] and [ʒital]. Distractors underwent the same procedure, by which only two syllables were kept; for instance, [konada] had its final syllable removed, giving [kona]. The deletion of syllables was performed in *Praat* (Boersma & Weeninck 2021), by simply selecting and removing the corresponding speech part from the audio file.

Truncation was necessary within our task to make stimuli ambiguous for participants. Without manipulation, we can reasonably assume that all participants would correctly match the audio with the written form of every stimulus, simply because no other possibilities exist: they would only fail if they think that a corresponding word with opposite spelling exists (e.g. **colision*, for *collision*). Truncated stimuli force participants to compare the partial audio with possible lexical competitors (as predicted by psycholinguistic models of lexical access, such as TRACE (McClelland and Elman, 1986) and COHORT (Marslen-Wilson and Welsh, 1978, Marslen-Wilson, 1987, 1989), among others); for example, [koli] may correspond not only to *collision*, but also to *colibri*, *coliflor*, etc.). We were not able to control for the number of lexical competitors for each truncated stimulus as this is too complex for L2 learners. Firstly, we cannot know exactly which L2 words are known to them. Secondly, since L1 and L2 lexical competitors may be activated during similar tasks (as predicted by models of bilingual lexical access and language control, such as the BIA+ model (Dijkstra and van Heuven, 1998), based on the TRACE model), one would also need to account for potential Italian and English competitors (all participants claimed some proficiency in English). However, since it can be predicted that participants are more prone to fail a trial when incongruous lexical competitors exist, we ran a post-hoc analysis (see 3.3) to verify a potential effect of their presence vs. absence. Incongruous lexical competitors are words starting (or ending) with the two syllables in the audio, but spelled with <C> instead of <CC> or vice versa (36 of 80 <C> stimuli had an incongruous lexical competitor in French or Italian, and 22 of 80 <CC> stimuli; see Appendix 1).

Additionally, experimental stimuli had their target consonant manipulated into five different lengthening conditions: +0% (=baseline value, no lengthening), +30% (the output consonant is 30% longer than the baseline), +60%, +90%, and +120%. This manipulation was inspired by Rochet and Rochet (1995), who used a similar procedure to test the native perception of Italian geminate consonants. The manipulation was applied regardless of whether the target sound was spelled as a single or as a double consonant, and was performed via an *ad hoc* Praat script written by the first author, which exploited the Manipulation feature provided by *Praat*. Each experimental stimulus was manipulated in all five lengthening conditions, but participants heard each in one condition only (see 2.5). Distractors did not undergo any lengthening manipulation. We chose to manipulate durations into 5 different steps (rather than 2, short vs. long) because we could not establish a priori the threshold at which consonants are heard as geminates in an L2: while the literature suggests geminate:singleton ratios of 1.7:1 to 2.5:1 in L1 Italian, studies on L2 gemination as an orthographic effect find smaller ratios (e.g., 1.3 by Bassetti et al., 2018). This study will therefore also provide an opportunity to verify if the perceptual threshold is the same in L1 and L2.

2.3 Bimodal truncated word-matching paradigm

The stimuli described above were used in a bimodal truncated word-matching task in *PsychoPy* (Peirce et al. 2019). The test was composed of two blocks of 80 trials each. The first block tested stimuli with a target sound at the onset of the second syllable (i.e., stimuli that were truncated from the third syllable to the end); the second block tested stimuli with a target sound at the onset of the last syllable (i.e., stimuli that were truncated from the beginning to the penultimate syllable). Each session was preceded by 3 training trials to familiarise participants with the task. The format of the test is illustrated in Figure 2 and ran as follows: after a short period of blank screen (400 ms), participants heard an audio stimulus, then after another short period of blank screen (400 ms), a word was orthographically displayed. Their task was to choose whether the audio stimulus corresponded to the initial syllables (in block 1) or final syllables (in block 2) of the word on the screen by pressing a key. For instance, they heard [sjonal] (with [n] manipulated at one of the 5 lengthening conditions), then saw the word *national* (pronounced [nasjonal] in French) on the screen, and had to decide whether the audio stimulus corresponded to the final syllables of the word displayed on the screen. The 80 distractors were introduced to provide a real mismatch between auditory and visual stimuli (e.g. [topys] instead of [tobys] for *autobus* [otobys]). The exact wording for the instructions are given in Appendix 2.

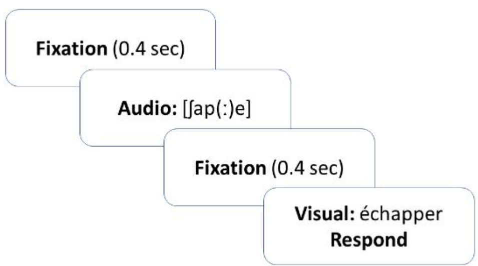

Figure 2. Bimodal truncated word-matching task.

Once participants had provided a response, they were taken to a stand-by screen and had to re-press a key to move on to the next trial. They could not change their response, or go back, or replay stimuli. *PsychoPy2* recorded participants' responses and response times.

We predict that Italian participants will have higher accuracy and shorter response times for congruous stimuli (i.e., where the lengthening condition reproduces the pronunciation expected from spelling), and lower accuracy and longer response times with incongruous stimuli (i.e., where the lengthening condition conflicts with the pronunciation expected from spelling). Notice that congruous stimuli are non-manipulated (i.e., short) for single consonants, and manipulated (i.e., long) for double consonants. This meant that longer (=manipulated) stimuli were potentially more artificial than shorter (=non-manipulated or less-manipulated) stimuli, thereby creating an asymmetry which unfortunately could not be avoided. A potential alternative approach could have involved 50% of stimuli for which the target consonant was recorded as long, then progressively manipulated to shorter durations along an analogous 5-step decreasing continuum. But this would have meant asking a L1 French native speaker to produce geminate consonants in their own language, which obviously would lead to equally unnatural and biased results. We evaluated our stimuli auditorily, and could not detect any artefacts caused by the manipulation; we, therefore, consider our approach to be the least-worst solution, despite this (auditorily irrelevant) bias.

2.4 Participants

We recruited 30 L1 Italian learners of L2 French (henceforth IT) and 30 L1 French control speakers (henceforth FR). IT participants were students at the Faculty of Foreign Languages in Turin, Italy. Nineteen of them were born in the local area and had grown up there, while 11 were born in other parts of Italy and had moved there later for their studies. Despite claims of regional variation for geminate consonants across Italy, recent large-scale studies have revealed that, due to the progressive standardisation of the language, speakers (and especially younger generations) do not show relevant regional differences (Giordano and Savy 2012; Mairano and De Iacovo 2020). The situation may be different for sandhi gemination, a.k.a. *raddoppiamento fonosintattico*, but this phenomenon is not relevant for our study. Among IT participants, 23 identified as women, 7 as men (average age: 25.1, SD = 3.7), reflecting the gender imbalance often found among students of Foreign Languages. The average age of first contact with French was 12 (range: 6 - 22). The self-declared proficiency level ranged from B1 to C1; 8 participants had been in Erasmus programmes in France, and 16 others had been at least once to a French-speaking country (median: 2 weeks, range: 1 - 40 weeks). A larger number of participants claimed to regularly read and listen to French (n = 24 and 23, respectively), than write and speak (n = 15 and 12). All IT participants declared having at least some knowledge of English.

Among FR participants, 20 identified as women, 10 as men (average age = 23.1, SD = 2.5). They were students at the Faculty of Linguistics at the University of Paris 8, France, and lived in the Paris area at the time of recording. No participants reported hearing conditions.

2.5 Procedure

Participants took the test in the university premises, either in a sound-proof booth, or in a silent room, depending on availability. They sat in front of a Mac with an AKG HSC 271 headset and ran the test on *PsychoPy2*. The whole test (two blocks of 80 experimental trials, each preceded by 3 training trials) was conducted without interruption and lasted approximately 20 minutes. In order to set the 'French mode' for L1 Italian participants, the instructions were in French (participants were allowed to ask for clarification if needed). The test was taken within a larger data collection project, so L1 Italian participants also performed other production and perception tasks for a total of approximately 75 minutes. The perception tasks were performed before the production tasks to avoid any potential priming effects. For this test, they were instructed to provide immediate, spontaneous and non-pondered responses. To avoid priming effects for repeated words, we adopted a Latin Square design with 5 presentation lists: lengthening conditions were balanced across presentation lists, so that each participant heard each stimulus only once, and in one condition only.

2.6 Statistical analysis

The results of the test were saved in .csv format and imported into *R* (version 4.3.0; R Core Team 2023) for analysis. We obtained 9600 experimental datapoints (160 experimental trials x 60 speakers) and 4800 distractor responses (80 distractor trials x 60 speakers). We eliminated response times (n = 311) beyond 2.5 standard deviations from each participant's mean, leaving 9289 observations. The observations were analysed with linear mixed-effects models using the *lme4* package (version 1.1.33, Bates et al 2015). The dependent variables of our models were Accuracy (correct, incorrect) and Response Time, and the fixed effects were Group (FR, IT), Spelling (C, CC), Step (+0%, +30%, +60%, +90%, +120%). We used a generalised linear mixed-effects model of the binomial family for predicting responses, and a linear mixed-effects model for predicting log-transformed response times. Group and Spelling were contrasted with dummy coding, the reference levels being Group=FR and Spelling=C. Given the ordinal nature of Step, this variable was contrasted with orthogonal polynomial coding. This type of coding (which is default on *R* for ordered variables) looks for linear, quadratic, cubic and quartic trends for a factor whose levels are equally spaced, by isolating each of these components to explain variance in the outcome (see Mason 2021 for an accessible introduction to polynomial coding with examples). To keep the analysis relatively simple and to smooth the prediction curve, higher order polynomials (quadratic, cubic and quartic) were dropped from our models if non-significant (see Elbers 2020).

The random effects considered were Participant (accounting for potential individual differences among participants) and Word (accounting for potential item-specific effects, such as lexical frequency), both coded with sum-to-zero contrasts. Random effects were fit with a maximal specification (Barr et al. 2013), including random intercepts for both random effects, by-participant random slopes for Spelling and Step, and by-word random slopes for Group. We set the bobyqa optimizer to run up to 100,000 function evaluations. Yet, given the complexity of the models and in order to deal with convergence issues and singular fit, we had to gradually reduce the specification of the random slope to the maximal converging structure, which in both cases involved dropping by-participant random slopes for Spelling and Step. The converging model formulae were the following: (1) *Accuracy ~ Group * Step * Spelling + (1|Participant) + (Group|Word)*; (2) *Log(ResponseTime) ~ Group * Step * Spelling + (1|Participant) + (Group|Word)*.

In order to establish statistical significance for predictors of our linear mixed effects model, *p* values were obtained via the *lmerTest* package (version 3.1.3, Kuznetsova et al. 2017). Post-hoc comparisons were performed using the *emmeans* package (version 1.8.6; Lenth 2018) with Tukey correction. In order to avoid an excessively lengthy analysis, we report post-hoc tests only for the three-way interaction. This addresses directly our hypotheses, which refer to the effect of Step across Groups and

Spelling conditions). Charts were generated from model predictions with the *ggeffects* package (version 1.2.2; Lüdecke 2018).

We ran additional models on IT data to check the potential effects of cognate words, lexical competitors and position within a word. The specifications of these models are given in 3.3.

3. RESULTS

3.1 Accuracy

The results reveal interesting differences across groups and interactions among variables. Table 1 gives a summary of the model predicting accuracy, and Figure 3 illustrates predicted probabilities of correct responses extracted from the model. The IT group has an overall lower accuracy rate than the FR group ($p < .001$), visible for all steps. This is not surprising, since it is expected that L2 learners should perform less well than L1 speakers due to the simultaneous activation of and overlap between the two language (see Spivey and Marian 1999, for similar results), and to the fact that lexical access is more prone to errors in the L2 (L2 words are less entrenched due to lesser input, see Kroll and Stewart 1994, Jiang 2000). Coming to interactions between Group and the other variables, the FR group does not seem to be affected by either Spelling (<C>, <CC>) or Step. Instead, the IT group is affected by Step, but only for words spelled with <C>, and not for words spelled with <CC>: for the former, Accuracy decreases significantly for duration manipulations beyond +60%. This is confirmed by the summary of the model, with a significant interaction between Step and Group when Spelling=C (p = .002 and <.001 for linear and quadratic), as well as a significant three-way interaction of Group x Step x Spelling (p = .042 and .003 for linear and quadratic).

Fixed effects					Random effects	
Parameter	Coeff	SE	*Z*	*p* val	Partic. SD	Word SD
Intercept	4.18	0.26	15.76	< .001 ***	0.87	1.15
Group [IT]	-1.31	0.32	-4.14	< .001 ***		0.98
Step [linear]	-10.51	10.65	-0.99	0.324		
Step [quadratic]	14.28	8.72	1.64	0.101		
Spelling [CC]	-0.3	0.26	-1.19	0.236		
Group [IT] × Step [linear]	-30.57	12.08	-2.53	0.011 *		
Group [IT] × Step [quadratic]	-35.55	10.26	-3.47	< .001 ***		
Group [IT] × Spelling [CC]	0.7	0.27	2.59	0.010 **		
Step [linear] × Spelling [CC]	13.19	14.41	0.98	0.326		
Step [quadratic] × Spelling [CC]	-24.12	11.42	-2.11	0.035 *		
(Group [IT] × Step [linear]) × Spelling [CC]	31.72	15.58	2.04	0.042 *		
(Group [IT] × Step [quadratic]) × Spelling [CC]	41.53	13.94	2.98	0.003 **		

Table 1. Summary of the following model: *Accuracy ~ Group * Step * Spelling + (1|Participant) + (Group|Word)*. Note that dummy coding was used for Group and Spelling, with reference levels Group=FR and Step=+0%; Step was ordinal and contrasted with orthogonal polynomial coding.

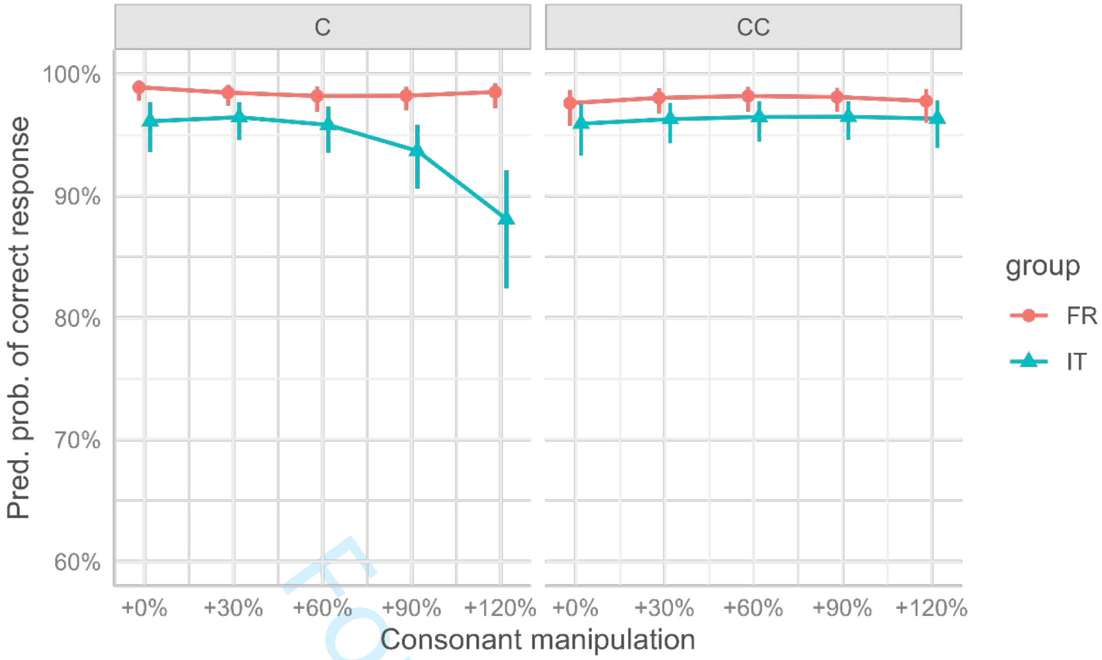

Figure 3. Predicted probabilities for correct response extracted from the model summarised in Table 1.

Post-hoc comparisons on the three-way interaction (table 2) confirmed that Step did not have any effect (linear or quadratic) on responses by FR participants in any spelling condition (all adjusted *p* values > .10), nor for the IT participants in the <CC> condition (all adj. *p* values > .64). Instead, in the <C> condition, Step had a significant effect with linear ($p < .001$) and quadratic ($p = .003$) components for IT participants.

Contrast	**Estimate**	**SE**	***z* ratio**	***p* value**
Spelling=C, Group=FR:				
linear	-0.765	0.780	-0.981	0.327
quadratic	1.239	0.757	1.638	0.101
Spelling=C, Group=IT:				
linear	-3.021	0.522	-5.789	< .001 ***
quadratic	-1.845	0.621	-2.972	0.003 **
Spelling=CC, Group=FR:				
linear	0.193	0.686	0.281	0.779
quadratic	-0.854	0.814	-1.049	0.294
Spelling=CC, Group=IT:				
linear	0.279	0.604	0.462	0.644
quadratic	-0.335	0.715	-0.468	0.640

Table 2. Post-hoc tests revealing the effect of Step on Responses by Group and Spelling condition (Tukey correction).

The analysis of distractors revealed that the rejection rate of mismatching stimuli was on average 93.58% (SD = 7.38%) among FR participants, and 83.46 (SD = 15.28%) among IT participants. It can be noticed that, globally, learners' accuracy was lower for distractors than for target stimuli: this is not surprising, because distractors were mismatch-trials and some L2 distinctions may have been hard to perceive by learners.

3.2 Response times

The output of the model predicting log-transformed Response Times is summarised in Table 3, and predictions are plotted in Figure 4. We can clearly observe that response times are overall higher for the IT group than for the FR group, reflecting once again the fact that auditory processing and lexical access demand a higher cognitive load in L2 than L1. Once more, Group interacts with Step and Spelling. More specifically, the FR Group does not seem to be affected by either of these variables, while the IT Group shows some effects: Response Times increase when processing longer consonant durations in the <C> condition (confirmed by the summary of the model, since we have a significant linear interaction of Step and Group when Spelling=C at p = .007, Table 3), and decrease when processing longer durations in the <CC> condition. Additionally, the three-way interaction of Group x Step [linear] x Spelling is highly significant (p < .001).

Fixed effects					**Random effects**	
Parameter	Coeff	SE	*t*	*p* val	Partic. SD	Word SD
Intercept	-0.303	0.054	-5.655	< .001 ***	0.28	0.122
Group [IT]	0.303	0.074	4.098	< .001 ***		0.09
Step [linear]	1.244	0.762	1.633	0.103		
Spelling [CC]	0.005	0.022	0.205	0.838		
Group [IT] × Step [linear]	2.91	1.077	2.701	0.007 **		
Group [IT] × Spelling [CC]	-0.010	0.021	-0.494	0.622		
Step [linear] × Spelling [CC]	-0.523	1.078	-0.487	0.626		
(Group [IT] × Step [linear]) × Spelling [CC]	-5.182	1.522	-3.405	< .001 ***		

Table 3. Summary of the following model: *log(ResponseTime) ~ Group * Step * Spelling + (1|Participant) + (Group|Word)*. Note that dummy coding was used for Group and Spelling, with reference levels Group=FR and Step=+0%; Step was ordinal and contrasted with orthogonal polynomial coding.

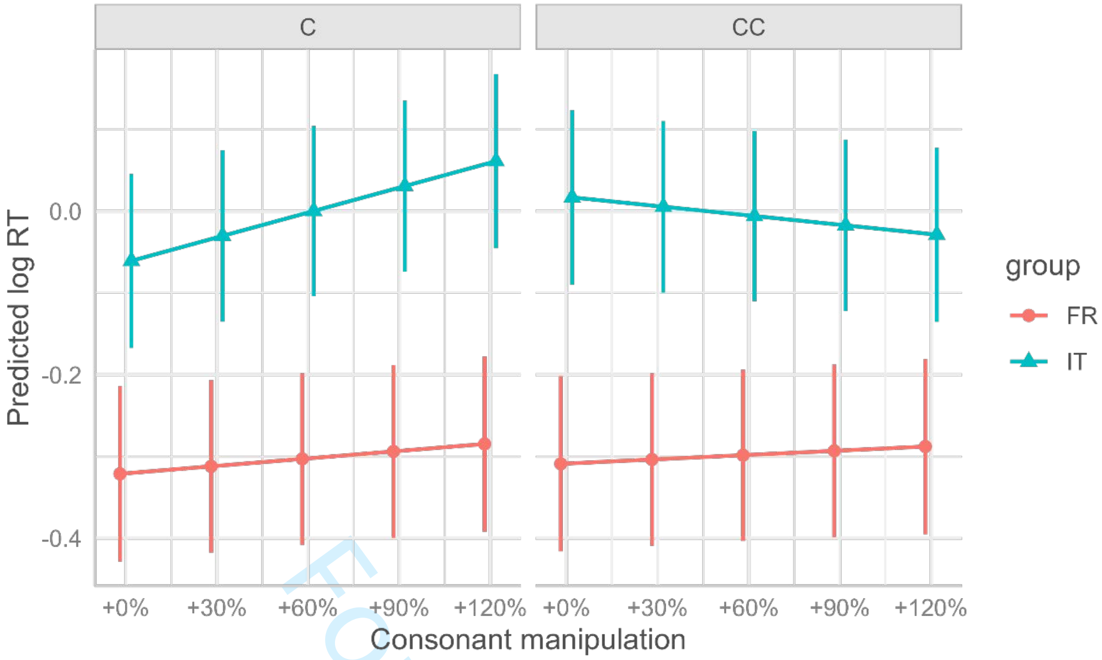

Figure 4. Predicted Response Times extracted from the model summarised in Table 2.

Post-hoc pairwise comparisons on the three-way interaction (Table 4) revealed that Step did not have any significant effect on Response Times within the FR group (all adj. *p* values > .103). In contrast, for the IT group, Response Times were linearly affected by Step in the <C> condition (*p* < .001) and in the <CC> condition (*p* = .042). Pairwise comparisons across groups revealed that response times by the FR group were significantly faster than by the IT group in all conditions (all adj. *p* values < .001).

Contrast	Estimate	SE	z ratio	*p* value
Spelling=C, Group=FR:	0.0913	0.0559	1.633	0.103
Spelling=C, Group=IT:	0.3047	0.0561	5.436	< .001 ***
Spelling=CC, Group=FR:	0.0528	0.0559	0.945	0.345
Spelling=CC, Group=IT:	-0.1139	0.0558	-2.042	0.041 *

Table 4. Post-hoc tests revealing the linear effect of Step on Responses by Group and Spelling condition.

3.3 Other variables

A certain number of extraneous variables may affect IT participants' responses and response times. The position of the target sound within a word was controlled (see section 2), while it was not possible to entirely control for the effects of cognate words and lexical competitors in the L1 and L2. In this section we try to give an account of the potential effects of these variables by running models exclusively on IT data: each model tests one of the three extraneous variables as a fixed effect, alongside Step and Spelling condition (which have been found to be significant in the previous sections) and all interactions. Participant and Word were kept as random effects with the maximal converging structure avoiding singular fit. The significance of the effects was established by checking the summary and type 3 Anova table of each model.

The models testing the position of the target consonant within the word (second vs. penultimate syllable) did not reveal any significant effect on participants' responses or response times (formulae: *Response ~ Position * Step * Spelling + (Position|Participant) + (1|Word)*; and *Log RT ~ Position * Step * Spelling + (Position|Participant) + (1|Word)*).

As for cognate effects, we ran two types of models. The first type tested the existence of a cognate word in the L2 (formulae: *Response ~ CognateExists * Step * Spelling + (1|Participant) + (1|Word)*; and *CognateExists * Step * Spelling + (Spelling|Participant) + (1|Word)*), the second type narrowed down on spelling congruency (congruous vs. incongruous) for the existing cognate words (*Response ~ CognateCongruency * Step * Spelling + (CognateCongruency|Participant) + (1|Word)*; and *CognateCongruency * Step * Spelling + (CognateCongruency|Participant) + (1|Word)*). Neither the existence nor the congruency of cognate words had a significant effect on participants' responses or response times.

The models testing the effect of the existence of an incongruous lexical competitor (henceforth: ILC, see 2.2) in French or Italian are illustrated in Figures 5 and 6. The model predicting responses revealed that accuracy was lower (β = -0.52, SE = 0.26, z = -2.01, *p* = .045) when Spelling=<C> and an ILC exists. The three-way interaction was not significant, but the visualisation suggests that the difference in accuracy was mainly driven by stimuli manipulated with longer durations. The model predicting response times revealed an interaction between ILC and spelling condition: for <C> stimuli, RTs tended to be longer when an ILC exists (β = 0.08, SE = 0.03, z = 2.37, *p* = .097), while for <CC> stimuli RTs tended to be shorter (β = -0.05, SE = 0.03, z = 1.66, *p* = .018).

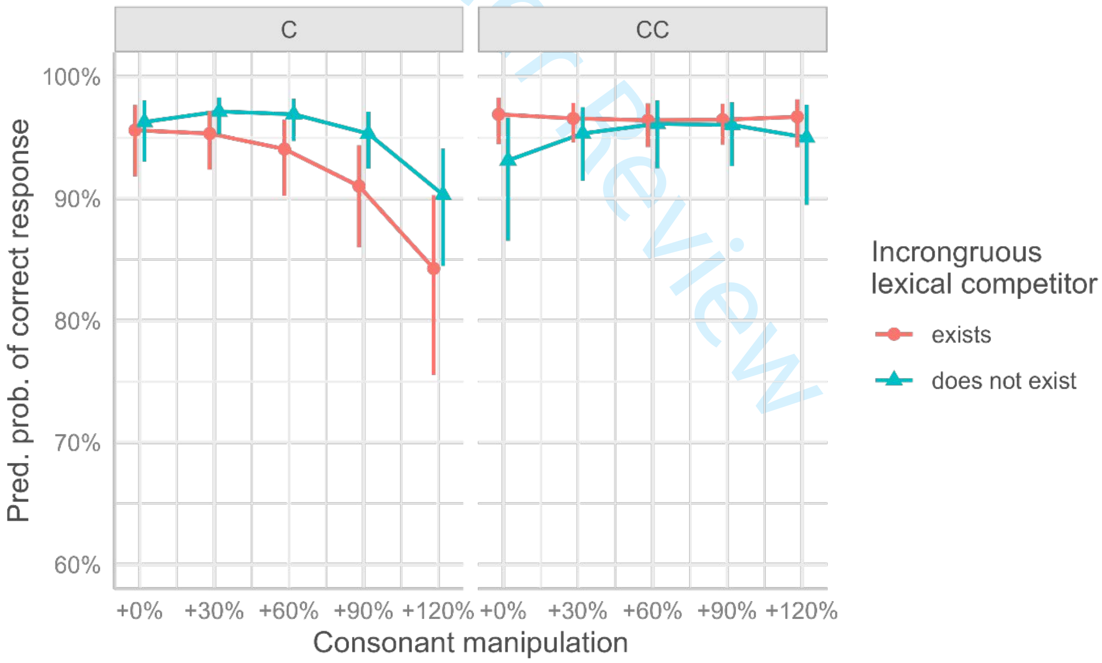

Figure 5. Predicted probabilities of correct response extracted from the following model: *Response ~ IncongruousCompetitor * Step * Spelling + (1|Participant) + (1|Word)*.

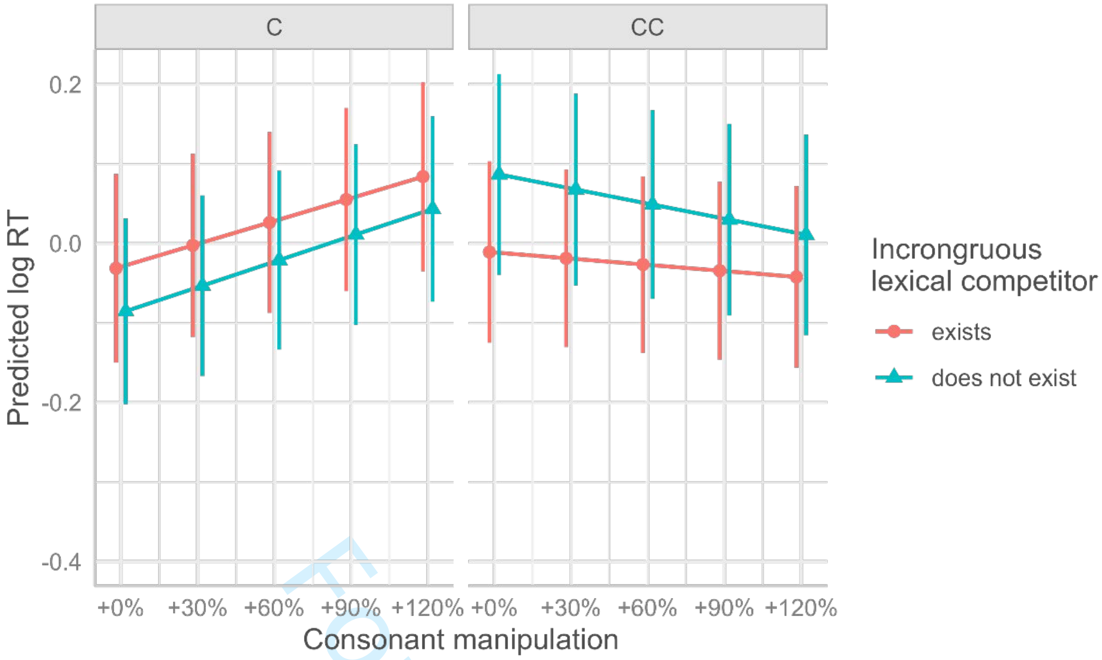

Figure 6. Predicted probabilities for Response Times extracted from the following model: *ResponseTime ~ IncongruousCompetitor * Step * Spelling + (1|Participant) + (1|Word).*

4. DISCUSSION

4.1 <C> stimuli

Globally, the behaviour for words spelled with a single target letter confirm our predictions. As for stimuli spelled with a single target letter and auditorily presented with a short consonant, we had predicted that they should not pose specific challenges to either group, since a short consonant is the default both in Italian and French. In fact, our results show that accuracy is high for both groups when duration manipulation is absent (+0%) or small (+30% and even +60%). Performance is slightly higher and response times are faster for FR than IT participants, but this difference is likely due to the higher cognitive load caused by the simultaneous activation of words in both languages (Spivey and Marian 1999) and to the lesser entrenchment of L2 words in the mental lexicon (Kroll and Stewart 1994, Jiang 2000).

Stimuli spelled with a single letter and auditorily presented with a long consonant revealed differences across groups, in the predicted way. FR participants were not affected by consonantal duration, neither in terms of accuracy, nor in terms of response time. Although we cannot exclude that FR participants noted unexpectedly long consonants, this did not affect their performance. The explanation for this behaviour is probably that listeners whose L1 does not have contrastive gemination are simply insensitive to consonantal duration, at least to a certain extent, or that such speakers interpret increased consonantal duration differently (non-phonemically), for example as emphasis or as speakers' idiosyncrasies. In contrast, IT participants were heavily affected by consonantal durations: stimuli with manipulated durations of more than +60% triggered lower accuracy and higher response times.

Interestingly, the effect of duration does not follow the same pattern for responses and response times. The latter are linearly affected, so that longer durations trigger progressively longer response times. Instead, responses show a quadratic-like pattern, by which accuracy is not altered until a certain threshold, after which it decreases: +0%, +30% and +60% are equally well recognised (although with increasing response times), while at +90% and +120% accuracy decreases. It is likely that longer consonants are not a good match, leading to more uncertainty and increased time to provide a YES response; after a certain threshold, the uncertainty is not only reflected by longer response times, but by listeners sometimes responding NO and thus dropping in accuracy. The threshold seems to be situated somewhere between +60% and +90%, loosely corresponding to the CC:C lengthening ratio reported by many studies on Italian geminate consonants, usually ranging from 1.7 to 2:5 for isolated words (see 1.2). This result contrasts with results on production, where L1 Italian learners were found to produce shorter durations for <CC> words in English than for L1 geminates: the average lengthening was between +11% and +39% in Bassetti et al. (2018), then between +33% and +53% in a larger-scale study on L2 English (Bassetti et al., 2020), and between +18% and +31% for L2 French (Mairano et al. 2018). Although production results vary depending on factors such as the choice of stimuli, target consonants, direct exposition to orthography, task types, length of naturalistic exposure, etc., it is clear that non-native gemination in L2 English and L2 French has globally shorter ratios than in the L1 (this also applies to L1 Japanese learners of L2 English, and L1 Arabic learners of L2 French, cf. Soković-Perović et al. 2020; Nawafleh 2022). Given that the perceptual threshold at which learners hear a consonant assimilated to a geminate is unchanged in the L2, we speculate that the smaller durations for consonants in <CC> words found in production tasks (Bassetti et al. 2018 and 2020, Authors 2018, Nawafleh 2022) may perhaps be due to a form of phonetic convergence towards native speakers.

4.2 <CC> stimuli

Results for stimuli spelled with a double target letter were not entirely as we had predicted. FR participants behaved as expected, and showed no effects: accuracy was high and response times remained unvaried in all conditions. Once more, this confirms that speakers whose L1 does not have a consonantal length contrast are not sensitive to variations of consonantal duration at a phonemic level.

It was hypothesised that the IT group would show higher accuracy and lower response times for CC stimuli if auditorily presented with a long consonant, given that they may expect these words to be pronounced with a longer consonant as an effect of spelling. However, accuracy for the IT group was high in all lengthening conditions; in fact, it was as high as for short C stimuli (see 4.1), suggesting that IT participants successfully recognised CC stimuli even if they were pronounced with a short consonant. Accuracy was globally lower for IT participants than for FR participants, but, as already mentioned, this was expected. As for response times, we observed a trend to decrease with longer durations, reflecting a facilitative effect for auditory stimuli that match spelling. However, the effect is smaller than the opposite effect found for <C> stimuli (see 4.1).

Stable accuracy for <CC> stimuli across lengthening conditions suggests that our participants have learnt not to expect long consonants in the speech of L1 French speakers and are able to correctly process such stimuli (although perhaps at a slightly higher cost – reflected by response times). This may also be due to the relatively advanced level of our participants (self-evaluated B1 - C1). One may argue that proficiency in L2 French (and possibly L2 English, since all our participants claimed at least some knowledge of this language) promotes a perceptual adaptation whereby short consonants can activate <CC> words (in addition to <C> words). It certainly is to a speaker-listener's advantage to stay flexible in the interpretation of phonological categories (Welby et al. 2022), and this is even more true in the context of L2 acquisition (Schertz et al. 2016), where instability and variation are extremely common. As suggested by an anonymous reviewer, it could also be that participants' experience with non-native Italian speech (where gemination in unlikely to follow native-like patterns) has an effect on this. At any rate, it seems that, for our participants and for <CC> words, perceptual adaptation prevails over the orthographic effect of double letters.

4.3 Asymmetric behaviour vis à vis <C> and <CC> stimuli

We had initially hypothesised that longer durations would trigger lower accuracy and higher response times for <C> stimuli, and vice versa, higher accuracy and lower response times for <CC> stimuli. Instead, as discussed in 4.1 and 4.2, we observed the expected effect of consonantal duration for <C> stimuli but hardly any effect for <CC> stimuli. This result is interesting for a number of reasons.

Firstly, the decreasing accuracy and higher response times for <C> stimuli auditorily presented with a long consonant clearly demonstrate that L1 Italian learners preserve sensitivity to consonantal duration in L2 French. So, even if they have learnt not to expect long consonants (or if they have adapted their perception to accept long consonants as short), they cannot turn off their sensitivity to consonantal duration in the L2: while FR speakers are not affected by unexpected consonant lengthening, IT learners clearly are. It is interesting to note that this is not a purely phonetic effect, instead it is clearly modulated by orthography. If it were purely phonetic, we would expect a symmetric behaviour of IT participants for <C> and <CC> stimuli, whereby in both cases longer durations would trigger lower accuracy and higher response time. Instead, longer durations have no negative effect on accuracy for <CC> stimuli, and response times even show a facilitative effect. All this points to a strong orthographic effect whereby IT participants perceptually accept long consonants reflecting L1 grapheme-phoneme correspondences, but are otherwise negatively affected by them. This confirms findings by previous studies proving that orthographic information is activated during auditory processing (Veivo and Kärvikivi 2013 and following). However, an alternative explanation has been suggested by an anonymous reviewer: it is possible that longer consonants allow for more processing time and, L2 processing being slower, longer consonants in a <C> word give learners more time to detect a mismatch than shorter consonants in a <CC> word. While this possibility cannot be completely ruled out, we argue that, in this case, we would expect to observe a linear (rather than quadratic) effect of consonantal duration (whereby every step of +30% duration would give an equal extra amount of time for processing) and a decrease (rather than an increase) of response time, reflecting the fact that the mismatch is more easily spotted.

Secondly, the results for <C> and <CC> stimuli give us insights into the type of adaptation that learners seem to have adopted. In 1.4 we had mentioned three possible changes, namely: (a) a modification of phonological representations for <CC> words to singleton consonants, (b) a modification of phonological representations for <CC> words to consonants with underspecified duration, (c) enhanced flexibility in the interpretation of acoustic cues for gemination, so that short realisations can match mental representations with long consonants and vice versa. We can rule out change (a), since learners produced longer consonants in L2 French (Mairano et al. 2018) and response times show a facilitative trend for longer durations corresponding to <CC> words. Change (c) can also be ruled out, since learners tended to reject longer durations for <C> words, suggesting that the adaptation they have adopted is unilateral. So, change (b) seems to apply: learners have moved from a situation in which singletons and geminates exist with L1 characteristics in their L2 French lexicon, to a situation in which <C> words are specified with a short duration and <CC> words have underspecified or fuzzy duration: this means that realisations with short durations can still activate <CC> words during auditory processing, while these words may still be realised with longer consonants in production. Asymmetries in the lexical encoding of phonological contrasts (e.g., Barrios and Hayes-Harb 2021) and fuzzy phonological representations (e.g., Darcy et al. 2015) have been previously observed in the L2, and when processing L1 and L2 accents (Dufour et al. 2019, Weber et al. 2014). It has been suggested that sounds involved in difficult L2 contrasts tend to be fuzzier (e.g., Cutler et al. 2006). In our case, fuzziness in the phonological representation of <CC> words is modelled by spelling (suggesting the existence of geminate consonants) and L2 experience (suggesting the absence of geminate consonants), and can be considered an improvement towards a full L2 acquisition. It could be speculated that this type of fuzziness may start with exposure to L2 auditory and orthographic input, and gradually increases with L2 experience until a culmination, possibly followed by the re-encoding of <CC> words with singleton consonants.

4.4 Cognate words and lexical competitors

We did not find cognate effects on accuracy and response times of our participants, neither in terms of L1 cognate existence, nor in terms of cognate congruency. One may expect that French words with an orthographically congruous Italian cognate (i.e., spelled with the same <C> or <CC> grapheme) may trigger a stronger effect of consonant manipulations (which would be deviant from both L1 and L2 spelling); in contrast, French words with an orthographically incongruous cognate may lead participants to more easily accept deviant consonant durations (given that they match more closely the expected duration for the L1 cognate). However, no significant effects of this type were uncovered. This may be due to the fact that incongruous spelling is found in only 7 (out of 144) cognate words, but similar results have also been found in previous studies by Bassetti et al. (2018, 2020) and globally seem to suggest that orthographic congruency is not a very relevant factor interacting with non-native gemination, both in production and perception.

Instead, we found significant effects for the existence of incongruous lexical competitors (ILCs). If at least one ILC exists in French or Italian for the truncated audio, our participants are more likely to be misled by manipulated consonantal durations in the <C> condition and show higher response times: ILCs therefore disturb participants' processing of the truncated audio and slow down their response. When processing truncated stimuli where an ILC does not exist, participants may be more likely to respond accurately even with manipulated consonants because they can find no better match in their mental lexicon. In contrast, if an ILC exists, they are less likely to respond accurately because they may consider the ILC to be a better match than the target word itself. However, we again observe this effect exclusively in the <C> condition, while in the <CC> condition the presence of an ILC does not have a significant effect on responses. Once more, we are led to conclude that relatively advanced learners of L2 French have unidirectionally adapted their perception so that they accept short consonants for <CC> words and this holds even if an ILC exists, while they are disturbed by longer duration for <C> words, and to a larger extent if an ILC exists. That said, the effect of ILCs may need to be further investigated in the future, since we were not able to control many factors that could potentially contribute to this effect: we were only able to control for the existence of at least one ILC in French or Italian, but we have no guarantee that said ILC is actually known (especially in the L2) by participants and, therefore, present in their mental lexicon. Additionally, we did not control for the number and frequency of ILCs: we can reasonably expect that a higher number of ILCs, and/or their higher lexical frequency, may result in a stronger effect.

4.5 The driving force of lexical expectations in our experiment

We have postulated that L1 Italian learners of L2 French encode consonantal duration in their mental lexicon based on how words are spelled, so the phonological representations of French words may contain long vs. short consonants. This, in turn, generates expectations about the pronunciation of consonant as short or long. However, our bimodal truncated word-matching paradigm includes visual presentations of words. This means that learners' expectations may not necessarily come directly from the phonological representations in their mental lexicon, but may also come from exposure to the written form of the word. Unfortunately, the present experiment does not allow us to conclude what exactly is the force that drives such expectations in L2 French. It may be reasonable to assume that both forces can play a role, and reinforce each other in a paradigm like the one used in this study. As suggested by an anonymous reviewer, one way to tease apart these two possible accounts would be to run a lexical decision task with audio stimuli, without exposure to written input. Should we still find that learners are less accurate and slower in accepting longer durations for <C> words than <CC> words, we could at last conclude that the driving force of such expectations comes indeed from phonological representations in the mental lexicon.

5. CONCLUSION

Our experiment has shown that Italian learners of L2 French generate expectations on consonant duration based on spelling with single vs. double letters. Participants in a bimodal truncated word-matching task with manipulated consonant durations showed an asymmetric behaviour for stimuli spelled with a single vs. double letter. In the single-letter condition, auditory stimuli with a lengthened consonant caused lower accuracy and higher response times. In contrast, in the double-letter condition, auditory stimuli with a lengthened consonant did not affect responses, and response times decreased. Although the facilitative effect of lengthening in the double-letter condition is reflected by response times but not accuracy, we still observe a plainly asymmetric behaviour across the two orthographic conditions. On the basis of these results, we argue that our participants (whose self-declared proficiency ranges from B1 to C1) have learnt to recognise French words even when their auditory form does not contain long consonants corresponding to double letters, and this is probably due to phonological representations with fuzzy specifications for consonant duration promoted by exposure to native French in the classroom or during stays in French-speaking countries. In other words, we think that learners' mental lexicon includes phonological representations of long vs. short consonants based on spelling; despite this, L2 experience favours the adaptation of such representations making them underspecified for consonant durations, so that learners manage to accurately process L2 speech (which does not contain geminates). They preserve perceptual sensitivity to consonantal duration in the L2, which may become an obstacle to L2 auditory processing when unexpected long consonants are presented corresponding to single letters. We find it reasonable to claim that this perceptual sensitivity to consonant durations (which was not observed for L1 French control speakers) is imported from the L1 phonological system, although mediated by spelling. It is possible that, as postulated in the framework of the Revised Speech Learning Model (SLM-r, Flege and Bohn 2021), L1 and L2 phonological categories co-exist in a common phonetic space (the original SLM used the term "common *phonological* space", Flege 1995), and are both constantly active. While our study was not devised to directly address the question of how and why perceptual sensitivity to consonantal duration is active in the L2 despite having learnt not to expect long consonants, we are still able to show that such sensitivity is clearly modulated by orthography: lengthened consonants have a disturbing effect for L1 Italian listeners of L2 French only if incongruous with spelling.

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APPENDIX 1: List of experimental stimuli

The table below gives stimuli for block 1 (target consonant at the onset of the second syllable). In the second column, consonants in bold and underlined indicate cognate words for which singleton/geminate status is incongruous across French and Italian spelling. The third and fourth columns give the existence of incongruous lexical competitors in French and Italian (if existent, an example is given) for the non-truncated part of the audio stimulus.

	Target word	IT cognate	FR incongr. compet.	IT incongr. compet.
<p>	capacité	capacità	cappadocien	Cappadocia
	diapason	diapason	/	/
	capuchon	ca**pp**uccio	/	*cf. IT cognate*
	Tripoli	Tripoli	/	trippone
	propolis	propoli	/	/
	reporter	riportare	/	/
	proposer	proporre	/	/
	repartir	ripartire	/	/
	reposant	riposante	/	/
	reposer	riposare	/	/
<pp>	apparat	apparato	apathique	Apatico
	appareil	apparecchio	apathique	Apatico
	appuyer	appoggiare	apurable	Apuano
	Hippolithe	Ippolito	hyponyme	Iponimo
	opportun	opportune	opossum	Opossum
	supporter	supportare	/	/
	supposer	supporre	/	/
	apparaître	apparire	apathique	Apatico
	opposant	opponente	opossum	opossum
	opposer	opporre	opossum	opossum
<t>	catalan	catalano	/	Cattaneo
	latitude	latitudine	/	lattico
	futuriste	futurista	/	/
	étoilé	stellato	/	/
	motoski	moto-sci	/	/
	retardé	ritardato	/	/
	atypique	atipico	attirer	attirare
	atonal	atonale	/	attonito
	retirer	ritirare	/	rettile
	étiré	stirato	/	/
<tt>	attaché	attaccato	atavique	atavico
	attitude	attitudine	atypique	atipico
	guttural	gutturale	/	/
	nettoyer	/	/	/
	ottoman	ottomano	otoscopie	otorino
	attardé	attardato	atavique	atavico
	attiédir	in**t**iepidire	/	/
	attiédi	in**t**iepidito	/	/
	attirer	attirare	atypique	atipico
	attiré	attirato	atypique	atipico
<l>	Palestine	Palestina	palléale	palleggiare
	polémique	polemica	/	polleria
	molécule	molecola	/	molleggiare

	policier	poliziotto	polliniser	polleria
	pélican	pe**ll**icano	pellicule	*cf. IT cognate*
	prolonger	prolungare	/	/
	élaborer	elaborare	/	/
	bilatéral	bilaterale	/	/
	bilinguisme	bilinguismo	/	/
	délaissé	/	/	/
<ll>	allergie	allergia	alerter	aleremmo
	collectif	collettivo	cholérique	colecistite
	collégial	collegiale	choléra	colera
	collision	collisione	colibri	colibrì
	pellicule	pellicola	pélican	pelino
	allonger	allungare	alogique	alonato
	collaborer	collaborare	colateur	colare
	collatéral	collaterale	colateur	colare
	illicite	illecito	Iliade	Iliade
	illégal	illegale	iléal	Ileana
<n/m>	domestique	domestico	/	/
	samaritain	samaritano	/	Sammarinese
	familial	famigliare	/	/
	animalier	animalesco	annihiler	annidare
	canicule	canicola	cannibale	cannibale
	amener	/	/	ammenda
	émigré	emigrato	/	/
	dénotation	denotazione	/	/
	rénovation	ri**nn**ovazione	/	/
	inondable	inondabile	/	/
<nn/mm>	commerçant	commerciante	/	/
	grammatical	grammaticale	/	gramaglia
	mammifère	mammifero	mamillaire	/
	anniversaire	anniversario	animal	animale
	cannibale	cannibale	canicule	canicola
	emmener	/	/	emenda/amenda
	immigré	immigrato	imiter	imitare
	connotation	connotazione	conoïde	conoscere
	innovation	innovazione	inoxydable	inossidabile
	innombrable	innumerevole	inonder	inondare

The table below gives stimuli for block 2 (target consonant at the onset of the penultimate syllable). In the last column, we have included (in brackets) IT incongruous cognates that are technically competitors of the IT cognate rather than of the target word, or that are formed with cognate suffixes (e.g., '-er' and '-are' for infinitive).

	Target word	IT cognate	FR incongr. compet.	IT incongr. compet.
<p>	rescaper	(ri)sca**pp**are	/	*cf. IT cognate*
	épopée	epopea	/	/
	onomatopée	onomatopea	autostopper	/
	handicapé	handica**pp**ato	kidnappé	*cf. IT cognate*
	canapé	/	kidnappé	/
	municipal	municipale	/	/
	épiscopal	episcopale	/	/

	découpeur	/	/	/
	précipice	precipizio	/	/
	archipel	arcipelago	/	/
<pp>	échapper	scappare	/	(derapare)
	envelopper	inviluppare	galoper	/
	autostopper	autostoppare	/	/
	sousdéveloppé	sottosviluppato	galoper	/
	développé	sviluppato	galoper	/
	antigrippal	/	/	/
	autostoppeur	autostoppista	/	/
	développeur	sviluppatore	galopeur	/
	Philippines	Filippine	/	/
	kidnappeur	/	/	/
<t>	tricoter	/	boycotter	(biscottare)
	société	società	/	/
	inquiétant	inquietante	/	picchiettante
	incompétent	incompetente	pipettant	rimpettente
	propriété	proprietà	/	/
	hôpital	ospedale	/	/
	coauteur	coautore	boycotteur	/
	éclatante	/	/	/
	fondateur	fondatore	/	(redattore)
	répéteur	ripetitore	/	(ispettore)
<tt>	boycotter	boicottare	tricoter	/
	endetter	indebitare	/	*cf. IT cognate*
	compromettant	compromettente	guillemétant	/
	intermittent	intermittente	limitant	/
	regretter	/	/	/
	sagittal	sagittale	digital	digitale
	boycotteur	boicottatore	tricoteur	/
	combattante	combattente	/	/
	transmetteur	trasmettitore	/	/
	émetteur	emittente	/	/
<l>	avaler	/	/	(avallare)
	picoler	/	décoller	(incollare)
	bricolant	bricolage	décollant	(incollante)
	signaler	segnalare	/	/
	désolant	desolante	grisollant	/
	démolir	demolire	ramollir	rammollire
	Coraline	/	coralline	coralline
	Caroline	Carolina	/	/
	insolente	insolente	/	/
	abolir	abolire	/	sobbollire
<ll>	emballer	imballare	brimbaler	/
	encoller	incollare	bricoler	calcolare
	autocollant	autocollante	bricolant	calcolante
	installer	installare	étaler	/
	excellent	eccellente	recélant	/
	ramollir	rammollire	démolir	demolire
	coralline	corallina	tétraline	centralina
	cristalline	cristallina	naphtaline	naftalina

	intellect	intelletto	/	/
	embellir	imbellire	/	/
<m/n>	proclamer	proclamare	programmer	programmare
	réclamer	reclamare	/	/
	épiphanie	epifania	/	/
	détoner	detonare	étonner	/
	litanie	litania	/	/
	matinal	mattinale	/	/
	libanaise	libanese	/	/
	cardinal	cardinale	/	/
	marginal	marginale	/	/
	national	nazionale	/	/
<nn/mm>	programmer	programmare	/	/
	enflammer	infiammare	/	/
	décennie	decennio	Sarracénie	(proscenio)
	étonné	/	détoné	detonato
	tyrannie	tirannia	hémicrânie	soprani/(emicrania)
	décennal	decennale	phénoménal	arsenale
	dépanneur	/		/
	biennal	biennale	phénoménal	schienale
	centennal	centennale	/	/
	septennal	settennale	/	/

Appendix 2: French translation of the instructions given to participants.

Instructions for block 1 read as follows:

'*Vous allez passer une expérience de perception qui consiste dans les étapes suivantes: (1) vous écoutez 2 syllabes (la première partie d'un mot), (2) un mot va apparaître, (3) vous devez décider (le plus rapidement possible) si le mot apparu correspond aux 2 syllabes que vous avez écoutées: appuyez sur la touche <S> si le mot correspond, ou <L> si le mot ne correspond pas.*'

They translate as follows:

You will complete a perceptual test consisting of the following steps: (1) you will listen to two syllables (the first part of a word), (2) a word will appear, (3) you will have to decide (as fast as possible) if the word on the screen corresponds to the two syllables you heard: press <S> if the word corresponds, or <L> is it does not correspond. (<S> and <L> are respectively on the left and right of a French keyboard).

Instructions for block 2 read exactly the same, except that we replaced '*the first part of a word*' with '*the last part of a word*'.