L1 PHONOTACTIC CONSTRAINTS MEDIATE PHONOLOGICAL AWARENESS OF NON-NATIVE GEMINATION

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ABSTRACT

Previous studies have revealed that L2 learners whose L1 has contrastive gemination may produce long consonants in an L2 which does not have gemination, due to orthography (e.g., in words with double consonants, such as 'Finnish' vs 'finish'). For the same reason, learners may reject rhymes such as 'very' and 'cherry'. In this study, we confirm that gemination affects the phonological awareness of L1 Italian learners of L2 French, but we find that it is mediated by L1 phonotactics. 24 Italian learners of French and 24 French control speakers participated in a discrimination test where the duration of target consonants was manipulated. Italian learners tended to rate stimuli with a lengthened consonant as different (non-)words, but only in contexts where gemination is licit in Italian. Vice versa, in contexts where gemination is illicit, responses by Italian learners do not differ from those of control French native speakers.

Keywords: second language acquisition, gemination, phonotactics, consonantal length, L2 perception.

1. INTRODUCTION

Phonological contrasts in quantity (i.e., gemination) for consonants exist in languages such as Italian, Arabic, and Japanese. Consonant duration is known to be the main cue of gemination, though secondary cues have been uncovered for various languages. In Italian, geminate consonants have been found to be approx. twice as long as singleton consonants in isolated words [1], but only approx. 1.7 times longer in running speech [2]. Geminating languages often have geminate consonants in intervocalic position, but far more rarely within clusters and in word-initial or word-final position [3]; gemination in these contexts is therefore considered as typologically marked.

Recent studies have uncovered that second language speakers whose L1 has contrastive gemination may produce long and short consonants in an L2 even if gemination is not lexically contrastive in the target language. We refer to this as *non-native gemination*. This phenomenon has been observed for Italian$_{L1}$ [4] and Japanese$_{L1}$ [5] learners of English$_{L2}$, as well as Italian$_{L1}$ [6] and Arabic$_{L1}$ [7] learners of French$_{L2}$. The presence of non-native geminate consonants is attributed to the effect of orthography: Bassetti et al. [4] demonstrated that English homophones such as '*finish*' and '*Finnish*' are pronounced respectively with a short vs long consonant by Italian$_{L1}$ learners following Italian grapheme-phoneme correspondence rules, since these words are spelled with a single vs double letter. The authors argue that such minimal pairs are evidence of the contrastive role of gemination in the mind of Italian$_{L1}$ learners, and also find that single vs double consonants in spelling affect rhyming judgments [8] and perception [9]. Mitterer [10] did not find comparable results with Maltese$_{L1}$ learners of English$_{L2}$, whose acquisition is less based on orthography (English$_{L2}$ is used outside the classroom), and concluded that the orthographic effect found for Italian$_{L1}$ learners is due to focus on orthography in formal education.

Interestingly, it seems that Italian$_{L1}$ learners may not only produce longer consonants for words like '*Fi<u>nn</u>ish*', but also (though far more moderately) for words where gemination is not possible in Italian and typologically marked, namely in clusters ('*gue<u>ss</u>ed*') and word-final position ('*a<u>dd</u>*') in English$_{L2}$ [4] and French$_{L2}$ ('*patte*' [pat], [6]). Although it is well-known that L1 phonotactics can have an impact on L2 production (e.g., Mandarin$_{L1}$ and Japanese$_{L1}$ learners produce an epenthetic / excrescent vowel for complex consonant clusters in English$_{L2}$, cf. [11, 12]) and L2 perception [13], the results on non-native gemination mentioned above suggest that the orthographic effect of double consonants override at least partially the phonotactic effect restricting contexts for gemination.

In this study, we aim to better understand the phonetic and phonological properties of non-native gemination, making abstraction of its roots in spelling. On the one hand, we aim to gather further evidence that gemination can have a contrastive role in the mind of Italian$_{L1}$ learners by demonstrating that French (non-)words are judged as different words if pronounced with a short vs long consonant. On the other hand, we wish to examine more closely the interplay of phonotactics on this phenomenon, by establishing whether such judgments differ in contexts where geminate consonants do vs do not comply with Italian phonotactic restrictions.

2. DATA AND METHODS

2.1. Stimuli

In view of developing an auditory discrimination test (cf. 2.2) for Italian$_{L1}$ learners of French$_{L2}$, we devised a set of 60 disyllabic stimuli, all of which were French non-words in French (as well as in Italian), corresponding to 3 different sets (20 stimuli x 3 sets), as shown in Table 1.

1. Stimuli in the first set were C_1V_1ˈ$C_2V_2C_3$ non-words, where C_2 is a geminable consonant in a ***legal context*** (intervocalic) by Italian phonotactic rules, and V_1 and V_2 are French vowels that have a direct counterpart in Italian (***native***) (e.g., [vaˈpiʀ]).
2. Stimuli in the second set were C_1V_1ˈC_2V_2 non-words, where C_2 is a geminable consonant in a ***legal context*** (intervocalic) by Italian phonotactic rules, and V_1 and V_2 are French vowels that do not have a direct equivalent in Italian (***foreign***) (e.g., [vyˈpɔ̃]).
3. Stimuli in the third set were $C_1V_1C_2$ˈC_3V_2 non-words, where C_3 is a geminable consonant in an ***illegal context*** (preceded by another consonant) by Italian phonotactic rules (e.g., [vɔʀˈpe]).

	[p]	[t]	[l]	[m]
legal	[vaˈpir]	[vaˈtir]	[daˈlir]	[baˈmir]
	[baˈpir]	[naˈtir]	[naˈlir]	[kaˈmir]
	[laˈpir]	[laˈtir]	[gaˈlir]	[gaˈmir]
	[ʃaˈpir]	[zaˈtir]	[maˈlir]	[taˈmir]
	[faˈpir]	[faˈtir]	[faˈlir]	[faˈmir]
foreign	[vyˈpɔ̃]	[vyˈtɔ̃]	[dyˈlɔ̃]	[byˈmɔ̃]
	[byˈpɔ̃]	[nyˈtɔ̃]	[nyˈlɔ̃]	[kyˈmɔ̃]
	[gyˈpɔ̃]	[gyˈtɔ̃]	[gyˈlɔ̃]	[gyˈmɔ̃]
	[ʃyˈpɔ̃]	[zyˈtɔ̃]	[zyˈlɔ̃]	[tyˈmɔ̃]
	[fyˈpɔ̃]	[fyˈtɔ̃]	[fyˈlɔ̃]	[ʒyˈmɔ̃]
illegal	[vɔrˈpe]	[vɔrˈte]	[vɔrˈle]	[bɔrˈme]
	[bɔrˈpe]	[bɔrˈte]	[nɔrˈle]	[kɔrˈme]
	[lɔrˈpe]	[lɔrˈte]	[gɔrˈle]	[gɔrˈme]
	[ʃɔrˈpe]	[ʃɔrˈte]	[mɔrˈle]	[tɔrˈme]
	[nɔrˈpe]	[nɔrˈte]	[fɔrˈle]	[zɔrˈme]

Table 1: The 60 experimental stimuli. For each stimulus, the target consonant is underlined.

The stimuli were recorded by a native speaker of French (a phonetician), in a sound-proof booth. Subsequently, every non-word was manipulated in *Praat* [14] by artificially lengthening the duration of the target consonant by steps of +30%, thereby obtaining 5 different stimuli covering the full range from singletons to geminate consonants: +0% (original recording), +30%, +60%, +90%, +120%. No artefacts of the manipulation were audible.

Additionally, 60 French non-words were recorded to be used as distractors. Each distracting non-word differed from a corresponding experimental non-word by one phoneme; for example, the distractor [vaˈmiʀ] was recorded to match the experimental item [baˈmiʀ].

2.2. AX auditory discrimination test

The stimuli described above were used for an auditory discrimination test with 120 experimental trials (and 4 training trials) in *PsychoPy2* [15]. The format of the test is illustrated in figure 1 and ran as follows: after a short fixation (0.4 sec.), participants heard a first stimulus (A), then a second one (X), separated by an interval of 1.2 seconds in order to trigger phonological rather than acoustic processing (cf. [16, 17]). Participants were told they would hear pairs of extremely rare French words that would probably be unknown to them; their task was to choose whether the two words were in fact the same, or different words, by clicking 's' or 'l' on the keyboard. They were exposed to audio only (the screen was blank) while listening; once the second stimulus had been played, a one-liner appeared on the screen reminding participants which keys should be pressed. Once they had provided a response, they were immediately taken to the following trial. They could not change their response, nor go back, nor re-play stimuli. *PsychoPy2* recorded participants' responses and response times.

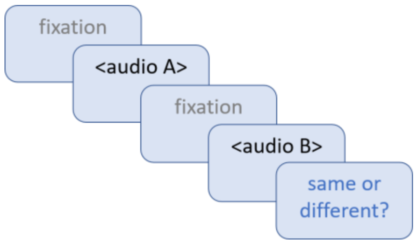

Figure 1. Auditory discrimination test.

60 trials tested experimental stimuli: 12 trials tested stimuli with the target consonant duration at +0% (our baseline, correct response = 'same'), 12 trials tested items with +30% duration, 12 trials tested items with +60% duration, 12 trials tested items with +90% duration, 12 trials tested items with +120% duration. We used a Latin square design with 5 presentation lists, so that participants heard each non-word only once (i.e., in only one of the 5 experimental conditions). The other 60 trials were control trials: participants heard an experimental item (A) and a distractor (X), so that the expected response was always 'different'. Trials testing experimental items and those testing distractors were randomised.

2.3. Participants

We recruited 24 Italian$_{L1}$ learners of French$_{L2}$ (henceforth IT) and 24 French$_{L1}$ native speakers (henceforth FR). IT participants were students at the Faculty of Foreign Languages in Turin. 15 of them were born in the local area and had grown there, while 9 were born in other parts of Italy and had moved to Turin 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 [2, 18] (except for sandhi gemination, a.k.a. *raddoppiamento fonosintattico*, not relevant for our study). Among IT participants, 20 identified as women, 4 as men (average age: 25.1, *SD* = 3.7), reflecting the gender imbalance found among students of Languages. The average age of first contact with French was 12 (range: 6 - 21). The self-declared level of French$_{L2}$ ranged from B1 to C1; 6 participants had been in Erasmus programmes in France, and 13 others had been at least once to a French-speaking country (median: 2 weeks, range: 1 week - 9 months). A larger number of participants claimed to regularly read and listen to French (*n* = 17 and 16, respectively), than write and speak (*n* = 11 and 9). Among FR participants, 16 identified as women, 8 as men (average age = 23.2, *SD* = 2.6). They were students at the Faculty of Linguistics at the University of Paris 8 and lived in the Paris area at the time of recording.

2.4 Procedure

Participants were asked to take 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 a AKG HSC 271 headset and ran the test on *PsychoPy2*. A training session of 4 trials preceded the real test, which was conducted without interruption and lasted approximately 10 minutes. Participants were instructed to take the test as spontaneously as possible, providing immediate and non-pondered responses. The test was taken within a larger data collection project, so participants also performed other production and perception tasks for a total of approximately 75 minutes.

3. RESULTS

3.1 Analysis of responses

In total, we obtained 2880 responses for experimental stimuli (60 x 48 participants). The data were analysed on R, building generalised linear mixed-effects models with *lme4* [19], *p* values were obtained with *lmerTest* [20]. We built a binomial model to predict participants' responses ('same' or 'different') on the basis of consonant duration (+0% to 120%), context (legal, foreign, illegal) and L1 (Italian, French). We included participant and consonant (/p/, /t/, /l/, /m/) as random effects, with random intercept and random slopes: *Response ~ ConsonantDuration * L1 * Context + (ConsonantDuration + Context | Participant) + (Step + L1 | Consonant)*. In order to deal with convergence issues, we set the *bobyqa* optimizer to run up to 100.000 function evaluations. It has to be noted that, due to the continuous nature of acoustic durations, consonant duration was coded as numeric, ranging from 1 to 2.2, despite the fact that we tested only 5 steps on the continuum (1 = +0%, 1.3 = +30%, 1.6 = +60%, 1.9 = +90%, 2.2 = +120%). To be on the safe side, we also ran the analysis with step as a 5-level factor instead of duration, and obtained comparable results. Model predictions extracted via *ggeffects* [21] are shown in figure 2.

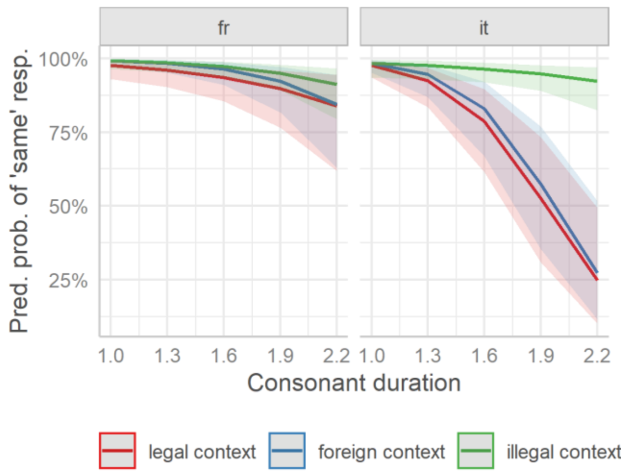

Figure 2: Predicted probabilities for responses as 'same' by L1 (fr, it) and consonant duration (ranging from 1 = +0%, to 2.2 = +120%).

The plots clearly show differences across groups: responses by FR participants do not seem to be heavily affected by the target consonant duration, while responses by IT participants are heavily affected by duration in contexts where gemination is phonotactically legal. The summary of our model revealed a significant effect of consonant duration on responses (*p* = .005), reflecting the overall decrease of 'same' responses for higher durations. Additionally, we observed a significant two-way interaction of consonant duration x L1 (*p* = .003), and a significant three-way interaction of consonant duration x L1 x context. We ran post-hoc pairwise comparisons with Holm correction via *emmeans* ([22]) at each of the 5 steps, confirming what had been inferred from the plots: responses by FR participants for the legal, foreign and illegal contexts do not significantly diverge from each other at any of the 5 steps (all adj. p values > .273). Instead, responses by IT participants significantly diverge for the illegal versus legal and foreign contexts at the 1.6 step and higher (adj. p values < .001 for the 1.6, 1.9 and 2.2 steps), while responses for the legal and foreign contexts do not significantly diverge from each other (adj. p = 1 at all steps). Additionally, responses given by IT participants in the illegal context do not significantly diverge from those given by FR participants (adj. p = 1 at all steps).

3.2. Analysis of response times (RTs)

The analysis of normalised (log-transformed) RTs was performed in a similar way. After eliminating outliers (RTs > 2 SDs of the mean, n = 103), we built a linear mixed-effects model to predict RTs: *log(RT) ~ ConsonantDuration * L1 * Context + (ConsonantDuration + Context | Participant) + (Step + L1 | Consonant)*. Model predictions are shown in figure 3.

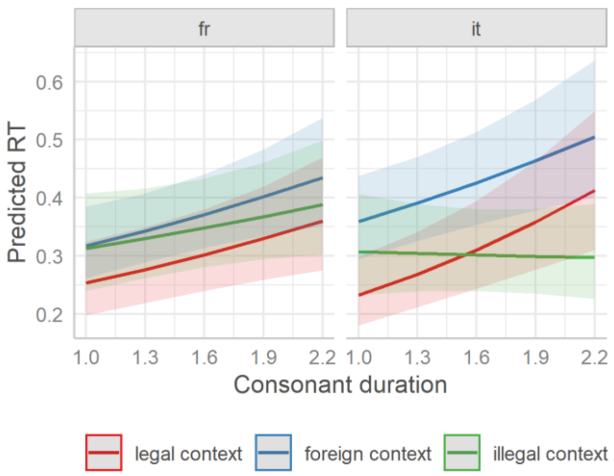

Figure 3: Predicted response time by L1 (fr, it) and consonant duration (ranging from 1 = +0%, to 2.2 = +120%).

The plots illustrate a general trend of RTs to increase with consonant duration for both groups, except for IT when gemination is illegal. The model summary confirms that the effect of consonant duration is significant (p = .002), and suggests the presence of a mild three-way interaction of consonant duration x L1 x Context (p = .054). Similar to above, we ran post-hoc pairwise comparisons with Holm correction at each step: RTs by FR participants for the legal, foreign and illegal contexts do not significantly diverge from each other at any step (all adj. p values > .087). Instead, RTs by IT participants significantly diverge for the foreign vs legal context (all adj. p values < .042, except at the last step), probably reflecting the higher cognitive demand in processing non-native sounds. RTs by IT participants in the illegal context are shorter than in the foreign context (adj. p values < .001 at steps 1.6 and higher).

4. CONCLUSIONS

The results of the auditory discrimination test revealed that IT participants respond to manipulated consonant durations in French$_{L2}$ differently from FR participants: when the target consonant duration is manipulated to sound like a geminate consonant (+60% and higher), IT participants tend to judge it to be a different word than the same stimulus with non-manipulated duration. We do not know if this effect is simply phonetic (e.g., longer durations directly activate gemination even though it does not exist natively in the L2), or if it is mediated by a reconstructed orthographic form (i.e., when listening to such stimuli, participants imagine it as spelled with a double consonant and hence judge it to be a different word). At any rate, it seems reasonable to conclude that gemination affects Italian$_{L1}$ leaners' phonological awareness of French$_{L2}$: for them, a stimulus with a long consonant is a different word than the same stimulus with a short consonant: clearly, gemination can have a contrastive role in their interlanguage (cf. also [4, 8, 9]).

The main result of this study is that non-native gemination seems to be mediated by phonotactic constraints: when the target consonant is preceded by another consonant (and therefore gemination is not possible in Italian), IT participants are not affected by consonant duration and respond similarly to FR participants; even their RTs are not affected by consonant duration in this condition. We think that various explanations are plausible. On the one hand, learners may simply transfer L1 phonotactic rules to the L2, and consider gemination as impossible in such contexts. Alternatively, their responses may be due to a phonotactically-conditioned length-deafness; in other words, Italian$_{L1}$ speakers may be deaf to consonant lengthening in contexts where gemination cannot exist in their L1. Such length-deafness may be caused by phonotactic rules themselves (i.e., L1 phonotactic restrictions make speakers deaf to consonant lengthening in other contexts), or driven by markedness (gemination being typologically marked in these contexts). While our present data do not allow us to definitively settle the exact cause, the fact that IT participants' RTs are not affected by consonant durations in the illegal context seems to suggest that these speakers do not notice variation in duration, thereby potentially hinting at a phonotactically-conditioned length-deafness. Future studies will address this issue more specifically.

5. ACKNOWLEDGMENTS

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