On the Pronunciation of the Japanese Consonantal Length Contrast by Italian, French and English Native Speakers

フランス語・英語・イタリア語母語話者の
日本語の促音の発音について

A Dissertation Presented to
the Graduate School of Arts and Sciences
International Christian University
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国際基督教大学　大学院
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Acknowledgements

First and foremost, my dissertation project would never have been possible without the help of all the wonderful Japanese, French, Italian and English native speakers who volunteered for the experiment. Thank you very much for your time and understanding. I would also like to thank the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT) for the financial support I was granted for three of the four and a half years I spent in ICU.

I would like to express my deep gratitude to my dissertation committee members Professor Junko Hibiya, Professor Machiko Tomiyama, Professor Yutaka Sato and Professor Seunghun J. Lee for their patient guidance, encouragements and for their valuable advice and critiques on my research work. As my research advisor, Professor Seunghun J. Lee has taught me more than any class could ever teach me, both when advising my dissertation and by giving me the opportunity to involve in various research projects. I am also indebted to my Master thesis research advisors from Paris Diderot University who encouraged me to pursue my studies in Japan: Professor Akiko Nakajima, Professor Takeki Kamiyama, and Professor Daniel Struve who supported me since my first year as an undergraduate student. I would never have been able to join the Ph.D. program at ICU without their help and encouragements. I would like to extend my thanks to Professor Murray Munro and Professor Shigeto Kawahara for their helpful comments.

Assistance provided by the administrative staff at ICU was greatly appreciated. Thank you for always your always patient advice and efficient work. Otsuka-san going to the Graduate School Office has never been so fun.

The following people also have been supporting me in my academic and professional carrier: Brigitte Koyama, Tomohiko Ooigawa, Atsushi Nozawa, Shoichiro Iwakiri, Hasumi Nishikawa, Tomoyuki Yoshida. I am also particularly grateful for the assistance given by my superiors and co-workers at Bunkyo Gakuin University: Professor Sandra Tanahashi and Professor Izumi Takiguchi for teaching me what and how to teach, and Diana Boiko, Flavia Feijo, Gabriel Guevara, Ify Mirabel Eyze for being such great co-workers. Many thanks go also to my fellow graduate students at ICU: Machi Niiya, Atsushi Oho, Michinori Suzuki, Sonny Bardot and Moe Kano.

I am indebted to my friends from ICU and from France for their continuous friendship, understanding, and moral support over the years: Ayuka Yamanaka, Justine Letrou, Saki Tabata, Ella Lee, Adrien Renaudet, Audrey Mazac, Suzanne Distain. You were always the right persons to complain to when I needed to. Thank you for still being with me after that. Thanks also to Sam and Daniel for always giving me inspiration. I am also grateful to Guillaume Albert who as my sempai at ICU (who was often mistaken for my brother), and as a friend gave me more academic and non-academic advice than I could ever hope for.

Finally, I would like to thank my family for their continuous support from the other side of the world. I cannot imagine how it might feel when your daughter decides to live at a 10000km distance from you, but I can only thank you for always being supportive of my educational and life choices. And last but not least, I would like to thank my husband Shinichiro Sano, who is responsible for the beginning of it all, and who is always the anchor in my life when things seem to be falling apart and the path is not clear. Thank you for being a great role-model, for your endless patience and support, and thank you for always having the right joke for desperate situations.

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CHAPTER 1: INTRODUCTION

When compared to L1 acquisition, our understanding of L2 acquisition process is less straightforward. As a consequence, it has been extensively studied in the literature, putting in competition several models trying to account for it. One view that all models share is the crucial role played by L1 phonology in the acquisition process of L2 pronunciation[1].

Early models focused on how the differences or similarities between L1 and L2 phonological inventories allow to predict error patterns in a learners' L1. This is for example the case of Lado's (1957) Contrastive Analysis Hypothesis (CAH), which assumes that identical phonemes should not be problematic, while different ones, or those in allophonic distribution with the learners' L1, should inversely be so. On the other hand, still based on the comparison between L1 and L2, models like the Crucial Similarity Measure (CSM, Wode 1976) focus on similarities as a basis to account for L1 transfer. Without being limited to identifying error patterns, the role of L1 is also major in the significant body of research that relates the L1 phonemic inventory to the formation of a learners' interlanguage phonology, which is both different from the L1 and the L2's (Suter 1967, Eckman 1981, Carlisle 1998 *interallia.*).

Crosslinguisitic speech perception models based on phonetic evidence like the Feature Competition Model (FCM, Hancin-Bhatt 1994), the Speech Learning Model (SLM,

[1] See Eckman (2004) and Mayor (2008) for a comprehensive review of L2 phonology acquisition.

Flege 1995) or the Perceptual Assimilation Model (PAM, Best 1995), also focus on the crucial role of L1 phonology.

Although what all of these studies agree on is the crucial role of L1 as a major predictor for L2 phonology acquisition, research has shed light on some weaknesses of these models based on the comparison between L1 and L2: (i) the criteria to define whether a phoneme is similar or equivalent is unclear (Rochet 1995, as cited in Eckman 2004), and (ii) some error patterns cannot be accounted for by the L1 influence only.

Opposed to these models derived from the CAH, the other major view in L2 speech acquisition is that rather than using only the L1 influence, research should focus on constraints, typological markedness and universal principles to account for L2 phonology. Based on the weaknesses of analyses placing L1 influence in a central position, works from this view claim that learner languages[2] are also characterized by patterns that can be explained neither by the L1 nor by the L2 phonology but that are within the limits of variation permitted by Universal Grammar.

Several models that add a factor to the sole L1-L2 difference were proposed in order to account for interlanguage patterns. This is the case of Eckman's Markedness Differential Hypothesis model (MDH, 1977), which makes use of the concept of typological markedness, of Major's Ontogeny Philogeny model (OPM, 2001) that claims that interlanguage should be analyzed based on the interplay of L1, L2 and Universals. The role of UG was also explored for both parameters[3] and prosody[4], and suggests that cross-linguistic universals can account for properties of interlanguages. Lastly, research in the framework of Optimality

[2] The concept of learner language is defined by Eckman (2004) as a mental grammar based on the L2 input, but that is a learner's "own version" of the L2.
[3] Minimal Sonority Distance parameter for Broselow and Finer (1991)
[4] See the comprehensive review in Young-Schoten and Archibald (2000), that accounts for how syllable structure acquisition can both be explained by universals and L1 influence.

Theory (OT, Prince and Smolensky 1993) provides interesting insights on the question by explaining interlanguage formation as based on a succession of constraints re-ranking (Hancin-Bhatt 1997, 2000).

Among the phonological characteristics of Japanese, segment length contrasts are especially of interest as, more than being a simple durational contrast, they are also closely related to the specificity of the language to have a mora timing. The lexical consonantal length contrast in Japanese opposes singleton (short) consonants to geminate (long) consonants as illustrated in the minimal pair in (1).

(1) *kata* 'shoulder' vs. *katta* 'had a pet'

This contrast has a peculiar status in Japanese phonology as it is involved in a variety of morpho-phonological processes (see Chapter 2). In terms of language acquisition, this implies that it has a high Functional Load (Hockett 1955, King 1967, Meyerstein 1970, Catford 1987, Brown 1991, Munro and Derwing 2006)[5] and is therefore pivotal for an effective communication with native speakers, as shown by the abundance of literature on the acquisition of Japanese geminates. This same literature sheds light on the challenge that this contrast represents for second language learners, and this especially when their native languages are stress-timed (e.g. English), syllable timed (e.g. French) and don't have such a contrast (Hirata 2009, 2015, Sonu et al. 2013, Toda 2003, Tsukada et al. 2015). In sum, L2 acquisition of the consonantal length contrast in Japanese is not only challenging because it requires learners to make a phonemic distinction between a short and a long consonant, but also because it involves the acquisition of a language-specific control of timing.

[5] See Chapter 3 for a definition of Functional Load.

With this dissertation, I hope to contribute to the field of the phonetics of second language acquisition, and propose to compare experimentally the pronunciation of the Japanese consonantal length contrast by learners from three different L1 backgrounds: Italian, French and English. While, similarly to Japanese, lexically contrastive gemination is well known for being one of the characteristics of Italian, it is not the case in the two other languages: the contrast for consonantal length is absent in English, and the phonemic reality of this contrast for French native speakers is questionable (see Chapter 2 section 2 for further details on the status of geminate consonants in the three languages).

A first issue to be addressed is whether it is the presence/absence of geminate that has an influence on acquisition, or whether it is the phonemic or non-phonemic nature of gemination that is to be considered. The former would oppose Italian and French to English, while in the latter it is Italian that is opposed to the two other languages. Secondly, we will show how the phonological inventory of these three languages allows to account for learners' production by looking in details at the learners' accuracy as well as the production cues active in their phonetic implementation of the target contrast in Japanese. The proposal is that they are subject to a bidirectional influence of their L1 phonology, which affects in a different way the building of phonemic categories for the contrast on the one hand, and its phonetic implementation on the other hand (see the discussion in Chapter 7). Lastly, the conclusion of this dissertation will provide some insights on the implications of the experimental results to a language teaching framework.

The remainder of this dissertation is structured as follows. The second chapter provides an overview of the literature relevant to the issues tackled in this dissertation. First, it introduces the definition of geminate consonants in Japanese in terms of both phonology

and phonetics before explaining its crucial role in the Japanese lexicon. In a second sub-section the review reports previous studies dealing with the acquisition of Japanese geminates, and the third sub-section focusses on consonantal length in the three languages targeted in this dissertation: English, Italian and French. This section introduces the theoretical grounding of this dissertation and provides a description of findings from previous studies that will constitute an important basis for the analysis. In Chapter 3, I introduce the goals and hypotheses of this research, and Chapter 4 explains both how these hypotheses will be accounted for experimentally, and the methodological considerations taken into account for experiment design and data analysis. Chapter 5 and 6 describe and analyze in detail the results of the empirical data collected. Specifically, Chapter 5 deals with the question of learners' accuracy based on durational accuracy, and Chapter 6 with the durational production cues that can be identified in Japanese native speakers and for the three learner groups. These results assess the effect of the learners' L1s on the acquisition of the Japanese consonantal length contrast, with regard to their phonological properties. Lastly, Chapter 7 provides a discussion on the findings of this dissertation and proposes to relate them to a theoretical modelization of the acquisition of L2 contrast, and Chapter 8 summarizes and concludes.

CHAPTER 2: LITERATURE REVIEWS

This chapter is devoted to a review of the literature relevant to the present research. Articulated in three parts, it will provide an overview of the literature pertaining to geminate consonants in the four languages targeted in this dissertation, and to the acquisition of geminate consonants in Japanese.

The first section presents a review of geminate consonants in Japanese. Specifically, I will introduce in detail the phonological and phonetic definitions of Japanese geminates before examining their functions in the Japanese lexicon and across the three lexical strata. In the second section, the review will focus on previous research on the L2 acquisition of the Japanese consonantal length contrast, a property of Japanese language that is well-known for being challenging for second language learners. Although this dissertation focusses only on learners whose L1s are French, Italian or English, the target of this literature review is wider and encompasses all learner populations that have been studied in the literature. Findings related to production and perception will be presented in separate sub-sections, which examine each several production and perception cues such as: duration, pitch accent, L1 influence, phonetic environment or speech rate. Lastly, the third section of this chapter will present, in three sub-sections, the phonological and phonetic characteristics of geminate consonants in the three other languages targeted by this study, respectively English, Italian and French.

1. GEMINATE CONSONANTS IN JAPANESE

1.1. Phonological definition

The segment called *sokuon* (促音) in Japanese is phonetically a long consonant, and phonologically a geminate obstruent. One of the main characteristics of geminate obstruents in Japanese is their peculiar phonotactics, as (to some exceptions) they appear only word internally in the coda position of a syllable[6]. In Japanese traditional phonology, they are represented as /Q/, and are one of the two consonants (with the mora nasal /N/) that can form a mora by themselves. They typically form the second part of a heavy syllable (Labrune 2006).

Geminate obstruents are found in all of the Japanese four lexical strata[7] but are subject to many phonotactic restrictions. In native and Sino-Japanese vocabulary, only voiceless obstruents can be geminated, that is /p/, /t/, /k/, /s/, /ʃ/, /ts/, /tʃ/. In the *gairaigo* ("loanword") stratum, voiced obstruents /b/, /d/, /dz/ and /dʒ/ can also be geminated but they show a strong tendency to devoicing (e.g. English 'bed' /beddo/ realized as [betto]). Nasal geminates do also exist and are called *hatsuon* 撥音 (Labrune 2006, Vance 2008 and Kawahara 2015). However, in Japanese they emerge phonologically as a sequence of the mora nasal /N/ followed by a nasal consonant (e.g. /miNna/ [minna] 'everybody'). Labrune

[6] The coda obstruent/Q/ shows interesting phonotactics restrictions: It is always in syllable-final position and is required to be word internal: it must be followed by another obstruent. Exceptions to these requirements exist in cases where /Q/ appears in utterance final position as a glottal stop (e.g. あつっ/atsuQ/ 'ouch', いたっ/itaQ/ 'ouch'), or initial position due to an elision process occurring in casual speech (Kawahara 2015 e.g. っせえな /QseRna/ from /uQseRna/ 'shut up'). However, as Labrune (2012) and Kawahara (2015) argue, these exceptions are involved specifically in mimetic or emphatic expressions, and consequently they only have an expressive and not semantically distinctive function.

[7] The Japanese four lexical strata are: native stratum (Japanese words), Sino-Japanese vocabulary stratum (old borrowing from Chinese), mimetics, and loanword stratum (recent borrowing). (Vance 1987)

(2006) also gives some marginal examples of geminated /h/ or /r/: e.g. the Japanese for 'Bach' /bahha/ or the mimetic /barrabara/ 'disordered'. In terms of frequency, geminate obstruents can be found in abundance as Imae (1960) shows that in the lexicon they represent 2,3% of the Japanese morae.

Although geminate obstruents are widely spread in modern Japanese, the general assumption is that it was inexistent in Old Japanese[8]. Indeed, as Kawagoe (2015) reports, linguists generally agree on the fact that Old Japanese had a simple syllable structure, namely (C)V open syllables with an optional C onset and avoidance of vowel sequences. As these phonotactic restrictions on the syllable structure disallowed codas, it appears that geminate obstruents couldn't possibly exist in Old Japanese. The enrichment of Japanese phonological system by the emergence of codas in Japanese syllable structure is attributed to the influence of imported Chinese syllables that allowed different types of codas: nasals and consonants. According to Shibatani (1990), the general belief among linguists is that these syllables imported from China started to be instrumental in the internal development of syllables after the Heian period[9], in early Middle Japanese[10]. Others, like Komatsu (1981) argue that they already existed in the mimetic vocabulary when the above phonological changes occurred. He proposes that the introduction of Chinese morphemes only helped to make these segments more salient and to become legitimate in Japanese phonological system. According to Takayama (2015), it is actually difficult to trace the exact period in which geminate obstruents appeared in Japanese because of the lack of a distinctive symbol in the writing system. However, some lexical evidence gives us hints of the early stages of gemination in native vocabulary strata (e.g. from Takayama (2015), *aware* "pathos" and *appare*

[8] The term "Old Japanese" is used as in Shibatani (1990) and refers approximately to the Japanese of Nara period, around 700-800.
[9] Heian period (794-1185)
[10] The term "Middle Japanese" is used as in Shibatani (1990) and refers approximately to the Japanese of Kamakura (1185-1331) and Muromachi (1331-1603) periods.

"admirable" are both etymologically derived from the same Old Japanese word *apare*). According to Takayama (2015), this emergence of an early stage of gemination might have taken place before the merger phenomenon that is dated around the eleventh century.

The three phonological properties that make of geminate obstruents special segments in Japanese are summed up by Kawagoe (2015) as follows: a geminate obstruent

(i) is an oral obstruent with no articulation of its own

(ii) is always followed by another obstruent

(iii) has a moraic status and occupies one mora.

In this section, I will present a brief overview of the literature dealing with the definition of the phonological status of geminates. Specifically, I will describe how the two main analyses of Japanese geminates in the literature account for these three properties. In a first part, I will introduce the Japanese traditional analysis, and the modern analysis derived from generative phonology in a second part.

1.1.1. The Japanese traditional analysis of geminate obstruents

In the Japanese traditional analysis, geminate obstruents are composed of two different parts: the first is called 促音 *sokuon* or coda obstruent, and the second part (the onset of the next syllable) a regular obstruent. In this analysis, the coda obstruent is a separate phoneme which phonemic representation is /Q/ (Arisaka 1940, Hashimoto 1950, Hattori 1958, Vance 1987). Traditional phonemic representations are as follows:

(1)	取って	*totte*	/toQte/	'take'
(2)	そっくり	*sokkuri*	/soQkuri/	'exactly the same'

Kawagoe (2015) gives the following minimal pairs to account for the phonemic status of /Q/ in the traditional analysis.

(3)

a.	[p/h]	[ippai] 'one defeat'	[ihai] 'a mortuary tablet'
b.	[t]	[ittai] 'a party'	[itai] 'a corpse'
c.	[k]	[ikkai] 'the first floor'	[ikai] 'underworld'
d.	[tʃ]	[ittʃi] 'agreement'	[itʃi] 'one'
e.	[s]	[issai] 'everything'	[isai] 'details'
f.	[ʃ]	[iʃʃi] 'one child'	[iʃi] 'volition'

The existence of such minimal pairs constitutes an evidence for the status of /Q/ as a phoneme because geminate and singleton consonants are in parallel distribution and show a semantic contrast. The first parts of the geminates in the examples above in (3) are in complementary distribution (all the coda consonants are complementary distributed so that [p] appears only before [p] and not [t] for example), which makes of them different allophonic realizations of the same phoneme /Q/ (Kawagoe 2015). A similar analysis was already proposed in Vance (2008). He affirms that all the phonetic realizations of /Q/ share enough phonetic similarities (obstruents, long and unreleased) to make it plausible to treat them all as realizations of the same abstract entity. The fact that /Q/ has the same duration as an ordinary mora, which is also reflected by native speaker's intuition, justifies, according to him, the appellation of "mora obstruent" for /Q/. He suggests that /Q/ is unreleased because it ends at a point within a phonetic extra-long obstruent that doesn't corresponds to an articulatory or acoustic shift. Furthermore, Vance (2008) calls /Q/ a "*chameleon phoneme*" because of its various phonetically different realizations. Indeed, it can't be described by itself in terms of place of articulation and degree of aperture since it is systematically assimilated to those of the following segment. Kawagoe (2015) writes that /Q/ doesn't have any phonological specifications other than being consonantal and non-nasal. For Koizumi (1978), /Q/ is only a phoneme made to integrate all of his allomorphs and doesn't have a substance of his own.

Vance (1987) suggests that the writing system also constitutes a good evidence for the analysis of /Q/ as a phoneme because the same kanji can be used to write it in its different allophonic realizations as shown in (4).

(4) e.g. from Vance (1987)

発火 /haQka/ “ignition”　　発車 /haQʃa/ “departure”　　発注 /haQtʃuR/ ”ordering”

Moreover, he affirms that because mora obstruents are represented using the kana *tsu* っ (in *hiragana*) or ッ (in *katakana*) reduced in size whatever their actual phonetic realization is, the analysis of geminate obstruents as the phoneme /Q/ is the more accurate and matches a very strong native speaker’s intuition that /Q/ is the same sound.

The present review of the traditional Japanese analysis of positing /Q/ as a separate phoneme allows to meet Kawagoe’s (2015) three requirements. Indeed, /Q/ has no articulation of its own as it is always assimilated to the one of the following obstruent (complementary distribution). Furthermore, the transcription of /Q/ as a phoneme gives it a moraic status.

1.1.2. A modern account to Japanese geminate obstruents

Kuroda (1965) and McCawley (1968) give an account of geminate obstruents in a generative phonology framework, which deals with allomorphs by derivation of underlying forms to surface forms by successive application of rules. Both of them claim that in generative phonology there is no level in which the phoneme /Q/ can’t be represented uniquely. Both Kuroda (1965) and McCawley (1968), derive phonetic representations from underlying forms by the application of a phonological system composed of a succession of rules. For example, Kuroda (1965) analyzes the inflectional verb forms with the suffixes *-ta,*

-te, *-tari* or *-temo* as shown in (5). In (5), the consonant that constitutes the coda of the verb stem *kap* 'buy' undergoes assimilation of all features with the obstruent that follows. This example provides a piece of evidence that at the underlying level, there is no unique representation of /Q/.

(5)

V. stem		**suffix**		**rule**		**derived form**	
kat 'win'	+	ta	→		→	katta	/kaQta/
kap 'buy'	+	ta	→	C. assimilation	→	katta	/kaQta/

In (6), another example from Kuroda (1965), derived forms are obtained by derivation with vowel deletion and consonant assimilation rules. It is clear with this example as well that /Q/ has no unique representation at both the underlying and derived form levels. Consequently, the analysis of /Q/ as a phoneme having several allophonic representations has to be rejected. Kuroda affirms that the native intuition about /Q/ is no more than a "linguistically arbitrary phenomenon".

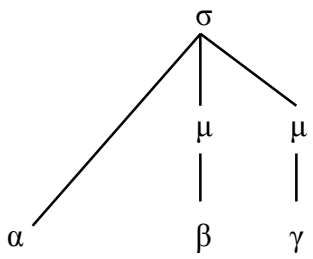
(6)

M1		**M2**		**rule**		**derived form**
gaku	+	*kō*	→	V. deletion	→	*gakkō* /gaQkoR/ "school"
situ	+	*pai*	→	V. deletion C. assimilation	→	*ʃippai* /ʃiQpai/ "failure"

In more recent works in the Optimality theory (henceforth OT) framework, that expands the derivation-based principles of generative phonology, there is also no level where the phoneme /Q/ can be represented. Therefore, OT based analyses propose to account for geminate consonants without using any special phoneme. Ito and Mester (1993) give an analysis of geminate consonants based on OT's moraic hypothesis (Hyman 1985, McCarthy and Prince 1986) and propose conditions for licensing coda consonants in Japanese. According to the moraic hypothesis, the mora unit is involved in syllable internal structure and the segments that can receive a mora are on the syllable rime, which is the relevant

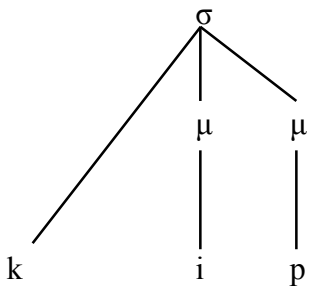
domain of syllable weight (Hyman 1985). To a heavy syllable are associated two morae and to light syllables only one. Ito and Mester (1993) assume that the syllable structure can be represented as in (7). According to them, syllable onsets are linked directly to the node of the syllable and not the mora node and they are therefore not structurally affiliated with syllable weight.

(7) The syllable internal structure in Ito and Mester (1993)

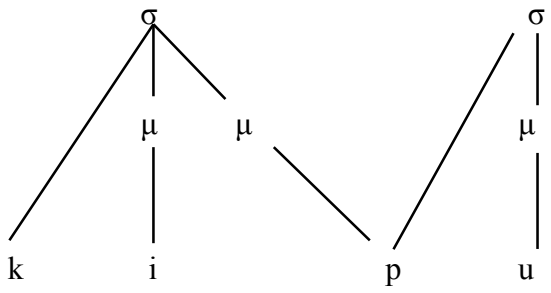


In the case of Japanese, although in modern Japanese the constraint NOCODA is not a high-ranked constraint anymore (codas are allowed, but for the special morae /N/ and /Q/ only), it appears that it was the case in Old Japanese. More generally, the coda of a syllable is universally subject to more restrictions than its other segments. Ito (1986, 1989) proposes the Coda Filter that excludes consonants' place features in coda position in several languages. This proposal is reformulated in Ito and Mester (1993) including the theory of the prosodic path and its conditions for a safe prosodic path. As a result, Ito and Mester (1993) propose two Segment Licensing Conditions for codas in Japanese: a segment in coda position is licensed if (i) it is a consonant or a nasal (corresponding to minimal sonority requirement for the mora in Japanese) (ii) it doesn't have a consonantal place feature. The syllable **kip* in (8) is not licensed in Japanese because the coda violates the two conditions: that is, it is neither a vowel nor a nasal and it has a place of articulation. In (9) however, the consonant /p/ has a link with both syllables, and therefore this double link makes of it both the (non-licensed) coda of the first syllable and the (licensed) onset of the second.

(8) **kip*



(9) *kippu*



Ito and Mester's (1993) analysis accounts for Kawagoe's (2015) three properties of geminate obstruents: The double link of the coda obstruent to both the coda of one syllable and the onset of the following one is the condition for well-formedness and therefore it explains why coda obstruents have no place of articulation of their own (i) and why they must be followed by another obstruent (ii). Lastly, the moraic status of geminate obstruent in Ito and Mester's (1993) analysis is derived from the basic assumptions of the Moraic Hypothesis (iii).

1.2. The phonetics of Japanese geminates

This section is an overview of the research that provides experimental phonetic data in order to investigate the phonetic characteristics of geminate obstruents in Japanese. In a first part, I will introduce studies on the acoustic characteristics of geminate obstruents. The second part will be devoted to research dealing with geminate obstruent perception cues in their perception by Japanese native speakers.

1.2.1. Acoustic characteristics

a. Constriction duration

One of the main properties of geminate obstruents in Japanese is their moraic status (Kawagoe 2015). Geminates contrast with singletons in length (e.g. /itta/ 'went' has three morae while /ita/ 'plank' has only two). According to Kawahara (2015), this moraic nature of geminates is reflected by a difference in the consonantal constriction: The primary acoustical correlate of that difference is the greater constriction duration (the closure for stops and the frication for fricatives) for geminates than for singletons.

The two figures below, from Kawahara (2015), represent the waveform and spectrogram of a singleton [t] (Figure 1) and a geminate [tt] (Figure 2). Their comparison indicates a clear difference in terms of duration between the singleton and the geminate consonant: Namely, the geminate consonant appears to be at least twice the length of the singleton. This difference in terms of duration between singleton and geminate consonants durations is contrastive. This is illustrated below in Figures 1 and 2 where the blue circles indicate the closure duration.

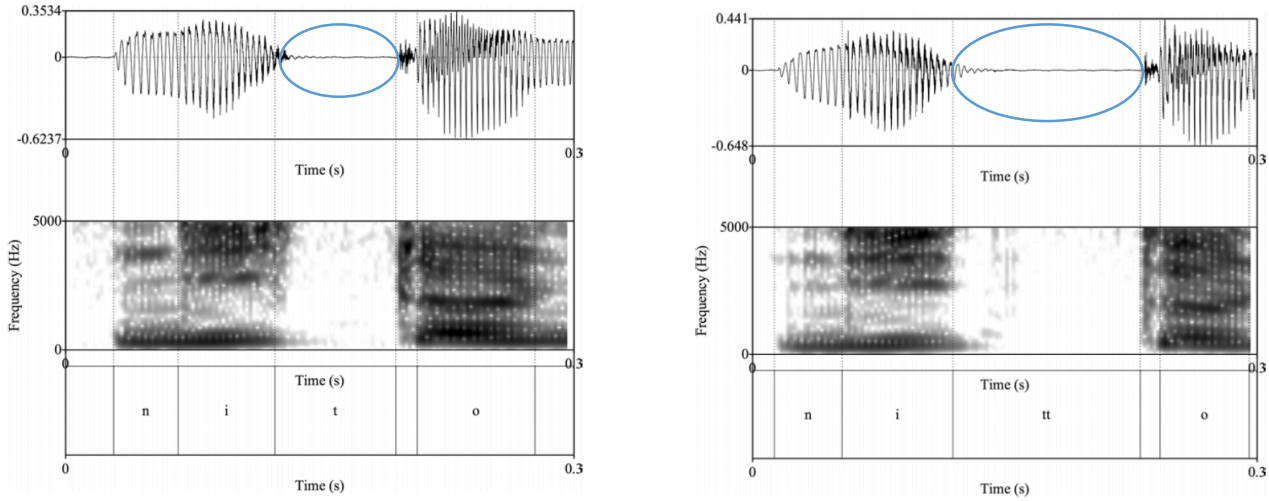


Figure 1 &2: On the left: A singleton [t] in Japanese by a female native speaker of Japanese. On the right: A geminate [t] in Japanese. Time Scale: 300ms (From Kawahara 2015)

Han (1962) measures both consonant types in several experiments and her results on average durations show a ratio of 1 to 2,6 between singletons and geminates. She finds 9 cs for [k] and 25 cs for [kk] and affirms that this difference constitutes a piece of evidence for the fact that the geminate [kk] should not be considered as a sequence of two [k]s and therefore twice the duration of a singleton [k]. In her view, the extra duration observed should be analyzed as equivalent to one mora, that is, as long as the surrounding CV morae. Consequently, she claims that the notation [kk] is not appropriate to accurately represent the durational value of the segments and that the [k:] should be used instead.

Homma (1981)'s investigation on/p, b, t, d, k, g/ and their geminate counterparts show results rather similar to those of Han (1962): she claims that the ratio was about 1 to 3. However, while Han (1962) affirms that the durational unit in Japanese is associated with a syllable, for Homma (1981) the domain of durational patterns is a word. Her claim is that observing durations at the word level allows to account for the moraic status of geminates. Indeed, in Homma's (1981) results, the comparison of three-mora words including a geminate with two-mora words shows a clear 3 to 2 ratio. Furthermore, she finds that a two-syllable word with a geminate consonant is one and a half times as long as a two-syllable word with singletons only.

Beckman (1982) measures geminates durations in an attempt to account for the hypothesis of mora isochrony. She predicts that if the mora hypothesis is correct, as geminate consonants are analyzed as composed of an unreleased moraic consonant plus the initial non-moraic consonant of the following CV mora, the duration should reflect this structure. She affirms that the experiments made by both Han (1962) and Homma (1981) are "suspect" because they show various problems in terms of methodology and that it is therefore difficult to consider them as reliable measurements. In order to make a comparison she reproduces Han (1962) and Homma (1981)'s measurements and calculations in her experiment and as

a result, in Beckman's (1982) measures appear both values including VOT[11] and not including it. Results including VOT have a ratio of 1 to 2,25 and do not correspond to the previous results by Han (1962) and Homma (1981), while in the case of the measurements that do not include VOT the ratio is closer to the previous works' results with 1 to 2,79. Beckman's (1982) claim is that no assessment should be made easily from the measured values of the consonant durations: If the measured ratio was of 1 to 3, the result would be consistent with the mora hypothesis, namely, all segments have roughly a constant duration. On the other hand, a ratio of 1 to 2 could be predicted by a simple gemination hypothesis. However, the results obtained are neither 1 to 3, nor 1 to 2. The results obtained by Beckman (1982) provide evidence against both Han's claim ("the moraic first part of the long consonant is on the average substantially shorter than the CV mora") and the mora hypothesis (two morae sequences are shorter than two times the length of one mora). She affirms that the mora is just a perceptual unit with no phonetic basis. Her results support Bloch's (1950) claim that native speakers' intuition of isochrony is probably only due to their knowledge of the writing system and of the way the word would be written in the moraic kana writing system.

The results of Sato's (1998) experiments support those of Beckman (1982) but she prefers a different conclusion. She argues that because there is no agreement on a necessary height for durational ratios, an analysis based only on a simple comparison of geminate and singletons segments' durations is insufficient to discuss the moraic status of geminates. Sato (1998) proposes to account for their moraic status by studying durations at the scale of a whole word. She affirms that there is "a tendency to differentiate the durations of the paired words which have the same number of syllables but different number of moras". Clearly,

[11] Voice Onset Time: duration between the release of the closure and the onset of voicing of the following vowel.

she claims, the tendency is to equalize word durations based on the number of morae and not syllables. Sato's (1998) results are consistent with Port et al. (1987) where three types of words' durations are tested: three-mora two-syllable words (e.g. from Port et al. 1987 /bukku/), three-mora three-syllable words (e.g. from Port et al. 1987 /bukudo/) and two-mora two-syllable words (e.g. from Port et al. 1987 /buku/). In Port et al. (1987), all three morae words have a similar duration regardless their number of syllables.

b. Other durational cues

Although constriction duration appears to be the primary cue when it comes to geminates, some variations in the duration of the preceding and following segments can also be observed. In Port et al.'s (1987) results, the vowel preceding a geminate is longer than a regular vowel. They find a duration of 90 ms for an [a] before a singleton in [baku] but 106 ms for the same vowel in [bakku]. Although the studied segments in this experiment where limited to [a] and [u], these results are supported by all studies that follow (Fukui 1978, Han 1994, Hirata 2007, Kawahara 2006, 2015). The phenomenon seems to extend even to the previous consonant as in Port et al.'s (1987) experiments, the consonants of the CV mora preceding the geminate were found to be longer than those before a singleton.

On the other hand the segments following the geminate consonant show a tendency to be shortened. Han (1994) claims that the average duration of a vowel following a geminate segment is reduced by 9 ms. However, in Hirata (2007), this difference between durations of vowels after singleton or geminate consonants is not a "*necessary and significant feature associated with the consonant quality distinction*". Indeed, in her results this difference shows to lack consistency when compared to differences observed before geminates.

As Port et al. (1980, 1987) suggest, timing in Japanese is constrained by "*an abstract temporally defined mora*", and a phenomenon of temporal compensation occurs in the

domain of a word. According to them, Japanese timing shows interdependence between the durations of adjacent segments where timing rules occur, and the segments adjust their durations in order to keep the duration at the word level.

1.2.2. Perceptual characteristics

Fukui (1978) and Fujisaki and Sugito (1977) run experiments in order to investigate the perception of the contrast between geminates and singletons. Findings for both studies are that a segment is perceived as a geminate when lengthened approximately two times. Compared with the previous results found in production studies (Han 1962, Homma 1981) where the duration of geminates was claimed to be about three times the singleton's, results show that for perception a segment needs to be only two times longer to be perceived as geminated. Furthermore, in Fujisaki and Sugito (1977) a difference is observed between durations of geminates in words in isolation and of those included in a sentence.

Figure 3 below represents the effect of closure duration on geminate perception. In Kingston et al.'s (2009) experiment, Japanese native speakers are asked to judge as geminate or singleton several segments which closure duration was modified by 15 ms steps. Results show that: (i) the longer the closure the most likely the segment will be perceived as a geminate, (ii) perception of geminates is rather categorical.

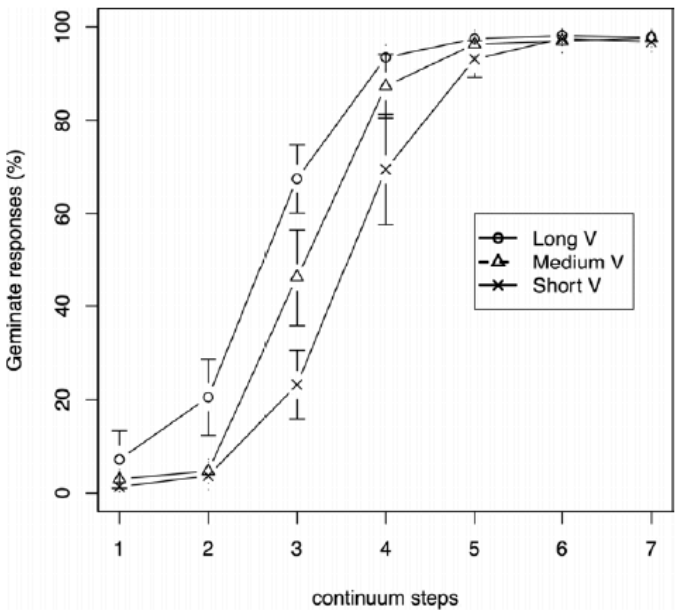


Figure 3: Effect of closure duration and the preceding vowel duration on the perception of geminates by Japanese listeners (from Kawahara 2015, adapted from Kingston et al. 2009)

Similarly to production studies, another issue about geminate consonant's perception is the influence of the duration of adjacent segments, and more precisely of the preceding vowel. In production, vowels have been shown to be longer before geminates than before singletons (Fukui 1978, Port et al. 1987, Han 1994, Kawahara 2006, Hirata 2007) and consequently, one might expect a tendency to perceive consonants as geminated when they follow a longer vowel. As reported by Kawahara (2015) research investigating this issue show two opposite tendencies: an "assimilative" and a "contrastive" pattern. In Arai and Kawagoe (1998) and Kingston et al. (2009) the results seem to be consistent with this prediction. As shown in Figure 3, native speakers are more likely to judge a consonant as geminated for a long preceding vowel. On the other hand, other studies (Hirata 1990a *inter alia*.) show the opposite pattern: longer closure duration is required after a longer vowel for the consonant to be perceived as a geminate.

1.3. Importance of Geminate Consonants in the Japanese Lexicon

In Japanese, geminate obstruents are special segments that have a "chameleon" role: depending on the lexical stratum their occurrences depend on various motivations. Furthermore, they achieve many functions such as: preservation of phonotactics, preservation of a preferred prosodic structure or intensifiers. This section will introduce the various functions of geminate obstruents across Japanese lexicon.

1.3.1. Native vocabulary

In Japanese native vocabulary gemination is mainly used as a mean of preservation of Japanese native phonotactic requirements. Indeed, geminate obstruents are one of the two allowed codas in Japanese phonology, and as such, they appear as a mean to repair unlicensed sequences that emerge in morpho-phonological processes. Consequently, geminates are rare in monomorphemic words and are typically found in inflectional forms, compounding and mimetics.

a. In inflectional forms

The agglutinative property of Japanese language is reflected in the characteristics of its verbal inflection system. Japanese traditional grammar describes Japanese verb inflectional forms as formed of stem and suffixes. Each verb has six stem types, each of them composed of a root and a stem-forming suffix. Bloch's (1946) descriptivist analysis makes a distinction between consonant ending verbs (henceforth C-verbs) and vowel ending verbs (henceforth V-verbs), both categories formed by a stem to which is added an inflectional suffix. Inflectional suffixes have allomorphic variants and can be divided in two

categories for each verb class: V-verbs stems are followed by one set of endings and C-verb stems by another. In Vance (1987), morphophonological changes in verb inflection are triggered by suffixes beginning with /t/ such as, past tense *–ta*, conditional *-tara*, concessive *-temo*, alternative *-tari* and gerundive *–te*. Consequently, geminates in verb inflection only occur with /t/ suffixes. Both Ito and Mester (2015) and Bloch (1946) make a similar analysis and distinguish two phonological categories for inflectional suffixes: C/V-suffixes (C initial allomorph and V initial allomorph) and T-suffixes (initial /t/ or /d/).

For Ito and Mester (2015) the choice of allomorphic variations of inflectional suffixes attached to the verb stem is made in order avoid a violation of the universal fundamental syllable constraints ONSET (syllables must have an onset) and NOCODA (no complex syllable, the CV structure is favored). It appears that these two constraints were high ranked in Old Japanese, even though that is not the case in modern Japanese anymore: ONSET is not a requirement anymore and codas are allowed for the coda consonants /N/ and /Q/. However, due to the diachronic reasons presented above, they seem to still play an active part in choosing between existing allomorphs of inflectional suffixes, and these same requirements are also active in choosing suffix allomorphs for complex stems (a stem + inflectional suffix formation). As a consequence, C/V-suffixes are chosen in order to have a C-final stem attached to a V-suffix and to a V-final stem a C-suffix. Because T-suffixes are always C-initial, if the suffixation to V-final stems satisfies the syllable structure requirements, the suffixation to C-final stems leads to the emergence of non-licensed codas: A phonological change has to occur (leading to a stem allomorphy and not suffix allomorphy) in order to create a coda that is licensed in Japanese. Ito and Mester (2015) affirm that this phonological change, known as *onbin* change creates forms that are not accidental but produces allowed codas in Japanese (/Q/, /N/ or vocoïd /i/).

b. In native compounding

Both Takayama (1995) and Komatsu (1981) affirm that gemination in native compounding has a role similar to sequential voicing also called *rendaku*. Indeed, both appear in a similar environment and indicate a compound internal morpheme boundary. Takayama (1995) gives the following example *hitori* 'one person'+ *ko* 'child' → *hitorikko* "only child". We can compare this compound with *futago* 'twins' resulting of the compounding of *futa* 'two' and *ko* 'child'. The word *ko* 'child' can undergo sequential voicing but can also be involved in gemination.

In the compounding of morphemes from the Japanese native vocabulary strata, gemination often occurs in one type of verb-verb compounds that Ito and Mester (1996) call "verbal root compounds". Vance (1987, 2002) affirms that there is an irregular alternation in those verb formations: the first verb is used in its stem form that often ends in /VCi/ that alternates with /VQ/ (e.g./hiki/ 'pull' +/haru/ 'stretch' =/hiQparu/ 'pull out'). A mora obstruent /Q/ can surface on the last mora of the first member of the compound if that first member is two morae long only. (e.g. from Vance 2002 /hanasi/ 'talk' or /hataraki/ 'work' can never alternate with */hanaQ/ or */hararaQ/). Furthermore, even when the conditions mentioned above are met, only a few verb stems are attested to be subject to that alternation and even among those stems it is irregular. According to Kawagoe (2015), the first verb stem in such compounds generally adds an intensive or emphatic meaning to the member on the right. (e.g. from Ito and Mester (1996) /buti/ 'strike' + /korosu/ 'kill' →/buQkorosu/ 'kill violently') Vance (2002) affirms that in some cases the combination of the same particular verbal roots can result in the coexistence of two phonetic realizations, which seem to show some semantic differences as well. The general tendency is that usually the one with the geminate consonant has the most intensive meaning. (e.g. from Vance 2002 /oituku/ vs. /oQtuku/ 'catch up')

c. In mimetics

The linguistic treatment of mimetic items in Japanese is controversial. Indeed, although they seem to etymologically belong to the native vocabulary and were established in the lexicon without any borrowing processes, their peculiar nature makes of them a special morpheme class. A quick glance at some phonological characteristics for example is enough to illustrate the problem of the classification of mimetic morphemes in one category or another. As seen in Kawagoe (2015), on the one hand mimetic morphemes share with the native vocabulary stratum a phonological property like the post-nasal voicing (e.g./noNbiri/ 'relaxed'). However, they allow singleton /p/ which is prohibited in native vocabulary (e.g. /pikapika/ 'shining'). Nasu (2007) makes a distinction between two types of coda obstruents occurrences in mimetic adverbs: the suffixation and the infixation types (see Martin 1952; Hamano 1986, 1998; Nasu 2002, 2007, 2008; Kurisu 2014; Kawagoe 2015).

Martin (1952) identifies medial geminates as an allomorph of the intensive infix which adds emphasis or liveliness to the discourse. Hamano (1986) affirms that the use of coda consonants in mimetic words has for function the production of emphatic forms: They are used as intensifiers. Hamano (1986) affirms that the iconic property of coda consonants in mimetics is linked to their phonological properties. /N/ is associated to a reverberation or involves elastic object, which reflects the fact /N/ is a resonant redirected to the nasal cavity. On the other hand, /Q/, an oral non-resonant, indicates a movement carried out vigorously in a single direction. However, for Nasu (2007), although it seems to match native speakers' intuition, the description of the expressive function of coda consonants is too vague: It would be irrational to consider that the choice of geminates in mimetics is motivated by their iconic property as many counterexamples can be found. Based on their frequency, Nasu (2007) claims that if geminates are the basic suffix form it is because they are rather neutral semantically while the other suffixes add some semantic nuance to the word. In conclusion,

in opposition to gemination in other strata of the Japanese lexicon, in the mimetic stratum gemination is not used as a mean to repair a phonotactically illegal /CC/ structure. Its particular properties and behavior suggest that their use is motivated by both prosodic and semantic reasons (Kawagoe 2015).

1.3.2. In Sino-Japanese compounding

In modern Japanese, a constant alternation between the /CV/ sequence and the mora obstruent /Q/ can be observed in compounding of Sino-Japanese morphemes. This phonological process, which results in the emergence of a geminate obstruent in such compounds, is called "contraction" (Ito and Mester 1996).

For Vance (1987), in the alternation in compounding between /CV/ and /Q/ within the same Sino-Japanese morpheme (written with the same kanji), the allomorph with a final vowel is considered as the basic form. Evidence for this claim is, on the one hand the marginal status of /Q/ as a syllable coda, and on the other hand the unpredictability of the other allomorph if /Q/ was the basic form. This alternation in modern Japanese can be explained by obvious diachronic reasons (Vance 1987): Old Japanese phonotactics required the absence of final consonants and morphemes borrowed from Chinese underwent phonological modification to enforce this[12].

Ito and Mester (1996) analyze the basic form of the first member of the compound's Sino-Japanese morphemes as (C)VC and claim that Sino-Japanese morphemes with such a structure can only have the voiceless obstruents /k/ or /t/ as a coda and observe two different patterns for alternation in Sino-Japanese compounds. In the first (and more common) pattern, vowel epenthesis occurs in order to avoid closed syllables or voiced geminates. Contraction

[12] See Vance (1987) and Martin (1952) for a detailed account of the patterns of /CV/～/Q/ alternation.

occurs in the second pattern: Ito (1986) first analyzed t-stems contraction (before any voiceless obstruent) and k-stems contraction (only before /k/) as different processes, but in Ito and Mester (1996) they account for the two contraction patterns using the same phenomenon that they call "root fusion". Although it involves different segments, root fusion can be explained by the same mechanism and differences follow from the different representations of /t/ and /k/. For k-stems and t-stems the coda fuses with the following C when it is identical though feature identity. On the other hand, when a t-stem is followed by the remaining voiceless obstruents /s/, /p/ or /k/, consonants undergo root fusion under feature compatibility, based on the assumption that the stem-final /t/ has no place specification.

1.3.3. In loanwords

In the loanword stratum, geminate consonant occurrences are numerous and follow a particular behavior, which shows fundamental differences from those of the native and Sino-Japanese stratum described above. It appears that their role in loanwords has nothing to do with repairing unlicensed segment sequences like in native or Sino-Japanese vocabulary, nor with semantic motivations as in mimetics. Therefore, one of the main issues pertaining to geminate consonant occurrences in loanwords is their role. What motivates the emergence of such a segment in words imported from foreign languages that mostly don't have singleton/geminate contrasts (i.e. English)? Researchers have proposed three different arguments to try to account for the phonological/phonetic motivations of gemination in such words: In the first account (Takagi and Mann 1994) gemination is viewed as a result of perception by native speakers of the acoustic and/or auditory cues of the foreign input. The second proposes that geminates occurrences are motivated by the preference for a particular prosodic structure Heavy-Light word-finally (Kitahara 1997, Kubozono, Ito and Mester

2008). Lastly, the third analysis postulates that gemination is used as a mean to retain the mora/syllable structures (Shinohara 2004, Otaki 2012).

1.4. Conclusion

The contrast in consonantal length between singleton and geminate consonants in Japanese is a well-documented topic in the study of Japanese phonetics and phonology. A review of the literature allows to shed light on the remarkable status of geminate consonants in Japanese. First, it appears that the contrast in consonantal length is diachronically recent in Japanese. Moreover, its peculiar phonotactics stand out as they have a remarkable repartition in the Japanese lexicon as the second part of a heavy syllable and as one of the two only segments (together with mora nasal) allowed as syllable codas.

Researchers view geminate obstruents as having a 'chameleon' role in the Japanese lexicon as their occurrences depend on various motivations and fulfill different functions depending on the lexical stratum. In the native and Sino-Japanese strata geminate obstruents are involved in several morpho-phonological processes such as in the phonological alternations associated with compounding or in verbal inflection. In mimetics, they are often used to mark emphatic meanings. Finally, motivations and functions of geminate obstruents in the loanwords stratum are more complex. Previous research suggests that in the transcription of foreign sounds several potential motivations can be mentioned for gemination, such as achieving an ideal prosodic structure, preserving an ideal mora/syllable structure, or occurrences motivated by perceptual factors.

In sum, both the peculiar status of geminate obstruents in Japanese in terms of phonetics and phonology, and the variety of morpho-phonological processes it is involved in, entail its high functional load. Consequently, an accurate acquisition of the contrast between singleton and geminate consonants in Japanese appears to be necessary for an

efficient communication with native speakers, as it impacts strongly learners' comprehensibility and intelligibility. In the next section, I will present an overview of previous findings on the acquisition of the singleton/geminate contrast in Japanese.

2. L2 ACQUISITION OF JAPANESE GEMINATE CONSONANTS

The consonantal length contrast between singleton and geminate consonants is well known for being a challenge for learners of Japanese. It is also one of the best-studied topics in Japanese L2 acquisition because of the importance and the high functional load of the consonantal length contrast in Japanese. Accurate acquisition of geminate consonants is fundamental for comprehensibility and intelligibility. In this section I will review separately studies on the acquisition of perception and production of Japanese geminate consonants, and sort findings by the factors influencing acquisition.

2.1. Perception

For perception of geminate stops, previous works have shown that the acoustic cues for Japanese native speakers are closure duration (or period of frication, Fukui 1987), pitch accent (Ofuka 2003), speech rate (Hirata 1990) and preceding vowel length (Han 1994). In this section I will introduce previous works investigating perception cues for consonantal length contrasts by L2 learners.

2.1.1. Duration

Hayes (2002) investigates the perception of English-speaking L2 learners for consonant duration in Japanese. Her data suggests that similarly to native speakers, L1 English learners of Japanese use duration as an acoustic cue for consonant length identification. Indeed, she finds that singleton-geminate pairs whose duration difference is

larger are easier to perceive. Hayes's (2002) results show that it was easier for learners to discriminate a singleton-geminate pair for /t/ (duration difference 180ms) than for /k/ (142ms) and /s/ (134ms).

Hung (2012) investigated Taiwanese learners' perception and also found that they are sensible to the durational cue for geminate/singleton identification. However, their perception is linear and not categorical as it was observed for native speakers. Furthermore, Taiwanese learners need longer closure duration than native speakers to identify a stop as geminated and a shorter one for singletons. Experimental results in Min (1987), Hirata (1990b), Enomoto (1992) and Toda (1998) also suggest that L2 learners have a more continuous pattern for perception than the categorical one that can be observed for native speakers (in Hirata 1990a for example). In addition, these works point out that perception becomes closer to the perception of native speakers (that is, more categorical) when the learners' proficiency level increases: advanced learners show a more categorical perception than beginners.

For Korean learners on the other hand, both Min (1987) and Horigome (1999) found a different tendency: the Korean learners involved in both experiments did not identify geminates and singleton based on their relative duration but on the phonetic characteristics (quality) of the stops. Namely, they tend to perceive them as Korean tense unaspirated stops.

Minagawa and Kiritani's (1996) results show another type of durational cue. In their experiment, Chinese and Korean learners mistook geminates as singletons for a High-Low (henceforth HL) accent pattern and measurements indicated that the average duration of the post-consonantal vowel was shorter in the HL than in the LH context. According to Minagawa and Kiritani (1996), this suggests that Korean and Chinese learners might use the durational ratio of stop closure to the following vowel as a perceptual cue. Toda (2003) also finds that beginner learners are sensible to the duration of the following segment for vowel

and even consonant. According to her, for beginners, these segments have to be longer to be perceived as long, and the duration boundary decreases with proficiency level improvement. For fricatives however, both beginner and advanced learners showed the opposite tendency.

These results offer an interesting difference with those of Hirata (1990a) for native speakers who concludes that they use the durational ratio of stop closure to the preceding vowel as a perceptual cue. Results in Hung (2012) indicate that the length of the preceding vowel has an influence on Taiwanese learner's perception of geminates: they have a higher accuracy score for a longer preceding vowel, which would suggest that Chinese L1 learners use the same cue as native speakers.

2.1.2. Pitch accent pattern

In Minagawa and Kiritani (1996), the authors investigate the influence of accentuation on perception of geminate and singleton consonants for five L1 group learners (Korean, Thai, English, Spanish and Taiwan Chinese). Learners were asked to judge whether they heard a geminate or a singleton consonant in 2/3 morae words in HL and LH accent contexts. Results showed that there is a high tendency for learners, regardless their L1, to exhibit the two following error patterns: to mistake geminates for singletons (henceforth CC→C) and singletons for geminates (C→CC). A detailed look at each group separately shows various distributions of the errors patterns according to the pitch accent context and the L1: Thai, Spanish and English L1 learners didn't show any variation in error patterns across the two pitch accent contexts. However, for Korean and Chinese L1 learners, pitch accent had a clear influence on their geminate/singleton perception: The rate of CC→C error pattern was high for the HL context while C→CC error pattern was low. For the LH context both error patterns were rather similar.

Hung (2012) also found an influence of accent pattern on singleton/geminate perception for Taiwanese learners. Experimental results in Hung (2012) shows clearly that the HL pitch accent pattern makes perception of geminates easier, as learners had better accuracy scores for this pattern.

2.1.3. Phonetic Environments and Context

In Hardison and Motohashi-Saigo (2010) English-speaking learners of Japanese were asked to identify geminate and singleton consonants in words placed in various contexts in order to test which factors other than segment duration have an influence on L2 learner's perception. Stimuli were inserted in a carrier sentence or presented in isolation to the participants and had the following structure: (C1)V1C2V2 where C1 is optional, V1 is /a/, C2 is /s/, /t/ or /k/ and is the target segment, and V2 is /a/ or /u/. Participants, divided in two proficiency groups, were provided with triplets of answers for each stimulus: one with a singleton, one with a geminate and one with a long vowel. The results of the experiment showed that perceptual accuracy of L2 learners cannot be explained only by durational cues: L2 learners' identification process of geminate and singleton consonants is a complex interplay of factors. Interestingly, the most common error pattern among learners regardless their proficiency level was to mistake a geminate for a long vowel. This, as the authors claim, indicates that learners are able to detect moraic weight but they attribute it to the wrong segment. Hardison and Motohashi-Saigo (2010) found two factors influencing perceptual accuracy of geminates/singletons: (1) The context: learners had better scores for words in isolation than for those inserted in a sentence. The authors suggest the problem is the learners' ability to focus their attention on geminate detection in the target word in a sentence context. (2) Sonority difference: The authors affirm that perception is more accurate, when there is a

larger sonority difference between the target consonant and the following vowel (e.g. words with C_2V_2 /su/ are more difficult than those with /sa/).

In Hardison and Motohashi-Saigo (2010) the segments investigated were /a, u/ for vowels and the obstruents /s, t, k/ for consonants. As the authors claim, the sonority scale is: low vowel [a]＞ high vowel[u]＞ fricative [s] ＞ stops [t, k], which means that a fricative will always have a smaller sonority ratio with the following vowel than a stop. Consequently, the perceptual accuracy is always greater for stops than for fricatives. These results support those of Toda (1998, 2003) who affirmed that length contrasts in stops were easier to acquire than in fricatives.

2.1.4. Speaking rate

Speaking rate also has an important influence of L2 learners' perception of consonantal length contrasts. Hirata (1990b) shows that English L2 learners base their judgment of segment's length on their absolute duration and not on the context. While Japanese native speakers identify consonantal length based on the durational ratio between the consonant and its preceding vowel and are able to adapt their perception to the speaking rate (Hirata 1990b), the English learners in Hirata (1990b) do not. A similar result was found in Toda (1998): in her experiment, learners were not able to adjust their perception to the length of the preceding vowel. Sonu et al. (2011) investigate Korean learners' perception of consonantal length contrasts. Their results show a tendency similar to those of Hirata (1990b) or Toda (1998), and suggest that Korean learners might be sensitive to the absolute duration of the consonant: Korean learners especially showed a tendency to identify single obstruents as geminates in words in isolation for a slow speaking rate. The authors propose

that training methodology for perception of length contrasts should be focused more on durational factors than on differences between phonological characteristics.

2.1.5. L1 influence

In Hirata and Ueyama (2009), English and Italian native speakers are asked to identify the number of mora they perceive in Japanese words. Although for vocalic length both English and Italian native speaker showed a rather similar error rate, the perception of consonantal length by Italian native speakers in a sentence context was significantly better than by English native speakers. Indeed, the former group showed an accuracy of 43.3 % versus 31.1% for the latter. Hirata and Ueyama (2009) suggest that the sensitivity of Italian native speakers to consonant length in their L1 has an influence in their perceptual accuracy in identifying consonantal length in Japanese.

2.2. Production

2.2.1. Duration

Han (1992) compares American learners' pronunciation of geminates and singletons in Japanese and in English (e.g. cat_tail). Her findings show that in English the closure duration of a geminated consonant (e.g. [tt]) is twice the closure duration of its singleton counterpart. On the other hand, the geminate/singleton ratio that Han (1992) found for Japanese native speakers is of 2,8:1. American learners' geminated consonants have a ratio of 2,0:1, that is, identical to their L1's. According to Han (1992) this is a clear example of negative L1 transfer: what they pronounce as a geminate according to their L1's specific timing control leads to underdifferenciation in Japanese. Toda (1993) conducts the same experiment with Australian English native speakers and finds that they have an even smaller

ratio than American English learners. Yet, as Australian learners don't have greater difficulties than Americans in Japanese timing acquisition, Toda (1993) concludes that the L1 negative transfer alone is not enough to account for it. An issue with both Han (1992) and Toda (1993) is that they compare purely phonetic and coincidental gemination in English (identical consonant sequence at word boundaries) with phonemic and contrastive gemination in Japanese, that is two different entities. In Toda (1994), the author demonstrates with an experiment on beginner level learners that underdifferenciation in production of singleton and geminate consonant contrasts might also be caused by learners' tendency to produce longer singletons and lengthen the vowels preceding geminates.

Masuda and Hayes-Harb (2005) investigate English L1 learners' productions of geminates and singleton consonants based on the ratio of the target consonant to its preceding vowel and according to their proficiency level. While naïve English native speakers had very close durational ratio values for singleton and geminates, for intermediate learners the authors could identify a tendency for the ratio to get closer to native speakers'. That is, an improvement was observed in production of the singleton/geminate consonant contrast. In Masuda and Hayes-Harb (2007), a similar experiment was conducted with Korean learners and the results showed a similar tendency: Korean learners with a low proficiency have greater ratios than native speakers, but this value tends to decrease with the improvement of proficiency to get closer to native speakers'. However, the same ratio measured for Korean and English L1 learners in Masuda (2009) showed no improvement regardless the proficiency level.

2.2.2. L1 influence and production strategies

In Masuda and Hayes-Harb (2005, 2007) and Masuda (2009), the durational ratio of the target consonant to the preceding vowel for singleton and geminates shows different

values for the two different L1 groups. English had smaller ratio difference values than Japanese native speakers while Korean learners had greater. Masuda (2009) claims that this constitutes a piece of evidence for the use of different production strategies for each L1 group. Another effect of the L1 can be observed in Korean learner's tendency to produce Japanese stops in intervocalic position as geminates. According to Min (2007), this phenomenon (also called 'geminate insertion') is an evidence for the fact that L2 phonology acquisition is greatly influenced by L1 phonology. Min (2007) affirms that geminate insertion is the direct consequence of resyllabification resulting from the match of Japanese intervocalic voiceless consonants to Korean tense consonants: The intervocalic voiceless stop is produced as a Korean tense consonant, the preceding vowel is shortened and resyllabification occurs to finally obtain a closed syllable. The shortening of the vowel leads to an inversion of the durational ratio between closure duration and the preceding vowel length, which results in the occurrence of a geminated stop.

Toda (2003) identifies two strategies operative in the pronunciation of English-speaking learners of Japanese: First, overexaggeration was shown a common strategy for geminate stops in order to produce the durational contrast, regardless the learners' proficiency level. According to Toda (2003), although it is commonly said that underdifferenciation in Japanese singleton/geminate contrast is caused by a too short geminate consonant, her findings suggest that this might instead be caused by a longer duration of singleton consonants which makes overexaggeration necessary to create a length contrast. Secondly, learners show a propensity to modify the syllable structure. Toda (2003) rapports that some learners produce CVCCV sequences as CVC-CV. According to her, this strategy reflects an underlying knowledge of English native speakers of the geminates at morpheme boundaries in their L1 (e.g. from Toda 2003 'cat tail'). She claims that this strategy demonstrates the role of the syllable for this L1 group, and that it supports the claim

that the segmentation unit is determined by the L1. Another syllable modification strategy consists of a lengthening of vowels before geminate consonants only, which according to Toda (2003) indicates that learners have L1 interference of the CVC- syllable structure and proves that they are successful in making the consonant length distinction but had a different phonetic realization

2.3. Conclusion

L2 acquisition of consonantal length contrast is a well-studied topic in the wide body of research on L2 acquisition of Japanese. However, the review of the literature shows that these studies target populations of L2 learners which are mostly either English native speakers or learners from Asian countries such as Korea, China or Taiwan. Although this can be easily explained by obvious geographic and historical considerations, the globalization process of modern society increases the need for studies targeting other L1 groups with as a final goal the improvement of teaching methods for Japanese pronunciation to these specific learner populations in order to ease their social and professional integration in the Japanese society. In this regard, the present dissertation hopes to provide some useful data on French and Italian learners, two learners populations for which, to the best of our knowledge, almost no acquisition data is available.

Findings on L2 acquisition of Japanese geminates from previous studies have shed light on the fact that the perception and production cues that L2 learners rely are different from those of native speakers presented in the first section of this chapter. Furthermore, what the reviewed studies show clearly is that the main factor that should be considered when making L2 pronunciation acquisition research is the importance of L1 interference. Although individual factors (e.g. ability, motivation) and Japanese education background are crucial

factors for a successful acquisition, findings from previous research suggest that the main correlate for error prediction lies in the influence of L1 phonology. The studies reviewed above indicate that each learner group encounters different difficulties in the acquisition process and that according to their L1 learners use different production and perception strategies.

3. GEMINATE CONSONANTS IN ENGLISH, ITALIAN AND FRENCH

In this section, the review will deal with the literature pertaining to geminate consonants in the three L1s of the learner populations targeted in the present research. It will examine each language separately in the following order: English, Italian and French and deal for each language with phonological and phonetic considerations.

3.1. Geminates in English

Although many occurrences of double letters in the spelling (e.g. happy) can be found in English, Kenyon (1977) affirms that they are rarely geminates except in compounding or when contiguous in speech. These double consonants are 'relics' of Middle English, when consonantal length contrast existed but was shortened, for which only the spelling was retained. In the case of affixation, he also claims that orthographic double consonants can be occasionally geminated. Some occurrences of gemination were observed in British dialects (e.g. from Wakelin 1972: apple) which are most likely the phonetic influence of Welsh on English (Wakelin 1972, Hughes and Trudgill 1979). Indeed, as Koch (1989) affirms, in intervocalic post-stress position, the following consonants /p, t, k, m/ can be geminated. However, these occurrences of gemination are non-distinctive and phonemic geminates do not exist in English (Malmberg 1963, Kenyon 1977, Ladefoged 2001, Kaye 2005 *inter alia.*). However, purely phonetic gemination can occur in two cases: at word boundaries (1a) or at a morpheme boundary of a word containing two morphemes (1b) (Ladefoged 2001).

(10) *e.g. from Ladefoged (2001)*

a. white tie [waɪt.taɪ] b. unknown [ʌnnoʊn]

The common view is that these are occurrences of 'fake geminates' (Spencer 1996): a case where two successive consonants occur at morpheme boundaries (Kaye 2005, Malmberg 1963), and these 'fake geminates' tend to undergo a degemination process in English (eg. From Malmberg (1963): unknown [ʌnnoʊn] vs. [ʌnoʊn]). Kaye (2005) affirms that Ladefoged (2001)'s 16th Rule for English provides an explanation for this degemination process. According to the rule, a consonant is shortened when it is before an identical consonant, which accounts for why *give me* can be pronounced [gɪme] after undergoing successively regressive assimilation (give me → gimme) and shortening of the first consonant. For Kenyon (1977), double consonants are often distinctive (e.g. *with a man* vs. *with the man*) and therefore degemination can occur only if the distinction in terms of meaning is retained.

In Kaye (2005) a search through various English dictionaries shows that in the case of orthographic double consonants induced by affixation, depending on the dictionary both pronunciations might be listed. His hypothesis is that native speakers may geminate some words in careful speech, which might sometimes be pragmatically based spelling pronunciations. On the other hand, in a more fast 'allegro' speech they undergo degemination. This view is also shared by Bailey (1983, 1985) who affirms that speech rate has an influence on gemination: it is more likely to occur in slow speech. He also suggests a 'sociolinguistic-phonological explanation' to gemination.

3.1.1. Production

Delattre's (1967-69) experiment results show that across word boundaries, geminates are about one and a half (ratio= 1,4 to 1) the duration of singleton consonants. This ratio is smaller than the one observed by Delattre (1967-68) in the same experiment for the Latin languages French and Spanish (1,9/1 and 1,8/1). He suggests that this difference might be

interpreted as a less distinct and less stressed consonant gemination for English than for the two Latin languages. Furthermore, the duration of the preceding vowel doesn't constitute a cue in consonantal length contrast identification as Delattre observed a ratio of 0,96 to 1 (see also 11 below). Stetson (1951) found 200ms for a double consonant and 100 to 140ms for a singleton.

(11) e.g. from Delattre (1967-68)

	The rAce ends vs.	*The rAce sends*
V duration	**17**(12)	**17**(23)

In Kaye's (2005) experiment, the focus is on the following pairs: *known/unknown*, *named/unnamed* and *mature/immature*. He observes that the double consonant is almost consistently longer than its short counterpart (*unknown* and *unnamed* were found to be almost four times longer and he observed a ratio of A to 1,82 for *mature/immature*) in the pair, and concludes that in a narrow-phonetic point of view gemination does occur in English although there are some 'degeminators' among native speakers.

3.1.2. Perception

Many studies have shown that although the consonantal length contrast is not phonemic in English, duration does play a role in production and perception in English: consonant duration varies according to various factors as phonetic context or position (Pickett and Decker 1960, Klatt 1977, Umeda 1977, Repp 1978). It has been shown that word-initial consonants are longer while word-internal or post stress consonant are longer (Delattre 1967-68, Klatt 1977, Umeda 1977). Results from Pickett and Dicker (1960) and Oller (1973) also show that consonantal length is a cue for the identification of morphological and lexical boundaries in English. In Hayes (2002) or Porretta and Tucker (2015) results on perception of non-native consonantal contrasts by naïve English native

speakers show that although they are able to detect the duration differences, they do not achieve a phonemic distinction.

Pickett and Dicker (1960) investigate the perception of geminated /p/ in the distinction between *topic* and *top pick* found that a consonant is perceived as a singleton when the closure is shorter than 150ms and as a geminate when longer than 250ms. This is illustrated in Figure 4 from Pickett and Dicker (1960) below.

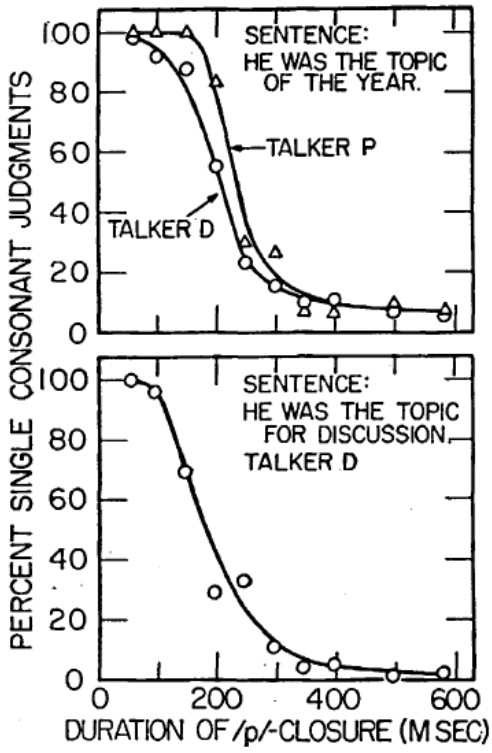


Figure 4: Perception of /p/ vs. /pp/ as a function of the closure duration of /p/ from Pickett and Dicker (1960)

In Delattre's (1967-68) perceptual gating experiment, for /n/ and /l/ American listeners perceived a singleton consonant below the range of 6, 8 and 10cs and 16, 18 and 20 cs for the fricative /s/. Concerning formant transitions, a reduction of the releasing transitions was shown more effective than those of arresting transitions for geminate perception, which as Delattre (1967-68) suggests, may indicate that the initial consonant phase of articulation contributes more than the final consonant phase of articulation in distinguishing consonantal length. He links these results to the property of English to final-consonant anticipation and

suggests that gemination recognition for speakers of a given language might be relying on the addition of the consonant phase that is the least common in that language.

3.2. Geminates in Italian

Among the Romance languages originated from Latin, Italian is well-known for being one of the only languages having retained the diachronical consonant length contrast from late Latin. Consonantal length is therefore contrastive and involved in many minimal pairs as illustrated in (12) below. In the spelling, these words belonging to minimal pairs are distinguished by a double grapheme for the geminate vs. a single for the singleton consonant (12).

(12) *fato* [‘fato] ‘fate’ *fatto* [‘fatto] ‘fact’
casa [‘kasa] ‘home’ *cassa* [‘kassa] ‘box’
pane [‘pane] ‘bread’ *panne* [‘panne] ‘creams’

Geminates in Italian can occur with stops (/p/, /t/, /k/, /b/, /d/, /g/), fricatives and affricates (/f/, /v/, /s/, /ʧ/, /dʒ/, /ʦ/, /dz/), nasals (/m/, /n/), liquids (/l/, /r/) and most geminated words are disyllabic with the stress placed on the first syllable of the word (Giovanardi and Di Benedetto 1998).

3.2.1. Phonology

a. Representation

The phonological representation of geminates in Italian has been debated among researchers for years. The traditional analysis (Swadesh 1937, Trubeckoj 1939, Porru 1939, Hall 1948, Mioni 1973, Bertinetto 1981, Vogel 1982, Lopocaro 1990) represents geminate consonants as a sequence of two identical consonants belonging to different syllables. In

opposition to this analysis, the alternative analysis (De Gregorio 1935, Romeo 1967, Saltarelli 1970, Martinet 1975, Luschützky 1984) considers geminates as tautosyllabic and single segments at the phonological level. The contrast between the traditional and the alternative analyses is represented in (13).

(13)	**Two-syllables analysis**	**Tautosyllabic analysis**
	VC.CV	V.C:V
	e.g. /fatto/ → [fat:o]	e.g. /fat:o/ → [fat:o]

The tautosyllabic analysis is based on two types of evidence: external and internal evidence. As external evidence, researchers provide pieces of evidence from the universal property of geminates: inalterability. They propose data from word games (Luschützky 1984) or slips of the tongue and euphemistic substitutions (Hurch and Tonelli 1982) to support their analyses. Hurch and Tonelli (1982) also affirm that because some geminates emerged from a strengthening process conditioned by primary stress position (vs. segment insertion), they should not be analyzed as bisegmental. However, diachronic data (Zamboni 1976) and data from Italian dialects (Canepari 1979) provide pieces of evidence for the non-inalterability of geminates in Italian that the tautosyllabic analysis cannot account for. For Lopocaro (1990), the inalterability of geminates should not be used to account for phonological representation because it should rather be sought in terms of phonetic constraints (e.g. closer coarticulation). Furthermore, she claims that the certainty of the bisegmental and heterosyllabic status of geminate consonants in Latin (Gianinni and Marotta 1989) constitutes a solid proof against the tautosyllabic analysis

The arguments proposed by researchers as internal evidences for a tautosyllabic representation of geminate consonants are as follows: A tautosyllabic analysis allows to have a unique representation for both underlying and surface form (Hurch and Tonelli 1982), while the traditional needs two, which requires an explicit motivation. Moreover, it implies

that the preceding syllable is an open CV, a syllable structure that is consistent which the tendency toward open syllables displayed by Italian.

b. Variations

Dialectal variations between Northern and Southern Italian have been pointed out by Hurch and Rhodes (1996). Their claim is that to the exception of Southern Italian (and Sardinian), all the Romance languages underwent degemination, which lead to a neutralization of the consonantal length contrast in many minimal pairs. This claim is illustrated in (14) below.

(14)	**Southern Italian (contrast)**	**Northern Italian (neutralization)**
	fato [fato] 'fate'	*fato* [fato] 'fate'
	fatto [fatto] 'fact'	*fatto* [fato] 'fact'

This neutralization phenomenon was tested experimentally by Chang (2000) with native Italian speakers. The results of the experiment were not supporting Hurch and Rhodes (1996) claim. Indeed, although the duration of geminate consonants in the Northern dialect was significantly shorter than in the Southern dialect, a significant contrast was still observed between the geminated and singleton consonants.

3.2.2. Phonetics

The primary phonetic correlate of gemination in Italian is an increase of consonant constriction duration. Previous studies have shown that the ratio between the singleton and geminate consonant is constant across speaking rate (Esposito and Di Benedetto 1999, Blumstein et al. 1998). The preceding vowel duration also plays an important role. Indeed, a temporal compensatory effect can be observed between the vowel preceding a singleton and a geminate, namely the vowel is lengthened before a singleton and shorter before a geminate consonant (Picket et al. 1999, Rossetti 1993, 1994, Giovanardi and Di Benedetto

1998, Esposito and Di Benedetto 1999, Mattei and Di Benedetto 2000, Faluschi and Di Benedetto 2001).

a. Production

Table 1 below presents a summary of the main findings in the results from Argiolas et al. (1995, a), Giovanardi and Di Benedetto (1998, b), Esposito and Di Benedetto (1999, c), Mattei and Di Benedetto (2000, d), Faluschi and Di Benedetto (2001, e). These studies are part of the Gemination Project (GEMMA 1992) of Rome, La Sapienza University started in 1992, and provide experimental data on the acoustic production cues for Italian geminates. The research methodology was similar for all experiments: six Italian native speakers were recorded when producing nonce words from the GEMMA data-base in isolation, corresponding to the singleton/geminate contrast. The GEMMA data-base contains bisyllabic words with a symmetrical structure VCV or VCCV where C is one the consonants that can be geminated in Italian and V one of the Italian cardinal vowels /a, i, u./. Each paper deals with a different manner of articulation and for each experiment, all words including a consonant of the target consonant category were selected. This selection was made in order to have the singleton and geminate environments for all three cardinal vowels: /a, i, u/. In each study, the correlation between gemination and three different types of parameters was measured such as: durational parameters (e.g. consonant closure duration, preceding vowel duration), frequency-related parameters (e.g. F0, F1) and energy related parameters (e.g. VOT and burst power and energy).

Table 1: Summary of the results obtained for Italian geminates for liquids (Argiolas et al. 1995, a), fricatives (Giovanardi and Di Benedetto 1998, b), stops (Esposito and Di Benedetto 1999, c), nasals (Mattei and Di Benedetto 2000, d), and affricates (Faluschi and Di Benedetto 2001, e).

Consonant type	Durational parameters correlation	Frequency parameters correlation	Energy parameters correlation	Preceding vowel duration	Consonant duration
Stop (c)	+	-	-	-25%	+100%
Fricative (b)	+	-	-	-28%	+73%
Affricate (e)	+	-	(+)	-25%	+62%
Nasal (d)	+	+ (F0/F1)	+ (total energy)	-32%	+134%
Liquid (a)	+	-	N/A	-30%	+194%

Duration-related parameters: In all studies and all geminates types the same significant effect of duration was observed: The analyses of the acoustic measurements show a strong correlation between gemination and duration of the consonant and the preceding vowel. Namely, in all studies, a significant lengthening of the geminate consonant with respect to the singleton one and a significant shortening of the vowel preceding a geminate consonant were observed. Some variations in terms of duration were also observed across the consonant manners of articulation. Although the singleton/geminate ratio was consistent, fricatives in general were found to have a longer duration. Giovanardi and Di Benedetto (1998) claim that this is due to the [-continuant] feature of stops, which causes fricatives to be longer than stops in average. Similarly, nasals in general were also found to be much longer that other consonant types (+134%). In the case of affricate consonants, Faluschi and Di Benedetto (2001) find that both the stop and the fricative parts are lengthened in the gemination environment, which makes the singleton/geminate distinction less straightforward than for other consonants.

Frequency-related parameters: To the exception of nasal consonants no significant correlations were observed between gemination and frequency related parameters. For nasal consonants, specific variations of F0 (at V1-C border) and F1 (at V2 onset) were observed in the singleton vs. geminate comparison.

Energy related parameters: For affricates and nasals only a propensity to emphasize energy and power in the case of gemination was observed. Energy-related parameters were non-relevant for all other consonant types.

b. Perception

Esposito and Di Benedetto (1998) investigate experimentally the perception of Italian geminated stops by native speakers. Participants were asked to judge whether stimuli are geminated or not in a gating experiment where the duration of both the preceding vowel (176ms or 116ms) and the consonant (10 different closure durations in 15ms increments) were modified. Their results are presented in Figure 5 below reproduced from Esposito and Di Benedetto (1998).

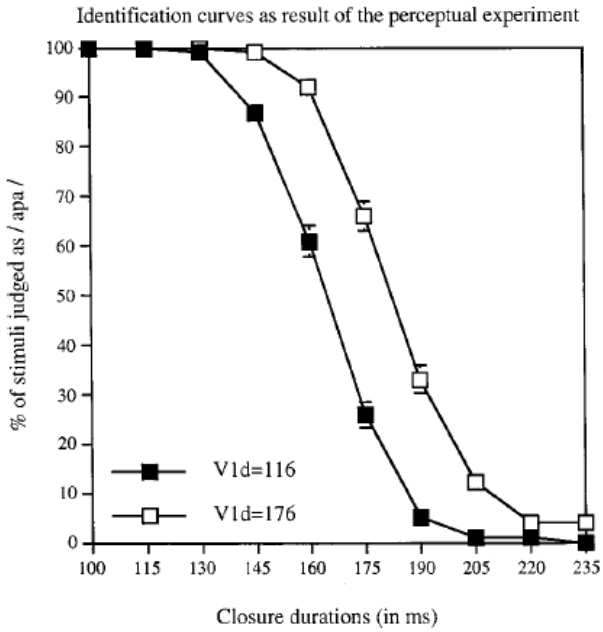


Figure 5: Identification curves of geminate consonants from Esposito and Di Benedetto (1998)

The identification curves in the Figure 5 above show a categorical perception of geminates consonants with a significant effect of the preceding vowel duration. Namely, for

a longer preceding vowel, the consonant needs to be longer to be perceived as geminated. Results in Esposito and Di Benedetto (1998) are consistent with previous perceptual experiments carried out in Rossetti (1994), which validate the significance of the preceding vowel and the constriction durations as acoustic correlates of gemination in Italian.

3.3. Geminate consonants in French

Graphic double consonants occur very frequently in French orthography (e.g. *appelle* 'call') but don't always reflect actual pronunciations. Tranel (1987) affirms that out of the twenty consonant letters in the alphabet, only seven can never be double consonants in the spelling: h, j, k, q, v, w, x. Furthermore, he writes that a double consonant in the spelling doesn't indicate anything concerning the actual pronunciation, the double consonant having only the phonetic value of a singleton (e.g. *année* [ane] 'year'). Some orthographic rules account for some of the ll, ss, cc and gg double consonants pronunciations which are respectively [j], [s], [ks] and [gʒ]. For other cases the double consonant is either pronounced as a singleton or as a geminate. The variations between a geminated or a singleton pronunciation depend on various intra and extra-linguistic factors such as: morpho-phonological environment, etymology, speech style or speaker. Walter (1976) reports that many classical French pronunciation manuals from the first half of the 20th century give warnings concerning the geminated pronunciation of double consonants. According to these manuals, a geminated pronunciation is acceptable only for rare and educated expressions; otherwise the speaker might sound 'ridiculous' (Grammont 1914, Martinon 1913).

French, which has the same Latin origins as Italian, used to have a consonantal length contrast but underwent a degemination process from the 7th or 8th century (Klein 1963,

Posner 1996). This process occurred only in Western Romance languages because they already previously underwent a lenition process on intervocalic singleton (e.g. from Meisenburg 2006 latin *sapere* 'to know' > [saber]). On the other hand, in the case of Eastern Romance languages that didn't underwent such a lenition process, the consonant quantity contrast remained, which explains why gemination does occur in modern Italian. In the case of modern French, even though there are no lexical consonant quantity contrasts, 'fake' geminates can appear in several cases: borrowings from Latin as educated forms, identical consonant sequences, morphologically induced geminates and identical consonant sequences induced by a schwa-deletion process word internally or at a word boundary (Lausberg 1972, Meisenburg 2006). This section will introduce each of these types of gemination in French. Another type of geminate occurrence in French, that will however not be considered any further here, is emphatic gemination occurring in an exclamatory context (e.g. C'est ***f****antastique!* [fːãtɑstik] 'it's fantastic!'). According to Tranel (1987) gemination is a phonetic manifestation of the emphatic stress that reinforces the first syllable with an initial consonant.

3.3.1. Word internally

a. Frequency of word internal geminates

Martinet's (1945) *Questionaire sur la prononciation du français* 'Questionaire on French pronunciation' is a survey on the pronunciation of French made during World War 2 in a prisoner camp. The data was collected from 409 French officers from all regions of France and aims at making an inventory of the variations in the pronunciation of French phonemes. In this survey, Martinet investigates gemination occurrences in French pronunciation by region and gets the following results (see Figure 6): The general tendency

is that gemination is observed more frequently in the North than in the South of France, and to the exception of the South-East of France, the percentage of non-gemination is low. Furthermore, Martinet observes that gemination seems to be increasing among young people and especially in Paris.

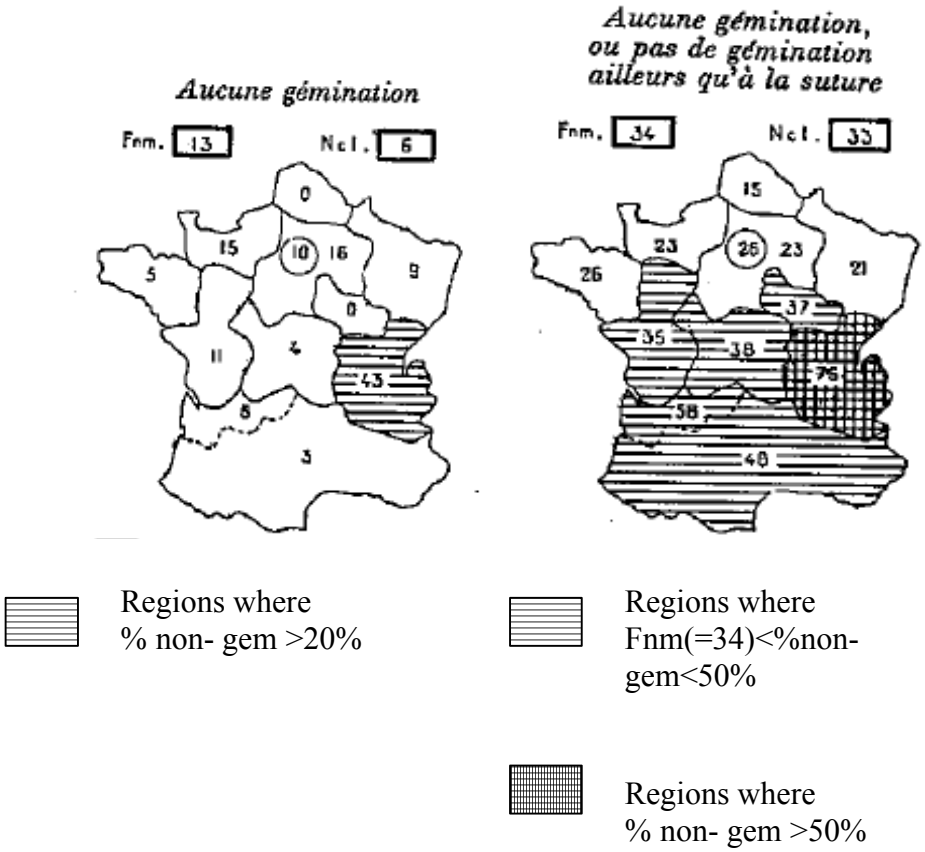


Figure 6: Repartition of non-gemination (left) and non-gemination or gemination at morpheme boundaries only (right) reproduced from Martinet (1945).

Walter (1982: 438), using a systematical dictionary search establishes a list of words with a word-internal graphic double consonant that might be realized as a geminate. She investigates word internal gemination with a survey and obtains the results in table 1 below. Results show that among the 1260 words found with double consonants, there are 21420 possibilities of gemination but only 5583 (26%) are actually geminated. Furthermore, we can observe that the percentage of gemination varies according to the nature of the consonant.

Sonorants show a higher propensity to undergo gemination when compared to obstruents. Specifically, the nasal /m/ (51%) and the lateral /l/ (35%) are often realized as geminates. A comprehensive summary of her results is presented in Table 2 below.

Table 2: Percentage of gemination of French words from Walter (1982)

Consonant	Word number	Word %	Gemination possibility	Gemination	%gem
mm	129	10%	2193	1113	51%
ll	383	30%	6511	2247	35%
nn	67	5%	1139	279	25%
rr	116	9%	1972	449	23%
ss	422	33%	7174	1203	17%
pp	8	0,6%	136	22	16%
tt	36	3%	612	86	14%
ff	50	4%	850	110	13%
bb	5	0.4%	85	10	12%
dd	10	0.8%	170	18	11%
jj	19	1.5%	323	26	8%
kk	15	1.2%	255	20	8%
Total= 1260			21420	5583	26%

However, the results of Walter's survey must be questioned because she uses a list that does not make a difference between the different types of geminates. Double consonant appearing at apparent morpheme boundaries (*illogique* 'illogical') and morpheme internal ones (*blesser* 'hurt') should not be treated the same way when surveying the frequency of geminates. The percentage of gemination for ss is also surprising as /s/ is never geminated in French: the orthographic difference between "s" and "ss" allows to make a difference between an [s] and a [z] pronunciation.

b. Distinction between imperfect and conditional

According to Tranel (1987), the distinction between the imperfect and conditional forms of the verbs *courir* 'to run' and *mourir* 'to die' is made by the consonantal length contrast as illustrated in (15). This is one of the only attested semantically distinctive

occurrences of gemination. Furthermore, this is the only word-internal double consonant case where gemination is systematic (Martinet 1945, Walter 1976, Tranel 1987). In this case, gemination occurs word-internally because of the concatenation of an –r ending stem and a conditional ending beginning with r.

(15)	**Imperfect**	**Conditional**
courir 'to run'	*courait* / cour+ait [kuʁɛ]	*courrait* / cour+rait[kuʁʁɛ]
mourir 'to die'	*mourait* / mour+ait [muʁɛ]	*mourrait* / mour+rait [muʁʁɛ]

The same contrast appears in –er verbs whose stems end in –r (e.g. *declarer* 'to declare', *déchirer* 'to tear') because of a schwa-deletion process (Meisenburg 2006) as in (16).

(16)	**Imperfect**	**Conditional**
déclarer 'to declare'	*déclarait* [deklaʁɛ]	*declare̲rait* [deklaʁʁɛ]

c. The negative prefix in-

The affixation of the negative prefix in- to words beginning with n, m, l or r, results in an identical consonants sequence at a morpheme boundary by regressive assimilation as illustrated in (17).

(17)					
	in +	nomable	→	*innomable*	'that can't be named'
	in +	lisible	→	*illisible*	'illegible'
	in +	mortel	→	*immortel*	'immortal'
	in +	réel	→	*irréel*	'unreal'

According to Meisenburg (2006) these are "etymological pronunciations of learned borrowings from Latin that contain a classical long consonant". He reports that in this case both pronunciations are valid (dictionaries usually give both) although the geminated one is

considered as an educated, elegant form and that many variations are observed depending on the speaker.

In Martinet (1945), this type of geminate is defined as “unstable” although both pronunciations exist, because the double consonant appears at a morpheme boundary that is not always easily identifiable. He claims that it is always easy for a native speaker to identify *réel* “real” in *irréel* “unreal” but not **manent* in *immanent* “immanent”. The annotated maps of France in Figure 7 below, from Martinet’s (1945) survey on French pronunciation, represent the geographic repartition and the frequency of the geminated pronunciation of the double consonant in *illogique* ‘illogical’ and *irrémédiable* ‘irremediable’ in France in the 1940’s.

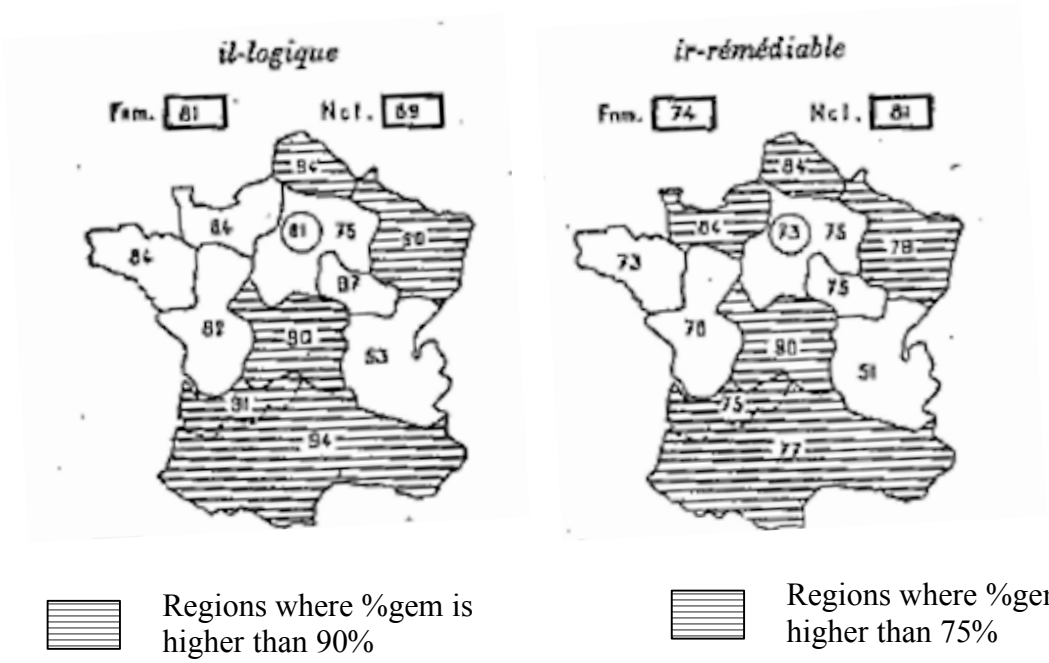


Figure 7: Gemination of illogique “illogical” (left) and Irrémédiable “irremediable” (right) reproduced from Martinet (1945)

Martinet’s (1945) data also shows that regardless speakers’ age, the gemination of this type of double consonants is very frequent in France in general and especially in the Southern and Northern parts.

d. Other double consonants

Depending on the speaker, many other double consonants may or may-not be realized as geminates (18a and b). Tranel (1987) notes that among those, only /m, n, l, r/ can be geminated without any stylistic effect while the gemination of other consonants is generally considered as "pedantic or affected" (18c). However, stylistic gemination is not limited to these consonants and can be applied to sonorants as well (18d) In the first case, both pronunciations are generally listed in the dictionary, but it is not the case for the marked stylistic gemination.

(18)	a. *sommaire*	[sɔmɛr] ~ [sɔmːɛr]	"summary"
	b. *syllabe*	[silab] ~ [silːab]	"syllable"
	c. *addition*	[adisjõ] ~ ??[adːisjõ]	"addition"
	d. *intelligent*	[ɛ̃tɛliʒɑ̃] ~ ??[ɛ̃tɛlːiʒɑ̃]	"clever"

Although they are not underlying geminates, obligatory geminates can emerge in the surface form in the case where a vowel, generally a schwa but possibly other vowels (19b), is deleted between two identical consonants (19a and b). Moreover, this phenomenon is not restricted to the domain of a word, and can also happen at word boundaries when in a schwa deletion triggering environment (19c). This case of gemination is observed exclusively in fast or casual speech. In (19) the vowels that can be subject to deletion resulting in gemination are underlined.

(19)	a. *netteté*	→	[nɛtte]	"neatness"
	b. *maman*	→	[mmɑ̃]	"mom"
	c. *il coupe pas*	→	[kuppa]	"it doesn't cut"

3.3.2. At word boundaries

a. The elided pronoun l'

Elision refers to the process of dropping the final vowel of a word when it precedes a vowel-initial word, or a word beginning with a mute h. It is indicated in French with an apostrophe in the spelling and usually occurs with the pronouns *le* (masculine) and *la* (feminine) before a verb beginning with a vowel or a mute h. An example of the elision process in French is given in (20) below.

(20)	*On a vu le film.*	→	*On l'a vu.*
	'We saw the movie.'		'We saw it.'

Although this pronoun should be pronounced as in (21a), a tendency to geminate the pronoun as in (21b) is observed among French speakers. Previous studies claim that this pronunciation of the elided pronoun l' as geminated is frequent in particular in region of Paris.

(21)	a. *Je l'ai dit*	[ʒə**l**edi]	"I said it"
	b. *Je l'ai dit*	[ʒə**l:**edi]	"I said it"

In Martinet's (1945), linguistic survey, one of the items examined is the pronunciation of the object clitic *l'* in je l'ai dit "I said it". Martinet (1945) observes that the national mean percentage of gemination for this pronoun is of 23%, with a higher propensity to gemination in the North-western part of France. Specifically, in the region surrounding Paris, the percentage of participants using the geminated pronunciation was of more than 50%. Moreover, this pronunciation is unsurprisingly observed more frequently among younger participants. Although Martinet doesn't provide any explanation for the reason that led him to testing this specific item, its presence in the survey suggests that a linguistic

change was already active in the first-half of the 20th century, at the time of the study. Figure 8 below from Martinet (1945) illustrates these results concerning the clitic l'.

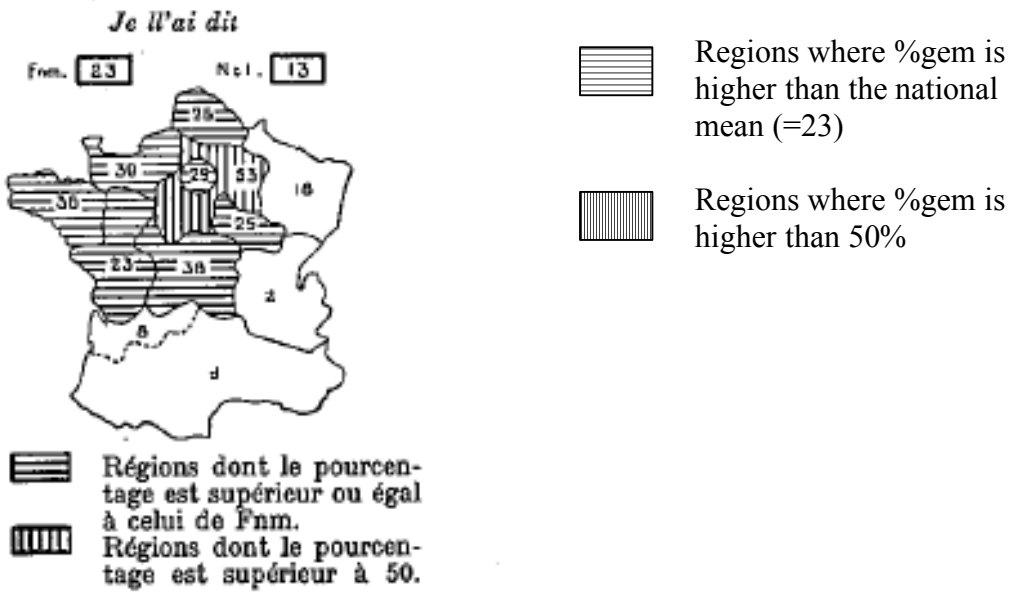


Figure 8: Geographic repartition of the gemination of the elided pronoun l' (in %) from Martinet (1945)

Tranel (1987) also notes that the elided pronoun *l'* might be geminated. He proposes two contrastive environments where it contrasts with its non-elided form, that is, before a verb with an initial consonant (e.g. *Tu **l'**apprendras* 'you will learn it' with a geminated /l/ vs. *Tu **la** prendras* 'you will take it' with a singleton), and where the elided pronoun contrasts with the elided definite *le* or *la* (*Nous voulons **l'**envoyer* 'we want to send it' with a geminated /l/ vs. *Nous voulons **l'**envoyé* 'we want the envoy' with a singleton). Table 3 below extracted from Tranel (1987) summarizes the two environments.

Gemination possible		No gemination
Tu **l**'apprendras "you will learn it"	[tyllaprãdra] [tylapr ãdra]	"you will take it" Tu **la** prendras
Nous voulons **l'**envoyer "we want to send it"	[nuvulõllãvwaje] [nuvulõlãvwaje]	"we want the envoy" Nous voulons **l'**envoyé

Table 3: From Tranel (1987) Contrastive contexts and the gemination of l'

Carvalho (2002) analyses this phenomenon as a generalization of the gemination of the object clitic in *il l'a dit* [illadi] 'he said it'. He affirms this phenomenon corresponds to a diachronically recent phonemicization of the geminate consonant in French, a change initiated by the educated pronunciation of sonorants in words like *sommet* [sɔmme] 'peak' or *illustre* [illystr] 'illustrious'. In his analysis, the morpheme boundary moves so that the geminate consonant itself is taken as the elided pronoun (22).

(22) *il l'a dit* → /il + l + a + di/ → /i + ll + a + di/

According to Carvalho (2002: 163), in an Optimality Theory framework, this strategy allows to satisfy the two following constraints:

LIAISON: A floating C is attached to the following segment only when it is a vowel (otherwise it may be deleted: e.g. *il mange* 'he eats'/ilmãʒ/ is often realized as [imãʒ]).

DISTINCTION: All relevant distinction has to be preserved.

(23)

il l'a dit	LIAISON	DISTINCTION
iladi	∗!	
→ illadi		∗

The OT tableau above in (23) illustrates Carvalho's analysis: the third person pronoun *il* should be realized /i-/ in order to satisfy LIAISON, but it would then violate DISTINCTION because *il l'a dit* 'he said it' and *il a dit* 'he said' would be both realized in the surface form as /iladi/. If the elided pronoun is realized as a geminate consonant, then the geminate itself is homo-morphemic and therefore spreads to the whole paradigm as in (24).

(24) From Carvalho (2002)

je l'ai dit	/ʒə	↑	e	di/	=	[ʒə l:edi]
tu l'as dit	/ty		a	di/	=	[tyl:adi]
il l'a dit	/I	ll	a/õ	di/	=	[il:adi], [il:õdi]
nous l' avons dit	/nu		avõ	di/	=	[nul:avõdi]
vous l'avez dit	/vu	↓	ave	di/	=	[vul:avedi]

In Meisenburg (2006) this phenomenon is investigated experimentally in terms of both perception and production for French native speakers. His results show that, although the elided pronoun is often pronounced as a geminated /l/ for the third person, results are non-consistent for the generalization to the first person, even in emphatic context. Similarly, Guillemot (2018b) compares for French native speakers from Paris, the perception of the elided pronoun with cases of positional (non-phonemic) gemination. Results are consistent with those of Meisenburg (2006) as, although it was observed that French native speakers are able to distinguish the consonant duration between long and short based on constriction duration, this does not lead to any phonemic distinction in their minds.

3.3.3. Phonetics of French geminate consonants

Delattre (1967) measures experimentally the ratio between singleton and geminate consonants at word boundaries (with schwa deletion) for production of /n/, /l/ and /s/ by

French native speakers. He finds a mean of 1 to 1,9 for the durational ratio of singleton to geminate. Moreover, he affirms that the duration of the preceding vowel is a negligible factor in geminate identification: although they are some variations in the duration according to the nature of the vowel, these might also be due to individual variations and the ratio is of 0,96 to 1. According to Delattre (1967), this is surprising considering the fact that vowels are shorter before a voiceless consonant than a voiced one. His comparison of durational ratios in four European languages shows that duration contrasts are wider for Latin languages than Germanic ones, English being the narrower.

In terms of perception, Delattre's (1967) results in a gating experiment show that the range of ambiguity below which consonants are perceived as single is 8, 10 and 12cs for /n/ and /l/ and 14, 16 and 18 for /s/. The comparison with the perception of geminates by native speakers of other languages shows that the duration required for a consonant to be identified as geminated is longer for French speakers that for English ones. In a second experiment on the influence of formant transitions on geminate identification, Delattre (1967) shows that the reduction of the arresting transition has more effect than those of the releasing transition. He affirms that this might be an indication that the final-consonant phase of articulation contributes more than the initial consonant phase to identification. The reverse pattern was observed for English native speakers on the same French stimuli. He claims that this is however a secondary cue for geminate identification, that is liable to be overridden by the duration cue.

Delattre (1967) also investigates word internal geminates and especially the /r/ vs. /rr/ contrast in the imperfect and conditional verb forms (see 2.2.1. a) with and without schwa deletion. He found a mean of 20,4cs for geminates and 11,2cs. For singletons with a ratio of

1 to 1,8 which is quite similar to the results for /l/, /n/ and /s/ although it was a different geminate type and their absolute duration are quite different. However, he notices that the geminate consonant in *courrait* “would be running” is shorter than in *désirerait* “would be desiring” where a schwa deletion process is involved. According to Delattre (1967), this constitutes a piece of evidence for “signs of life between /r/ sounds” of a schwa that is supposed to be deleted”. Furthermore, his results show that French /r/ and /rː/ are also distinguished by a two-phase articulation and a narrower constriction. This last point is illustrated in Figure 9 below from Delattre (1967-78) which represents the articulation of /r/ for a singleton on top and a geminate on the bottom.

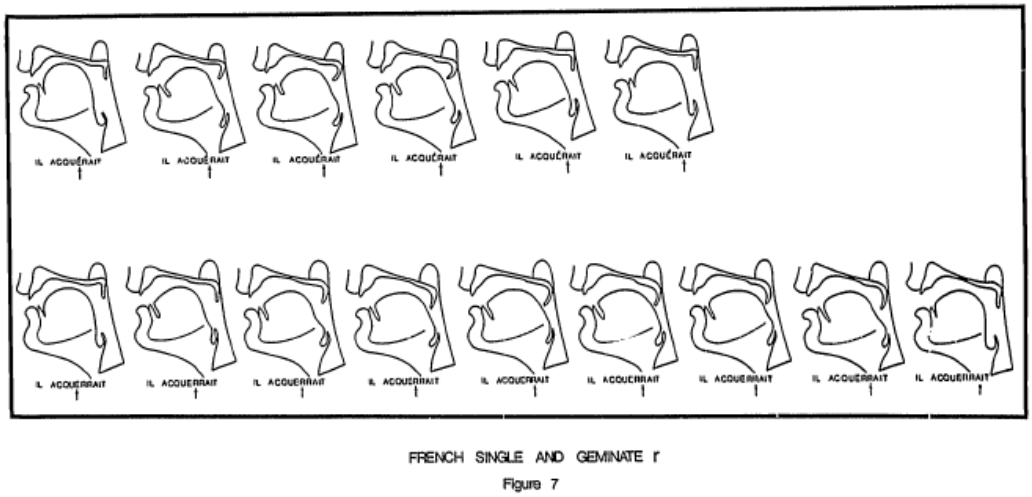


Figure 9: Articulation of French singleton and geminate /r/ from Delattre (1967-78)

Although Delattre’s findings provide interesting data on gemination for French native speakers, it is important to mention that his experiments deal with non-phonemic geminates, that is, cases of phonetic gemination emerging at word boundaries due to a

sequence of identical consonants[13]. As such, we can expect that in these cases of 'fake' gemination, durational cues for both consonants and vowels might be different than for phonemic gemination. For example, Guillemot (2018b) investigated the perception of geminated /l/ and compared identical consonant sequences with a case of phonemic gemination reported in the literature. The results show that French native speakers are able to perceive the difference between long and short consonants in an identical consonant sequence with a perceptual boundary located between 13 and 16ms. However, patterns were different for the case of phonemic gemination: the participants were not able to distinguish the two consonant types.

[13] In particular, the use of geminated /s/ is questionable considering the fact that /s/ is never geminated in French, while /l/ and /n/ can be like in cases of stylistic gemination. e.g. *syllabe 'syllable'*

CHAPTER 3: GOALS AND HYPOTHESES

The review of the literature presented in Chapter 2 sheds light on several characteristics of geminate consonants in Japanese. Building upon the previous findings in the literature, this dissertation aims at understanding better L2 acquisition of consonant durational contrasts in Japanese. This Chapter will present the goals of the dissertation in a first sub-section and the research hypotheses in a second sub-section.

1. GOALS OF THE PRESENT RESEARCH

The literature on the phonological status and on the phonetic characteristics of Japanese geminate consonants is abundant and sheds light on their peculiar status in Japanese. Geminate consonants in Japanese are inherently linked to the property of this language to have a mora timing, and referred to as a "special" mora. As such, they stand out phonotactically, as they are one of the few segments in Japanese that can be the second part of a heavy syllable and allowed as syllable coda. Involved in many minimal pairs, they also occur in all the strata of the Japanese lexicon where they achieve various goals and play an important role in terms of morphophonological processes (e.g. verbal inflection, compounding).

Research on second language pronunciation and teaching makes use of the concept of Functional Load (Hockett 1955, King 1967, Meyerstein 1970, Catford 1987, Brown 1991,

Munro and Derwing 2006) in order to rank segmental contrasts in priority order. As defined in King (1967) functional load is "a measure of the work which two phonemes do in keeping utterances apart". Among factors that contribute to functional load measurements, can be found for example the number of minimal pairs and their frequencies with regard to parts of speech, or probabilities that a member of the minimal pair occurs. Munro and Derwing's (2006) experimental findings show that in L2 speech, errors related to a higher functional load have a greater impact on native listener's judgment on comprehensibility and accentedness than errors related to a lower functional load. More than just confirming the functional load hypothesis their results also suggest that the acquisition of linguistic contrasts with a high functional load is crucial for comprehensibility.

As seen in Chapter 2, Japanese language has abundant occurrences of geminate consonants, which contrast with singleton consonants, their short counterparts. As such, this contrast is involved in a variety of minimal pairs that can be found in all strata of the Japanese lexicon. Moreover, the consonantal length contrast in Japanese is not only involved in many minimal pairs, it also plays a major functional role in verbal inflection in the marker for past and suspensive forms for example, and has therefore a high frequency in the lexicon. Likewise, it is found in abundance in phonological alternations resulting from native or Sino-Japanese compounding. These properties of geminates in Japanese constitute evidence for the high functional load of the consonantal length contrast. Thus, an accurate acquisition of the contrast between singleton and geminate consonants in Japanese by L2 learners appears to be necessary for an efficient communication with native speakers, considering its strong impact on comprehensibility and intelligibility.

Both the important role of the consonantal length contrast in Japanese and its challenging aspects in terms of acquisition for second language learners (Hirata 2009, Sonu et al. 2013, Tsukada et al. 2015) justify the abundance of research on the topic. Because the

Japanese consonantal length contrast is closely linked to the moraic nature of the language, it is especially difficult to acquire for learners whose native languages are stress-timed (e.g. English) or syllable-timed (e.g. French) and don't have such a contrast (Hirata 2009, 2015, Toda 2003).

The primary goal of this dissertation is to investigate in details the production of the consonantal length contrast in Japanese by second language learners. Specifically, productions by L2 learners will be compared with those of Japanese native speakers in order to identify production cues and learner strategies. Previous studies have shown that closure/frication duration is the primary acoustic cue for Japanese native speakers in production of the consonantal length contrast (Port et al. 1980, 1987, Homma 1981, Han 1992 *inter allia*), but also a propensity to have a longer vowel before a geminate than before a singleton (Port et al. 1987, Kawahara 2006) and a shorter one after a geminate consonant (Han 1994, Hirata 2007). The timing control in Japanese that involves geminate consonants and their surrounding vowels' duration is language specific (Kawahara 2015) as indicated notably by the fact that other languages exhibit different patterns[14]. From the few findings available concerning geminates in L2 learners' pronunciation and involving production data (Han 1992, Toda 1993, 1994, Masuda and Hayes-Harb 2005, 2007), it appears that L2 learners' closure duration for geminate consonants doesn't match those of Japanese native speakers. In the present study, I will look in detail at learners' productions and compare them to native speakers' in order to identify production cues such as: closure/frication duration, duration of the preceding vowel, duration of the following vowel and ratios of the vowels to

[14] As mentioned in Kawahara (2015, 2018), Japanese is not the only language to show lengthening of vowels preceding a geminate consonant: as some research shows similar tendencies in Turkish or Finish for example. However, most languages appear to exhibit the opposite tendency with a shortening of the preceding vowel as it is the case in Italian, or no significant difference as in Egyptian Arabic. See Kawahara (2015) for a comprehensive review of the durational correlates of geminate consonants in languages other than Japanese.

the consonant's closure duration. Furthermore, these production cues will be examined separately with regard to each manner of articulation.

A second primary goal of this study is to look at the influence of L1 phonology on the acquisition of the consonantal length contrast. Research evidence from the literature on L2 acquisition of geminates consonants[15] points out the central role of the influence of the learners' L1 phonology on their acquisition, production and perception of the contrast in their target language. Thus, for this dissertation it was chosen to target learners from three different L1 background with different phonological properties regarding timing and presence/absence of a consonantal length contrast: Italian, French and English.

Italian and French were chosen for their syllable timing and English for its stress timing. While in Italian the consonantal length contrast is semantically contrastive, it is not the case in the two other languages. However, when comparing English and French with regard to consonantal length contrasts, it appears that it has never been contrastive in English, while French (which has the same Latin origins as Italian) used to have a consonantal length contrast but underwent a degemination process (Klein 1963, Posner 1996). This process occurred only in Western Romance languages, and in the case of Eastern Romance languages the consonant quantity contrast remained, which explains why it can still be found in modern Italian. Yet, modern French appears to show some remnants of geminate consonants as some "fake" geminates appear, even though no lexical quantity contrasts are involved. This is especially the case in "educated" pronunciations, where a geminated pronunciation of a double consonant in the spelling marks "educated" pronunciation. Lastly, the only case of phonemic gemination in French, that is gemination that allows to make a distinction in terms of meaning is in the contrast between imperfect and conditional tenses

[15] See Chapter 2 section 2.

of the verbs *courrir* 'to run' and *mourrir* 'to die'. A summary of the comparison of Japanese phonological properties with those of the L1s of the three target learner populations can be found in Table 1 below.

Table 1: Comparison of the phonological properties of the four languages targeted by this dissertation

	Japanese	Italian	French	English
Timing	Mora	Syllable	Syllable	Stress
Consonantal length contrast	Yes *e.g. kata* 'shoulder' vs. *katta 'bought'*	Yes e.g. *fato* 'fate' vs. *fatto* 'fact'	Yes (?) no minimal pairs BUT *imperfect vs. conditional & stylistic gem.*	No

The prediction that can be made based on the properties of their L1 is that Italian native speakers will be more successful in their acquisition of Japanese geminates. Moreover, in the case of French native speakers, the existence of a consonantal length contrast, even non-semantically distinctive, allows to presume that French learners may benefit from a positive transfer from this property of their L1. In sum, we expect Italian learners to be the most successful, followed by French learners, and English learners to encounter the most difficulties in their acquisition of the consonantal length contrast. From the examination of each L1 groups, a secondary goal of this dissertation will be to identify difficulties, production cues and strategies that are specific to a L1. Lastly, we will propose a model for the influence of L1 phonology on acquisition based on the analysis of learners' productions.

The review of the literature on the L2 acquisition of geminate consonants brings out the lack of data on some learner populations. As already mentioned in Chapter 2, most of the research on L2 acquisition of Japanese in general, and of the consonantal length contrast in particular, focus on learners whose L1 is English or learners from Asian countries

surrounding Japan. What we notice is that, to the best of our knowledge, although most of them don't have geminates, European languages are understudied. A secondary aim of this dissertation is to provide acquisition data on two languages that have been understudied until now when it comes to Japanese L2 acquisition: Italian and French.

Lastly, based on the comparison of the three learner groups, we expect the analysis to shed light on some language specific difficulties and therefore to understand better what is challenging for each learner group. This is necessary especially in the case of French and Italian learners, whose acquisition of Japanese L2 phonology has been understudied until now: This implies few data available and a lack of knowledge of their difficulties. Furthermore, language specific pronunciation teaching methods, if they even exist, might not be adapted to the specific needs of these L2 learner populations. Using the results of the experiments in this dissertation, we intend to provide acquisition data that will constitute useful knowledge on French and Italian learners' acquisition of Japanese and that might be applied directly to the improvement of effective pronunciation teaching methods. Furthermore, the results might also benefit learners whose L1 has similar timing and phonological properties. (e.g. other syllable-timed L1s that belong to one of the two consonant length typologies: languages with a consonantal length contrast, languages without a consonantal length contrast.)

To summarize this section, the goals of this dissertation are:

(i) Investigate the production of the consonantal length contrast by L2 learners

(ii) Compare L2 learner groups with different L1 phonological properties in order to identify language specific difficulties and production cues, and propose a model for L1 influence on Japanese consonant length contrast acquisition.

(iii) Provide acquisition data on understudied L2 learner groups: Italian and French learners

(iv) Provide data and better knowledge of specific difficulties of a learner population in order to contribute to the improvement of teaching methods in Japanese language and pronunciation class.

2. RESEARCH HYPOTHESES

Building upon the goals presented above, this dissertation addresses the two following research questions: What is the influence of a learner's L1 phonological properties in terms of durational contrasts on his/her production of L2 durational contrasts? How can the production of the consonantal length contrast by L2 learners of Japanese be described in terms of production cues?

These research questions will be answered by collecting experimental production data from three L2 learner groups: Italian, French and English, in order to look at the influence of the durational contrasts in their L1 phonology on their L2 productions of L2 durational contrasts. Identical data will also be collected from Japanese native speakers for comparison purposes.

In order to answer the research questions above, we formulated the following null hypotheses, that were used as a basis for the design of the production tasks used in the experiment. The three following subsections will present the three hypotheses investigated for this dissertation.

2.1. Hypothesis 1

Hypothesis 1 formulated below examines the null hypothesis, that is, that there is no difference between the three learner populations in terms of accuracy.

Hypothesis 1: There is no difference in terms of accuracy between all three learner groups in their pronunciation of L2 Japanese geminates.

To examine this hypothesis, I propose the use of durational accuracy (whether durational values obtained for learners are consistent with those of Japanese native speakers) in order to have an objective judgement of learners' production, instead of using native speakers' accuracy judgement based on perception. In this purpose, based on the analysis of the production data of native speakers obtained experimentally, I will define a range of values for singleton-geminate durational ratios as "accurate". The defined durational accuracy range will be compared to L2 learners' productions in order to judge them as accurate or inaccurate and based on this data, I will compare accuracy score in all three learner groups. Hypothesis 1 will be verified if no difference in terms of accuracy is observed between the three groups.

As mentioned in section 1 above, Italian, French and English have different phonological properties regarding consonant durational contrasts. As such, the prediction that we make concerning learners' accuracy is as follows in (1).

(1) Italian learners ＞ French learners ＞ English learners

2.2. Hypothesis 2

Among the three learner populations targeted by this study, the consonant durational contrast is semantically distinctive in Italian, non-distinctive in English, and mainly stylistic

in French. In Italian, stops, fricatives, affricates, nasals and liquids can be geminated (Giovanardi and Di Benedetto 1998) and /t/ and /l/ have the highest frequencies (20%) as pointed out by Bortolini and Zampolli (1979). On the other hand, as presented in Chapter 2 section. 3.3, in French there are three main environments where gemination can occur. Among these three, one is no more than phonetic gemination resulting from a sequence of identical consonants, the second is stylistic gemination occurring in "educated" speech, and the last and only case where consonantal length is contrastive is in the distinction between imperfect and conditional. In Walter (1982), the most frequent cases of gemination are reported for the nasals /m/ and /n/ and the liquids /l/ and /r/. Stops in general appear only as phonetic gemination, that is identical consonant sequences at morpheme boundaries or due to schwa deletion and both fricatives and affricates are never (or rarely) geminated.

In Japanese, the segments that can be geminated are stops, fricatives, affricates and nasals[16]. As all these consonant manners are also subject to gemination in Italian, we can predict that Italian learners will perform equally in terms of accuracy for all manners, except for stops that might have a higher accuracy, as they have the highest frequency in Italian. In the case of French learners, based on the nature and the frequency of gemination in French, we can postulate that they might perform better for nasals than for stops. Furthermore, there are no geminated affricates or fricatives in French, which suggests that fricatives and affricates might be the most challenging for French learners. Concerning the order between fricatives and affricates, because geminated affricates behave like geminated stops in Japanese (lengthening of the closure and not the frication) we can postulate that affricates have a higher accuracy than fricatives.

[16] Although Japanese phonology classifies obstruent geminates '*sokuon*' and nasal geminates '*hatsuon*' as different entities, phonetically, nasal are also subject to gemination in Japanese (Kawahara 2015).

The prediction can be summarized as follows in (2)[17]:

(2) Italian learners: stops > nasals = affricates = fricatives
French learners: nasals > stops > affricates > fricatives

Concerning learners whose L1 is English, as consonantal length is not contrastive in English, we can expect that they would found all manners equally challenging or that their pronunciation would reflect universal acoustic properties of the consonants.

Hypothesis 2 examines the following null hypothesis: t

Hypothesis 2: There is no difference in terms of accuracy between manners of articulation in all three learner groups' pronunciation of L2 Japanese geminates.

To investigate this hypothesis, the experiment will be designed in order to have tokens including consonants from each manner of articulation: stop, fricative, affricate, nasal. For the analysis, the same data as for Hypothesis 1, making use of durational accuracy, will be used. However, here the analysis will go further in detail by looking not only at accuracy by language group, but also at the differences in accuracy within each language group in order to make it clear whether any difference in accuracy can be observed when looking at each manner of articulation separately. The results obtained will then be compared with the predictions made in (2) above based on the phonological characteristics of the three languages and Hypothesis 2 will be verified if no difference is observed.

In the case where results would show an absence of divergences in accuracy across learner groups and manners of articulation it would suggest that rather than the influence of L1 phonological properties, universal acoustic properties of consonants should be

[17] Although liquids are often geminated in Italian and the only contrastive case of gemination in French, in Japanese there is no phonemic contrast between long and short consonants for them (Kawagoe 2015).

considered. Another issue that will be considered is the level of the learners, that might be non-appropriate for such analysis. On the other hand, if differences can be observed, it would constitute evidence supporting L1 influence on L2 production.

2.3. Hypothesis 3

The variety of experimental research in the literature on the phonetics of Japanese geminate consonants has shed light on the acoustic cues on which Japanese native speakers rely for phonetic implementation of the consonantal length contrast. The primary acoustic cue is the difference in closure duration for stops and affricates and the frication duration for fricatives (Port et al. 1980, 1987, Homma 1981, Han 1992 *inter allia*) and secondary cues are the property of the preceding vowel to be longer before a geminate consonant (Port et al. 1987, Kawahara 2006) and of the following vowel to be shorter after a geminate consonant (Han 1994, Hirata 2007). These patterns of timing control are language specific, which suggests that learners might rely on different durational cues in L2 production. Geminate consonants in Italian for example exhibit a different pattern, with a shorter preceding vowel in a geminate environment than in singleton one (Picket et al. 1999, Rossetti 1994, Giovanardi and Di Benedetto 1998, Esposito and Di Benedetto 1999, Mattei and Di Benedetto 2000, Faluschi and Di Benedetto 2001).

I formulate the null hypothesis as follows: no difference can be observed in the use of durational cues between Japanese native speakers and L2 learners.

Hypothesis 3: There is no difference between L2 learners and Japanese native speakers in the use of durational cues for consonantal length production.

In order to provide an account to Hypothesis 3, I will look in detail at the influence of learners' L1 durational cues in their L2 phonetic implementation. In order to examine this property of learners' pronunciation, for each of the four L1 populations, I will examine segment durations and durational ratios in both singleton and geminate environments. Specifically, measurements will be made on the consonant closure/frication duration and the preceding/following vowels to make it clear whether and how learners make use of consonant constriction and surrounding vowels durations to distinguish singletons from geminates in their pronunciation.

The analysis will also look in detail at each manner of articulation separately and compare durational patterns by manner of articulation. The findings of this data analysis should allow us to identify the production cues that learners rely on for L2 production and bring out some patterns specific to each language group. These will be compared between learner groups and with those observed for Japanese native speakers.

CHAPTER 4: EXPERIMENT METHODOLOGY

In the previous chapter, were introduced the research questions and hypotheses that constitute the basis for this dissertation. By examining the production of the Japanese consonantal length contrast by Japanese native speakers' and L2 learners with different L1 backgrounds, I intend to provide a description of the production cues used by all speaker groups, and compare and relate them to L1 phonological properties. The three null hypotheses formulated in Chapter 3 are reproduced below:

Hypothesis 1: There is no difference in terms of accuracy between all three groups of learners in their pronunciation of L2 Japanese geminates.

Hypothesis 2: There is no difference in terms of accuracy between manners of articulation in all three learner groups' pronunciation of L2 Japanese geminates.

Hypothesis 3: There is no difference between L2 learners and Japanese native speakers in the use of durational cues for consonantal length production.

A production experiment was designed in order to collect the data necessary to investigate and provide an answer for these hypotheses. The present chapter is devoted to the methodological considerations involved in the experiment design and experimental procedures. The first part of this chapter will describe the design of the production tasks and of all experiment-related materials. In the second part, the experiment procedures and the demographic data concerning the participants will be examined. Lastly, the third part will introduce the methodology used for data measurement and analysis.

1. TASK AND MATERIAL DESIGN

Three tasks evaluating participants' production were created in order to examine L2 learners' production for this experiment. First, a reading task composed of an elicitation paragraph in Japanese, developed in order to evaluate learners' pronunciation skills[18]. A second reading task of ten sentences in Japanese was also created for the experiment purpose. Finally, acting as a distractor, a task constituted of grammar exercises to solve orally was added to the reading tasks. This section will describe the development of the three tasks used for the production experiment. Section 1.1 of this chapter describes the process of creating the proficiency test. In section 1.2. I present the sentences reading task and 1.3. is devoted to the grammar task.

1.1. Proficiency test[19]

1.1.1 Test design

The first reading task is an elicitation paragraph developed in order to evaluate the pronunciation of Japanese by L2 learners. A comprehensive review of the literature on Japanese second language acquisition shed light on the fact that no such test is available for the evaluation of the pronunciation of L2 learners of Japanese. Indeed, to the best of our knowledge, the Japanese proficiency tests available (e.g. Japanese Language Proficiency Test: JLPT, provided by The Japan Foundation/Japan Educational Exchanges and Services) provide a comprehensive evaluation of the reading, writing and listening competences, but they do not consider oral aptitudes and especially not pronunciation. This is a logical

[18] Thanks to Professor Junko Hibiya who suggested the creation of this test in order to evaluate the experiment participants' oral proficiency.
[19] An early version of this section appears in Guillemot (2018a).

consequence of the focus on reading and writing in Japanese language education in general[20] but also of the challenging aspect, in terms of logistics, that such a test would represent considering the scale. Indeed, although English proficiency tests include the evaluation of this competence, both the scale and the necessity of such a test in the case of Japanese may not be enough to motivate the effort it would represent.

In an experimental framework however, the problems listed above related to the organization of tests focusing on pronunciation is not relevant, and as such an elicitation paragraph was created in order to evaluate the participants' proficiency level without having to rely only on their writing/reading skills for this dissertation. The test was made specifically for the needs of the present dissertation and focusses mainly on segmental properties of Japanese[21], it can however be used more generally as an indicator of learners' oral proficiency level. Namely, in the present study, the test is used in order to divide learners in several groups according to their pronunciation level that will be defined further later, and not based on their writing and reading aptitudes.

The paragraph is presented in Japanese in (1) below, together with a romanization in (2) and an English translation in (3). The version that was presented to learners during the experiment uses Japanese writing with furigana (smaller Japanese characters giving indications on pronunciation) and can be found in the appendix.

(1) Proficiency test elicitation paragraph (in Japanese)

今日は自転車で広いデパートへ買い物に行きました。ビルの地下1階から9階までお店が沢山あります。屋根に一本の旗がそっと揺れています。洋服屋でセールをやっていたので、ワンピースとキャミソールを一着ずつ買いました。ワンピースはベージュで、肩に緑

[20] Some insightful remarks on this problem in the case of Japanese language education in France can be found for example in Shochi (2012) and EDUSCOL (2010).
[21] Specifically, pitch accent was not taken into account for minimal pairs.

の葉っぱとリボンが付いています。次に、文房具屋で、青いペン、雑誌と消しゴムを買った時、店員さんに飴をもらいました。病気で一緒に行けなかった娘に子供服とおもちゃの売り場で大好きな像のぬいぐるみを買ってあげました。そして、北陸新幹線の切符を買いました。来週は夫と娘と三人で金沢を旅行する予定です。その後は、美容院に予約を取りに行ったら、ずっと会えていなかった友達に偶然会いました。昔二人で中国へ留学したことは、一生の思い出です。二人で牛乳入りの紅茶を飲みながら、学校で好きだった授業の話に夢中になりました。帰る時は、外は雨が降っていました。傘は持っていなくて、そのままじゃちょっと帰りづらかったので、バーでビールを飲みながら雨が止むのを待ちました。

(2) Proficiency test elicitation paragraph (Romanized version in modified Hepburn system)

Kyō wa jitensha de hiroi depāto e kaimono ni ikimashita. Biru no chika ikkai kara kyū kai made omise ga takusan arimasu. Yane ni ippon no hata ga sotto yureteimasu. Yōfukuya de sēru o yatteita no de wanpiisu to kyamisōru o itchaku zutsu kaimashita. Wanpiisu wa bēju de, kata ni midori no happa to ribon ga tsuiteimasu. Tsugi ni bunbōguya de, aoi pen, zasshi to keshigomu o katta toki, ten'insan ni ame o moraimashita. Byōki de isshoni ikenakatta musume ni, kodomofuku to omocha no uriba de daisuki na zō no nuigurumi o katte agemashita. Soshite, hokuriku shinkansen no kippu mo kaimashita. Raishū wa otto to musume to sannin de kanazawa o ryokō suru yotei desu. Sono ato wa, biyōin ni yoyaku o tori ni ittara, zutto aeteinakatta tomodachi ni gūzen aimashita. Mukashi futari de chūgoku e ryūgaku shita koto wa isshō no omoide desu. Futari de gyūnyū iri no kōcha o nominagara, gakkō de suki datta jyugyō no hanashi ni muchū ni narimashita. Kaeru toki wa, soto wa ame ga futteimashita. Kasa wa motteinakute, sono mama ja chotto kaerizurakatta node, bā de biiru o nominagara ame ga yamu no o machimashita.

(3) Proficiency test elicitation paragraph (English translation)

Today I went to a large department store by bicycle. It has shops from the basement floor to the 9th floor. And there is a flag softly swaying on its rooftop. There were promotions at the clothes store so I bought a dress and a camisole. The dress is beige and has a green leaf and a ribbon on the shoulder. Next, when I bought a blue pen, a magazine and an eraser at the stationeries shop, the staff gave me a candy. At the kids' floor, I bought a stuffed elephant for my daughter who is sick and couldn't come with me. After that, I bought train tickets for the Hokuriku bullet train. Next week, my daughter my husband and I are planning to visit Kanazawa. After that, I went to the hairdressers to make a reservation and met a friend that I hadn't seen in years. A long time ago we were together in an exchange program in China and I think I will remember all my life those good memories. We talked about the classes we used to like back at school, while drinking tea with milk. When we decided to go home, it was raining so strong that it would have been difficult to go outside like that, so we had beer in a bar while waiting for the rain to stop.

The paragraph presented above in (1), (2) and (3) was designed based on the principle of the Speech Accent Archive (Weinberger 2015), which is an online database of speech samples of English native and non-native speakers providing an overview of the various accents of English-speakers from diverse origins for research and analysis. It is a collaborative platform where users with the appropriate hardware can provide and share speech samples and phonetic transcriptions. Each speech sample consists of an elicitation paragraph containing the inventory of consonants, vowels and clusters of American English. In the case of Japanese, its moraic nature makes it irrelevant to consider isolated consonant or vowels only. As such, the principle of the Speech Accent Archive was adapted to Japanese in a more comprehensive manner so that the paragraph in the test includes the inventory of segments and possible segment sequences in Japanese based on the *hiragana* syllabary (called in Japanese *gojuuonzu* literally 'table of the 50 sounds').

In addition, a comprehensive review of the literature on both Japanese phonology and its acquisition by L2 learners allowed to identify the phonological properties of Japanese that are crucial for speech comprehensibility, intelligibility and naturalness. Accordingly, the difficulties that are specific to the acquisition of Japanese were added to the paragraph. As a result, the test examines the following features: (a) segments: all of the CV combinations, (b) mora timing-related: geminate consonants and long vowels, (c) vowel devoicing, (d) pitch accent, (e) mora nasal assimilation and (f) some other difficult phonemic contrasts unique to Japanese. The choice of each of these features will be discussed in detail in the following sub-sections.

The present proficiency was designed in order to target learners who have already reached an intermediate level in Japanese for the following reasons: First, it is expected that learners in the very first stages of their acquisition are burdened by the acquisition of lexical items and rarely can afford to pay much attention on pronunciation. Secondly, such a reading task might be arduous for beginner level learners, as it implies that their reading proficiency skills might interfere in the evaluation of their pronunciation skills (e.g. speech rate, hesitations). Concerning the contents of the paragraph itself, in order to allow all the learners targeted by the study to understand it, it was written in the style of the textbooks used in Japanese classes (e.g. *Minna no Nihongo*, 3a Network 2012), based on an everyday life situation. The word choice was made based on the lists given on an indicative basis for the two lower levels of the JLPT (N5 and N4)[22]. Fourteen other words that do not belong to the list above were also included when they allowed to test some specific items (e.g. minimal pairs, rare CV sequences found only in mimetics). Lastly, grammar forms to be used were also chosen based on the analysis of beginner level textbooks. Most of the words used in this

[22] To the best of our knowledge, there is no official list of words for the five levels of the JLPT. The only lists available are provided in textbooks only on an indicative basis and using data from previous years' JLTP test.

paragraph are therefore supposed to be known by all learners but the use of a glossary can be useful in case they still don't feel comfortable with some of the words[23]. The contents of the paragraph were checked by a native speaker of Japanese for naturalness and grammatical accuracy[24].

1.1.2 Linguistic items examined

What follows is devoted to a presentation of the considerations taken into account for the choice of each of the linguistic items evaluated in the paragraph. Together with the methodology, each sub-section will also provide a comprehensive list of words in the paragraph that can be used to evaluate each of the targets. Although this section describes in detail the test design methodology, the present dissertation does not make uses of the evaluation of separate items but only of the oral proficiency.

a. Segments

As mentioned above, owing to the moraic nature of Japanese language, it was decided to use the CV sequence as the basic unit for the present test (vs. segment in the Speech Accent Archive). Using the *hiragana* syllabary, all possible CV sequences in Japanese were included in the paragraph, as well as their voiced counterparts with diacritics (e.g. /ka/ vs. /ga/, /ha/ vs. /pa/) and the palatalized CjV sequences (e.g. /kja/, /kju/, /kyo/). Yet, Japanese's phonotactic restrictions required the exclusion of some sequences that

[23] In the present case, participants were told to ask directly the experimenter about words they did not understand.

[24] It has been brought to my attention by a native reviewer that some of the expressions used in the paragraph were not what a native speaker would find the most natural. For example, the paragraph makes use of *gyūnyū iri no kōtcha* 'tea with milk' instead of *miruku tii* 'milk tea' which would be the expected form. This was an informed choice allowing to insert some specific segments sequences (e.g. in the example above, the sequences /gyu:/ and /nyu:/).

appear only in specific lexical environments. Some of the palatalized sequences were of those, as they appear mainly in the mimetic stratum (onomatopoeia e.g. /nja/). In a similar way, low frequency was used as a criterion of exclusion for diachronically recent sequences that are mostly found in loanwords (e.g. /ti/) and therefore usually written using the *katakana* syllabary. Moreover, the *hiragana* characters じ and ぢ in standard Japanese are neutralized and pronounced as the alveolo-palatal affricate [dʑi]. Only the former, and most frequent in Japanese, was included in the test (see the general orthographic reform of 1946).

b. Mora timing

The mora-timed nature of Japanese language is well known for being a challenge in terms of acquisition for L2 learners[25]. Specifically, the segmental length contrasts of vowels (short vs. long) and consonants (singleton vs. geminate) have been widely pointed out in the literature for being arduous. In Japanese, these contrasts have a high functional load (King 1967, Wang 1967, Brown 1988, Munro and Derwing 2006), which implies that their accurate pronunciation is crucial for intelligibility and comprehensibility in the communication with native speakers. It was therefore logical to include both contrast types in the present test, as this is an essential characteristic of Japanese phonology.

The five vocalic phonemes of Japanese phonological inventory /a/, /i/, /u/, /e/, /o/ contrast in terms of length with their counterparts /aː/, /iː/, /uː/, /eː/, /oː/ (Labrune 2006, Vance 1987)[26]. This contrast is involved in many minimal pairs across all lexical strata of the Japanese lexicon as exemplified in (4).

[25] See Chapter 2 section 2.
[26] For readability 'u' is used instead of 'ɯ' in phonemicizations/romanizations of Japanese.

(4)	a. /to:ru/	'to go through'	vs.	/toru/	'to take'	native
	b. /bi:ru/	'beer'	vs.	/biru/	'building'	loans
	c. /dʑo:kjo:/	'situation'	vs.	/dʑokjo:/	'lecturer'	Sino-Japanese

The following table presents all the words containing a long vowel in the elicitation paragraph.

Table 1. List of words containing a long vowel

/a/		**/e/**	
デパート /depa:to/	'department store'	セール /se:ru/	'sale'
バー /ba:/	'bar'	ベージュ /be:ʑu /	'beige'
		予定 /jote:/	'prevision'
/i/		**/o/**	
ビール /bi:ru/	'beer'	今日 /kjo:/	'today'
ワンピース/wampi:su/	'dress'	洋服 /jo:ɸuku/	'clothes'
		キャミソール/kjamiso:ru/	'camisole'
/u/		文房具 /bumbo:gu/	'stationeries'
九階 /kju:kai/	'ninth floor'	病気 /bjo:ki/	'sick'
来週 /raiʃu:/	'next week'	一生 /iʃʃo:/	'lifelong'
偶然 /gu:zen/	'coincidence'	ゾウ /dzo:/	'elephant'
中国 /tʃu:goku/	'China'	旅行 /rjoko:/	'trip'
留学 /rju:gaku/	'study abroad'	美容院 /bijo:in/	'hairdresser'
夢中 /mutʃu:/	'passionate'	紅茶 /ko:tʃa/	'tea'
牛乳 /gju:nju:/	'milk'	学校 /gakko:/	'school'

The two minimal pairs in (5a) and (5b) below are also used in the paragraph as items to evaluate the vocalic length contrast.

(5)	a. /iʃʃ**o**:/	'lifelong'	vs.	/iʃʃo/	'together'
	b. /b**i**:ru/	'beer'	vs.	/biru/	'building'

Similarly to the case of the vocalic length contrast presented above, Japanese has a length contrast for consonants that opposes singleton to geminate consonants. The phonological and phonetic characteristics of geminate consonants as well as their particular status in Japanese were introduced in detail in Chapter 2 section 2 and won't be mentioned

any further here. The elicitation paragraph contains both inflectional geminates (e.g. /kau/ 'buy' + /ta/ 'past marker' → /katta/ 'bought') and word-internal geminates (e.g. /gaku/ 'learn' + /koː/ 'building' → /gakkoː/ 'school') from the native and Sino-Japanese strata. However, only voiceless geminates were included owing to the marked nature of voiced ones in Japanese phonology. The choice of words was made in order to include all three types of obstruent geminates (stops, fricatives and affricates) in the paragraph. The following minimal pairs can be found in the paragraph.

(6) a. /kata/ 'shoulder' vs. /ka**tt**a/ 'bought'
b. /soto/ 'outside' vs. /so**tt**o/ 'softly'

All occurrences of obstruent geminates included in the paragraph are listed up in Table 2 below.

Table 2. List of words containing a geminate consonant

Stops (1/2):		**Stops (2/2):**	
/p/		**Inflectional /t/**	
一本 /ippon/	'one long object'	やっていた /jatteita/	'was doing'
葉っぱ /happa/	'tree leaf'	買って /katte/	'buy'
切符 /kippu/	'ticket'	買った /katta/	'bought'
		行けなかった /ikenakatta/	'couldn't go'
/k/		だった /datta/	'was'
一階 /ikkai/	'first floor'	降っていた /ɸutteita/	'was raining'
学校 /gakkoː/	'school'		
		Fricatives and Affricates	
/t/		雑誌 /dzaʃʃi/	'magazine'
夫 /otto/	'husband'	一緒 /iʃʃo/	'together'
そっと /sotto/	'softly'	一生 /iʃʃoː/	'life long'
ちょっと /tʃotto/	'a little	一着/ittʃaku/	'one piece of clothing'
ずっと /dzutto/	'forever'		

Finally, and although phonologically sonorant geminates are not relevant in Japanese, the geminated /n/ emerges phonetically as the moraic nasal followed by an /n/ and called *hatsuon* in Japanese. In addition to the nasal singletons that are introduced in Table 3 in the sub-section c below, the test contains one occurrence of a nasal geminate illustrated in (7).

(7) /sannin/ 'three persons'

c. Mora nasal

The characteristics of moraic nasals gather much attention in Japanese phonology. Indeed, it has a special status in Japanese as, although it is not vocalic, it constitutes one mora and is one of the two only codas that are allowed in Japanese phonotactics. It is in particular its moraic nature that makes of it a challenge for learners: As reflected in its name, the mora nasal is one mora long and therefore has the same length as a CV sequence. Another difficulty lies in the fact it also systematically undergoes place assimilation with the following consonant so that it can be realized either as /n/, /m/ or /ŋ/, as illustrated below in (8):

(8) n → m/ __ p, b, m
n → ŋ/ __ k, g, ŋ

Lastly, the mora nasal in intervocalic position is realized as a nasalized vowel (Labrune 2006). In the test paragraph, it was decided to include words containing mora nasals in various environments (followed by vowels, consonants with different places of articulation, in intervocalic position and word-finally) in order to trigger assimilation and to look at Japanese L2 learners' mora nasal production. Its occurrences are listed up in Table 3 below. In Table 3 word containing mora nasals are divided in several categories depending on their phonetic realization [n], [m], [ŋ] or as a nasalized vowel in intervocalic position. As several words include more than one /n/ consonant, targets are indicated in bold. It allows to differentiate a simple nasal consonant (C of a CV mora) from mora nasals and to specify with of the /n/s correspond to each realization.

Table 3. Words containing mora nasals

N realized as [n]		**N realized as [m]**	
自転車 /dʑite**n**ʃa/	'bicycle'	文房具 /bu**m**bo:gu/	'stationeries'
たくさん /takusa**n**/	'many'	**N realized as [ŋ]**	
一本 /ippo**n**/	'one long object'	新幹線 /ʃi**n**kansen/	'bullet train'
店員さん /teni**n**sa**n**/	'store staff'	観光 /ka**n**ko:/	'tourism'
新幹線 /ʃinka**n**se**n**/	'bullet train'		
三人 /sa**n**ni**n**/	'three persons'	**Intervocalic N**	
偶然 /gu:ze**n**/	'coincidence'	店員さん /te**n**insan/	'store staff'

d. Vowel devoicing

Vowels in Tokyo Japanese exhibit a strong tendency to undergo devoicing when between two voiceless consonants or word finally when preceded by a voiceless consonant (9).

(9) V → V̥/ [-voice] __ [-voice], [-voice] __#

e.g. /takusan/ 'many' → [takṵsan]

This process is mainly observed for the high vowels /u/ and /i/. However, devoicing may also occur with /o/ and /a/ (e.g. /kokoro/ 'heart' or /kakashi/ 'scarecrow'), but with more restrictions. Namely, in addition to the environment triggering high vowel devoicing, the target vowel also has to be unaccented and in a reduplication environment (Labrune 2006). The present test includes a variety of high vowels in environments triggering devoicing both in word internal and word final positions. Table 4 below presents a comprehensive list of words that might be subject to vowel devoicing in the paragraph. The target vowel is indicated in bold.

Table 4. Words with vowel devoicing.

/u/ devoicing		/i/ devoicing	
たくさん /tak**u**san/	'many'	そして /soʃ**i**te/	'then'
洋服 /joːɸ**u**ku/	'clothes'	昔 /mukaʃ**i**/	'long ago'
好き /s**u**ki/	'love'		
大好き/dais**u**ki/	'adore'		
二人 /ɸ**u**tari/	'two persons'		
+ Verbs in the non-past form /mas**u**/ or /des**u**/		+ Verbs in the past form -/maʃita/	

e. Pitch accent

Japanese has a lexical pitch accent, as opposed to stress accent that can be found in English. Japanese pitch accent is characterized by variations in the fundamental frequency and more specifically by a drop in pitch indicating the syllable that bears the accent (that is, the one preceding the drop). In Japanese, the accent is either high (H) for the accent-bearing unit or low (L) (Vance 2008). Japanese words follow pitch patterns and can be either unaccented, which corresponds to a pitch raise on the second mora and an absence of pitch fall (e.g. LHHH), or accented on any mora (e.g. LHLL, LLHL etc.). In the light of the wide body of research on Japanese L2 acquisition concerning especially pitch accent (see Ayusawa 2003 for a comprehensive review of research on pitch accent acquisition), this aspect of Japanese phonology appears to be quite challenging for L2 learners. This is particularly the case since pitch accent has a high functional load in Japanese, which is reflected by the variety of minimal pairs it is involved in. This is exemplified in (10) below, where the accent bearing unit is underlined. The three words in (10) constitute minimal pairs in the sense they are identical at the segmental level and can be distinguished by their accentual patterns.

(10)	*kaki ga*	HLL	'oyster'	(accent on the first mora)
	kaki ga	LHL	'fence'	(accent on the second mora)
	kaki ga	LHH	'persimmon'	(unaccented)

It is needless to say that an accurate production of pitch accent is crucial for intelligibility and comprehensibility. Because the present test is focusing mainly on segmental aspects, items evaluating explicitly pitch accent are limited (a separate test might be required for a comprehensive evaluation of pitch accent). However, in addition to pitch accent accuracy that can be evaluated throughout the paragraph, it also includes the following minimal pair (11).

(11)	*ame*	HL	'rain'
	ame	LH	'candy'

f. Others

Lastly, although they are not cited in the literature, three other segment sequences that might constitute a challenge for L2 learners were also included in the paragraph. These were chosen based on impressionistic observations from the author's own experience as a Japanese L2 learner and might not be relevant for learners of all L1 backgrounds. The first one, illustrated by the minimal pair in (12), is the contrast in syllabification between /CjV/ and /Ci/+/jV/ which seems to be a common mistake among learners. The second one is the sequence of affricates (voiced followed by voiceless) in (13). Lastly, (14) presents a sequence of three consecutive vowels.

(12)	/bjo:ki/	'sickness'	vs.	/bijo:in/ 'hairdresser'
(13)	/dzutsu/	'one of each'		
(14)	/aoi/	'blue'		

1.2.3. Evaluation

The present test was designed in order to fit the needs of the researcher and therefore both allows to examine one separate item (e.g. duration of consonants, duration of vowels)

according to the goal of the study, and to give a general appreciation on the learner's pronunciation level through the comprehensive use of the variety of Japanese phonological characteristics inserted in the paragraph.

Learners' production of each of the linguistic items introduced above (sections a. to f.) can be evaluated individually by making acoustic measurements. However, as this will be done with other production tasks, in this dissertation the test was used for proficiency evaluation only. Concerning the evaluation of the proficiency level itself, I decided to rely on Japanese native speakers' judgment on learners' productions' naturalness and comprehensibility. Because judging learners' proficiency is not the main focus of the present research, we propose to use a representative extract of the paragraph in order to evaluate learners' level. What follows describes quickly a methodology for proficiency evaluation using the present test. The actual experimental procedures used for this dissertation will be discussed more in detail in section 2.1.2.b.

Three sentences were chosen for evaluation as presented in (15).

(15) a. 来週は 夫と 娘と 三人で 金沢を 旅行する 予定です。
Raishū wa otto to musume to kanazawa o ryokō suru yotei desu.
'Next week I'm planning to travel to Kanazawa with my husband and daughter.'

b. その後は、美容院に予約を取りに行ったら、ずっと会えていなかった友達に偶然会いました。
Sono ato wa biyōin ni yoyaku o tori ni ittara, zutto aeteinakatta tomodachi ni gūzen aimashita.
'After that, I went to the hairdressers' to take an appointment and met by coincidence with a friend that I had not seen in years.'

c. 昔二人で中国へ旅行したことは、一生の思い出です。
Mukashi futari de chūgoku e ryūgaku shita koto wa isshō no omoide desu.
'I will never forget our going together to a school exchange in China a long time ago.'

The choice of the three sentences in (15a, b, c) was motivated by the fact it constitutes a representative sample of the linguistic items introduced above. Namely, it contains eight long vowels (/o/ and /e/), six occurrences of geminate consonants (both inflectional and word internal geminates, with stops, fricatives and sonorant geminates), three mora nasals, several vowels in a devoicing environment and uses as much as 45 different CV/CjV sequences.

Native speakers were asked to judge learners' productions of these three sentences using Munro's quasi continuous scale, namely a 1024-points scale. The use of such a scale was suggested to me by Professor Murray Munro[27]: it presents the advantage to be more intuitive as the native speakers involved in the rating do not rely on numbers but only on the scale that appears as a line on the screen. Native speaker judgment was processed using a MFC experiment on the software Praat (Boersma and Weenink 1992-2018). Listeners were asked for each sentence they hear to rate the degree of naturalness (from "not accented at all" to "heavily accented") and comprehensibility (from "very easy to understand" to "very difficult to understand") of learners' productions. As a result, each native speaker assigned a naturalness score and a comprehensibility score to each sentence, and the global score on 2048 points was obtained by adding the mean scores for each category. Four pronunciation levels (low, low intermediate, high intermediate, and high or near native) were defined for this study in order to divide participants in level groups based on the global score such as "low" (from 0 to 500 points), "low intermediate" (from 501 to 1000), "high intermediate" (from 1001 to 1500 points) and "high" (1501 to 2048). The level obtained was used in the analysis of the production data collected from Japanese L2 learners in this study. This will be presented more in detail in section 2.1.2.b.

[27] This was suggested by Professor Murray Munro in a private conversation on May 12th 2017 and at the workshop on L2 pronunciation organized by the International Christian University Institute for Educational Research and Service that took place at International Christian University on May 15th and 16th 2017.

1.2.1. Sentence reading task

The second reading task is constituted of 10 sentences that participants were asked to read (see numbered examples (17) to (26) below). In contrast with the proficiency test, this task uses words that might be not familiar for learners. Indeed, the goal of this task is to present stimuli containing the target segments in a controlled environment to the participants and therefore didn't leave the experimenter much choice in picking words. The target segments were inserted between two similar vowels as follows: VCV with a singleton consonant or VCCV with a geminate, in order to have a set of (near) minimal pairs including each vowel and consonant type. The words chosen for this task were obtained using a systematic dictionary search based on the following principles:

First, while all five Japanese vowels were considered when making this task, only voiceless consonant were used, as only voiceless consonants can be geminated in native Japanese phonotactics[28]. More generally, due to the phonotactic restrictions specific to Japanese, some combinations didn't match any word (or were words with a low frequency in the Japanese lexicon and/or words that were judged too difficult for learners) and were excluded. This is the case of sequences with /p/ for example: To the exception of the loanword stratum, /p/ mainly appears in Japanese as the result of a phonological process, resulting in rare occurrences of singleton /p/ in the native vocabulary. When a singleton-geminate pair for a specific VCV combination couldn't be formed because no relevant matching word could be found, the VCV combination itself was excluded.

For nasal geminates, only /n/ was considered for two main reasons: First, it seemed better to use a subset of Japanese nasal consonants in order to keep the data manageable and to prevent the experiment from being too long and tiring for the participants. Secondly, the

[28] Voiced geminates are not uncommon in Japanese but appear exclusively in the loanwords stratum. Moreover, these are usually subject to devoicing (e.g. *baggu* "bag" → *bakku*) and therefore emerge as voiceless geminates in the surface form. (Kawahara 2015)

use of other geminated nasal consonants introduces a new level of difficulty as they occur as a consequence of nasal assimilation (e.g. underlying /n/ surfaces as geminated [m] as in *san* 'acid' + *mi* 'taste' → sammi 'acidity'), which requires as a prerequisite that learners have successfully acquired this property in Japanese. Lastly, pitch accent information was not taken into account when making the pairs and the sentences. As a result, the segments considered for the CVC combinations in the word search were: /a/, /i/, /u/, /e/, /o/, /k/, /t/, /p/, /s/, /n/.

What follows in numbered examples (17) to (26) presents the ten sentences comprised in the second reading task with a Romanization and an English translation. Target words are indicated in bold (singletons) or underlined (geminates) in the sentences.

(17) **娘**は**また 遅い**時間にこっそり 帰って来て、がっかりしました。
*M**usu**me wa m**ata oso**i jikan ni kossori kaettekite gakkari shimashita.*
I was disapointed by my daugther coming back home late at night on the sly again.

(18) この六つの**音**から、一致していないものを探しましょう。
*Kono muttsu no **oto** kara itchi shiteinai mono o sagashimashō.*
Let's looks for the sound that doesn't match among those six sounds.

(19) 千年前から**バナナ**の葉っぱで石鹸を作っている工場についてのエッセイを必死に書いています。
*Sennen mae kara b**ana**na no happa de sekken o tsukutteiru kōjō ni tsuite no essei o hisshi ni kaiteimasu.*
I'm desperately writting an essay about a factory that has been making soap with banana leaves for a thousand years.

(20) 夫は毎日**朝**から**筋肉**のトレーニングをしてから、日記を書いている。
*Otto ha mainichi **asa** kara kinniku no torēningu o shite kara, nikki o kaiteiru.*
My husband writes in his diary every morning after doing some exercise.

(21) 卒業**式**の**レセプション**に**むけて**、**服**と**靴**を決めましょう。
*Sotsugyōsh**iki** no r**ese**pushon ni muk**ete** **fuku** to k**utsu** o kimemashō.*
Let's choose clothes and shoes for the reception after the graduation ceremony.

(22) このテーブルに**赤い石**が六個もあった。
*Kono tēburu ni **aka**i **ishi** ga rokko mo atta.*
There are as much as six red stones on this table.

(23) 観光案内窓口の女性は**ミニ**スカートをはいている。
*Kankō annai madoguchi no josei wa **mini** sukāto o haiteiru.*
The girl at the tourism information desk is wearing a miniskirt.

(24) 日本で**一**番好きな**所**には、山には雪がいつもうっすらと積もっている。
*Nihon de **ichi**ban suki na t**oko**ro ni wa yama ni wa yuki ga itsumo ussura to tsumotteiru.*
In my favorite place in Japan, there is always a bit of snow.

(25) ブックカバーをあっさり捨てた。
Bukku kabā o assari suteta.
I threw away the book cover coolly.

(26) **パパ**とは**世間**話しかしない。
Papa to wa s**eke**nbanashi shika shinai.
I only make small talks with my dad.

Table 5 presents a summary of the words chosen for each CVC combination and inserted in the sentences for this task ordered by vowel and consonant types. The target is indicated in bold for each word. Some VCV combinations (high vowels with voiceless obstruents) inherently trigger devoicing in Japanese. As such, for the sequences resulting from the combination of /i, u/ and /k, t/, devoicing was expected on the first vowel. It was in fact inconsistently devoiced by Japanese native speakers[29] but voiced for most of the learners. In the results presented in Chapter 6 of this dissertation, tokens where the first vowel was

[29] A possible explanation for the inconsistence of devoicing where it was expected in Japanese native speakers' production is the context of the experiment: the reading task might trigger hypercorrectness/careful speech.

devoiced were excluded as it was not possible to measure accurately the preceding vowel duration.

Table 5. CVC combinations in the reading task

	k	t	P	s	n
a	***akai*** 'red' *g**akka**ri* 'deception'	*m**ata*** 'again' ***atta*** 'there was'	*p**apa*** 'dad' *h**appa*** 'leaf'	***asa*** 'morning' **assa**ri 'coolly'	***bana**na* 'banana' ***anna**i madoguchi* 'information desk'
i	*sh**iki*** 'ceremony' *n**ikki*** 'diary'	***ichi*** 'one' ***itchi*** 'maching'		***ishi*** 'stone' *h**isshi*** 'desperately'	*m**ini**sukāto* 'miniskirt' *k**inni**ku* 'muscle'
u	***fuku*** 'clothes' *b**ukku*** 'book'	*k**utsu*** 'shoe' *m**uttsu*** 'six'		*m**usu**me* 'daugther' ***ussu**ra* 'a little'	
e	*s**eke**nbanasi* *'small talk'* *s**ekke**n* 'soap'	*muk**ete*** *'in preparation'* *ka**ette*** 'go back'		*r**ese**pushon* 'reception' ***esse**i* 'essay'	
o	***toko**ro* 'place' ***rokko*** 'six objects'	***oto*** 'sound' ***otto*** 'husband		***oso**i* 'late' *k**osso**ri* 'on the sly'	

1.3 Questionnaires and consent forms

Information concerning the participants was collected using two different types of questionnaires that can be found in the appendix. The first type of questionnaire, in Japanese, was used for Japanese native speakers. The questions allowed to collect the basic demographic data and information about eventual long term stays abroad that might influence their native pronunciation. The second type of questionnaire was used for L2 learners and was available in English and French. More than just collecting basic demographic information, it asked specific information to the participants concerning their proficiency level and Japanese education history, the amount of Japanese they use in their daily life and the media they use the most. Learners were also asked to rate their own Japanese proficiency in terms of writing, reading, listening, speaking and pronunciation in a five-points scale from 'poor' to 'very good'. Results from their ratings can be found in

section 2.1.2.a. Lastly, learners were asked to rate several items concerning their feelings towards Japanese such as: whether they are used to speak in Japanese in front of other people, whether they have trouble to understand or to be understood by Japanese native speakers, or whether they think they have a foreign accent when speaking in Japanese.

The three last questions of the questionnaire asked participants to report whether they had access to Japanese native speakers when younger and especially before age 5, and whether they had ever take a pronunciation class.

Consent forms were also presented to participants in Japanese, French and English versions, and can be found in the appendix. All experiment materials were submitted to ICU's research ethics committee in August 2017 and approved in September 2017.

2. Experiment description

2.1. Participants

2.1.1. Demographics

Participants were recruited according to two main criteria: their L1 and their Japanese proficiency level. First, only learners whose L1 is one of the target languages: Italian, French and English were recruited as participants for the experiment. The selection was made carefully in order to record speakers with a sufficient L2 proficiency so that the interference of the participant's reading skills on their pronunciation would be minimal (with regard to reading mistakes and speech rate). The level condition for participants' selection was to have at least one year of Japanese education, which was judged a sufficient period of education allowing one to perform the reading tasks of the experiment. This was controlled with the recording of an English native speaker with only two months of Japanese education in the Japanese Language Program course at International Christian University (speaker EN1M). It turned out that his language ability was not enough for him to perform the oral proficiency

test. This speakers' productions were included in the native judgement test and rated the lowest with a score close to 0, the speaker was therefore excluded of the speech data analysis although his data is included in the demographic data that follows.

The participants (Japanese and foreign) were recruited among International Christian University students who were taking part in the Japanese Language Program offered by the University, and using groups on social networks such as Facebook for communication between foreigners in Japan.

Three groups of speakers (N=25) were created such as, 8 native speakers of English (4 female, 4 male, mean age = 20.7), 10 native speakers of French (7 female, 3 male, mean age = 27.2) and 7 native speakers of Italian (3 female, 4 male, mean age = 28.8). 8 native speakers of Japanese (5 female, 2 male, mean age= 22.5 years), were also recruited as a control group.

Learners of Japanese as a second language reported a period of Japanese education going from 2 months to 10 years and had all been living in Japan for at least 4 months at the time of the experiment. In addition to the requirement of at least 1 year of Japanese education prior to the experiment, their proficiency level was determined using the information from the demographic questionnaire described in the previous section and that they were asked to fill before the recording (Japanese Language Proficiency Test certificate and current or last level in a Japanese language class). In addition, a rating of their oral proficiency was made by native speakers in terms of comprehensibility and naturalness using the oral proficiency test made especially for this dissertation[30].

[30] See experiment procedures in 2.1.2.b

Among the 25 second language learners who were recorded, 17 were currently students in a university in Japan as a part of an exchange program and majoring in Japanese language at their home universities. The other 8 participants were working in Japanese companies and, to the exception of two of them, found a job in Japan after finishing an exchange program in a Japanese university. Participants reported various motivations for learning Japanese, such as: an interest for Japanese culture or language, for business, or family reasons. Two learners (speakers EN4F and EN6M) informed the experimenter that they had access to some Japanese native speakers when younger due to family/friend environment, but started learning Japanese as adults. Lastly, only one learner (FR1M) reported having benefited from a Japanese pronunciation class at university, which focus was on intonation. However, no significant difference was observed in their productions suggesting that their exposure was not long enough or not relevant. All participants reported no hearing impairment and participated as volunteer subjects as it was explicitly explained to them during the recruiting process and in the consent form. They were however thanked with small gifts at the end of the experiment.

2.1.2. Participants' proficiency level

Two different ways of measuring proficiency were used to describe the participants' level: their "global" proficiency and their "oral" proficiency. These terms will be used henceforth in this dissertation to designate the two types of proficiency, and this section will present in a first part the former, and the latter in the second part.

a. Global proficiency

The term global proficiency used for this dissertation refers to the proficiency level based on writing, reading and listening skills that is commonly used for Japanese language learners. In the present case, the participants were assigned global proficiency levels according to their answers concerning their history of Japanese education in the questionnaire described in 1.4. of this Chapter. Namely, they were asked to provide information about their level in the language class they were currently taking and/or their Japanese Language Proficiency Test level. For learners who were not currently attending a school and who did not have any proficiency certificate, the proficiency level was decided based on the level of the last class they attended.

Levels from 1 to 4 were defined as follows: Level 1 is the lowest and corresponds to "beginner". Only one learner was assigned Level 1 and his data was not used in the analysis because of his low proficiency level. Level 2 corresponds to "low intermediate" and includes learners whose level is equivalent to JLPT N4. Level 3, "high intermediate" gathers learners from JLPT levels N3 to N2 and level 4 is for "advanced" learners who have a level equivalent to JLPT N1. Table 6 below presents a summary of the number of participants by levels for each language.

Table 6: Participants' level by language group

	Italian	French	English	Total
1: beginner	0	0	1	1
2: low intermediate	3	3	3	9
3: high intermediate	1	3	0	4
4: advanced	3	4	4	12
Total	7	10	8	25

Participants were also asked to rate their own proficiency on a 5 points scale in terms of overall proficiency, reading, writing, listening, speaking and pronunciation. Speaking and pronunciation skills are presented in separate categories as the former refers to the learner's

perceived own fluency regardless the pronunciation. The mean results by level can be found in Table 7 below.

Table 7: Results of the learners' self-evaluation

	Writing	Reading	Listening	Speaking	Pronunciation	Overall	Mean
1: beginner (N=1)	1	1	1	1	2	1	1.16
2: low intermediate (N=9)	2.77	2.88	2.11	2	2.88	2.71	2.55
3: high intermediate (N=4)	2.8	3.6	3	3.4	3.6	3	3.23
4: advanced (N=12)	4	4.18	4.36	4.27	4.09	4.3	4.2
Mean score	3.2	3.48	3.24	3.2	3.52	3.4	3.34

The observation of the mean values for the learners' self-evaluation of their proficiency in Table 7 shows that learners were able to give quite objective ratings of their own proficiency level. Indeed, mean scores are increasing consistently with the learners' levels so that beginner level scores were the lowest and advanced level scores the highest. Concerning pronunciation, learners from levels 1 to 3 tend to give themselves better rating for pronunciation than for other categories, while for the advanced learners their evaluation of pronunciation is lower than other categories. The fact that the advanced learners tend to give a good rating to their pronunciation but still lower than other categories might suggest that at the advanced level they have acquired a higher awareness of their pronunciation, while for lower levels pronunciation might be an aspect of language learning they don't really feel concerned about when compared to lexical items (i.e. vocabulary, grammar).

b. Oral proficiency

The expression "oral proficiency" used in this dissertation refers to the learners' pronunciation level, that is, the oral proficiency score that was measured based on the oral

proficiency test created specifically for this dissertation which was presented earlier in this Chapter (see 1.1.1).

In order to examine participants' pronunciation level, a subset of the task composed of three representative sentences was selected for each learner for native speaker judgement. The three sentences presented in (15) in the beginning of the chapter are reproduced in (31) below.

(31) a. 来週は 夫と 娘と 三人で 金沢を 旅行する 予定です。
Raishū wa otto to musume to kanazawa o ryokō suru yotei desu.
'Next week I'm planning to travel to Kanazawa with my husband and daughter.'

b. その後は、美容院に予約を取りに行ったら、ずっと会えていなかった友達に偶然会いました。
Sono ato wa biyōin ni yoyaku o tori ni ittara, zutto aeteinakatta tomodachi ni gūzen aimashita.
'After that, I went to the hairdressers' to take an appointment and met by coincidence with a friend that I had not seen in years.'

c. 昔二人で中国へ旅行したことは、一生の思い出です。
Mukashi futari de chūgoku e ryūgaku shita koto wa isshō no omoide desu.
'I will never forget our going together to a school exchange in China a long time ago.'

Three trained Japanese native speakers were asked to judge learners' productions according to two criteria: (i) what is the degree of foreign accentedness? and (ii) how easy to understand is this sentence? These native speakers were linguists, had a sufficient background of knowledge on second language acquisition and were familiar with the concepts of comprehensibility and naturalness.

Using a Praat (Boersma and Weenink 1992-2018) MFC experiment, native speakers were asked to rate the sentences they heard in terms of comprehensibility in the first part of the experiment, and foreign accentedness in a second part. The listening experiment was

conducted in a quiet room using a computer and headphones. The Praat MFC experiment script used for this task can be found in the appendix and is a version of the 1024-points quasi-continuous scale script kindly provided by Professor Murray Munro[31] adapted to the needs of the present task. The quasi-continuous scale presents the advantage of requiring an intuitive judgement to listeners as no numbers are provided on the rating bar. Figure 3 below is the screen of the experiment using Praat, where the red line in the middle of the screen is the 1024-points scale ranging from 'very difficult to understand' to 'very easy to understand' on the right.

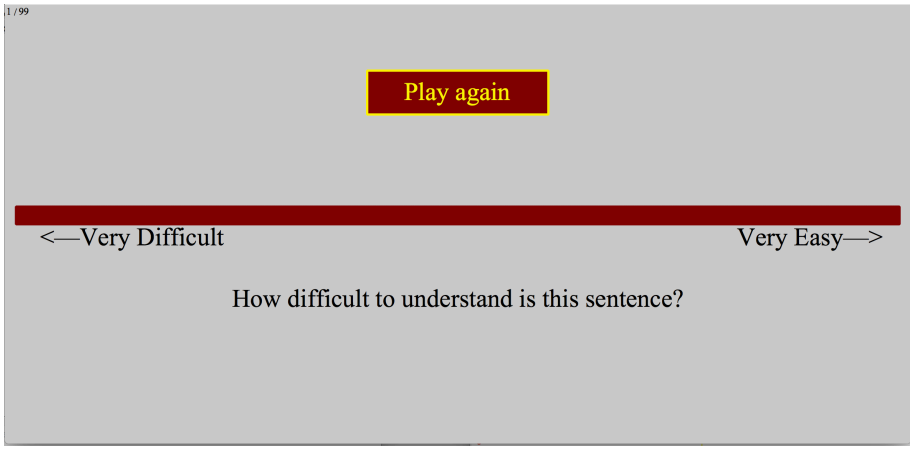


Figure 1: Praat native judgement MFC experiment

Stimuli were created using the sound files recorded from the learners in the proficiency test, by isolating only the three selected sentences and creating a separate file for each.

In addition to the three sentences for each L2 learner, three sentences for each Japanese native speaker recorded were included in the perception test to control its validity, for a total of 99 sentences (33 speakers x 3 sentences) for each of the two rating tasks (i.e.

[31] Thanks to Professor Murray Munro for providing us with the Praat script for the 1024 points scale during the L2 acquisition workshop that took place in ICU in May 2017.

naturalness and comprehensibility). All sentences were presented to participants in a randomly shuffled order and they were able to listen to the sentence again once using the button 'play again' on the screen. Participants were also able to have a break every 25 sentences.

The naturalness (on 1024 points) and comprehensibility (on 1024 points) scores assigned to each sentence by native speakers were gathered in an excel file in order to calculate each learners' level. The final level is based on the sum of the comprehensibility and naturalness mean scores (for the three sentences). Four levels were defined such as low (from 0 to 500 points), low intermediate (from 501 to 1000), high intermediate (from 1000 to 1500 points), and high or near native (1500 to 2048). The results of the proficiency test can be found in the Tables 8 to 11 below, compared with the participants' global proficiency level.

Table 8: Results of the Oral proficiency task rating by native speakers: individual results for Japanese native speakers

ID	Comprehensibility	Naturalness	Oral Proficiency	Oral Level	Global Proficiency
JP1F	1010	1014	2024	4	NA
JP2F	995	1016.8	2011.8	4	NA
JP3F	1012.1	1012.1	2024.3	4	NA
JP4F	1010	1017	2027	4	NA
JP5F	1008.8	1017	2025.8	4	NA
JP6M	839.5	752.1	1591.6	4	NA
JP7F	1008.6	1013.1	2021.8	4	NA
JP8M	1012.3	1014.6	2027	4	NA

Table 9: Results of the Oral proficiency task rating by native speakers: individual results for French learners

ID	Comprehensibility	Naturalness	Oral Proficiency	Oral Level	Global Proficiency
FR1M	428	485.5	913.5	2	3
FR2F	661.6	545.8	1207.5	3	3
FR3F	513.5	321.3	834.8	2	2
FR4F	552.8	594	1146.8	3	2
FR5M	519.8	486.3	1006.1	3	4
FR6F	819.1	721.6	1540.8	4	4
FR7M	756.3	713.1	1469.5	3	4
FR8F	480.6	472.1	952.8	2	3
FR9F	623.5	432	1055.5	3	4
FR10F	673.3	449	1122.3	3	2

Table 10: Results of the Oral proficiency task rating by native speakers: individual results for Italian learners

ID	Comprehensibility	Naturalness	Oral Proficiency	Oral Level	Global Proficiency
FR10F	673.3	449	1122.3	3	2
IT1F	349.8	129	478.8	1	2
IT2F	481.66	318.5	800.1	2	2
IT3M	468.83	389.3	858.1	2	2
IT4M	501.5	474.8	976.3	2	4
IT5F	558.1	225.8	784	2	3
IT6M	363.6	468.3	832	2	4
IT7M	551	360.5	911.5	2	4

Table 11: Results of the Oral proficiency task rating by native speakers: individual results for English learners

ID	Comprehensibility	Naturalness	Oral Proficiency	Oral Level	Global Proficiency
EN1M	31.8	71.5	103.3	1	1
EN2F	535.6	345	880.6	2	2
EN3M	205.3	296	501.3	2	2
EN4F	618.1	595.1	1213.3	3	4
EN5F	593.5	576.3	1237.5	3	4
EN6M	561.1	576.3	1137.5	3	4
EN7M	683.3	548.3	1231.6	3	2
EN8F	560.3	452.3	1012.6	3	4

The first observation that can be made from the results of the proficiency test in Table 8 is the high score for Japanese native speakers (ranging from 2011.83 to 2037.6 points) that

confirms the validity of the test. Indeed, to the exception of JP6M, all Japanese native speakers have a score close to the maximum possible, which indicates that they were judged by the Japanese listeners as having a native pronunciation with regard to naturalness and comprehensibility. Concerning JP6M, his data was excluded from the analysis as he reported several years spent abroad when younger and the results of native judgement on his pronunciation confirm that it is relevant to exclude him as his score (1591.6), although it places him in level 4 like other native speakers, is closer to those of L2 learners (highest = 1540.83) than those of Japanese native speakers. Results also show that the decision to exclude EN1M's recordings of the data analysis because of his low proficiency was also relevant, as native listeners give him the lowest score (103.33).

A second observation that can be made about the results, is that the Oral proficiency level appears to follow different patterns when compared to the Global proficiency level. Indeed, in Tables 8 to 11, the Global proficiency level is usually higher than the Oral Proficiency, indicating that a learner can have advanced skills in Japanese but an intermediate pronunciation level. However, those two different types of levels appear to be consistent as there is no contradiction in the level: no learner has beginner Japanese skills and an advanced pronunciation or advanced skills but a beginner pronunciation. Table 12 below shows in detail the relationship between scores, L1 and levels.

Table 12: Means of the Global and Oral proficiency scores by L1

	Comprehensibility	Naturalness	Score	Oral level	Global level
Italian	467.8	388	805.85	1.8	3
French	602.88	522.1	1124.98	2.2	3.1
English	473.66	416.91	890.5	1.75	2.87
Mean	514.78	425.68	940.44	1.91	2.99

First, the mean scores presented in Table 9 show that French L2 learners (M= 1124.98) were judged as having a better pronunciation than English learners (M=890.5), and than Italian learners (M=805.85), who had the lowest scores. Considering the difference in

Global proficiency level between English (M=2.87) and French learners (M=3.1) the lower score for English learners is not surprising. However, what is surprising is the low score for Italian learners, considering the fact that their Global proficiency level (M=3) was higher than those of English learners.

When comparing Italian and English learners' scores for Naturalness and Comprehensibility, we notice that although their Comprehensibility score are rather similar, the Naturalness score for Italian learners (M=388) is lower than for English learners (M=416). Because the present proficiency test does not include any space for Japanese native raters' comments on learners' pronunciation, we lack information on what influenced their judgement and what causes Italian native speakers' score to be lower. This should be included in further versions of this proficiency test. However, the experimenter postulates that a factor that might have influenced their rating of the Italian native speakers who took part in the experiment is their remarkable propensity to pronounce Japanese /u/ ([ɯ]) as Italian [u] and Japanese /r/ as Italian alveolar trill which might constitute a crucial cue for foreign accentedness rating.

The means presented in Table 12, confirm the difference in patterns between Oral proficiency and Global proficiency observed in Table 8 to 11: Regardless the L1, there is a difference of about 1 point between the Global proficiency and the Oral proficiency levels. The behavior of Naturalness and Comprehensibility scores is also of interest as we observe that for all three L1 groups the Naturalness score is lower than the one for Comprehensibility. This is consistent with the claim in Munro and Derwing (1995) that Naturalness and Comprehensibility are different entities as one can attain a high Comprehensibility even with a strong foreign accent.

A linear mixed effect analysis was performed on the results of the proficiency test using R (R core team 2017) and the lme4 package (Bates et al. 2015) in order to investigate the relationship between the participants' Oral Proficiency score and their Global proficiency level. The fixed effects entered in the model were Global proficiency level and L1 (without interaction term) and the random effects were intercepts for L2 learners and Japanese native speakers' raters as well as by-learner and by-rater random slopes for the effect of Global proficiency level. p-values were obtained by likelihood ratio tests of the full model with the effect in question against the model without the effect in question, and the model that fits better was chosen based on the AIC scores. The linear mixed effect model showed a significant effect of L1 ($\chi2(1)=7.52$, $p=0.006$) on Oral proficiency score, especially for Italian leaners whose score was lowered by 249 points ± 82 (standard errors). Global proficiency level also had a significant effect ($\chi2(1)=5.77$, $p=0.016$) on the learners' Oral proficiency score, which was higher by 138.6 points ± 46 (standard errors) for a higher level.

Inversely, the time spent in Japan ($\chi2(1)=4e-04$, $p=0.97$, *ns*.) and the length of their Japanese education background ($\chi2(1)=0.2$, $p=0.65$, *ns*.) did not have a significant effect on Oral proficiency and were excluded of the model. Similarly, the addition of the sentence as a random factor (the 3 different sentences for each speaker that can be found in (31a, b, c)) did not show any significant effect on the model ($\chi2(1)=0$, $p=1$, *ns*.) and was therefore not included.

What we learn from the linear mixed effect model analysis above, is that the Oral proficiency level was not affected by the time spent in Japan or the time spent learning Japanese, but only by the learners' L1 and their proficiency level. This suggest that the time spent in Japan and the time spent learning Japanese is independent of the proficiency level and the pronunciation of the learners, but that proficiency level is correlated with pronunciation. Lastly, the most important correlate for learner's Oral proficiency score was

the influence of their L1.

In conclusion, running the present Oral proficiency test allowed to determine two types of Japanese proficiency levels: Oral proficiency, which is based on Japanese native speakers' rating of learners' pronunciation, and Global proficiency which is based on the four skills. These two levels will be used in following sections for statistical analysis of the participants' pronunciation. Table 13 summarizes the number of learners for each Oral proficiency level by L1.

Table 13: Participants' Oral proficiency level by L1 group

	Italian	French	English	Total
1: beginner	1	0	1	2
2: low intermediate	6	3	2	11
3: high intermediate	0	6	5	11
4: advanced	0	1	0	1
Total	7	10	8	25

3. Experimental Procedures

3.1. Place

As the present study focuses on duration, the use of a sound proof room was not indispensable for the recording, and it was decided to conduct recordings in quiet indoor environment. The advantage was that, as all the participants in this study were volunteers and the experimenter went to various places around Tokyo at the participants' convenience, it was easier to have access to that kind of environment.

For International Christian University students, recordings were conducted in the group study rooms of the Othmer library which have the advantage of offering both a silent environment and an easy access for the participants, especially because most of them were

living on campus as the time of recording. For other participants, the experimenter used places such as participants' apartment or office, and karaoke rooms.

3.2. Recording Procedures

Recordings were conducted using a headworn microphone (Shure WH-30 Headworn XLR microphone) and a Linear PCM recorder (TASCAM DR-100MKIII) with a 44.1kHz sampling frequency and a 16bits quantization. Files were saved in several hard drives in waveform audio file format (.wav) for further analysis, and in order to facilitate analyses, a name was allocated to each file according to the speaker's information and the nature of the task as follows in (1), where "L1" corresponds to one of the target languages (Japanese=JP, English=EN, French=FR, Italian= IT), "speaker number" to the order of the recordings for each L1 group, and "sex" is either M or F. An abbreviation was allocated to each task and included in the file name such as: proficiency test "tx", grammar task "gr", sentence reading task "s".

(1) **File name:** (L1)(speaker number)(sex)-(contents of the task).wav
e.g: EN1M-s.wav, JP1F-tx.wav

For each participant, the experiment was conducted as follows: Recording might be a stressful experience for second language learners, some of who have little confidence in their Japanese skills, and this especially because for all of them it was the first time taking part in such an experiment. Accordingly, in order to reduce participants' stress, each session started with a quick casual talk about their life in Japan. They were asked to read the Consent form before receiving detailed explanations from the experimenter. Specifically, the experimenter focused the explanation on privacy, withdrawal, and risk and benefits of taking part in the experiment. They were also reminded that their participation to the experiment was volunteer.

Participants were provided with a Consent Form in Japanese, French or English according to their native language, or the language they felt the most comfortable with. Accordingly, the experimenter used the same language for communication during the experiment. Once the consent form signed, they were asked to fill in a quick questionnaire concerning their Japanese education background[32]. Depending on their L1, different questionnaires were given to the participants. Japanese native speakers were provided a questionnaire in Japanese (see appendix), while L2 learners were given the choice between a questionnaire in English or French (see appendix).

In the next part of the session, the contents and the order of the tasks for the recording were explained in detail to the participants. All of them were told that they can have a break and stop the recording whenever they feel like. It was also explained that the goal of the experiment was not to judge the accuracy of their performance in terms of grammar, so that they should not be worried about making mistakes.

The three tasks of the production experiment were performed in the following order: First the proficiency test, then the grammar task and lastly the sentence reading task. The grammar task was inserted between the two reading tasks for two primary reasons. First, the different nature of the task was expected to act as a distractor from the reading for participants. Secondly, this was also set up in order to allow the participants some rest. Some time was provided before each task for participants to read through the task and understand fully what they were asked to do. They were also encouraged to write on the printed version of the task that was given to them, or to ask any information they needed, including word meanings, to the experimenter.

[32] See section 1.3 of this chapter for a description of the questionnaire.

3.3. Measurements

Segment duration measurements were made using the speech analysis software Praat (Boersma and Weenink 1992-2018) as follows: For each segment, an interval on a text grid was created and labelled manually. Duration measurements were automatized using a Praat script (Liennes 2002) that calculates the duration of each labelled interval on a text grid. The source code of the script used for duration measurements can be found in the appendix.

The following methodology was used for conducting acoustic measurements on recorded files. For singleton and geminate stops the closure duration was measured from the onset of the consonant closure (or the offset of the voicing of the preceding vowel) to the beginning of the burst. The burst itself was not included in consonant duration, and VOT in general was not included in the measurements as previous studies (Homma 1981 *interalia.*) demonstrate that it is not a cue for Japanese native speakers in terms of phonetic implementation of the consonantal length contrast. Figure 1 below presents the annotation procedures for a geminated voiceless stop /t/ by a Japanese native speaker. In Figure 1, the top part presents the waveform of the recorded sound (sound pressure, amplitude), and in the middle the spectrogram of the recorded sound (Frequency in Hz), the x-axis corresponds to the time in seconds. The boxes in the bottom are the text grid added manually for annotations.

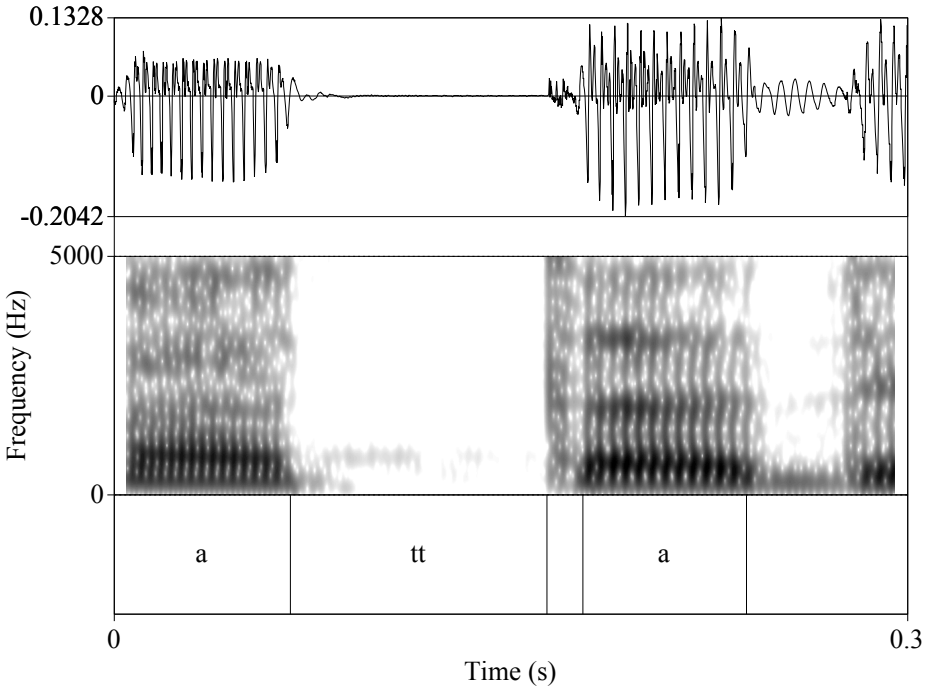


Figure 2: Closure of a geminated /t/ by a Japanese native speaker

In the case of fricatives, the frication period, which can be identified by a characteristic high-frequency frication noise on the spectrogram, and for sonorants, the constriction duration was identified by the nasal pole on the spectrogram. Similarly to stops, measurements for fricatives and nasals were also made from the offset of the voicing of preceding vowel to the onset of voicing of the following vowel. Some glottal stops were observed for some vowels in pre- and post-vocalic position but were not taken into account in the duration measurements. Disfluent tokens were also excluded from the data. Figure 3 below presents an example of the annotation for fricatives.

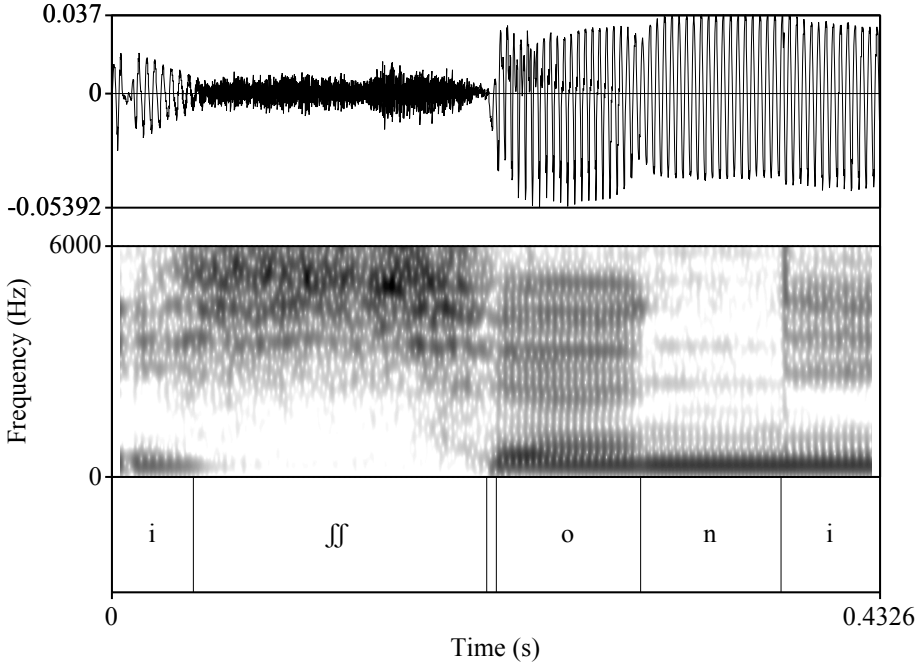


Figure 3: Example of fricative, nasal and vowel segmentation in the production of isshoni 'together' by a Japanese native speaker

In order avoid the influence of speech rate on segment durations in the analysis, values were normalized using ratios. As such, the preceding and following vowels' durations are expressed in terms of ratio to the consonant. The relation between the singleton and geminate consonants is also expressed by their ratio. The duration data obtained was coded in an excel file and saved as a comma-separated file in order to conduct data analysis and test of the statistical skews using the software R (R core team 2017).

CHAPTER 5: RESULTS ON ACCURACY

The first and second hypotheses of this dissertation, reproduced below in (1) and (2), deal with the question of accuracy of learners' production of the consonantal length contrast.

(1) **Hypothesis 1:** There is no difference in terms of accuracy between all three groups of learners in their pronunciation of L2 Japanese geminates.
(2) **Hypothesis 2:** There is no difference in terms of accuracy between manners of articulation in all three learner groups' pronunciation of L2 Japanese geminates.

This chapter presents the results concerning L2 learners' accuracy. Specifically, in order to provide an answer to the two hypotheses stated above, the analysis will look in detail at L2 learners' accuracy with regard to their L1, and the manner of articulation of the consonant. In Chapter 3, building upon the phonological properties of the learners' L1s, we made the following predictions concerning their accuracy:

First, considering the important influence of L1 phonology on the acquisition of L2 phonology, the presence or absence of a consonantal length contrast in the learners' L1 was used as a predictor of their accuracy for the pronunciation of the same contrast in their target language: Japanese. We postulate that Italian learners will have a higher accuracy than learners who don't have a lexical consonant length contrast in their L1: French and English native speakers.

Moreover, French learners should be more successful than English-speaking learners in their pronunciation of geminates, as this contrast is potentially available in French too, although it is not semantically contrastive. The ranking in terms of accuracy should therefore be: Italian > French > English.

The second prediction, based on the frequency of each geminated segment in the learners' source language (when they have one), accounts for differences in accuracy related to manners of articulation. This assumption presupposes that learners in their L2, would be more comfortable with pronouncing geminate consonants with a higher frequency in their L1s, rather than those that are rare, and that therefore the former would be more accurate. Because all consonants that can be geminated in Japanese (i.e. stops, fricatives, affricates and nasals) can also be geminated in Italian, the expectation concerning Italian L2 learners is that they would perform equally good in terms of accuracy for all manners of articulation, with a slight preference for stops, due to the high frequency of geminated stops, especially /t/ in Italian (Bortolini and Zamponi 1979). In the case of French, the frequencies and natures of geminates consonants (e.g. stylistic gemination, gemination induced by a sequence of identical consonants) allow to assume the following ranking for consonant manners in terms of accuracy for French L2 learners: nasals > stops > affricates > fricatives. Lastly, the absence of gemination in English, except for "fake geminates" (Spencer 1996), leads to the assumption that they would either (i) perform equally for all manners, or (ii) exhibit differences between manners that correspond to consonants' universal phonetic properties.

1. METHODOLOGY FOR ACCURACY EVALUATION

There are several ways of evaluating accuracy. The first is to rely on native speakers' judgement based on perceptual information to decide whether the pronunciation of each item is accurate or not. In the present case, the size of the data collected would make it difficult to manage a measurement of accuracy based on native speakers' judgment for each token. Thus, the choice was made to use a different method relying on objective measurements of durational accuracy based on the durational values of native speakers' productions. A similar use of durational accuracy for geminate consonants has also been made in previous studies on L2 pronunciation, for example in Hirata and Takiguchi (2015).

Because raw durational data depends too much on interspeaker speech rate variations, accuracy measurements were based on normalized values: that is durational ratios. The data used to measure learners' accuracy is the set of singleton-geminate (near) minimal pairs from the sentence reading task, that provide each consonant type in similar phonological environments: VCV or VCCV, and where both preceding and following vowels are identical.

Durational accuracy measurements made for this dissertation were based on the productions recorded from Japanese native speakers. Namely, the range of values for singleton to geminate ratio in native speakers' production was considered as the acceptable range for an accurate singleton-geminate ratio. The range of values for the ratios was calculated from native speakers' data after removing outliers from the data set using the outlier package of R (R core team 2017). Indeed, these are abnormal values for Japanese native speakers, and therefore including them in the data would lead to substantial variations in terms of accuracy when comparing it to learners' productions.

The three following scales were considered to calculate accuracy range:

(i) **The item level:** The range of SG ratio values in Japanese native pronunciation for each pair is compared to the exact same pair by L2 learners.

e.g. the range of SG ratio values for token *mata* vs. *atta* in native pronunciation compared to the same exact pair for L2 learners.

(ii) **The manner level:** The range of SG ratio values in Japanese native pronunciation for each manner of articulation is compared to the items with the same manner of articulation in L2 learners' data.

e.g. the range of SG ratio values for all pairs including stops in Japanese native pronunciation compared to each pair containing a stop in L2 pronunciation.

(iii) **The global level:** The range of values for SG ratio is calculated based on all items in native speakers' productions, and the range is applied on all items in L2 learners' data.

e.g. the range of SG ratio values for all tokens in Japanese native pronunciation compared to each pair containing in L2 pronunciation.

The level that was finally selected for accuracy measurement is the manner level. Indeed, at the item level, ratio value ranges would be too dependent on individual (interspeaker) variations, because the limited number of Japanese native speakers recorded implies a limited number of data points for each item.

Moreover, the literature on geminate consonants points out different durational properties depending on the consonant manner (Beckman 1982, Campbell 1999, Port et al. 1987, Sagisaka and Tohkura 1984, Giovanardi and Di Benedetto 1998, Kawahara 2015), which is also observed in the detailed analysis of each consonant manner presented in

Chapter 6. As a consequence, the manner level was preferred to the global level: The latter does not take into account the variations in the expected ratio values for each manner of articulation due to their different phonetic properties (e.g. lower ratio for fricatives in general).

Accuracy was calculated using the measurements on the production data recorded from L2 learners with conditional and logical functions using excel so that the cell shows the value "TRUE" when the conditions, that is the accurate range of ratio values, are met; and "FALSE" when they are not. The percentage of accurate values (i.e. TRUE) and inaccurate values (i.e. FALSE) were calculated and used for accuracy analysis, which results are presented in the following sub-section.

2. RESULTS

2.1. By L1

Table 1 and its graphic representation in Figure 1 below present the results for accuracy in percentage of accurate/inaccurate production for each L1 group.

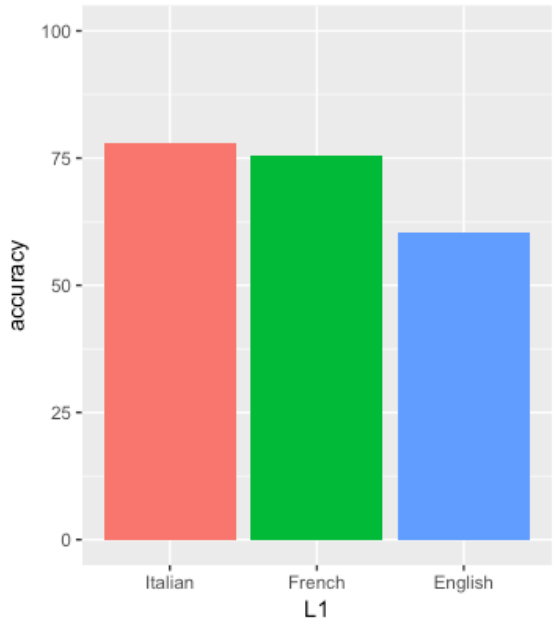


Figure 1: Accuracy by L1

Table 1: Accuracy percentage by L1

	Accurate	Inaccurate
Italian	77.8%	22.2%
French	75.6%	24.4%
English	60.3%	39.7%

The measurements of accuracy on L2 learners' productions by L1 shows the following results: All three learner groups have a high accuracy with more than 50% of accurate productions. Specifically, Italian L2 learners have the highest accuracy with 77.8% of accurate productions, followed by French L2 learners, whose accuracy is of 75.6%. English learners' productions were less accurate with only 60.8% of accurate productions. The results in Table 1 and Figure 1 show the following ranking in % accuracy: Italian > French > English, which is consistent with the prediction made above in section 1. This will be discussed further below (section 3), together with the statistical analyses of the results.

2.2. By manner of articulation

Table 2 and Figure 2 below present the same accuracy data in detail with regard to the manner of articulation of the consonant. In the bar plot in Figure 2, the data is divided between the four manners of articulation: stop, affricate, fricative and nasals, and the three bars represent learner accuracy by L1. In Figure 2, the results for Italian learners are illustrated in red, for French learners in blue and English learners in orange.

Table 2: Accuracy % by manner of articulation for each learner group

	Stops	Affricates	Fricatives	Nasals
Italian	80.9%	64.3%	80%	71.4%
French	72.2%	60%	84%	85%
English	58.7%	42.8%	65.7%	71.4%
Mean	70.6%	55.7%	76.5%	75.9%

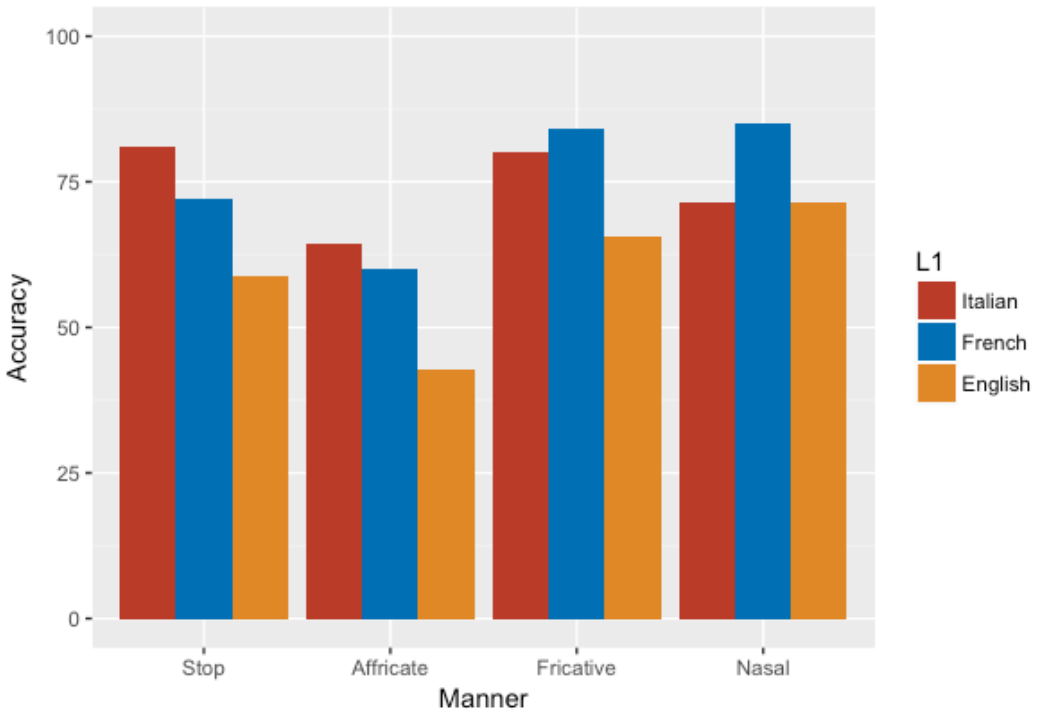


Figure 2: Accuracy by manner of articulation for each learner group

The first observation that can be made from Figure 2 and Table 2 above is that stops and affricates seem to follow different patterns when compared to fricatives and nasals. For stops and affricates, the accuracy by L1 follows the same order as observed in Table 1 and Figure 1, that is, Italian learners have the highest, followed by French learners, and English-speaking learners have the lowest accuracy. For fricatives and nasals, however, the observed pattern is different: French learners have the best accuracy scores, and Italian learners show a lower accuracy. English native speakers still have the lowest accuracy scores. However, among their productions fricatives and nasals are the most accurate. In summary, the following order (3) is observed for accuracy by manner of articulation:

(3) - **Global:** Fricative ≥ Nasal > Stop > Affricate
- **Italian:** Stop ≥ Fricative > Nasal > Affricate
- **French:** Nasal ≥ Fricative > Stop > Affricate
- **English:** Nasal > Fricative > Stop > Affricate

What we notice is the low accuracy values for affricates regardless the learners' L1: for all learner groups, among all manners, affricates have the lowest accuracy. This is true for both the mean value for all learners (m= 55.7%), and for each learner group separately, as the accuracy is of only 64.3% for Italian learners, 60% for French learners and 42.8% for English native speakers.

According to the prediction made above concerning the second hypothesis, Italian learners should perform equally good for any of the four manners of articulation because all of them can be geminated in both Japanese and Italian. Furthermore, the high frequency of geminated stops in Italian suggested that stops might be the most accurate, and in the present results, stops have indeed the highest accuracy. However, there is only little difference when compared with the accuracy of fricatives, and values for other manners show differences from the prediction that is therefore not supported by the results.

In the case of French L2 learners, the prediction was that nasal consonants would be the most accurate owing to their abundance in French (although not semantically distinctive), and that fricatives would be the least accurate as geminate fricatives do not occur in French. However, the pattern observed here, although nasals are the most accurate, does not support this prediction. In addition, although English does not have geminate consonants, the pattern observed for English native speakers is similar to French native speakers' (although English learners have a lower accuracy in general). Generally, the patterns observed in manner ranking suggest that learners can be divided in two groups: Italian learners (presence of lexical consonantal length contrast), and English and French learners (absence of lexical consonantal length contrast).

3. ANALYSIS

Because of the binary nature of the accuracy data (i.e. TRUE/FALSE), the relationship between accuracy and the learners' L1 was tested using a mixed effects logistic regression with the glmer function of the lme4 package (Bates et al. 2015) on R (R Core Team 2017). The fixed effects entered in the model were the L1 of the learner, the oral proficiency score, the time spent studying Japanese, and the intercepts for items were added as random effects. The model that fits best was chosen by comparison of AIC scores for the various models tested. *p*-values were obtained by likelihood ratio tests of the full model with the effect in question against the model without the effect in question.

The mixed effect logistic regression model showed a significant effect of L1 ($\chi2(2)=14.82$, $p<0.001$) on accuracy. Specifically, the model confirms the significance of the higher accuracy values for Italian and French learners with significant differences between English and Italian ($z=-3.45$, $p<0.001$) and English and French ($z=-2.63$, $p=0.008$). However, no significant difference could be observed between the accuracy of Italian and French learners ($z=1.08$, $p=0.27$).

Oral proficiency score also had a significant effect ($\chi2(1)=6.96$, $p=0.008$) on learners' accuracy as well as, to a lesser extent, the time spent studying Japanese ($\chi2(1)=4.22$, $p=0.039$). On the other hand, other factors like the time spent in Japan ($\chi2(1)=3.06$, $p=0.08$, *ns*.), the global proficiency level ($\chi2(2)=2.23$, $p=0.32$, *ns*.) or the manner of articulation ($\chi2(3)=2.38$, $p=0.49$, *ns*.) did not have a significant effect on accuracy and therefore were excluded of the model as they did not contribute to improve its fit. Similarly, the addition of the speaker variation as a random factor did not show any significant effect on the model ($\chi2(1)=0$, $p=1$, *ns*.) and was therefore not included, the item factor being the only random factor considered here.

4. Discussion

4.1. Hypothesis 1

Statistical testing allows to confirm that the L1 of the learners is strongly correlated with their accuracy. In Figure 1 of this chapter, the percentage of accurate productions had the following order: Italian (77.8%) > French (75.6%) > English (60.3%). The mixed effect logistic regression model shows that there is a significant difference between the accuracy of English-speaking learners; and French and Italian learners. However, no significant difference could be observed between Italian and French learner populations.

This result allows to refute the first null hypothesis stating that there would be no difference in accuracy between all three learner groups: the present results show a significant difference in terms of durational accuracy between learners whose L1 is English and the other learners. Furthermore, Italian learners have the highest accuracy in accordance with the prediction. What doesn't match the prediction made regarding accuracy is French L2 learners' score. Although the observed accuracy was slightly lower for French learners than Italian learners, the difference was not significant, indicating that their accuracy is similar and that the observed score is no more than a tendency.

I postulate two possible explanations for this result concerning the similarity between French and Italian learners:

First, the difference in terms of oral proficiency level can be a plausible explanation. Indeed, although statistical testing showed no correlation between accuracy and global proficiency level, a correlation between oral proficiency and accuracy was observed. In Chapter 4 section 2.1.2.b, the results of the oral proficiency test show that although the mean global proficiency level for Italian learners (m=3) and French learners (m=3.1) was similar,

there was a substantial difference in their mean Oral proficiency scores (m=805.85 for Italian learners and m=1124.98 for French learners).[33] I suggest that this difference in Oral proficiency scores causes French and Italian learners to have equal accuracy and that, in a case where their Oral proficiencies would be equivalent, French learners would exhibit a different behavior with a lower accuracy. This shall be accounted to in further studies with more control on participant's Oral proficiency level.

A second explanation would be that the difference between the semantically distinctive consonantal length contrast in Italian phonological system and the (mostly) non-distinctive consonantal length contrast in French phonological system is not reflected in the learners' production. That is, the presence of a contrast, whether it is semantically distinctive or not, would be enough to give an advantage to L2 learners when acquiring a L2 consonantal length contrast. However, the first explanation sounds more plausible as previous research has shown for both English and French native speakers, that in their L1 even if they are able to detect duration differences between a long and a short segment[34], this is not linked to a phonemic distinction (Pickett and Dicker 1960, Hayes 2002, Porretta and Tucker 2015, Meisenburg 2006, Guillemot 2018b). These results indicate that the consonantal length is not perceived as phonemic by French native speakers, similarly to English native speakers, and suggest that the two L1s native speakers might have the same behavior in their production of L2 Japanese. Furthermore, observations on accuracy by manner for each L1 (as presented in the results above) seem to indicate a similar pattern for English and French L2 learners, which is different from Italian L2 learners'.

[33] The Oral proficiency score for English learners (M= 890.5) was rather similar to those of Italian learners (M=805.85), which also supports this postulate.
[34] Most tests were performed on identical sequences at morpheme or word boundary.
e.g. English: *cat tail*, *unknown ;* French: *coupe pas, illégal*

4.2. Hypothesis 2

Although some differences in terms of accuracy between manners of articulation were observed in the data presented in Figure 2, its testing by mixed effect logistic regression indicated that there is no significant correlation between manner of articulation and accuracy. The null hypothesis formulated for Hypothesis 2 can therefore be validated: there is no difference in terms of accuracy between manners of articulation in all three learner groups' pronunciation of L2 Japanese geminates.

Statistical testing indicates that the manner of articulation is not a factor significantly correlated with accuracy[35]. However, the patterns observed in the data are of interest even if these are no more than tendencies. In (3) reproduced in (4) below, we can see that the accuracy scores ranking for Italian learners who have lexical geminates in their native phonology is different from the ranking in English and French learners who don't have such a contrast.

(4)	**Italian:**	Stop	≥	Fricative >	Nasal	> Affricate
	French:	Nasal	≥	Fricative >	Stop	> Affricate
	English:	Nasal	>	Fricative >	Stop	> Affricate

These patterns suggest some influence of the learners' L1 phonology on the accuracy manner ranking. First, while stops are the most accurate for Italian learners, this is not the case for other learners. I postulate that because the primary acoustic correlate is closure duration for stops for both Italian and Japanese, it gives an advantage to Italian learners in the pronunciation of these consonants when compared to French and English learners. On the other hand, in the case of affricates, while the primary acoustic correlate in Japanese is

[35] As the patterns observed in Figure 2 of this chapter suggested the existence of two distinct patters: one for stops and affricates, and another for fricatives and nasals, the statistical testing was made once again using natural classes instead of manner. Stops and affricates were coded as [-continuant] and fricatives and nasals as [+continuant]. However, here again no significant effect was observed.

similar to stops, it is not the case in Italian where both closure and frication are lengthened (Faluschi and Di Benedetto 2001). This might be an explanation for the low accuracy of affricates for Italian learners. For English and French learner groups, the higher scores for nasal and fricatives may be related to their continuancy when compared to stops, which causes a [+continuant] singleton to be longer than singleton stops in general (Beckman 1982, Campbell 1999, Port et al. 1987, Sagisaka and Tohkura 1984, Giovanardi and Di Benedetto 1998, Kawahara 2015). Namely, less contrast is required between singleton and geminate consonant for these manners, which may make it easier for learners. Inversely, the [-continuant] nature of stops causes them to be shorter, and a greater contrast in closure duration is therefore required between a singleton and a geminate stop, which may make it arduous for learners who don't have such a contrast in their L1. Lastly, the low accuracy of affricates might be attributed to the same process, as affricates share with stops the [-continuant] feature for their stop part. Furthermore, the marked nature of affricates (i.e. a sequence of two consonants) when compared to other manners, might constitute another explanation for their low accuracy in general.

What the observed patterns for Italian learners on the one hand and French and English-speaking learners on the other hand suggest, is that L2 learners who have a consonantal length contrast in their L1 are subject to some extent to the influence of their L1 lexical patterns: namely linguistic conditioning. On the other hand, in the case of L2 learners whose L1 doesn't have such a contrast, their pronunciation is affected by universal acoustic properties of the consonants.

5. CONCLUSION

The present chapter focused on learners' production accuracy. In order to account for the two first hypotheses of this dissertation, durational accuracy of the singleton geminate ratio was calculated based on the same ratio in Japanese native speakers' productions. Specifically, because previous studies indicated variations in durational ratios depending on the manner of articulation (Kawahara 2015), a range of acceptable values for SG ratio was calculated for each manner of articulation separately, and applied to tokens of each corresponding manner in learners' productions.

The results of the data analysis allowed to refute the first null hypothesis: a difference in accuracy was observed between the three L2 learner groups. Namely, French and Italian learners' productions were significantly more accurate, than those of learners whose L1 is English. Although no significant difference could be observed between Italian and French learners, the difference in terms of oral proficiency between the two groups might be responsible for this result, and I suggest that if they had the same oral proficiency, French learners' productions would be less accurate than Italian learners'.

For the second hypothesis, statistical testing showed no significant difference in accuracy between manners of articulation, which allows to validate the second null hypothesis formulated in this dissertation. The accuracy ranking observed, although it is non-significant and therefore no more than a tendency, indicates a different pattern for Italian learners on the one hand and English and French learners on the other hand. This suggests that the pronunciation of the Japanese consonantal length contrast by learners who are native speakers of a language with phonemic gemination (i.e. Italian) exhibit different patterns than those of native speakers of a language without such a phonemic contrast (i.e. French, English). Namely, the tendency would be that one group might be subject to L1 influence

while the second group's productions are affected by universal acoustic properties of consonants.

CHAPTER 6: RESULTS ON PRODUCTION CUES

1. INTRODUCTION

In order to provide an answer to the third hypothesis formulated in this dissertation (see in (1) below), this sixth chapter will present the results and analyses of the production experiment introduced in the preceding sections.

(1) **Hypothesis 3:** There is no difference between L2 learners and Japanese native speakers in the use of durational cues for consonantal length production.

The durational cues involved in the production of the consonantal length contrast in Japanese for native speakers have been extensively studied until now, and allowed to identify durational cues (constriction duration, singleton-geminate ratio, longer preceding vowel and a tendency to a shortened following vowel duration) active in native production. These works shed light on the language-specific nature of the timing control involved in the singleton-geminate distinction in Japanese. Based on the language specific nature of these durational cues, the prediction that was made concerning L2 learners is that they rely on different durational cues than native speakers for the production of the Japanese consonantal length contrast.

The goal of this chapter is to identify whether there is or not a difference between Japanese native speakers and L2 learners in the use of durational cues. Namely, whether Hypothesis 3 can be validated or not. In the case where a difference is observed between learners and native speakers in the data collected in the present experiment, L2 learners'

productions will be examined in detail, in order to identify what are the durational cues active in their production.

1.1. Methodology

The analysis of the data presented in this chapter will make use of both segment raw durations and normalized data using ratios. Indeed, the use of ratios allows to avoid the influence in the results of inter and intra-speaker variations due to differences in the speech rate. In the data collected for this dissertation, if the speech rate was rather consistent among Japanese native speakers, it was not the case for the three L2 learner groups. Specifically, individual variations in speech rates were observed among speakers but also within the recorded speech samples for the same speaker. Among the reasons that might account for the intra-speaker variations observed, I suggest the role of differences in their Japanese proficiency level, as well as in reading skills in general: Some of the participants reported to be slow readers even in their L1.

Based on the raw duration measurements made on the recorded files, the following ratios were calculated, and will be used in this chapter for further analysis of the data:

(i) <u>Singleton-geminate ratio (henceforth SG ratio):</u> This ratio is obtained by dividing the geminate consonant duration by the singleton duration. Similarly to the analysis of accuracy presented in Chapter 4, the SG ratios were calculated based on the VCV-VCCV token pairs where the consonants appear in a similar phonological environment. For each pair, the SG ratio was obtained using the following formula: *SG ratio = CC duration /C duration*

SG ratio provides information on the primary acoustic correlate for geminate consonants, that is, the difference in closure duration between geminate and singleton consonants.

(ii) Preceding vowel to consonant (singleton or geminate) ratio (henceforth V1C ratio): This ratio is obtained by dividing the consonant duration (singleton or geminate) by the preceding vowel duration. The formula used to obtain the V1C ratio is as follows: *V1C ratio = C duration /V1 duration*

(iii) Following vowel to consonant (singleton or geminate) ratio (henceforth V2C ratio): This ratio is obtained by dividing the consonant duration (singleton or geminate) by the following vowel (V2) duration. The formula used to obtain the V2C ratio is as follows: *V1C ratio = C duration /V2 duration*

1.2. Hypothesis 3

In order to test Hypothesis 3, an independent-samples t-test was conducted to compare SG ratios for Japanese native speakers and learners. The results showed a significant difference between the native speakers (M= 2.07) and the L2 learners (M=2.32) populations [$t(494.4) = 2.72$, $p < 0.01$]. This is illustrated in Figure 1 below.

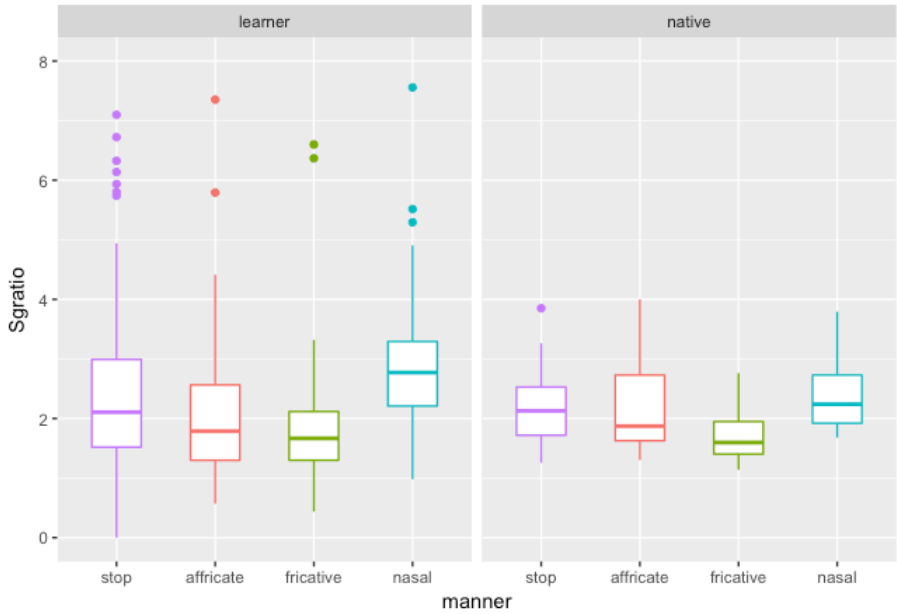


Figure 1: SG ratios for L2 learners (left) vs. Japanese native speakers (right) by manner of articulation

The data distribution represented by the boxplots in Figure 1 suggests a greater variability in SG ratios for learners when compared to Japanese native speakers. The relationship between SG ratio, the speakers' L1, and manner of articulation were tested using a linear mixed effects model with the lmer function of the lme4 package (Bates et al. 2015) on R (R Core Team 2017). The model that fits best was chosen by comparison of AIC scores for the various models tested, and *p*-values were obtained by likelihood ratio tests of the full model with the effect in question against the model without the effect in question. The fixed effect entered in the model was the intercept of the learners' L1 and manner of articulation of the consonant. As random effects, I added intercepts for the speaker and for the item. The linear mixed effect model showed that L1 and manner of articulation are significantly inter-dependent, and significantly correlated to SG ratio ($\chi 2(9)= 27.06$, $p= 0.001$).

The results of the tests above suggest that the SG ratio, that is, the contrast between singleton and geminate closure/constriction duration, is correlated with both the L1 of the speaker and the manner of articulation of the consonant. Namely, the SG ratio appears to

follow different patterns depending the L1 and the consonant manner. It is therefore not possible to validate Hypothesis 3, which postulates an absence of difference in durational cues between speakers' L1. Accordingly, the following sections will present a detailed analysis of the data in order to identify the durational cues on which each L1 group relies.

First (section 2 of this chapter), the analysis will focus on the data recorded from Japanese native speakers as a control group, in order to provide a basis for comparison it with the same data for L2 learners. The three sections that follow present the same results for each learner group separately in the following order: French (section 3), Italian (section 4) and English (section 5).

2. JAPANESE NATIVE SPEAKERS

Before analyzing the results from the three groups of second language learners, the present section will describe the data obtained from the 8 Japanese native speakers recorded as a control group in the experiment. Indeed, a control group was needed here, as the comparison with previous studies only would lack accuracy because the data is collected with a different methodology. The use of the control group will allow to identify and confirm production cues from previous findings in the literature for the consonantal length contrast in Japanese native speakers' pronunciation. The results obtained from the control group will also be used as a reference for comparisons with the three learner groups.

As mentioned in Chapter 4, the data of one of the Japanese native speakers (JP6M) was excluded from the data set after an analysis of his responses to the questionnaire reporting a stay of more than 10 years in England as a child. This was especially reflected in his Oral proficiency score that confirmed that his pronunciation was closer to those of L2 learners than of Japanese native speakers.

2.1. General description

2.1.1. Consonant duration

As shown in Table 1 below, the mean raw consonant durations observed experimentally for singleton and geminates in Japanese native speakers' pronunciation are respectively 70ms and 150ms. An independent-samples t-test was conducted to compare the mean consonant duration for singleton and geminates, which showed a significant difference [$t(237) = 21.14$, $p < .001$]. The general mean SG ratio observed is 2.08, that is, an average geminate consonant is 2.08 times longer than its singleton counterpart. The distribution of the data in Table 1 is illustrated graphically in Figure 2 below. Figure 2 indicates the presence

of some outliers in the SG ratio, which values (e.g. 4) are higher than what is normally expected for native speakers' production. These are due to some geminate consonants pronounced with a longer closure duration, which might be the consequence of some overexaggeration due to the nature of the task (i.e. reading).

Table 1: Numerical values for consonants in Japanese native speakers

	Min	1st Qu.	Median	Mean	3rd Qu.	Max
SG ratio	1.138	1.598	1.961	2.076	2.508	4.00
C duration	Singleton:	70ms	Geminate:	150ms		

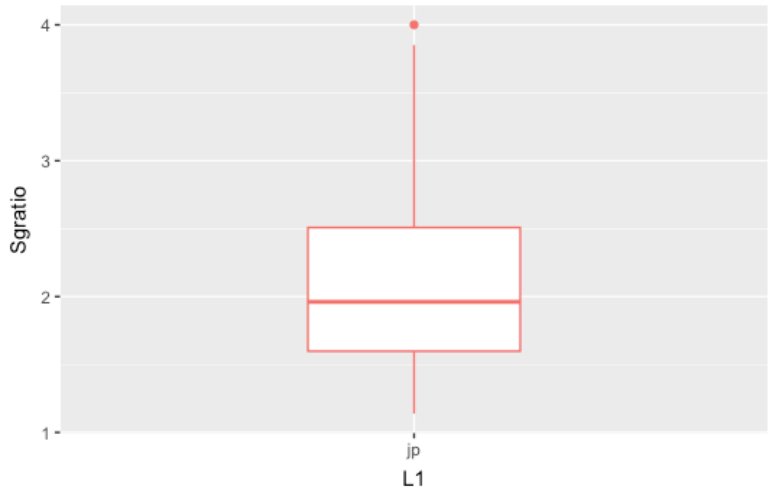


Figure 2: Singleton geminate ratio in Japanese native speakers

The present experimental results are consistent with previous studies on Japanese geminate consonants (Beckman 1982, Han 1962, 1994, 1992, Homma 1981, Kawahara 2006, Port et al. 1987 *inter alia*.) that report that they are at least twice as long as singletons with a ratio between 2 and 3. The low value of the ratio found here may be explained by the differences inherent to empirical studies, but also by the fact that most of these studies mainly investigate the duration of geminate obstruents (and specifically stops) while the data presented above is a mean including stop, fricative, affricate and nasal. This will be further

explored in what follows (see 2.2.) with a separate account to each manner of articulation: stop, affricate, fricative and nasal.

2.1.2. Vowel durations

The durations of the surrounding vowels, secondary acoustic correlates for consonantal length contrast, are also of interest. Table 2 below presents a summary of the global mean ratios for vowel durations in the pronunciation of the Japanese native speakers who took part in the experiment.

Table 2 Mean ratios for Japanese native speakers

	Singleton	Geminate
V1C ratio	1.58	2.45
V2C ratio	1.51	2.97

In these experimental results, V1C ratio was 1.58 and V2C ratio 1.51 for singleton consonants. A t-test confirmed that there is no significant statistical difference between V1C ratio and V2C ratio populations in the case of singleton consonants [$t(220) = 0.67$, $p = 0.5$, ns.], which suggests the uniformity of V1 and V2 durations in a singleton environment. In the case of geminate consonants, the ratio to the preceding vowel V1C ratio was 2.45 and showed a statistically significant difference with the ratio to the following vowel V2C which was 2.97 [$t(218) = -3.68$, $p < .001$]. These experimental results indicate a greater contrast between a geminate consonant and its following vowel than the with its preceding vowel, and suggest therefore that the vowel preceding a geminate is longer.

Table 3: Relative segment lengths calculated from mean ratios in Japanese native speakers

	V1	C	V2
Singleton	0.63	1	0.66
Geminate	0.85	2.08	0.70
Ratio	1.34	2.08	1.06

Table 3 above presents relative segment durations for singleton and geminates. Values in Table 3 were obtained by the following process: Relative mean durations for consonants in singleton and geminate were obtained from the singleton geminate ratio (2.08): that is, if the duration of a singleton consonant is 1ms, then its geminate counterpart is 2.08 ms. Durations for V1 and V2 were obtained using the mean V1C and V2C ratio with C = 1ms for singleton and C= 2.08 ms for geminates. e.g. for singletons V1C ratio = C/V1 ⇔ V1= V1Cratio/C ⇔ V1=1/C. The results obtained in Table 3 are illustrated in Figure 3 below.

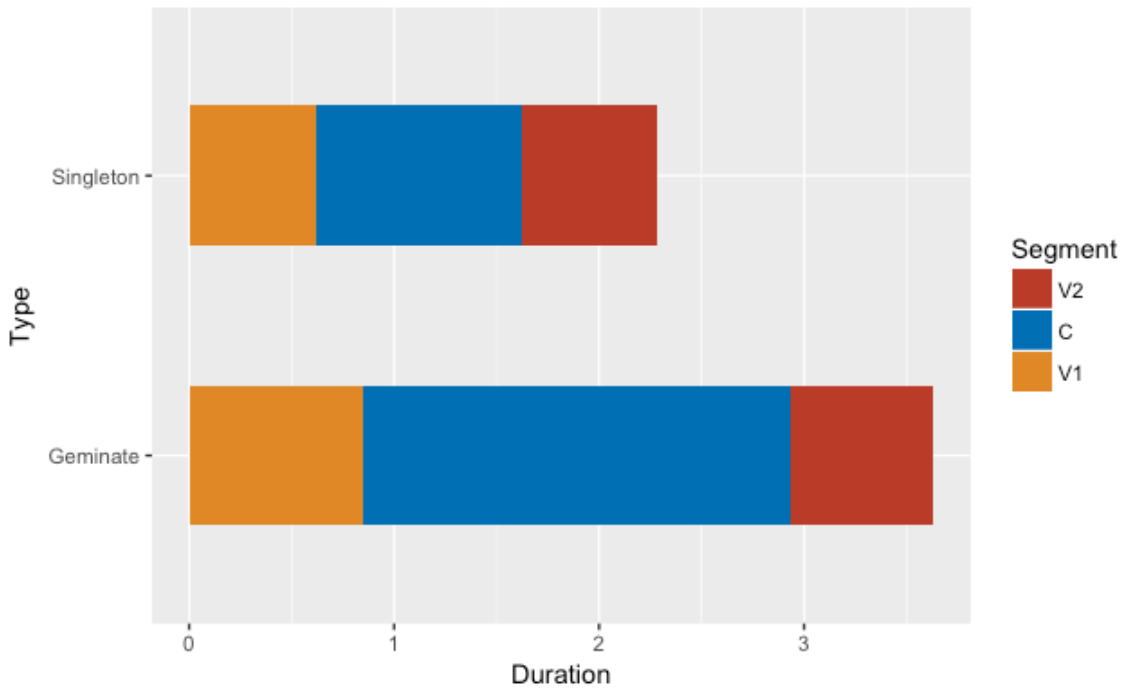


Figure 3: Segments relative mean durations in singleton vs. geminate consonants for Japanese native speakers

The observation of Table 3 and Figure 3 above indicates that the ratio of preceding vowels duration is 1.34, that is, a vowel preceding a geminate is 34% longer than one

preceding a singleton. On the other hand, V2 does not seem to undergo a significant increase (ratio=1.06) in duration between singleton and geminate environments.

The statistical significance of these results was tested using an independent samples t-test. The difference in consonant duration between singleton and geminate was significant [$t(237.4) = 21.138$, $p < .001$] as well as the difference in V1 durations [$t(213.75) = 4.6833$, $p < .001$]. However, no difference could be observed in V2 between the singleton and geminate condition[$t(222.65) = -1.8572$, $p = .06$, ns.].

These results confirm those of previous studies concerning the duration of preceding vowels in singleton and geminate consonants (Fukui 1978, Han 1994, Hirata 2007, Idemaru and Guion 2008, Kawahara 2006, 2013, Port et al. 1987 *inter alia*). As mentioned in Chapter 2, the findings in these studies indicate that a vowel preceding a geminate is longer than one before a singleton. The studies cited above also claim that vowels following a geminate consonant exhibit the reverse pattern. Namely, a tendency for a vowel to be shortened after a geminate consonant. This last point couldn't be confirmed by the present experimental results.

2.2. Results by consonant manner

This section provides a description of the results obtained for Japanese native speakers in terms of durational contrasts with regard to the manner of articulation of the target consonant.

2.2.1. Consonantal length

Table 4 below presents numerical values of SG ratio by manner of articulation. This is also illustrated in the box plot in Figure 4 that compares the SG ratio for the four manners of articulation.

Table 4: Distribution of SG ratio by manner of articulation for Japanese native speakers

	Min	1st Qu.	Median	Mean	3rd Qu	Max
Stop	1.257	1.719	2.129	2.173	2.527	3.851
Affricate	1.303	1.628	1.872	2.222	2.729	4.000
Fricative	1.138	1.403	1.597	1.702	1.949	2.763
Nasal	1.678	1.922	2.241	2.425	2.729	3.793

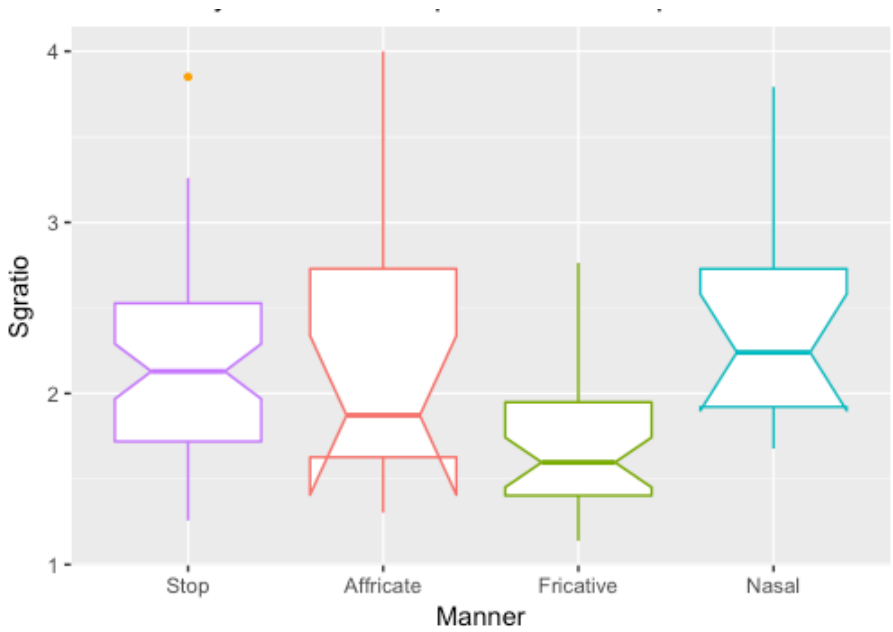


Figure 4: Singleton geminate ratio by manner for Japanese native speakers

The observation of Figure 4 and Table 4 suggests that the manner of articulation of the consonant is responsible for some differences observed in terms of data distribution. Firstly, stops and nasals appear to have a close distribution: as shown by their means, medians and similar likely ranges of variation. In particular, the interquartile range (*IRQ* = 3rd Quartile – 1rd Quartile) for stops is 0.808 and for nasals 0.807. Secondly, the mean for

affricates' SG ratio is also close to those of stops and nasals, which suggests that they might belong to the same population. However, the box representing affricate consonants appears to be positively skewed (that is, data points are gathered to the upper part of the box), as shown by their lower median (M=1.8) which might be explained by the limited size of the data set for affricates when compared to other manners[36]. Lastly, the lower location of the box for fricatives on the *y* axis suggests a different behavior of these consonants, which is confirmed by the position of the notches on the box, indicating that fricatives might belong to a different population.

A one-way between subjects ANOVA was conducted to compare the effect of the manner of articulation on SG ratio in stop, fricative, affricate, and nasal conditions (see Table 5 below). There was a significant effect of manner of articulation on the SG ratio at the $p < .05$ level for the three conditions [$F(3, 122) = 7.665$, $p < .001$].

Table 5: One-way ANOVA results table for SG ratio

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
manner	3	7.49	2.4971	7.665	9.79e-05 ***
Residuals	122	39.74	0.3258		

Post hoc pairwise comparisons using a Tukey HSD test indicated a significant difference for fricatives' SG ratio when compared with affricates ($p = .02$), stops ($p < .001$) and nasals ($p < .001$). However, the mean score for stops, affricates and nasals did not significantly differ from each other (see Table 6 below).

Table 6: Results of the Tukey HSD test on SG ratio for Japanese native speakers

	diff	lwr	upr	p adj
fricative-affricate	-0.51971349	-0.9898492	-0.04957775	0.0240144
nasal-affricate	0.20307083	-0.3588489	0.76499050	0.7826428
stop-affricate	-0.04851546	-0.4877883	0.39075736	0.9916640
nasal-fricative	0.72278431	0.2526486	1.19292004	0.0006138
stop-fricative	0.47119803	0.1577742	0.78462185	0.0008482
stop-nasal	-0.25158629	-0.6908591	0.18768653	0.4455383

[36] In the case of affricate consonants, several data points were excluded from the measurements due to devoicing of the preceding or following vowel, making difficult any accurate duration measurements.

These results suggest that only fricatives behave in a different way in terms of durational contrasts in singleton versus geminates. This confirms the observations on Figure 4 concerning the difference in terms of population for fricatives. It appears that fricatives have a smaller singleton geminate ratio in Japanese native speakers' pronunciation, that is, the contrast in duration between a singleton and a geminate consonant is smaller than for other consonant types

On the other hand, stops, affricates and nasals appear to belong to the same population, in accordance with what was shown by notches on Figure and Table 4.

2.2.2. Ratio to the preceding vowel

This section is devoted to a comparison of the ratio to the preceding vowel for each manner of articulation in singleton and in geminate conditions in Japanese native speakers' pronunciation. The comparison if each segment duration within each manner of articulation will be presented later in section 2.2.4.

a. Singletons

Figure 4 below is the graphic representation in boxplots of the distribution of the ratio of the target (singleton) consonant to the preceding vowel V1C. Corresponding numerical values are gathered in Table 7.

Table 7: Distribution of V1C ratio in singletons by manner of articulation for JNS

Singleton	Min	1st Qu.	Median	Mean	3rd Qu	Max
Stop	0.6726	1.2800	1.5772	1.5267	1.7563	2.4839
Affricate	0.6818	1.0160	1.2951	1.6691	2.5540	2.5540
Fricative	0.6748	1.2775	1.7099	1.8428	2.1508	4.8867
Nasal	0.4132	0.6757	1.0666	1.0681	1.4698	1.7568

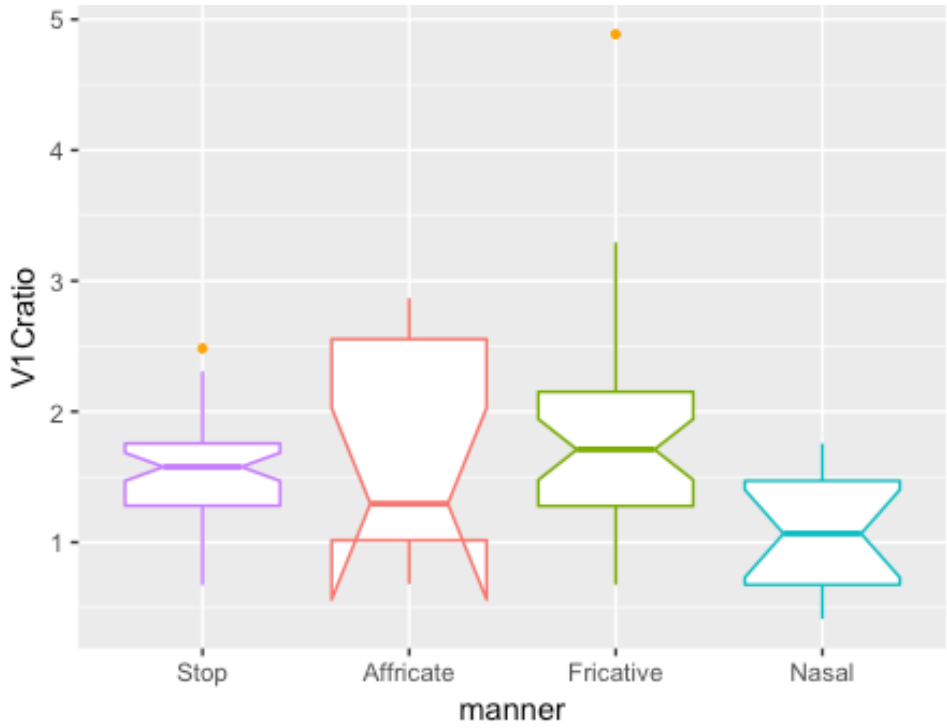


Figure 5: Ratio to the preceding vowel by manner in singleton consonants for JNS

The observation of the V1C ratio distribution for singleton consonants gathered in Figure 5 and Table 7, suggests that the ratio for nasal consonants follows a behavior different from other manners. Lower V1C ratio values indicate that there is less contrast between the vowel and the consonant durations when the target consonant is nasal. In comparison, the boxes for stops and fricatives suggest more contrast between V1 and C durations. Stops in particular show a very low IQR: this indicates a low variability of the V1C ratio across stop consonants. Here again, affricates have a positively-skewed distribution with wider variations in the ratio values.

A one-way between subjects ANOVA was conducted to investigate whether the manner of articulation has a significant effect on V1C ratio for singletons in stop, fricative, affricate, and nasal conditions (see Table 8). The manner of articulation was shown to significantly effect V1C ratio [$F(3, 105) = 5.44$, $p = .001$] for singletons.

Table 8: Results of the one-way ANOVA for V1C ratio in singletons

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
manner	3	6.31	2.1035	5.44	0.00162 **
Residuals	105	40.60	0.3866		

Post hoc pairwise comparisons were made by running a Tukey HSD test. The test results indicated a significant difference in the ratio to the preceding vowel only for nasals when paired with fricatives (p = .008). No significant difference could be observed between nasals when paired with affricates (p = .08) and stops (p = .07), as well as for stops, affricates and fricatives in the effect of manner on V1C ratio (see Table 9 below), suggesting that the behavior of the preceding vowels for these three manners of articulation is similar.

Table 9: Results of Tukey HSD test on V1C ratio for Japanese native speakers

	diff	lwr	upr	p adj
fricative-affricate	0.1737123	-0.38740518	0.73482985	0.8504494
nasal-affricate	-0.6009741	-1.25503007	0.05308187	0.0835483
stop-affricate	-0.1423609	-0.68397074	0.39924887	0.9021502
nasal-fricative	-0.7746864	-1.28802663	-0.26134624	0.0008372
stop-fricative	-0.3160733	-0.67533657	0.04319003	0.1053191
stop-nasal	0.4586132	-0.03332837	0.95055470	0.0769818

The results of the ANOVA and Tukey HSD test do not allow to confirm the observations on Figure 5: The only significant difference observed was for nasals when paired with fricatives. All other observations were proved non-statistically significant and therefore, no more than tendencies. We can conclude than in a singleton environment, the V1C ratio is in general similar for all consonants manners. The only exception was for nasals, which had a lower ratio when compared with fricatives.

b. Geminates

Figure 6 below is the graphic representation in boxplots of the distribution of V1C ratio in geminate environment. Corresponding numerical values are gathered in Table 10.

Table 10: Distribution of V1C ratio in geminates by manner of articulation for JNS

Geminate	Min	1st Qu.	Median	Mean	3rd Qu.	Max
Stop	1.458	2.013	2.341	2.493	2.729	4.598
Affricate	1.399	1.690	2.189	2.253	2.621	3.284
Fricative	1.255	1.923	2.227	2.658	2.900	7.603
Nasal	1.054	1.634	1.728	1.897	1.991	3.490

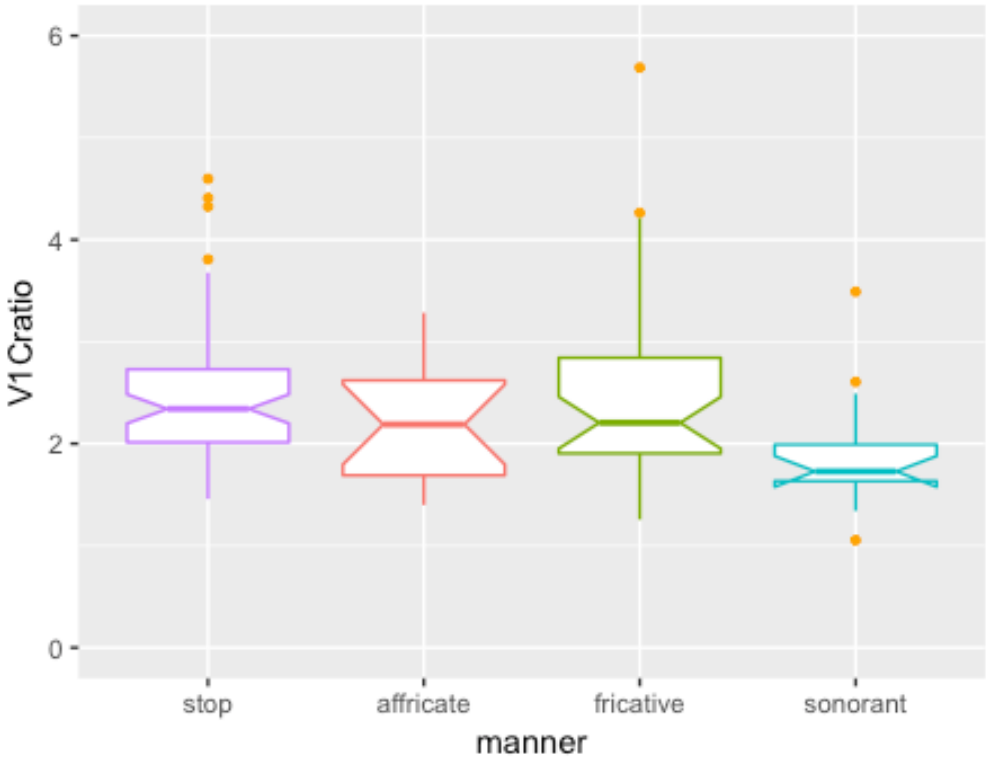


Figure 6: Ratio to the preceding vowel by manner in geminates consonants for JNS

The present results indicate that V1C ratios in a geminate environment have greater values than in a singleton environment: the ratio for geminate is about 1.5 times the one for singletons observed in the previous section. Concerning the distribution, the observation of Figure 6 and Table 10 above suggests that V1C ratios in geminates can be divided in two groups: stops, affricates and fricatives in one group, and nasals in the other. Indeed, stops affricates and fricatives appear to share a similar distribution, while the box for nasals indicates a lower IQR, that is, a smaller variation range, and lower mean and median. The

position of notches in Figure 6 also seem to indicate a similar population for stops, affricates and fricatives, and a different one for nasals.

These observations were tested by conducting a one-way between subjects ANOVA comparing the effect of the manner of articulation on V1C ratio for geminates in stop, fricative, affricate, and nasal conditions (see Table 11). The manner of articulation was shown to significantly effect V1C ratio values [$F(3, 122) = 2.788$, $p = .04$].

Table 11: Results of the one-way ANOVA for V1C ratio in geminates

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
manner	3	6.45	2.1515	2.788	0.0435 *
Residuals	122	94.12	0.7716		

Post hoc pairwise comparisons were made by running a Tukey HSD test which result can be found in Table 12 below. The only significant (to a small extent) difference observed is between nasals and fricatives ($p = .03$). However, these results suggest here again that the lower V1C ratio in nasals, which was observed in Figure 6, was not proven significant by statistical testing to the exception of the nasal-fricative contrast. This indicates an absence of difference in durational ratio patterns for V1C across consonant manners in geminate environment.

Table 12: Results of Tukey HSD test on V1C ratio for Japanese native speakers

	diff	lwr	upr	p adj
fricative-affricate	0.4046688	-0.31886444	1.12820196	0.4667356
nasal-affricate	-0.3566609	-1.22144847	0.50812669	0.7058244
stop-affricate	0.2392936	-0.43674191	0.91532918	0.7931348
nasal-fricative	-0.7613296	-1.48486285	-0.03779645	0.0350746
stop-fricative	-0.1653751	-0.64773059	0.31698034	0.8084682
stop-nasal	0.5959545	-0.08008102	1.27199007	0.1045380

c. Conclusion

The analysis of the experimental results for the V1C ratio in Japanese native speakers' pronunciation showed the following characteristics: First, as a logical consequence of the longer closure duration for a geminate, V1C ratio is about 1.5 times higher in the geminate than in the singleton environment, that is there is more contrast between the preceding vowel and the consonant durations in geminate than in singleton context. Secondly, in both singleton and geminate environments, no significant differences could be observed between manners of articulation in the distributions of V1C ratios. This suggests that the contrast between the preceding vowel and the consonant is following a similar pattern for all manners of articulation, that is a timing control process is at work to maintain the required durational contrast between the two segments. This constitutes a piece of evidence for the effect of mora timing. The only exception observed, with however a low significance, was a greater ratio/contrast for fricatives when compared to nasals, a difference that was consistent in both environments.

2.2.3. Ratio to the following vowel

a. Singletons

Figure 7 below is the graphic representation of the distribution of V2C ratio for singleton environment. Corresponding numerical values can be found in Table 13.

Table 13: Distribution of V2C ratio by manner of articulation in singleton for JNS

Singleton	Min	1st Qu.	Median	Mean	3rd Qu	Max
Stop	0.5408	0.8725	1.1307	1.1887	1.4106	2.8125
Affricate	0.9114	1.1044	1.4802	1.6689	1.6692	4.4650
Fricative	0.8968	1.4658	1.9773	2.3366	2.5715	6.4800
Nasal	0.4600	0.7103	0.7385	0.7458	0.8077	1.0078

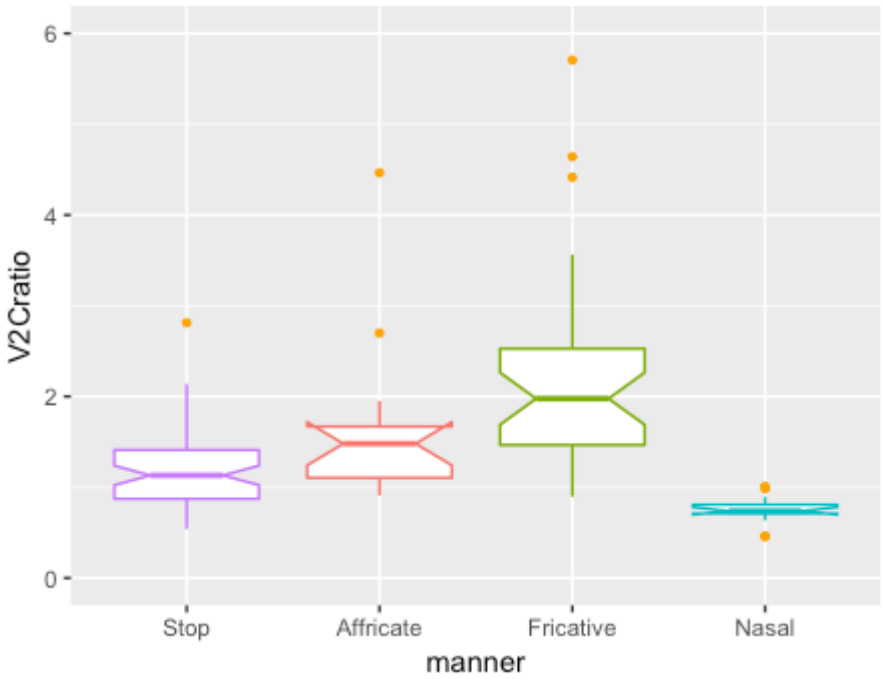


Figure 7: Ratio to the following vowel by manner for singleton consonants

The observation of Figure 7 and Table 13 above indicates a similar behavior in terms of V2C ratio for stops and affricates. On the other hand, the boxes for fricatives and nasals suggest that these two types of consonant show a rather different tendency. Fricatives' ratio shows a wider range of variation (*IQR* = 1.1) than stops (*IQR* = .54) and affricates (*IQR* = .56), and have higher values in general (*m* = 2.3), suggesting that a greater contrast is needed with the following vowel when compared to the other consonant types. Inversely, the ratio for nasals shows lower values (*m* = .75), suggesting less contrast, and have an exceptionally low variation range (IQR = .09).

The statistical significance of the observations above was tested using a one-way between subjects ANOVA, conducted to compare the effect of the manner of articulation on V2C ratio for singletons in stop, fricative, affricate, and nasal conditions (see Table 14). The manner of articulation had a significant effect on V2C ratio [$F(3,122)=19.91$, $p<.001$].

Table 14: Results of the one-way ANOVA for V2C ratio in singletons for JNS

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
manner	3	38.94	12.982	19.91	1.44e-10 ***
Residuals	122	79.57	0.652		

Post hoc comparisons were conducted by running a Tukey HSD test (see Table 15 below). The test results allowed to identify significant differences in the ratio to the following vowel for fricatives when paired with any other consonant type: stops (p = 0), affricates (p = .04), sonorant (p = 0). A significant difference was also observed between affricates and nasals (p = .01).

Table 15: Results of Tukey HSD test on V2C ratio in singleton for JNS

	diff	lwr	upr	p adj
fricative-affricate	0.6676939	0.002489158	1.3328987	0.0487745
nasal-affricate	-0.9231024	-1.718174167	-0.1280306	0.0158728
stop-affricate	-0.4801492	-1.101685345	0.1413870	0.1891323
nasal-fricative	-1.5907963	-2.256001086	-0.9255916	0.0000000
stop-fricative	-1.1478431	-1.591312918	-0.7043732	0.0000000
stop-nasal	0.4429532	-0.178582939	1.0644894	0.2524182

These results confirm the observations on Figure 6: In terms of ratio to the following vowel, fricatives follow a behavior significantly different from the other consonants with a greater contrast. On the other hand, and although the difference between stops and nasals was non-statistically significant, nasals also seem to exhibit divergent patterns, as observed with the lower ratio when compared to fricatives or affricates. Lastly, the statistical test confirms the similar behavior of stops and affricates in terms of V2C ratio.

b. Geminates

Figure 8 below is the graphic representation of V2C ratio by manner of articulation for native speakers when the target consonant is a geminate. Corresponding numerical values are gathered in Table 16.

Table 16: Distribution of V2C ratio by manner of articulation for geminates in JNS

Geminate	Min	1st Qu.	Median	Mean	3rd Qu.	Max
Stop	1.585	2.294	2.696	2.932	3.341	5.782
Affricate	1.737	2.004	2.531	2.823	3.343	5.727
Fricative	1.500	2.190	3.047	3.550	4.304	10.509
Nasal	1.248	1.583	1.636	1.833	2.148	2.753

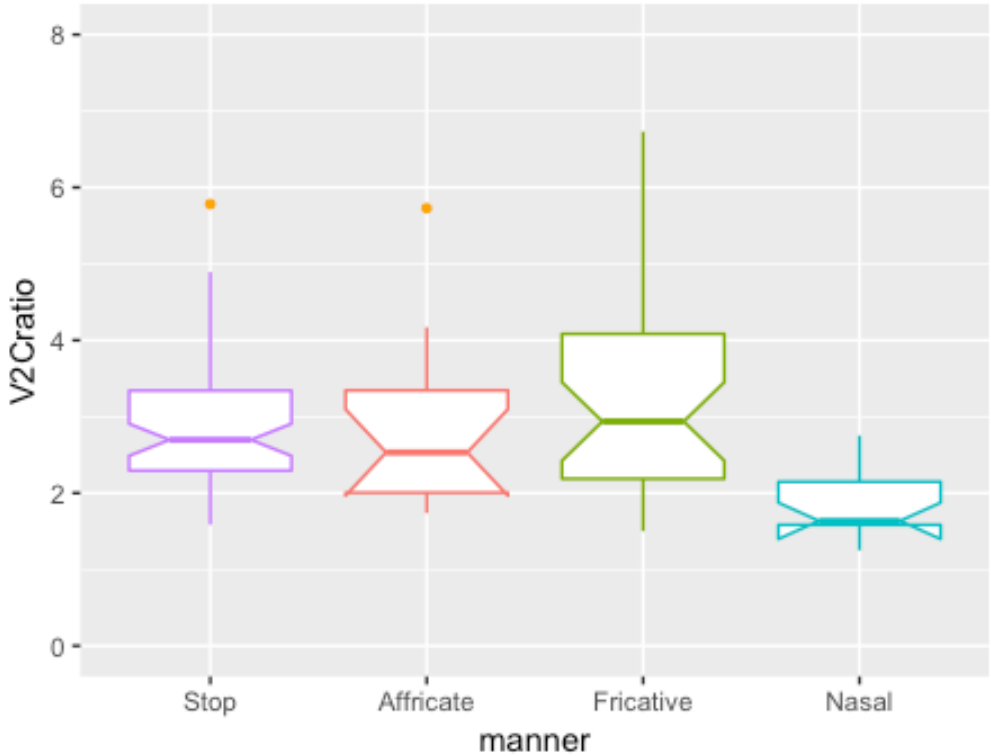


Figure 8: V2C ratio by manner of articulation for geminate consonants in JNS

The distribution of the boxes in Figure 8 seems to replicate to a lesser extent the tendencies observed for singleton consonants in Figure 7 in the preceding sub-section. While stops and affricate consonants seems to share the same properties in terms of V2C ratio, fricatives show greater V2C ratio (M=3.55), indicating a greater durational contrast, and wider variations (IQR = 2.11). On the other hand, nasals seem to follow patterns that differ from the other manners, with lower ratio values (M=1.83) and variation range (*IQR* = .56). Lastly, the mean V2C ratio values in geminate environment are about twice the values for the same ratio in singleton environment.

The statistical significance of these observations was tested using a one-way between subjects ANOVA in which the effect of the manner of articulation on V2C ratio for geminates was compared in stop, fricative, affricate, and nasal conditions (see Table 17 below). The manner of articulation was shown to significantly effect V2C ratio [$F(3,121) = 6.613$, $p < .001$].

Table 17: Results of the one-way ANOVA for V2C ratio in geminates for JNS

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
manner	3	30.25	10.083	6.613	0.000356 ***
Residuals	121	184.48	1.525		

Post hoc pairwise comparisons were made by running a Tukey HSD test which result can be found in Table 18 below. The results of the Tukey HSD test confirm the difference between nasals and fricatives ($p < .001$) and nasals and stops (p=.01) only. The difference in the nasal-affricate pair was non-significant. All other pairs did not show any statistically significant difference, and stop-affricate pair showed an outstandingly high p value ($p = .99$), suggesting the high degree of similarity of the two populations.

Table 18: Results of Tukey HSD test on V2C ratio in geminates for JNS

	diff	lwr	upr	p adj
fricative-affricate	0.7265220	-0.2906852	1.7437292	0.2505637
nasal-affricate	-0.9899668	-2.2057619	0.2258284	0.1522243
stop-affricate	0.1081673	-0.8436561	1.0599907	0.9909322
nasal-fricative	-1.7164888	-2.7336960	-0.6992816	0.0001388
stop-fricative	-0.6183547	-1.2984432	0.0617338	0.0887264
stop-nasal	1.0981341	0.1463107	2.0499575	0.0167853

Statistical tests only partly confirm the observations in Figure 8: Findings show a statistical difference in terms of contrast between the geminate consonant and its following vowel for nasals when compared with stops and fricatives only. For affricates this difference was not significant. This result suggests a smaller contrast with the following vowel when the consonant is a nasal geminate. Other manners appear to follow similar contrast patterns,

and although the boxes in Figure 8 indicated a similarity in the patterns between singleton and geminate environment, this was not confirmed by statistical testing.

c. Conclusion

The global results in terms of V2C ratio indicate that: First, logically following from the longer consonant and the shorter V2 in geminate environment, the ratio to the following vowel is greater for the geminate environment than for the singleton one. Secondly, in singleton environment, a greater contrast is needed for fricatives than for other manners. On the other hand, nasals follow the opposite behavior. For geminates, only nasals followed a different pattern with less contrast than other manners. In general, for both singleton and geminates, the contrast between the following vowel and the consonant was similar for stops and affricates.

In the case of V1C (see section 2.2.2.) we postulated that the similar patterns observed for all manners might be due to some mechanism of contrast preservation related to mora timing in order to ensure the realization of the minimal required contrast to distinguish the singleton from the geminate consonant. However, for V2C some significant differences were observed between manners. This suggests that in the case of V2C the contrast is less crucial for length distinction. Lastly, stops and affricates follow identical patterns in terms of durational contrast for all ratios and all environments.

2.2.4. Comparison within each manner of articulation

In the preceding section, SG, V1C and V2C durational ratios were compared by manner of articulation in both singleton and geminate environments. This allowed to see

variations in durational contrasts between manners of articulations for each of the target segments.

In contrast, the current section will present a separate analysis for each manner of articulation, in order to examine the significance of durational contrasts related behaviors within manners of articulation.

a. Stops

Figure 9 below compares in a bar plot the relative mean durations of V1 (blue), C (green) and V2 (red) when the target consonant is a stop, between singleton (top) and geminate (bottom) for Japanese native speakers. Corresponding numerical values can be found in Table 19.

Values in Table 19 were obtained by the same process as in section 2.1. for the global relative durations. Mean durations for consonants in singleton and geminate were obtained from the singleton geminate ratio (2.173): that is, if the duration of a singleton consonant is 1ms then its geminate counterpart is 2.173ms. Durations for V1 and V2 were obtained using the mean V1C and V2C ratio with C = 1ms for singleton and C= 2.173ms for geminates. All tables that follow derive from the same process.

Table 19: Mean duration values for stops by JNS

	V1	C	V2
Singleton	0.65	1	0.84
Geminate	0.87	2.173	0.74
Mean ratio	1.33	2.173	0.88

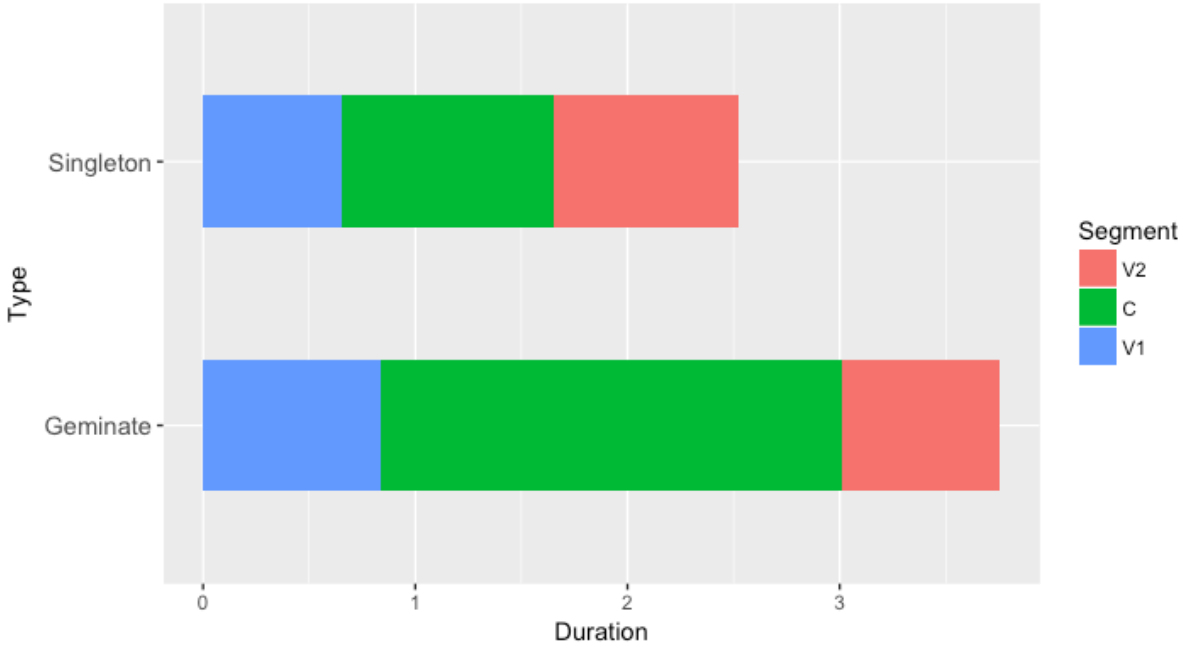


Figure 9: Relative segment mean duration for stops in singleton and geminate consonants by JNS

Figure 9 and Table 19 indicate the following characteristics in the contrast between singleton and geminate stops. First the ratio of the singleton to the geminate consonant is 2.173, that is, the duration of a geminated stop is 217.3% the duration of a singleton stop. The preceding vowel is longer before a geminate consonant than before a singleton (133%), and the following is shorter before a geminate consonant than before a singleton (88%).

An independent-samples t-test was conducted to compare the duration of the preceding vowel for singleton and geminate consonants. A significant difference was observed between the two populations [$t(89) = 3.98$, $p < .001$]. The same test was conducted and indicated similar results for the consonant duration [$t(97) = 18.58$, $p < .001$]. and for the following vowel duration [$t(100) = -3.19$, $p = .001$].

These results indicate that the vowel preceding a geminated stop is longer, and the vowel following one is shorter, which is consistent with the analysis grouping all consonant manners provided in 2.1.1, and supports results from previous studies already cited in the

same section (Beckman 1982, Han 1962, 1994, 1992, Homma 1981, Kawahara 2006, Port et al. 1987 *inter alia*.).

b. Affricates

Figure 10 below represents the relative mean durations of V1 (green), C (orange), the frication period F (blue) and V2 (red) when the target consonant is an affricate, between singleton (top) and geminate (bottom) for Japanese native speakers. In order to adapt the analysis to the properties of affricate consonants, the frication period, which occurs right after the closure, has been added to the data. Corresponding numerical values can be found in Table 20.

Table 20: Relative mean duration values for affricates by JNS

Affricates	V1	C	Frication	V2
Singleton	0.6	1	0.93	0.6
Geminate	0.99	2.222	0.85	0.79
Mean ratio	1.65	2.222	0.91	1.31

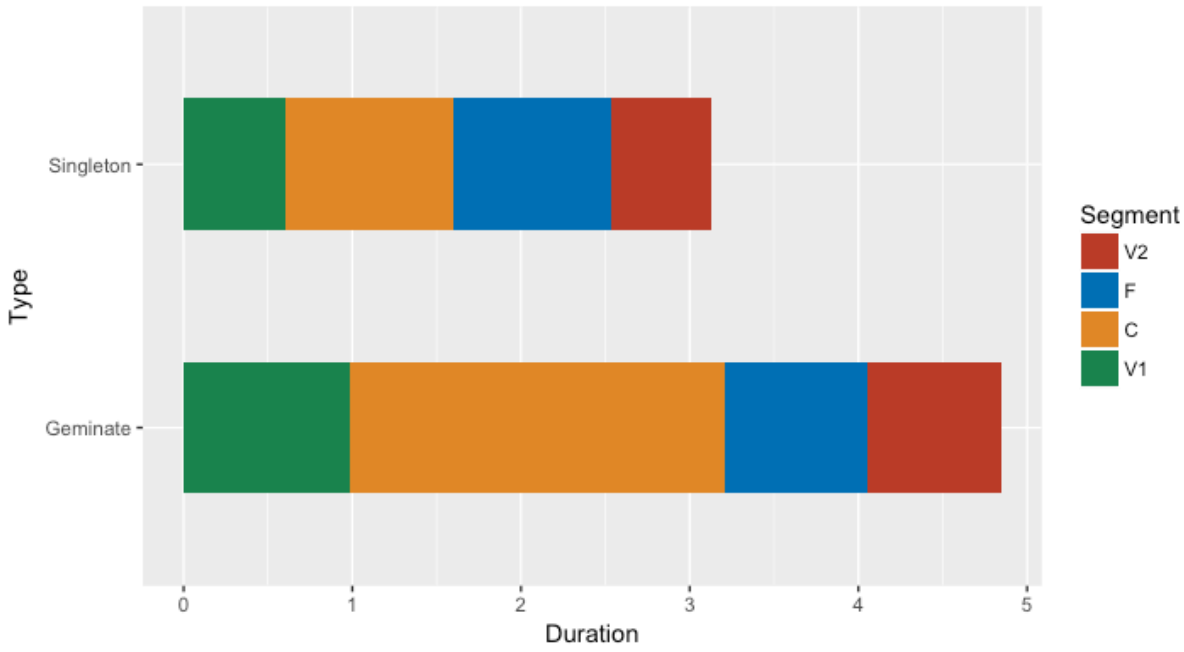


Figure 10: Relative segment duration for affricates in singleton and geminate consonants

The observation of Figure 10 and Table 20 above indicates that V1 is longer before a geminate than before a singleton (165%). A similar pattern is observed for the following vowel, which is longer (131%) after a geminate consonant. The mean ratio for consonant closure indicates that geminate closure is more than twice the duration of singleton's (222%), and the frication duration indicates a shorter frication for geminates (91%).

These observations were tested by conducting independent samples t-tests. The results confirmed that V1 is longer before a geminate consonant [$t(13) = 2.99$, $p = .009$], and indicate a statistically significant difference between the singleton and geminate durations [$t(22) = 8.17$, $p < .001$]. However, the observations for frication and V2 durations are no more than tendencies as t-tests indicate no difference in the frication duration F between singleton and geminate contexts [$t(25) = -1.59$, $p = .1$, ns.], and no difference as well for the following vowel duration [$t(24) = 0.84$, $p = .4$, ns.].

c. Fricatives

Figure 11 below compares in a bar plot the relative mean durations of V1 (blue), C (green) and V2 (red) when the target consonant is a fricative, between singleton (top) and geminate (bottom) for Japanese native speakers. Corresponding numerical values can be found in Table 21.

Table 21: Mean duration values for fricatives by JNS

Fricatives	V1	C	V2
Singleton	0.54	1	0.43
Geminate	0.64	1.702	0.48
Mean ratio	1.18	1.702	1.12

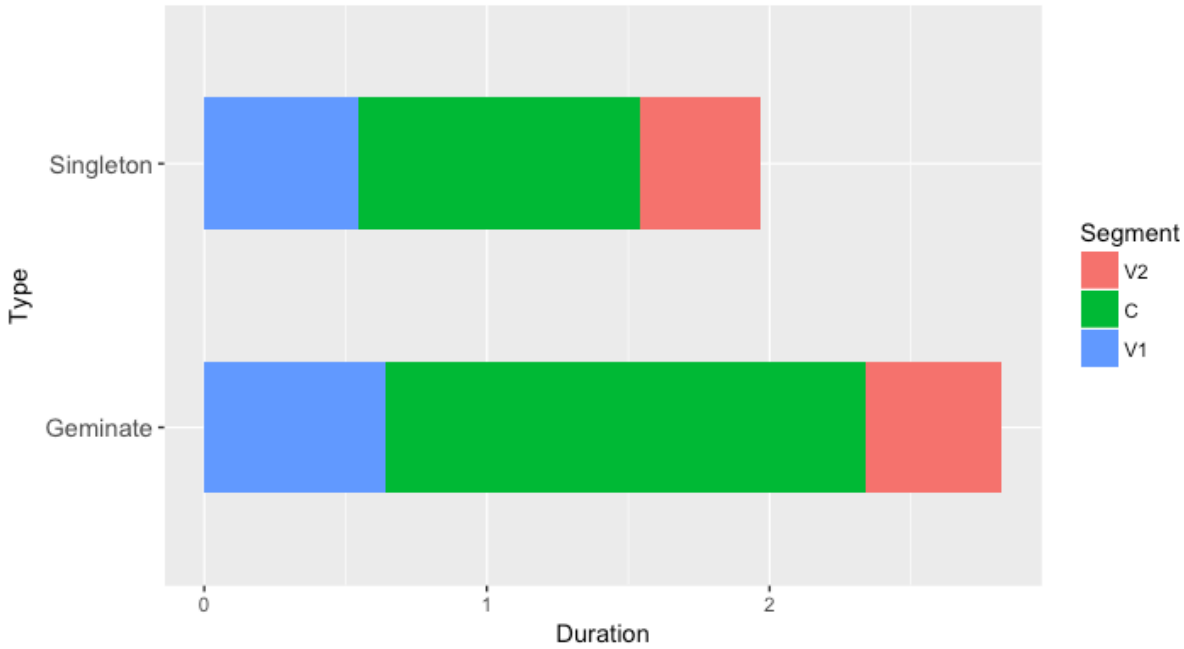


Figure 11: Relative segment duration for fricatives in singleton and geminate consonants

The observation of Figure 11 and Table 21 indicates that: The duration of a geminated fricative is 170.2% the duration of a singleton one. Furthermore, a longer duration is observed for the preceding vowel when before a geminate compared to when it precedes a singleton (118%). The following vowel shows the same behavior and is 112% the duration of the vowel following a singleton consonant.

These observations were tested with independent samples t-tests. Firstly, results indicate that the consonant duration in singleton vs. geminate is significantly different [$t(66) = 11.2$, $p < .001$]. However, no significant difference could be found for the increase in duration observed for V1 and V2 between singleton and geminate conditions.

The present results indicate that, in contradiction with results of previous studies (cited above) and with findings on stops and affricates in a. and b. of this section, there is no difference in terms of duration between a vowel preceding a singleton and one preceding a geminate for fricatives. A similar result was found for the duration of the following vowel.

d. Nasals

Figure 12 below compares in a bar plot the relative mean durations of V1 (blue), C (green) and V2 (red) when the target consonant is a nasal, between singleton (top) and geminate (bottom) for Japanese native speakers. Corresponding numerical values can be found in Table 22.

Table 22: Mean duration values for nasals by JNS

Nasals	V1	C	V2
Singleton	0.93	1	1.34
Geminate	1.27	2.425	1.32
Mean ratio	1.37	2.425	0.99

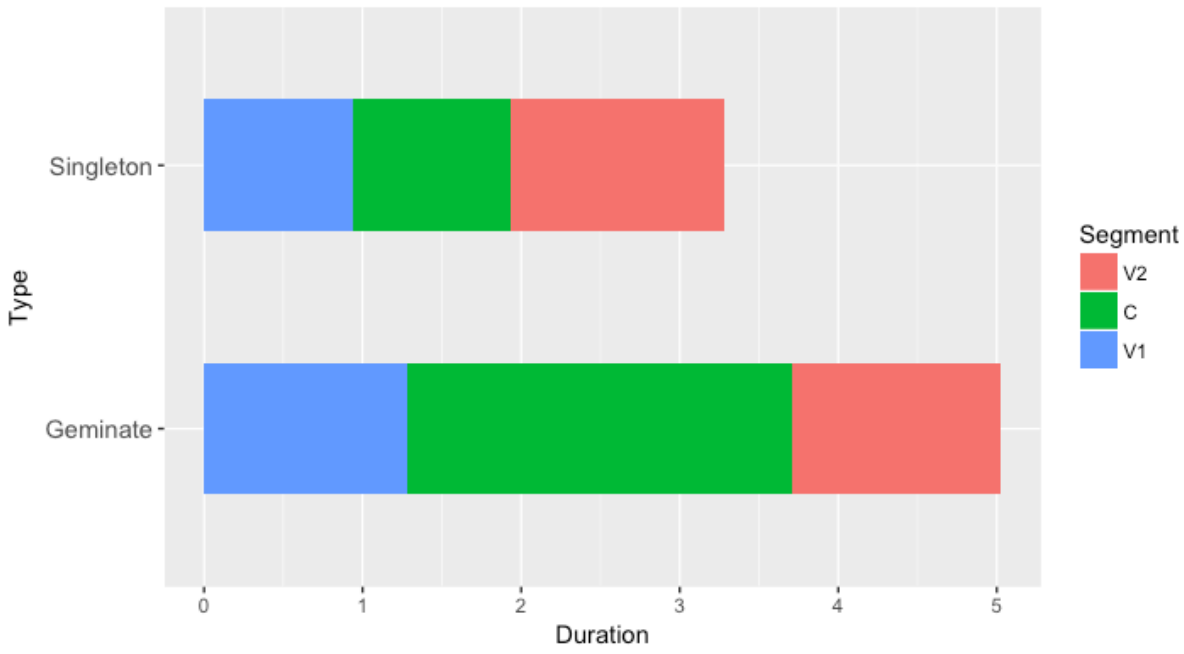


Figure 12: Relative segment duration for nasals in singleton and geminate consonants

The observation of Figure 12 and Table 22 above show that: A nasal geminate is 242.5% the length of a singleton one. Furthermore, a vowel preceding a nasal is longer when the consonant is a geminate (137%) and the one following the nasal is of equal length in both consonant types.

Independent-samples t-test were conducted to compare durational cues for singleton and geminated nasal consonants. The results of the t-tests showed no significant difference for the preceding vowel duration between singleton and geminate contexts [$t(24) = 1.65$, $p = 0.1$, ns.]. Similarly, no significant difference could be observed in the following vowel [$t(25) = -0.44$, $p = 0.7$, ns.]. The only significant difference was for the consonant duration between singleton and geminate [$t(18) = 10.77$, $p < .001$].

Although results confirm the difference (ratio = 2.4) in consonantal length (constriction duration) for nasals between singleton and geminates, which is consistent with the definition of the primary cue for geminate consonants, the results of statistical tests for the preceding and following vowels suggest that their durations are identical for both singleton and geminate environments.

e. Conclusion

This section provided an analysis of the duration of each segment in the singleton vs. geminate contrast by looking at consonants of each manner of articulation separately. The investigation of statistical cues indicates the following characteristics for native speakers' pronunciation. First, it was confirmed that a singleton consonant is shorter than a geminated one for all manners of articulation. Secondly, the preceding vowel is longer before a geminate than before a singleton for stops and affricates. In fricatives and nasals, no difference could be observed for V1 duration. Moreover, only stops indicated a significant difference between singleton and geminates for the following vowel, which is shorter, while for fricatives, affricates and nasal, the difference between the two environments was non-significant. It appears that nasals and fricatives in general seem to follow a different behavior from the two other consonant types, as there was no significant duration difference for both V1 and V2. This difference may be attributed to the [+continuant] feature of fricatives and

nasals. However, the two consonant manners have opposite behaviors, as less durational contrast seems to be needed for nasals and more for fricatives. This will be further discussed in following sections.

Lastly, the analysis of affricates showed that frication duration doesn't vary between singleton and geminates, which supports previous studies on Japanese affricates claiming that they behave like stops. Namely, the primary production cue for affricate geminates is similar to stops', that is, closure duration (Oba, Brawn & Handke 2009). This also accounts for the outstandingly similar behavior observed between stops and affricates in the present results.

1.3. Summary of the findings for Japanese native speakers

In this section I provided a description of the characteristics of the experimental production data on singleton and geminates consonants pronounced by Japanese native speakers. After presenting the characteristics of the singleton-geminate contrast in general in section 1.1., section 2.2. proposed a more detailed analysis of the same contrast by looking at the manner of articulation of the consonant. 2.2.1. investigated the differences between manners of articulation, while 2.2.2. was looking at the differences in segment durations within each manner of articulation. The findings of this section describing the characteristics of Japanese native speakers' pronunciation allow to confirm most of the production cues found in previous studies (Beckman 1982, Han 1962, 1994, 1992, Homma 1981, Kawahara 2006, Port et al. 1987 *inter alia*.).

To summarize results from this section, the present data allows to make the following claims concerning the characteristics of Japanese native pronunciation:

(i) Geminate duration is at least twice the singleton duration as indicated by SG ratio in our results. This confirms that the primary cue for consonant length distinction is constriction duration.

(ii) The difference between V1 and V2 was significant for geminates (V1 > V2) but not for singletons.

(iii) V1 was longer for geminate than for singleton context, but differences in V2 duration between the two environments were non-consistent.

(iv) A different behavior was observed for nasal and fricatives when compared with affricates and stops.

(v) The results of the comparisons between and within manners of articulation are summed up in Table 23 and 24 below where "S" stands for stops, "A" for affricates, "F" for fricatives and "N" for nasals.

Table 23: Summary of the results for the comparison in contrasts between manners of articulation

	V1	C	V2
Singleton	S=A=F=N (F≠N)	F＜S=A=N	N≤S=A＜F
Geminate			

Table 24: Summary of the results for the comparison within each manner of articulation

	Stop	Affricate	Fricative	Nasal
V1	V1sing＜V1gem		V1sing =V1gem	
C	S＜G			
F	NA	Fsing=Fgem	NA	NA
V2	V2sing＞V2gem	V2sing=V2gem		

3. FRENCH L2 LEARNERS

The goal of this third section of the chapter is to identify the production cues active in French learners' pronunciation of the Japanese consonantal length contrast. It will present results from the 10 French native speakers recorded for this experiment. The current section has the following structure: a first part will introduce general results before presenting a detailed analysis of the results between manners of articulation in the second part, and within each manner of articulation in the third, in the same order as for Japanese native speakers. Comparisons between the French learners and the control group will also be provided in the conclusion of each sub-section.

3.1. General description

3.1.1. Consonant duration

As shown in Table 25 below, the observed experimental mean consonant durations for singleton and geminates for French learners of Japanese are respectively 90ms and 180ms. These values were compared using an independent-samples t-test, which showed a significant difference [$t(321) = 12.89$, $p < .001$], indicating that the two groups are from different populations. The general mean SG ratio observed is 2.36, that is, an average geminate consonant is 2.36 times longer than its singleton counterpart. The box plot in Figure 13 below is a graphic representation of the distribution of the SG ratio in French L2 learners' pronunciation.

When compared to native speakers' SG ratio distribution, SG ratio for French learners shows more variations, and for a more reader-friendly format, outliers above 7.5 have been excluded from the graph. They are however included in the data presented in Table 25 and the analysis. It appears that outliers for French learners have high values,

indicating that they enhance the contrast between singleton and geminate durations. A more detailed look at the data shows that this tendency is caused by longer geminate consonants (and not shorter singletons), exclusively in stops. This suggests that French learners are conscious of the contrast, and consciously produce a greater duration contrast between the singleton and geminate consonants.

Table 25: Numerical values for consonants

	Min	1st Qu.	Median	Mean	3rd Qu.	Max
SG ratio	*0.44*	*1.46*	*2*	*2.35*	*2.69*	*14.10*
C duration	*Singleton:*	*90ms*	*Geminate:*	*180ms*		

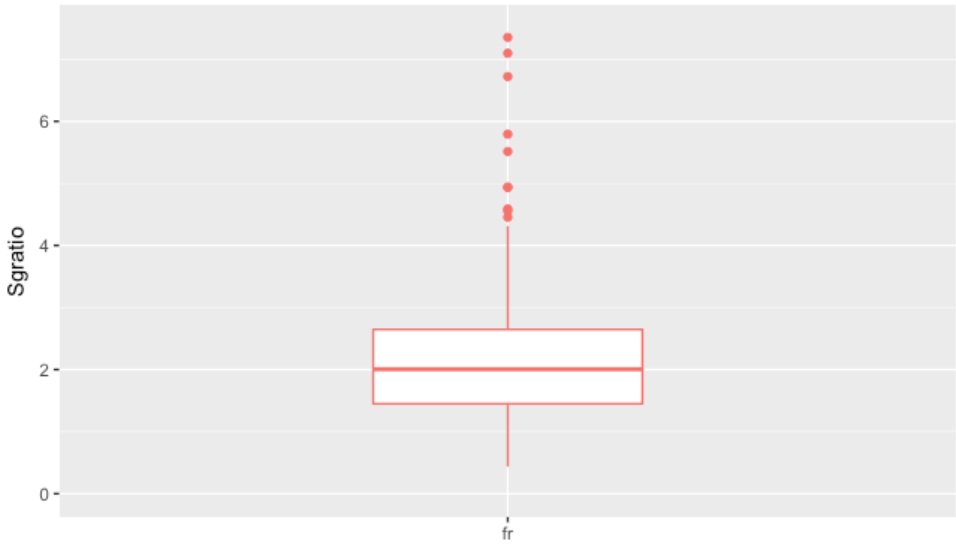


Figure 13: Singleton geminate ratio for French learners

The present experimental results concerning SG ratio are consistent with those of Japanese native speakers in section 2, for who the closure/frication duration is the primary production cue for the consonant durational contrast. Results are also consistent with those of previous studies (Beckman 1982, Han 1962, 1994, 1992, Homma 1981, Kawahara 2006, Port et al. 1987 *inter alia*.) on Japanese geminate consonants that report geminate duration as at least twice as long as singleton' with a ratio between 2 and 3. As far as I know, this experiment present the first results on production of Japanese geminate consonants pronounced by French learners, which means that it cannot be compared with previous data

from the same population. However, these results indicate that when looking at the consonants' global lengthening patterns, although a wider range of variation is observed for French learners, they rely on the same primary production cue as Japanese native speakers.

3.1.2. Vowel duration

In this section, we will look at the global results in terms of duration for the preceding and following vowels. Table 26 below sums up the mean ratios for vowel lengths pronounced by the French learners of Japanese who took part in the experiment.

Table 26 Mean ratios for French L2 learners

	Singleton	*Geminate*
V1C ratio	*1.43*	*2.78*
V2C ratio	*1.34*	*2.53*

For French learners of Japanese, V1C ratio was of 1.43 and V2C ratio of 1.34 in singleton consonants. A t-test confirmed that there is no statistically significant difference between V1C ratio and V2C ratio in the case of singleton consonants [$t(305) = 0.94$, $p = .35$, ns.], indicating that there is no difference in the contrasts between the consonant and its two surrounding vowels. In the case of geminate consonants, the ratio to the preceding vowel (V1C ratio) was 2.78, and also had no significant difference with the ratio to the following vowel (V2C ratio) which was 2.97 [$t(354) = 1.45$, $p = .15$, ns.]. These results indicate that there is no significant variation in terms of preceding and following vowel durations between singleton and geminate in French learners' pronunciation of Japanese: V1 and V2 are of similar durations when surrounding a singleton, as well as in the case of a geminate consonant. These results differ from the observations on Japanese native speakers in section

2. of this chapter, in which V1 and V2 were of similar durations in singleton, but differed in geminates with a longer V1.

Table 27 below presents relative segment lengths calculated using the mean SG ratio and V1C, V2C mean ratios for singleton and geminates. The table indicates that the preceding vowel ratio is 1.21, implying that a vowel preceding a geminate is 21% longer than one preceding a singleton. The following vowel is also longer (25%) in a geminate environment. This is represented graphically in Figure 14 below.

Table 27 Relative segment lengths calculated from mean ratios

	V1	C	V2
Singleton	0.70	1	0.75
Geminate	0.84	2.35	0.93
Ratio	1.21	2.35	1.25

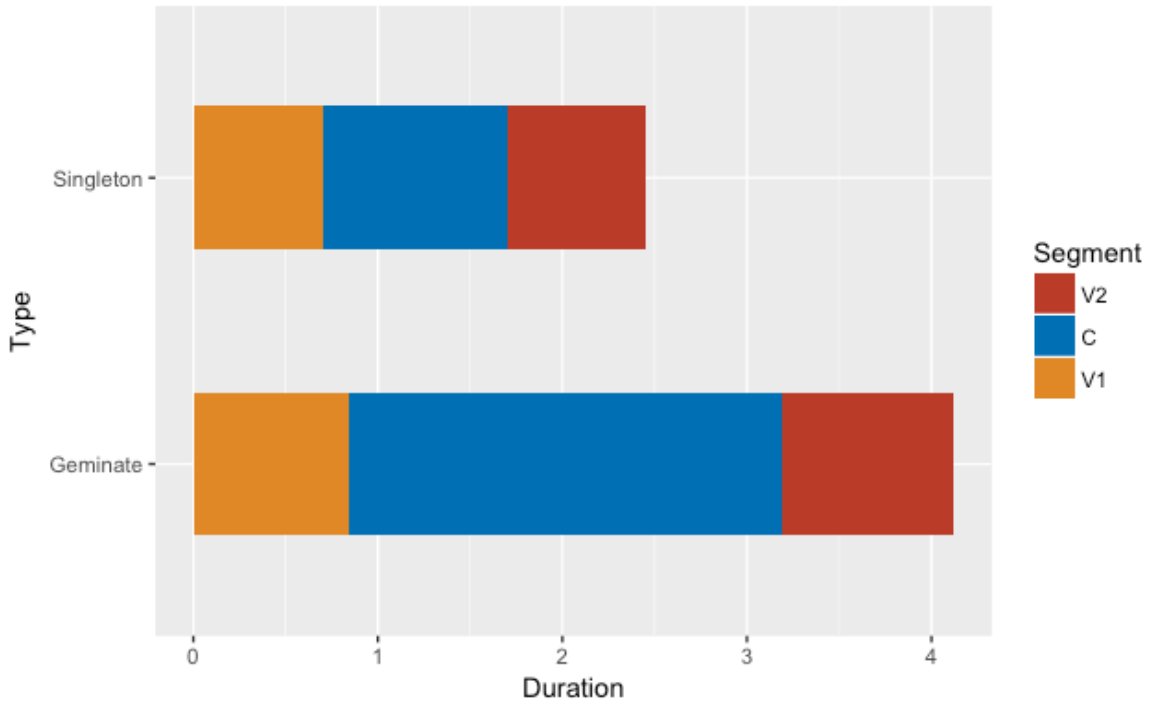


Figure 14: Relative global segment duration in singleton geminates consonants for French learners

Concerning the difference in V1 duration between singleton and geminate, statistical testing showed no significant difference [$t(325) = 0.53$, $p = 0.59$, ns.]. Similarly, the independent samples t-test for V2C ratio in singleton and geminate conditions indicated no difference [$t(351) = -0.48$, $p = .63$, ns.].

All together the results of this section indicate that French learners, similarly to Japanese native speakers use the closure/frication duration as the primary cue for the consonantal length contrast, as shown by the differences between the singleton and geminate raw durations and by the SG ratio which was of 2.35. On the other hand, French learners do no rely on vowel duration as production cues. Indeed, results indicate that the duration of V1 shows a significant increase between singleton and geminates in Japanese native speakers' pronunciation, while it is not the case for French L2 learners. This contrasts with results from previous studies on Japanese geminates demonstrating that vowels preceding geminates are longer than those before singletons (Beckman 1982, Han 1962, 1994, 1992, Homma 1981, Kawahara 2006, Port et al. 1987 *inter alia*.).

The following section will investigate further the durational correlates between singleton and geminate environments by comparing the consonants by manner of articulation.

3.2. Results by consonant manner

This section describes and analyses the results obtained from the data recorded from French learners with regard to the manner of articulation of the target consonant.

3.2.1. Consonantal length

Figure 15 below compares in a box plot the SG ratio distribution according to the manner of articulation of the target consonant for French learners. Table 28 presents the corresponding numeric values. As in Figure 13 in the preceding section, some of the outliers were removed when re-scaling the plot.

Table 28: Distribution of singleton geminate ratio by manner of articulation for French learners

	Min	1st Qu.	Median	Mean	3rd Qu	Max
Stop	0.6033	1.5375	2.2058	2.4460	3.0108	7.0982
Affricate	0.7377	1.3710	2.1382	3.3696	2.9428	14.1079
Fricative	0.4363	1.2956	1.7139	1.7023	2.0536	2.7795
Nasal	0.9805	2.1059	2.6010	2.5832	2.9209	5.5147

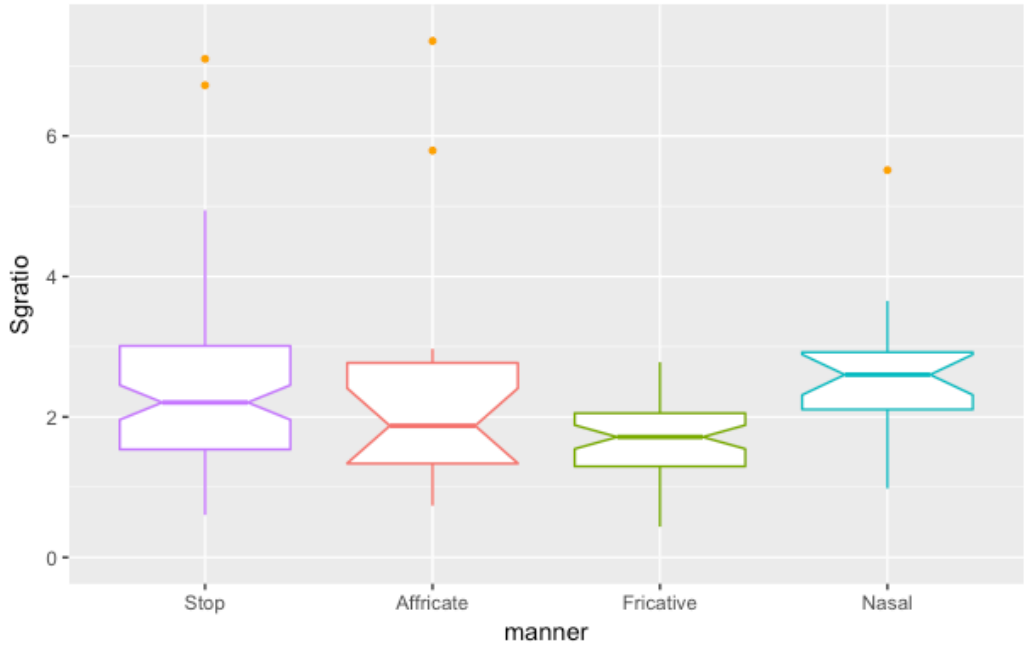


Figure 15: Singleton geminate ratio by manner of articulation for French learners

The observation of Figure 15 and Table 28 indicates several differences in terms of distribution of the SG ratio depending on the manner of articulation of the consonant. First, stops (M=2.2), affricates (M=2.1) and nasals (M=2.6) seem to have higher SG ratio values than fricatives (M=1.7), implying a greater contrast between singletons and geminates for

stops, affricates and nasals than for fricatives. Secondly, the interquartile range (IQR) shows a wider variation range for stops (*IQR* = 1.47) and affricates (*IQR* = 1.67) than for the two other manners of articulations: fricatives (IQR = 0.76) and nasals (IQR = 0.82).

A one-way between subjects ANOVA was conducted to compare the effect of the manner of articulation on SG ratio in stop, fricative, affricate, and nasal conditions (see Table 29 below). There was a significant effect of manner of articulation on the SG ratio at the p <.001 level for the three conditions [$F(3, 175) = 6.466$, $p < .001$].

Table 29: One-way ANOVA results table

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
manner	3	43.7	14.557	6.466	0.000355 ***
Residuals	175	393.0	2.251		

Post hoc pairwise comparisons using a Tukey HSD test indicated a significant difference for fricatives' SG ratio when compared with affricates ($p < .001$) and stops ($p = .02$). However, no difference could be observed for affricates, stops and nasals when compared to the other manners. Specifically, the Tukey HSD test strongly suggests that stops and nasals have identical populations ($p = .98$).

Table 30: Results of the Tukey HSD test on SG ratio for French learners

	diff	lwr	upr	p adj
fricative-affricate	-1.6673767	-2.6970779	-0.63767560	0.0002463
nasal-affricate	-0.7864860	-2.0172142	0.44424231	0.3493726
stop-affricate	-0.9236483	-1.8867350	0.03943854	0.0653539
nasal-fricative	0.8808908	-0.1488104	1.91059194	0.1221058
stop-fricative	0.7437285	0.0558851	1.43157189	0.0284258
stop-nasal	-0.1371623	-1.1002491	0.82592450	0.9827318

These results suggest that, to the exception of fricatives when compared with affricates and stops, all other manner behave in a similar way. This is consistent with the same results for native speakers in section 2 of this chapter, where only fricatives showed a difference with the other manners of articulation in terms of SG ratio. Similarly to the case

of Japanese native speakers, in French learners' pronunciation of the consonantal length contrast, only fricatives show a lower ratio. This indicates that for fricatives, the phonetic implementation of the consonant durational contrast requires less difference between the singleton and the geminate duration than for other consonant types.

3.2.2. Ratio to the preceding vowel

This section presents the analysis of the distribution of the ratio to the preceding vowel in singleton consonants (3.2.2.a.), and geminated ones (3.2.2.b.).

a. Singletons

Figure 16 below is the graphic representation in boxplots of the distribution of the ratio of the target (singleton) consonant to the preceding vowel in French learners' pronunciation. Corresponding numerical values are gathered in Table 31.

Table 31: Distribution of V1C ratio in singletons by manner of articulation for French learners

Singleton	Min	1st Qu.	Median	Mean	3rd Qu	Max
Stop	0.186	0.997	1.296	1.380	1.674	3.007
Affricate	0.2048	0.6032	0.8155	0.9341	1.0890	2.4184
Fricative	0.830	1.248	1.757	1.876	2.196	4.386
Nasal	0.5336	0.6935	0.8325	0.9452	1.1324	1.7176

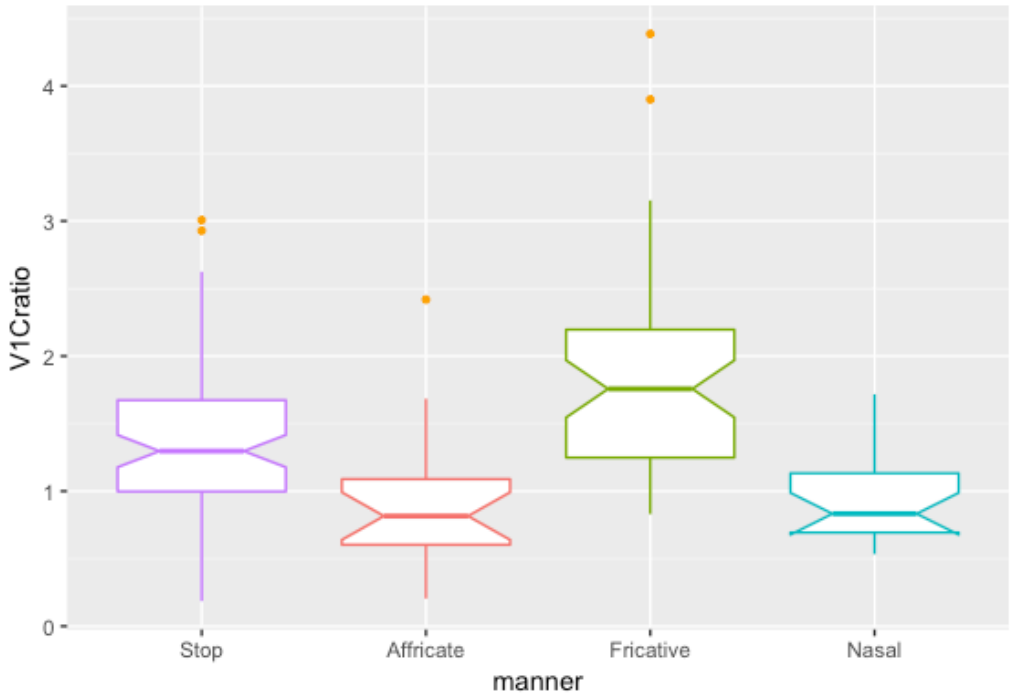


Figure 16: Ratio to the preceding vowel by manner of articulation in singleton consonants for French learners

The observation of the data in Figure 16 and Table 31 suggests a similar behavior in terms of V1C ratio for affricates (M=0.82) and nasals (M=0.83), which is also indicated by the notches on the corresponding boxes in the plot. They also have similar variation ranges: affricates (IQR=0.49), nasals (IQR=0.44). These results suggest less contrast between V1 and C for affricates and nasals than for stops and fricatives. Stops show a higher V1C ratio (M=1.3) when compared to affricates and nasals, with also a wider variation range (IQR=0.68). In addition, fricatives exhibit a different behavior with even higher V1 ratio (M=1.7) and variation range (IQR=0.95).

A one-way between subjects ANOVA was conducted to investigate whether the differences observed in Figure 16 and Table 31 have a statistical significance. That is, whether the manner of articulation has a significant effect on V1C ratio for singletons in stop, fricative, affricate, and nasal conditions in French learners' pronunciation. The manner

of articulation was shown to significantly effect V1C ratio [$F(3, 165) = 17.61$, $p < .001$] for singletons.

Table 32: Results of the one-way ANOVA for V1C ratio in singletons

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
manner	3	19.53	6.511	17.61	5.76e-10 ***
Residuals	165	61.00	0.370		

Post hoc pairwise comparisons were made by running a Tukey HSD test (see results in Table 33 below). Results indicate a significantly different behavior of fricatives regarding V1C ratio when compared to affricates ($p < .001$), nasals ($p < .001$) and stops ($p < .001$). The same thing can be said for stops, for which the difference is also significant when paired with affricates (p=.02) and nasals (p=.02). Only the nasals-affricates pair shows a remarkable similarity (p=.99).

Table 33: Results of Tukey HSD test on V1C ratio in singleton for French learners

	diff	lwr	upr	p adj
fricative-affricate	0.94230980	0.51700657	1.3676130	0.0000003
nasal-affricate	0.01108433	-0.49448002	0.5166487	0.9999336
stop-affricate	0.44599563	0.04324915	0.8487421	0.0235127
nasal-fricative	-0.93122547	-1.34875285	-0.5136981	0.0000002
stop-fricative	-0.49631418	-0.78081113	-0.2118172	0.0000668
stop-nasal	0.43491129	0.04038500	0.8294376	0.0243979

The results of the ANOVA and Tukey HSD test give a statistical significance to what was observed in Figure 16: the p-value remarkably close to 1 for the affricate-nasal pair confirms observations concerning the similarity of their distribution. Results also confirm that stops and fricatives are different both from each other and from the two other manners of articulation. This suggests that the duration of a vowel preceding a nasal or an affricate singleton needs less contrast than one preceding a stop. Furthermore, vowels preceding fricatives had a greater contrast with the consonants.

b. Geminates

Figure 17 below is the graphic representation in boxplots of the distribution of the ratio of the target (geminate) consonant to the preceding vowel in French learners' pronunciation. Corresponding numerical values are gathered in Table 34.

Table 34: Distribution of V1C ratio in geminates by manner of articulation for French learners

Geminate	Min	1st Qu.	Median	Mean	3rd Qu.	Max
Stop	0.9248	1.7965	2.5013	2.8272	3.2338	11.6235
Affricate	0.569	1.336	1.544	1.948	2.519	5.141
Fricative	1.239	2.135	2.929	3.198	3.631	10.009
Nasal	0.9031	1.4368	1.9852	2.3577	2.8203	6.0031

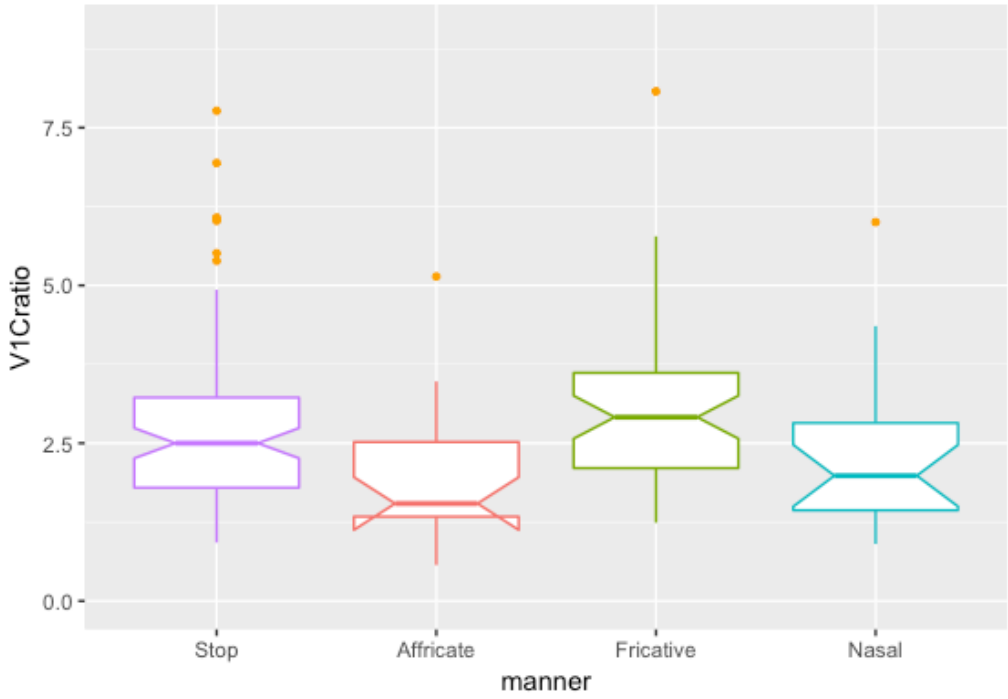


Figure 17: Ratio to the preceding vowel by manner of articulation in geminate consonants for French learners

Concerning the ratio values, Figure 17 indicates a V1C ratio for geminate consonants that is more than twice the same ratio for singletons. It also suggests a similarity with what was observed in Figure 16 for singleton consonants in the distribution. The V1C ratio is

smaller for affricates (M=1.54) and nasals (M=1.98) than for stops (M=2.5) and fricatives (M=2.9). Furthermore, there is more contrast between the preceding vowel and the geminate consonant before stops and fricatives than when the consonant is either an affricate or a nasal. Lastly, the position of notches on the corresponding boxes indicates that affricate and fricative may belong to different populations.

The data presented above was tested by conducting a one-way between subjects ANOVA comparing the effect of the manner of articulation on V1C ratio for geminates in stop, fricative, affricate, and nasal conditions (see Table 35). The manner of articulation was shown to significantly effect V1C ratio values [$F(3, 176) = 3.652$, $p = .01$].

Table 35: Results of the one-way ANOVA for V1C ratio in geminates

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
manner	3	26.3	8.780	3.652	0.0137 *
Residuals	176	423.2	2.404		

Post hoc pairwise comparisons were made by running a Tukey HSD test which result can be found in Table 36 below. The only significant difference observed (to a small extent) is between fricatives and affricates ($p = .01$).

Table 36: Results of Tukey HSD test on V1C ratio for Japanese native speakers

	diff	lwr	upr	p adj
fricative-affricate	1.2497682	0.1856795	2.3138568	0.0140984
nasal-affricate	0.4093891	-0.8624401	1.6812183	0.8377890
stop-affricate	0.8788528	-0.1153819	1.8730874	0.1036210
nasal-fricative	-0.8403791	-1.9044677	0.2237096	0.1744301
stop-fricative	-0.3709154	-1.0803078	0.3384771	0.5285541
stop-nasal	0.4694637	-0.5247709	1.4636983	0.6120002

The statistical analysis of the experimental results for the V1C ratio in Japanese native speakers' pronunciation only allowed to confirm that fricatives have a greater contrast than affricates in the geminate environment. No difference could be observed between any

of the other manners of articulation, which suggests that they follow the same general tendency in terms of V1C contrast when before a geminate consonant.

c. Conclusion

The analysis of the production data for French learners allowed to shed light on the following characteristics of V1C ratio in their pronunciation: First, similarly to what was observed in native speakers' data, the V1C ratio is greater (more than twice) for geminate than singleton environment. This confirms the use of duration as a cue for the pronunciation of the consonantal length contrast. Secondly, in the singleton environment, to one exception, the V1C ratio exhibited a significantly different pattern for each manner of articulation. Namely, fricatives had the higher ratio, followed by stops. Affricates and nasals had the lower V1C ratio values and were significantly similar. The present results contrast with those of Japanese native speakers where in general all manners of articulations were found to behave identically in terms of contrast to the preceding vowel. This indicates that the similarity of the ratios to the preceding vowel observed for native speaker constitutes a piece of evidence for language-specific timing control, and more specifically for mora timing. Indeed, the control of the preceding vowel duration allows them to maintain a consistent moraic rhythm throughout the utterance. This seems to be not acquired yet by the learners in the present case.

Lastly, for V1C ratio in the geminate environment, the results share some similarities with the same data for Japanese native speakers, where, to one exception, results showed no significant difference in V1 to C contrasts between manners of articulation.

3.2.3. Ratio to the following vowel

a. Singletons

Figure 18 below is the graphic representation of the distribution of V2C ratio in French learners' pronunciation. Corresponding numerical values appear in Table 37.

Table 37: Distribution of V2C ratio by manner of articulation in singleton for French learners

Singleton	Min	1st Qu.	Median	Mean	3rd Qu	Max
Stop	0.2612	0.6105	0.9520	0.9987	1.2850	2.2535
Affricate	0.3432	0.5513	0.8407	1.1515	1.0846	3.9500
Fricative	0.9489	1.3840	1.7824	2.2737	2.6926	7.2647
Nasal	0.2853	0.5235	0.6836	0.6624	0.7430	1.3153

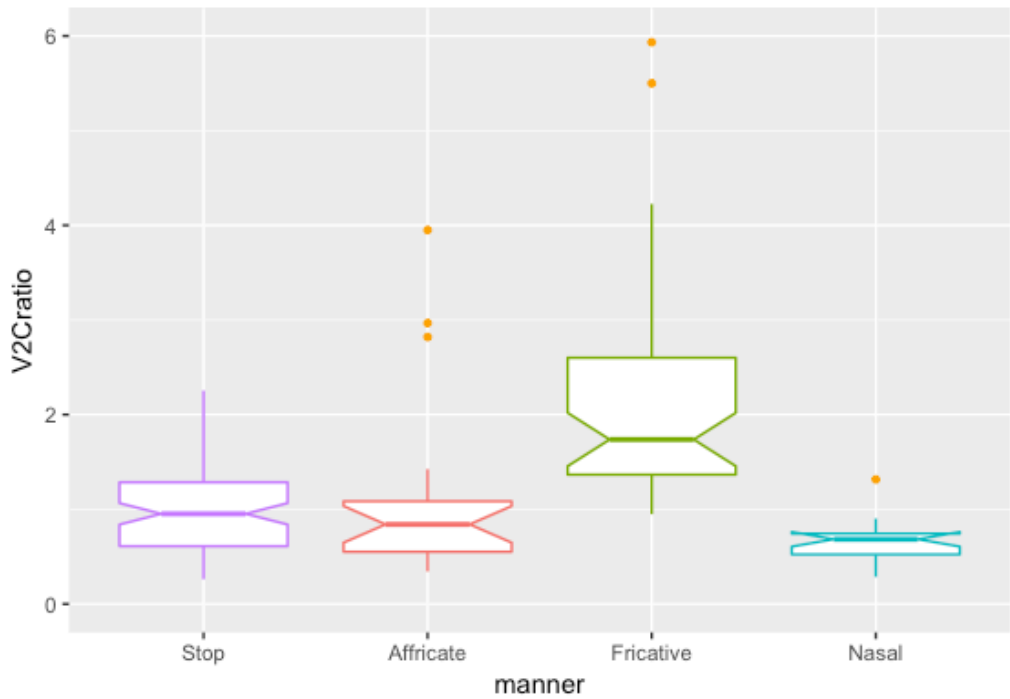


Figure 18: Ratio to the following vowel by manner in singleton for French learners

The observation of Figure 18 above indicates a similar behavior in terms of V2C ratio values for stops and affricates (respectively M=0.95 and M=0.84) and variation ranges (respectively IQR=0.67 and IQR=0.53). On the other hand, the boxes for fricatives and

nasals suggest that these two types of consonant have different patterns. Fricatives have both a higher V2C ratio in general (M=1.78) and a wider variation range (IQR=1.3), suggesting that more contrast is required between the following vowel and the consonant for singleton fricatives than for the other manners. Nasals seem to follow the exact opposite behavior with low V2C values (M=0.68) and an outstandingly low variation range (IQR=0.22).

The significance of the observations above was tested using a one-way between subjects ANOVA, conducted to compare the effect of the manner of articulation on V2C ratio for singletons in stop, fricative, affricate, and nasal conditions (see Table 38). The manner of articulation was shown to have a significant effect on V2C ratio [$F(3,174)=26.99$, $p < .001$].

Table 38: Results of the one-way ANOVA for V2C ratio in singletons

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
manner	3	63.81	21.271	26.99	2.21e-14 ***
Residuals	174	137.14	0.788		

Post hoc comparisons were conducted by running a Tukey HSD test (see Table 39 below). The test results allowed to identify significant differences in the ratio to the following vowel for fricatives when paired with any other consonant type: stops ($p < .001$), affricates ($p < .001$), sonorant ($p < .001$). Comparisons between other manners revealed no significant difference.

Table 39: Results of Tukey HSD test on V1C ratio for French learners

	diff	lwr	upr	p adj
fricative-affricate	1.1221956	0.5015414	1.7428498	0.0000324
nasal-affricate	-0.4891023	-1.2268832	0.2486787	0.3165923
stop-affricate	-0.1528209	-0.7348263	0.4291845	0.9041589
nasal-fricative	-1.6112978	-2.2206046	-1.0019911	0.0000000
stop-fricative	-1.2750165	-1.6820352	-0.8679978	0.0000000
stop-nasal	0.3362813	-0.2336076	0.9061702	0.4214202

The results of the ANOVA and Tukey HSD test above confirm some of the observations made about Figure 17 and Table 37 above: Fricatives appear to follow a behavior significantly different from other consonants with a higher V2C ratio, that is a greater contrast between the following vowel and the consonant for singletons fricatives. The statistical analysis of the data for nasal, stop and affricate groups excluded any significant difference, implying that durational contrast patterns for the three manner groups are identical when the consonant is a singleton.

The present findings replicate those found for Japanese native speakers, where fricatives only were different from other consonant types.

b. Geminates

Figure 19 below is the graphic representation of the distribution of V2C ratio in French learners' pronunciation when the target consonant is a geminate. Corresponding numerical values are gathered in Table 40.

Table 40: Distribution of V2C ratio by manner of articulation in geminates for French learners

Geminate	Min	1st Qu.	Median	Mean	3rd Qu.	Max
Stop	0.5925	1.6890	2.3300	2.6821	2.9774	17.7809
Affricate	0.5258	1.0173	1.7948	1.7579	2.0661	3.8306
Fricative	1.071	2.203	2.675	2.848	3.388	5.890
Nasal	0.8545	1.4361	1.7408	1.8971	2.1027	3.7229

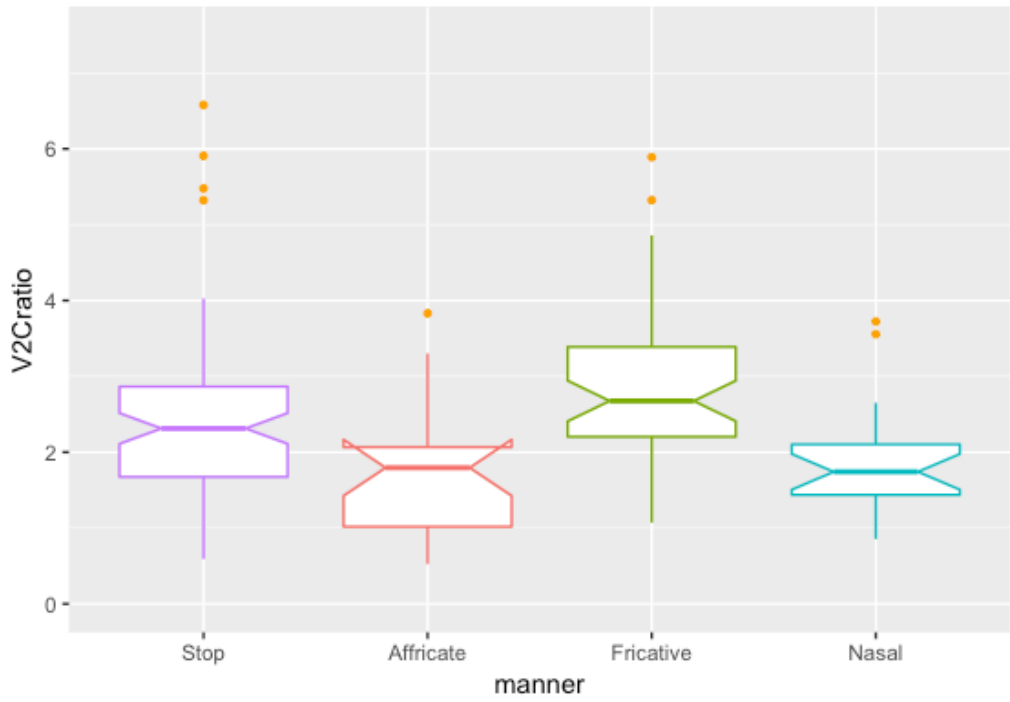


Figure 19: V2C ratio by manner of articulation in geminate consonants in French learners

The data in the box plot in Figure 19 seems to replicate the tendencies observed for V1 in geminate consonants in Figure 17 (section 3.2.b.). Figure 18 indicates a smaller V2C ratio for affricates (M=1.79) and nasals (M=1.74) than for stops (M=2.33) and fricatives (M=2.68), that is, there is a greater durational contrast between V2 and the consonant for stops and fricative geminates. Moreover, the V1C ratio values are about 1.5 times the same values in the singleton environment.

The statistical significance of these observations was tested using a one-way between subjects ANOVA in which the effect of the manner of articulation on V2C ratio for geminates was compared in stop, fricative, affricate, and nasal conditions (see Table 41 below). The manner of articulation was shown to significantly effect V2C ratio [$F(3,173) = 3.57$, $p = .01$].

Table 41: Results of the one-way ANOVA for V2C ratio in geminates for French learners

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
manner	3	26.9	8.969	3.57	0.0153 *
Residuals	173	434.6	2.512		

Post hoc pairwise comparisons were made by running a Tukey HSD test which result can be found in Table 42 below. The results of the Tukey HSD test indicate no significant difference between any of the pairs. It is also worth mentioning that the p-value for the affricate-nasal pair (*p*=.99) and the stop-fricative pair (p=.94) are especially high, implying a high degree of similitude between the corresponding populations.

Table 42: Results of Tukey HSD test on V2C ratio in geminates for French learners

	diff	lwr	upr	p adj
fricative-affricate	1.0896475	-0.001359351	2.1806544	0.0504175
nasal-affricate	0.1391745	-1.161042874	1.4393920	0.9924997
stop-affricate	0.9241558	-0.094368827	1.9426804	0.0901283
nasal-fricative	-0.9504730	-2.041479853	0.1405339	0.1115927
stop-fricative	-0.1654917	-0.898378526	0.5673950	0.9362629
stop-nasal	0.7849812	-0.233543368	1.8035058	0.1922236

Statistical tests show that, in contrast with the observations made on Figure 19, there is no difference whatsoever in terms of durational contrasts between the following vowel and the geminate consonant for any of the four manners of articulation: That is, French learners don't make any distinction in V2C ratio between manners of articulation. This result differs from those of Japanese native speakers, where fricatives and nasals had divergent patterns.

c. Conclusion

This section provided a comparison of the variations in V2C ratio in geminate and singleton conditions by manner of articulation for French L2 learners. The following tendencies were observed: First, similarly to the results for the ratio to the preceding vowel,

the values of V2C ratio are greater (about 1.5) in geminate than in singleton environment. Secondly, results in singleton condition replicated those of Japanese native speakers, with fricatives showing a greater durational contrast than for the other manners, which were significantly similar to each other. In geminate condition however, in contrast with results for Japanese native speakers, no difference could be observed between any of the four manners of articulation.

3.2.4. Comparison within each manner of articulation

The preceding section investigated the experimental data collected from French learners of Japanese by comparing all four manners of articulation for each target segment in singleton and geminate conditions. In this section, the durational behaviors of the target segments between singleton and geminate environment will be examined separately for each manner of articulation.

a. Stops

The bar plot in figure 20 is a graphic representation of the relative mean durations of V1(orange), C (blue) and V2 (red) pronounced by French learners when the target consonant is a stop, in singleton (top) and geminate (bottom) environments. Corresponding values are gathered in Table 43.

Table 43: Mean duration values for stops by French learners

	V1	C	V2
Singleton	0.72	1	1.00
Geminate	0.87	2.45	0.91
Mean ratio	1.19	2.45	0.91

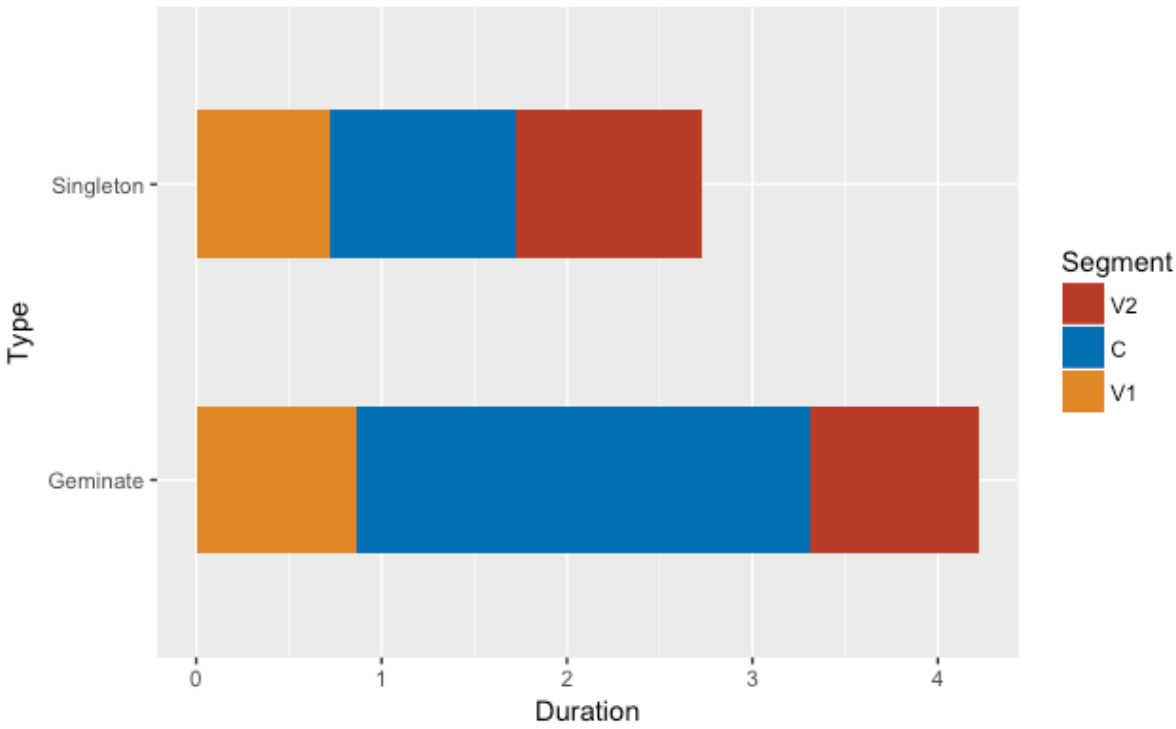


Figure 20: Relative segment mean duration for stops in singleton and geminate consonants by French learners

Based on Figure 20, the following observations can be made concerning the characteristics of the consonantal length contrast for stops in French learners' pronunciation. First, we observe a SG ratio of 2.45, that is a geminated stop is 245% the length of a singleton one. Secondly, the preceding vowel is longer before a geminate (119%) than before a singleton consonant and the following is shorter (91%) for a geminate than for a singleton. This result is consistent with Japanese native speakers' data.

An independent-samples t-test was conducted to compare the duration of the preceding vowel, the following vowel and the target consonant in singleton and geminate environments. Although a significant difference was observed for the consonant duration between singletons and geminates [$t(118) = 10.992$, $p < .001$], results were non-significant for the preceding [$t(169) = -1.35$, $p = .18$, ns.] and the following vowel [$t(138) = 0.56$, $p = .56$, ns.] durational contrasts.

These results suggest that the differences in vowel duration observed are non-significant, that is, both the preceding and the following vowels are of equal length in singleton and geminate conditions. This behavior is different from what was observed for the pronunciation of the same segments by Japanese native speakers, where the duration of the preceding vowel was shown to be an important production cue and to be significantly different between singleton and geminate.

b. Affricates

Figure 21 below represents the relative mean durations of V1 (green), C (orange), the frication period F (blue) and V2 (red) when the target consonant is an affricate, between singleton (top) and geminate (bottom) for French learners of Japanese.

Table 44: Relative mean duration values for affricates by French learners

Affricates	V1	C	Frication	V2
Singleton	1.07	1	2.15	0.87
Geminate	1.73	3.37	2.99	1.92
Mean ratio	1.62	3.37	1.40	2.21

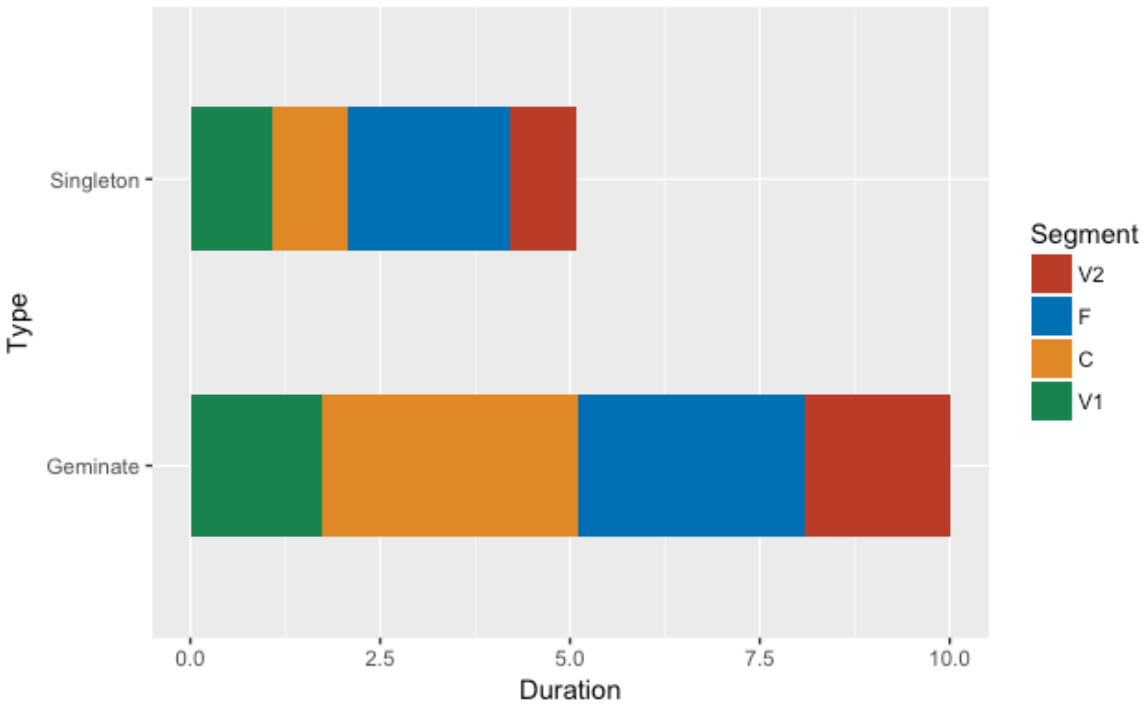


Figure 21: Relative segment duration for affricates in singleton and geminate consonants for French learners

The observation of Figure 21 and Table 44 above indicates that V1 is longer before a geminate than before a singleton (162%). A similar pattern is observed for the following vowel, which is longer (221%) after a geminate consonant. The mean SG ratio indicates an exceptionally high ratio, with geminate closure being more than three times the one of a singleton (337%). The frication duration also shows some increase with a ratio of 1.40 from the singleton to the geminate environment. Moreover, it is also worth mentioning the high value of frication duration, when compared to native speakers', for both singleton (where is it 2.15 times the length of the closure) and geminate (where is it about the length of the geminated consonant closure). In native speakers' case the frication duration is about the same length as the closure for a singleton consonant and no significant variation was observed for a geminated one.

These observations were tested by conducting several independent samples t-test. The test results indicate a significant difference between the singleton and geminate durations [$t(23) = 3.80$, $p < .001$]. However the increase observed in V1 duration was non-significant [$t(30) = 1.33$, $p = .19$, ns.], as well as the longer duration of the following vowel V2 between singleton and geminate [$t(34) = 1.99$, $p = .05$, ns.]. Lastly, similarly to Japanese native speakers' case, the increase in frication duration is non-significant [$t(36) = 0.65$, $p = .51$, ns.] between the two environments.

To conclude, affricates in French learners' pronunciation share with native speakers the significant increase in closure duration between singleton and geminate, which is also the primary production cue for gemination. On the other hand, the absence of difference observed in the durations of preceding and following vowels are in contrast with native speakers' pronunciation. The role of frication in French learners' pronunciation is also worth mentioning as, although no significant difference is observed between singleton and geminate conditions, its value is more than twice the frication duration in singleton consonants. The behavior of the frication duration in affricates will be discussed further later on.

c. Fricatives

Figure 22 below compares in a bar plot the relative mean durations of V1 (orange), C (blue) and V2 (red) when the target consonant is a fricative, between singleton (top) and geminate (bottom) for French learners. Corresponding numerical values can be found in Table 45.

Table 45: Mean duration values for fricatives by French learners

Fricatives	V1	C	V2
Singleton	0.53	1	0.44
Geminate	0.53	1.702	0.60
Mean ratio	1	1.702	1.36

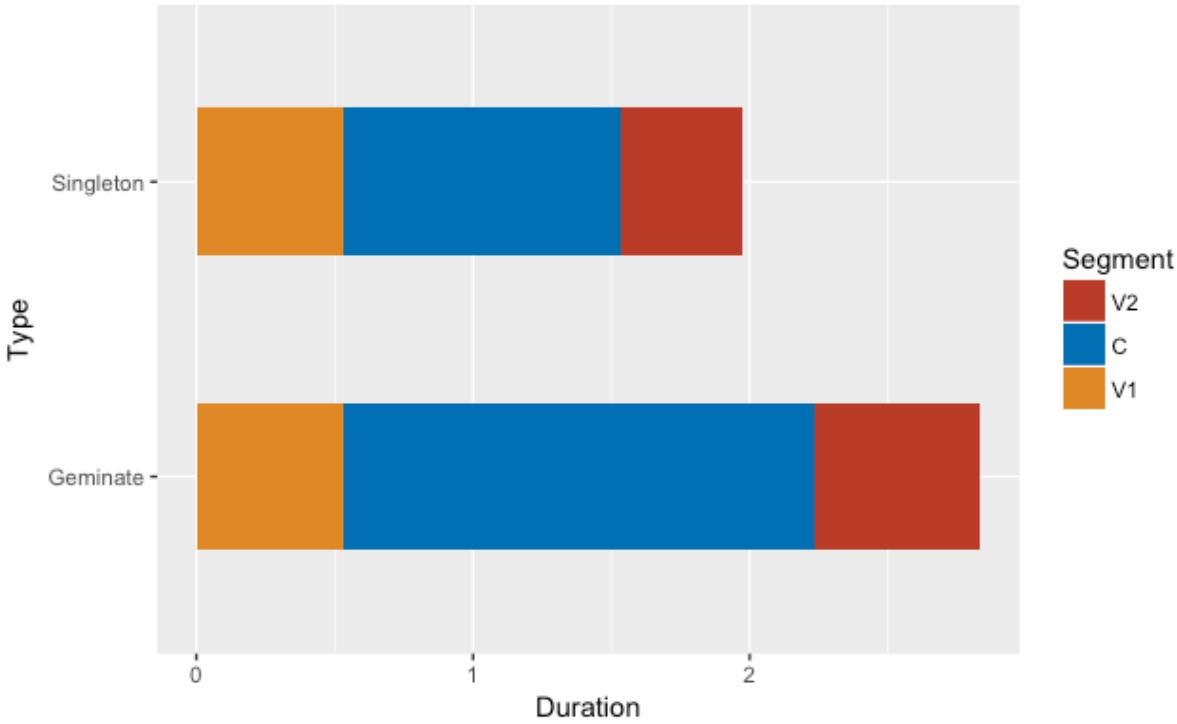


Figure 22: Relative segment duration for fricatives in singleton and geminate consonants for French learners

The observation of Figure 22 and Table 45 indicates that: The duration of a geminated fricative is 170.2% the duration of a singleton one. Furthermore, the duration of the preceding vowel seems to stay unchanged between singletons and geminates, but we observe a longer duration for the following vowel when before a geminate than a singleton (136%).

These observations were tested with independent samples t-tests. The results confirmed the difference in singleton and geminate duration [$t(94) = 6.08$, $p < .001$], and

the absence of a significant difference for the preceding vowel [$t(96) = -0.59$, $p = .56$, ns.]. The increase observed in the following vowel was also non-significant [$t(94) = 1.34$, $p = .18$, ns.].

d. Nasals

The bar plot in Figure 23 below presents the relative mean durations of V1 (orange), C (blue) and V2 (red) when the target consonant is a nasal, between singleton (top) and geminate (bottom) environments for French learners of Japanese. Corresponding numerical values can be found in Table 46.

Table 46: Mean duration values for nasals by French learners

Nasals	V1	C	V2
Singleton	1.06	1	1.51
Geminate	1.10	2.58	1.36
Mean ratio	1.04	2.58	0.90

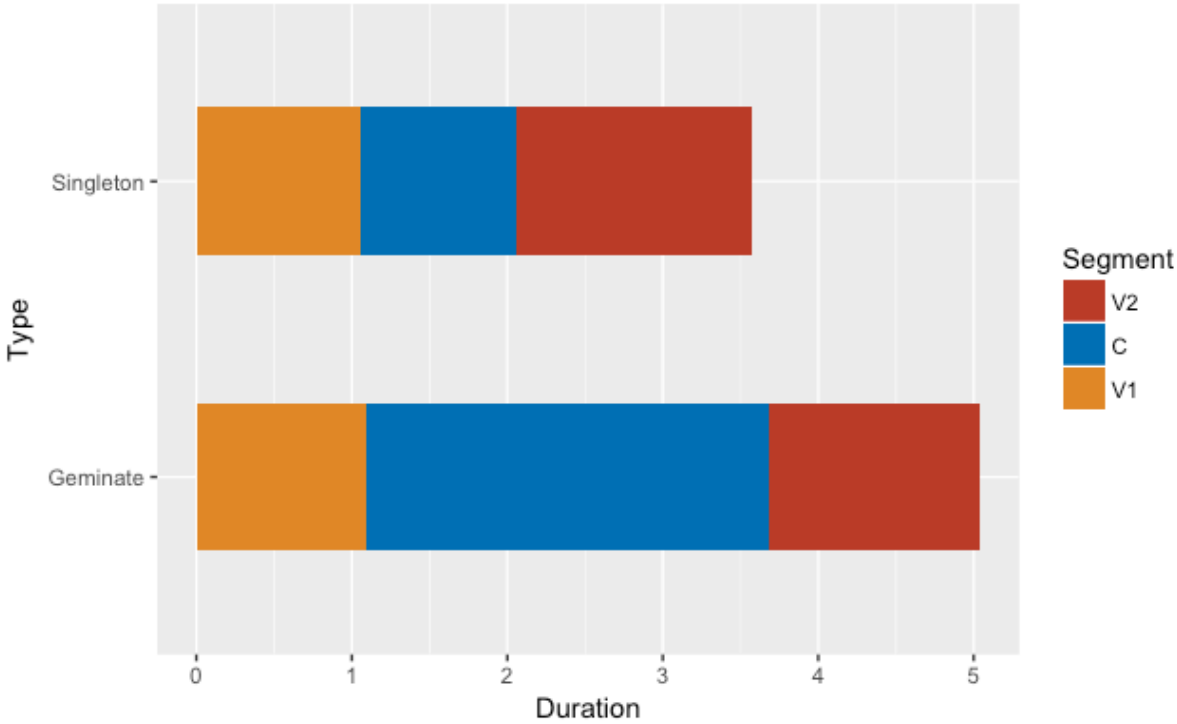


Figure 23: Relative segment duration for nasals in singleton and geminate consonants for French learners

The observation of Figure 23 and Table 46 above allows to identify durational patterns in French learners' pronunciation. As seen in the analysis of consonants from other manners of articulation, for nasals as well geminates are longer (258%) than singletons consonants. The values for V1 seem to indicate that the preceding vowel duration doesn't change between singleton and geminate (104%), and data for the following vowel suggest a shorter V2 after a nasal geminate (90%).

Independent-samples t-test were conducted to compare durational cues for singleton and geminated nasal consonants. The difference between the durations of nasal singletons and geminates was confirmed [$t(21) = 6.87$, $p < .001$]. However, the results of the t-tests showed no significant difference for the means of the preceding vowel durations [$t(35) = 0.57$, $p = .57$, ns.] and the following vowel durations [$t(35) = -1.08$, $p = .28$, ns.] in a singleton and in a geminate context. The results of the statistical tests suggest that the duration of V1 and V2 are similar between the two environments, a result which matches those of native speakers for nasals.

e. Conclusion

This section provided an analysis of the target segments' duration for the singleton geminate contrast by looking at consonants from each manner of articulation separately. Specifically, the statistical significance of the observed durational correlates was examined, and allows to make the following claims about French learners' pronunciation of Japanese consonantal length contrast. First, results confirmed that French learners rely on the same primary production cue as Japanese native speakers for the singleton geminate distinction: For all manners of articulation singleton consonants were significantly shorter than

geminated ones, with a SG ratio matching native speakers'. Secondly, no significant difference was observed regarding the duration of the preceding vowel between singleton and geminate environments for any of the fours manner groups. The same behavior was observed for the following vowel. The similar durations of both V1 and V2 regardless their environment suggests that this is not a cue active in French L2 learners' pronunciation of Japanese geminates.

3.3. Summary

The third section of this chapter was devoted to the analysis of the patterns observed experimentally in French learners' pronunciation. In order to identify the production cues active these learners' pronunciation of the consonantal length contrast in Japanese, the investigation focused on the global results in section 3.1. before comparing the effect of manner of articulation on the behavior of each target segment in section 3.2. Specifically, 3.2.1 explored the differences between manners for each segment in singleton and geminate condition and 3.2.2. the differences within manners. Findings for each item studied were also compared with those of Japanese speakers from the control group.

The results of the analyses conducted in the present section suggest the following patterns for of French learners' production of Japanese consonantal length contrasts:

(i) The global results indicate that geminate duration is at least twice the singleton duration (SGratio =2.35).

(ii) There is no difference regarding the preceding and following vowels' durations in singleton and geminate.

(iii) The results of the comparisons between and within manners of articulation are summed up in Table 47 and 48 below:

Table 47: Summary of the results of the comparison between manners of articulation for French L2 learners

	V1	C	V2
Singleton	N=A＜S ＜F	F＜S=A=N	N=S=A＜F
Geminate	S=A=F=N		S=A=F=N

Table 48: Summary of the results for the comparison within each manner of articulation in French learners

	Stop	Affricate	Fricative	Nasal
V1	V1sing =V1gem			
C	S＜G			
F	NA	Fsing=Fgem	NA	NA
V2	V2sing=V2gem			

As predicted, the results showed both similar and divergent patterns when compared to Japanese native speakers' data. It appears that the primary cue in the phonetic implementation of the consonantal length contrast for Japanese native speakers, that is closure/frication duration, is also active in French L2 learners' pronunciation. This is indicated in particular by both the raw durations for singleton and geminate, and by the mean SG ratio observed for French learners which was of 2.35[37]. On the other hand, the analysis of the duration of the preceding and following vowels reveals pattern that do not correspond to those of native speakers. There was no significant difference between the duration of the preceding vowel when before a singleton and a geminate consonant. This was also true for following vowels. These results suggest that, for French learners, the duration of surrounding vowels is not an active cue in their pronunciation, and that the closure duration is the only durational cue they rely on for phonetic implementation of the Japanese consonantal length contrast.

[37] When looking at manners separately, all manners had a SG ratio above 2, to the exception of fricatives. This was however also consistent with Japanese native speakers' data.

4. ITALIAN L2 LEARNERS

In this fourth section, we examine the results obtained by the analysis of the data recorded from Italian L2 learners of Japanese. Specifically, it focusses on the identification of production cues that might be active in Italian L2 learners' production of the Japanese consonantal length contrast.

The structure of this section is similar to those of the two preceding ones reporting results from Japanese and French native speakers: After introducing general results, the analysis will look in detail at the results by manner of articulation in a second part. Lastly, a third sub-section will deal with the durational patterns for each segment within each manner of articulation. The analysis also includes descriptive comparisons on Italian native speakers' production with the control group of Japanese native speakers.

4.1. General description

4.1.1. Consonant duration

Table 49 below presents values for the singleton geminate ratio as well as the observed mean consonant raw durations for singleton and geminates. The observed singleton mean duration was of 96ms and it was of 190ms for geminate consonants. When compared with an independent-samples t-test, the difference between singleton and geminate consonants' raw durations was shown statistically significant [$t(240.11) = 9.2854$, $p < .001$]. The general mean singleton geminate ratio observed was 2.306, indicating that a geminate consonant is about 2.3 times longer than its singleton counterpart. The distribution of the values for singleton geminate ratio in Table 49 is represented graphically by the box plot in Figure 24 below.

Table 49: Numerical values for consonants in Italian learners' production

	Min	1st Qu.	Median	Mean	3rd Qu.	Max
SG ratio	*0.00*	*1.646*	*2.099*	*2.306*	*2.714*	*6.6*
Mean C duration	*singleton*	*96ms*	*geminate*	*190ms*		

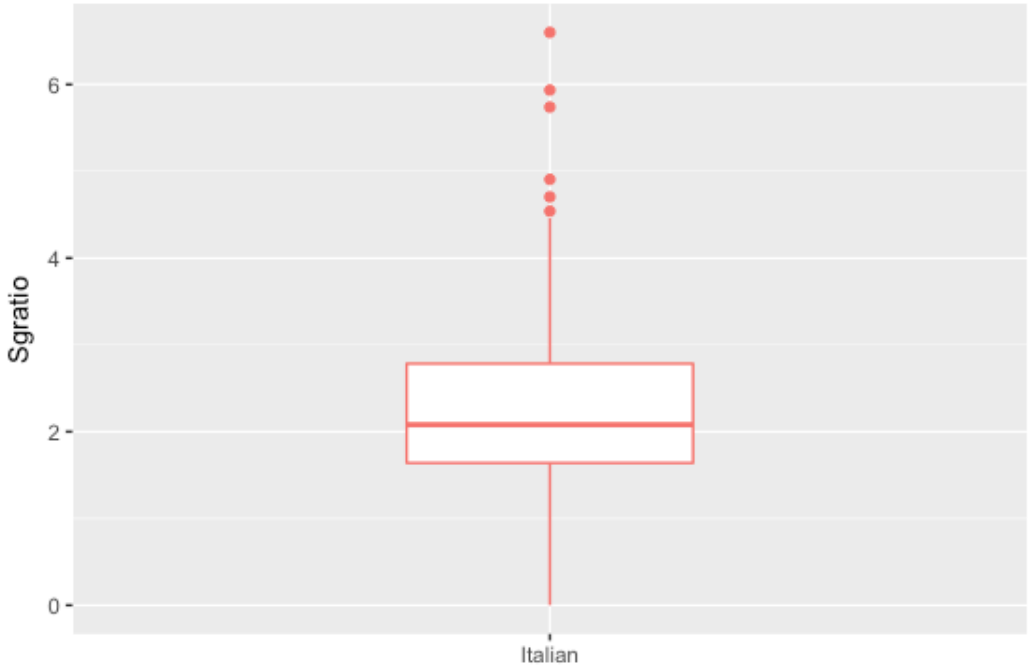


Figure 24: Singleton geminate ratio for Italian learners

Although the mean singleton and geminate values are greater for Italian learners than for Japanese native speakers (for who the mean durations were 70ms for a singleton and 150 ms for a geminate consonant), the experimental results on SG ratio are consistent with those of Japanese native speakers. This indicates that they are able to maintain a consistent ratio across speech rate. Furthermore, although the variation range of the ratios is wider for Italian learners, they rely on the same primary production cue as Japanese native speakers for the Japanese singleton-geminate contrast, that is, closure/frication duration. Results are also consistent with those of previous studies on Japanese geminate consonants (Beckman 1982, Han 1962, 1994, 1992, Homma 1981, Kawahara 2006, Port et al. 1987 *inter alia*.), that report that they are at least twice as long as singletons with a ratio between 2 and 3.

I am not aware of any production studies on Japanese geminates in Italian native speakers' pronunciation that would provide some similar data for comparison. However, the presents results were expected, as previous studies on Italian geminates showed that the primary production cue is similar for the two languages (Esposito and Di Benedetto 1999, Blumstein et al. 1998).

4.1.2. Vowel duration

In this section, I will introduce the global results in terms of duration for the preceding and following vowels. Table 50 presents a summary of the global mean ratios for vowel durations when pronounced by the Italian learners of Japanese recorded in the experiment.

Table 50: Mean ratios for vowels in Italian L2 learners' pronunciation

	Singleton	*Geminate*
V1C ratio	*1.23*	*2.66*
V2C ratio	*1.3*	*2.15*

For Italian learners of Japanese, the mean of the ratio to the preceding vowel was of 1.23, and to the following vowel was 1.3 for singleton consonants. The difference between the two populations was examined using a t-test, which showed an absence of significant difference between V1C and V2C in singleton consonants [$t(231.96) = -0.57$, $p = .57$]. This result indicates the absence of difference between the durations of the preceding and following vowels. For geminate consonants, the mean ratio to the preceding vowel was 2.66 and it was 2.15 for the following vowel. The difference was tested using a t-test, which results indicates a significant difference between V1C ratio and V2C ratio when C is a geminate consonant [$t(228.93) = 3.86$, $p < .001$]. This difference suggests that V1 and V2

have a different duration when in a geminate environment, with a shorter V1 indicated by the higher ratio (more contrast between the consonant and the vowel duration). These results present interesting divergences from what was observed for Japanese native speakers in the first section of this chapter: In the case of Japanese native speakers, similarly to Italian learner, V1 and V2 did not differ significantly in singleton but did so in geminate environment. However, this difference for the geminate environment is reflected in the opposite way for Japanese native speakers and Italian learners, as the preceding vowel is longer for Japanese native speakers and shorter for learners.

Table 51 Relative mean segment durations calculated from mean ratios

	V1	C	V2
Singleton	0.86	1	0.77
Geminate	0.81	2.35	1.07
Ratio	0.94	2.35	1.39

Table 51 above presents relative segment lengths calculated using the mean SG ratio and V1C, V2C mean ratios for singleton and geminates. The table indicates that the preceding vowel ratio is 0.94, implying that a vowel preceding a geminate is 6% shorter than one preceding a singleton. The following vowel appears to be longer (39%) in a geminate environment when compared to the singleton environment. This is represented graphically in Figure 25 below.

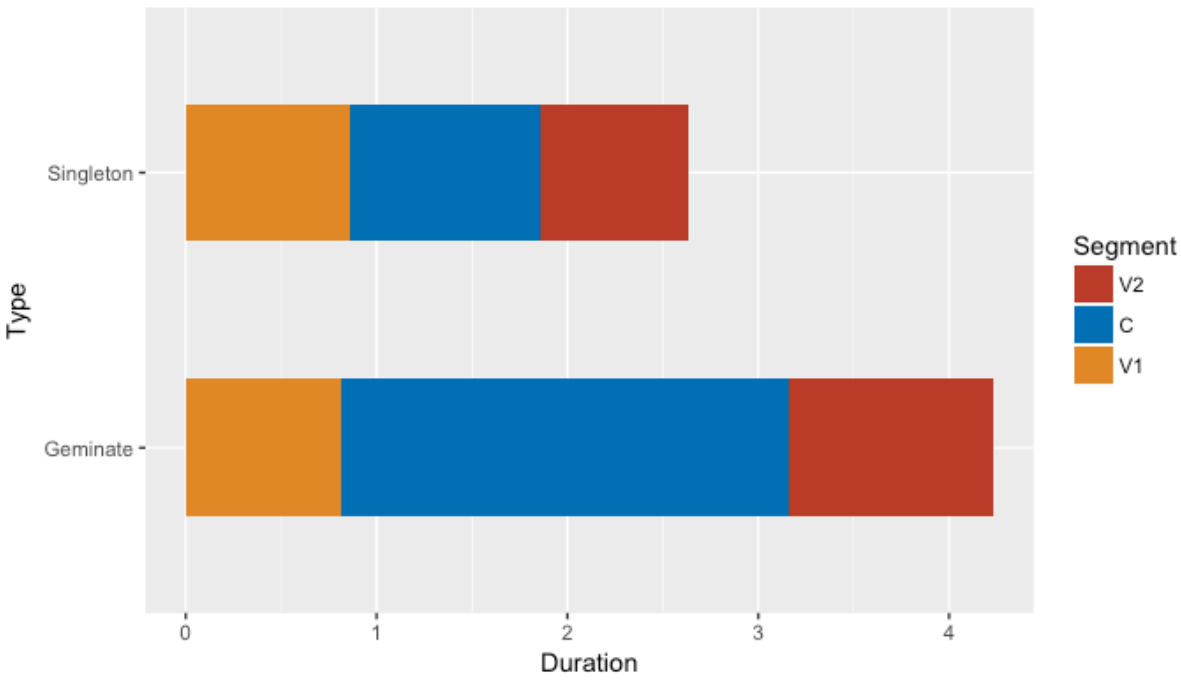


Figure 25: Relative global segment duration in singleton geminates consonants for Italian learners

The difference in V1 duration between singleton and geminate contexts was significant, as shown by the results of the independent samples t-test in singleton and geminate condition [$t(208.73)= 2.17$, $p = 0.03$]. However, the same test for V2 duration indicated no difference [$t(228.65) = 1.59$, $p =.11$], implying that the observed difference between V2 durations above is no more than a tendency. In conclusion, the global means show that V1 is shorter before a geminate, and no difference is observed for V2 between singleton and geminate environment.

The shortening of the vowel preceding a geminate consonant is a well-known production cue for Italian geminates: V1C ratio is strongly correlated with gemination as introduced in Chapter 2, section 2.2. (Picket et al. 1999, Rossetti 1993, 1994, Giovanardi and Di Benedetto 1998, Esposito and Di Benedetto 1999, Mattei and Di Benedetto 2000, Faluschi and Di Benedetto 2001). The present results suggest that Italian native speaker rely on their L1's production cues for geminate production in Japanese.

In sum, the global analysis of the results for Italian learners, indicates that the primary cue active in Italian learners' productions in Japanese is the closure/frication duration, similarly to Japanese native speakers, and similarly to their L1. The singleton geminate ratio was of 2.3 which is also consistent with experimental results for Japanese native speakers, as well as with those observed in previous studies.

What is observed here suggests that another similarity with Japanese native speakers' production lies in the use of the preceding vowel length as a cue for geminate production, which was not observed in the case of French learners. However, in the case of Italian learner, the vowel is shortened before a geminate, while it is lengthened in Japanese.

These cues will be investigated further by comparing each segment by manner of articulation in the following sections.

4.2. Results by consonant manner

This section describes the results of the analysis of the data recorded from Italian learners of Japanese in terms of durational contrast with regard to the manner of articulation of the target consonant.

4.2.1. Consonantal length

Figure 26 below compares in box plots the singleton geminate ratio distribution with regard to the manner of articulation of the target consonant for Italian learners. Table 52 contains the corresponding numerical values.

Table 52: Distribution of singleton geminate ratio by manner of articulation for Italian learners

	Min	1st Qu.	Median	Mean	3rd Qu	Max
Stop	0.000	1.729	2.206	2.434	3.050	5.935
Affricate	0.5696	1.2765	1.6460	1.6189	1.8038	2.7142
Fricative	0.8473	1.4416	1.7513	1.9914	2.2883	6.5997
Nasal	1.876	2.469	3.119	3.165	3.803	4.906

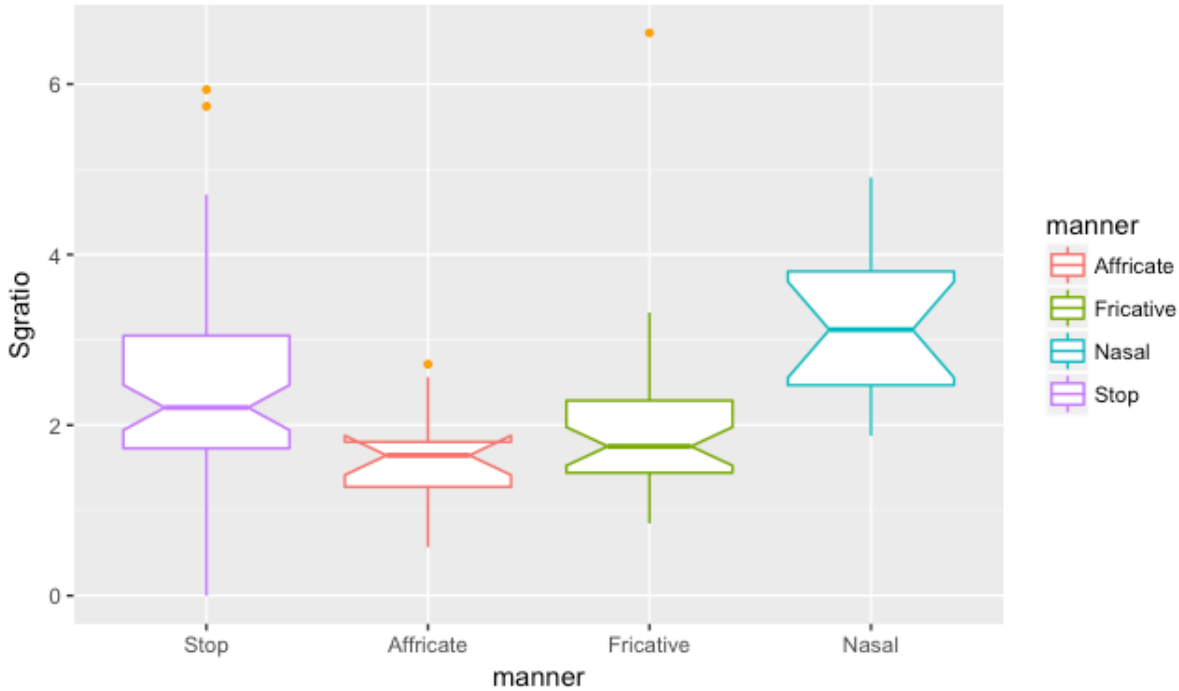


Figure 26: Singleton geminate ratio by manner for Italian learners

The observation of Figure 26 and Table 52 above suggests that SG ratios can be divided into three categories according to their manners of articulation. First, affricates (M=1.62) and fricatives (1.99) have lower SG ratios than the two other manners, implying less contrast between the singleton and geminate consonants. These two manners also have a narrower interquartile range, with *IQR*= 0.53 for affricates and *IQR*=0.85 for fricatives, which indicates a narrower range of variations in the SG ratio. On the other hand, the variation range for stops (*IQR*=1.32) and nasals (*IQR*=1.33) appears to be similar, although they show outstandingly different SG ratio values. Stops have higher SG ratios (M=2.43)

than fricatives and affricates, and the ratios observed for nasals (M=3.17) show the highest values.

A one-way between subjects ANOVA was conducted to compare the effect of the manner of articulation on SG ratio in stop, fricative, affricate, and nasal conditions (see results in Table 53 below). There was a significant effect of manner of articulation on the SG ratio at the p <.05 level for the three conditions [$F(3, 120) = 6.556$, $p < .001$].

Table 53: One-way ANOVA results table

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
manner	3	20.94	6.981	6.556	0.000384 ***
Residuals	120	127.78	1.065		

Post hoc pairwise comparisons using the Tukey HSD test (see Table 54) confirm the similarity of fricatives and affricates (p=.68). The test also partly validates the observation made on Figure 26 that nasals are significantly different from fricatives (p= .002) and affricates (p < .001). However, the difference in terms of SG ratio between stops and the other groups was not supported by the results of the post hoc test.

Table 54: Results of the Tukey HSD test on SG ratio for Italian learners

	diff	lwr	upr	p adj
fricative-affricate	0.3725868	-0.500657876	1.24583142	0.6830915
nasal-affricate	1.5458728	0.510332021	2.58141355	0.0009406
stop-affricate	0.8153441	-0.004788617	1.63547676	0.0519635
nasal-fricative	1.1732860	0.323086189	2.02348584	0.0026234
stop-fricative	0.4427573	-0.125672726	1.01118733	0.1830302
stop-nasal	-0.7305287	-1.526079566	0.06502214	0.0839985

The post hoc test confirms that affricates and fricatives have a similar behavior in terms of SG ratio, and are different from nasals. Although the observation of Figure 26 suggests that stops follow different patterns from affricates and fricatives as well as from nasals, statistical tests indicate a lack of statistical significance, and that it is no more than tendencies.

These results need to be put into perspective with those of previous studies for Italian geminates introduced in Chapter 2 and reproduced in Table 55 below (Esposito and Di Benedetto 1999, Faluschi and Di Benedetto 2000, Giovanardi and Di Benedetto 1998, Mattei and Di Benedetto 2000). Although statistical significance couldn't be established for all the manner pairs in our results, it is interesting to note that the tendencies observed in Italian learners' productions of Japanese geminates are similar to those in their L1: Affricates and fricatives behave in a similar way with low SG ratios, geminated stops are twice the duration of singletons, and nasals have the highest ratio values.

Table 55: Mean ratios by consonant manner for Italian geminates in previous studies

	Stop	Affricate	Fricatives	Nasals
Mean SG ratio	2	1.62	1.73	2.34

The comparison of the experimental results for Italian learners with those of the control group of Japanese native speakers observed in 2.2.1 sheds light on several discrepancies between the two groups. Indeed, the experimental results point out the fact that in Japanese native speakers' pronunciation, only fricatives follow a significantly different behavior from other consonants with a lower SG ratio (M=1.7), and the difference between stops (M=2.17), affricates (M=2.22) and nasals (M=2.43) was not significant. As results from the previous section suggest, that Italian native speakers rely on their L1 production cues for the pronunciation of Japanese geminates, we can impute the low SG ratio for affricates to the property of Italian affricate geminates to lengthen both the closure and the frication part, making the distinction between singleton and geminates less straightforward, and inducing a lower SG ratio. Inversely, in Japanese affricates geminates lengthening is applied to the closure part only, causing the ratio to be similar to stops'. Italian learners' pronunciation of Japanese affricate geminates will be discussed further in Chapter 6.

4.2.2. Ratio to the preceding vowel

This section presents the analysis of the distribution of the ratio to the preceding vowel for Italian learners in singleton consonants (4.2.2.a.), and geminated ones (4.2.2.b.).

a. Singletons

Figure 27 below accounts for the distribution of the ratio of the target (singleton) consonant to the preceding vowel V1C ratio, in Italian learners' pronunciation. Corresponding numerical values are gathered in Table 56.

Table 56: Distribution of V1C ratio in singletons by manner of articulation for Italian learners

Singleton	Min	1st Qu.	Median	Mean	3rd Qu	Max
Stop	0.3742	0.8359	1.0256	1.1716	1.4427	3.7521
Affricate	0.4212	0.6100	0.8734	1.1595	1.0948	4.8977
Fricative	0.6556	1.0986	1.3396	1.5701	1.9239	3.7513
Nasal	0.3876	0.4806	0.6858	0.7251	0.9419	1.1947

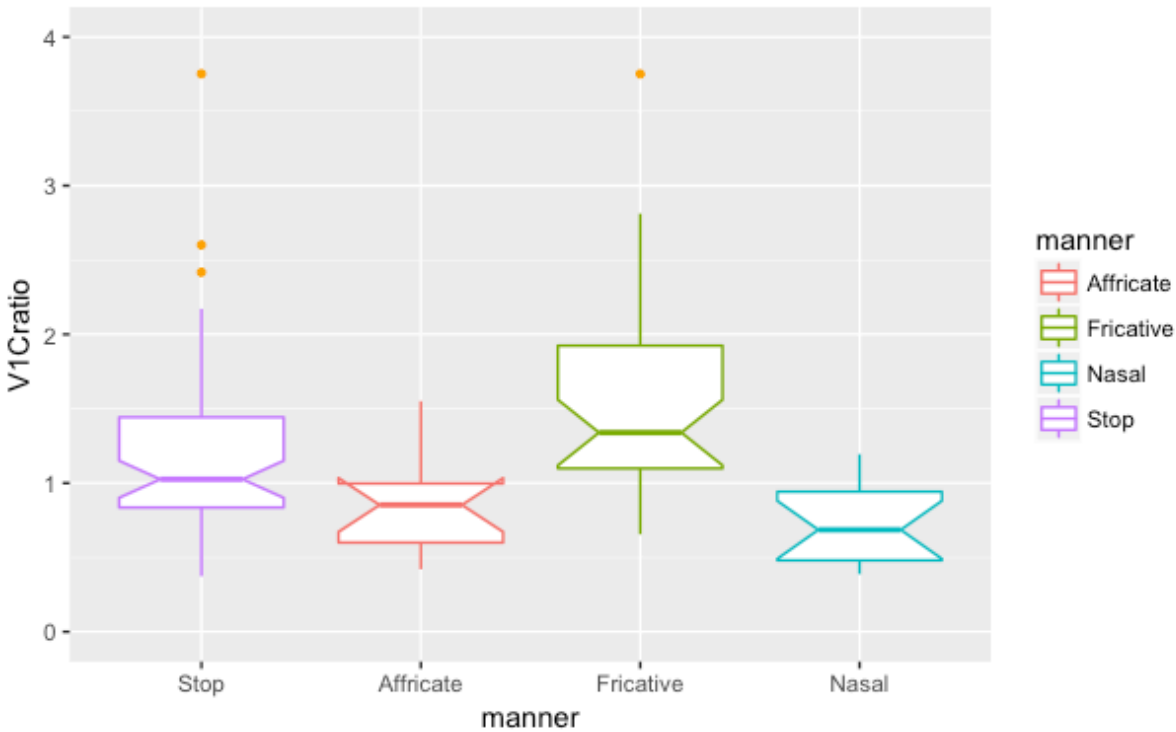


Figure 27: Ratio to the preceding vowel by manner in singleton consonants for Italian learners

The observation of the data in Figure 27 and Table 56 above suggests that stops (M=1.17) and affricates (M=1.16) have similar populations, as indicated by notches in the corresponding boxes in the plot. Fricatives' V1C ratio appears to be higher (M=1.57) than for all other consonant manners, suggesting a greater contrast between the vowel and the consonant durations. On the other hand, the box for nasals indicates a lower V1C ratio (M=0.73) and a different behavior of nasals when compared to stops and fricatives.

A one-way between subjects ANOVA was conducted to investigate whether the differences observed in Figure 27 and Table 56 are statistically significant. That is, whether the manner of articulation has a significant effect on V1C ratio for singletons in stop, fricative, affricate, and nasal conditions in Italian learners' pronunciation. The manner of articulation was shown to significantly affect V1C ratio [$F(3, 117) = 5.865$, $p < .001$] for singletons.

Table 57: Results of the one-way ANOVA for V1C ratio in singletons

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
manner	3	7.88	2.627	5.865	0.000913 ***
Residuals	117	52.42	0.448		

Post hoc pairwise comparisons were made by running a Tukey HSD test (see results in Table 58 below). Results confirm the difference between fricatives and stops (p=.03) and fricatives and nasals ($p < .001$). Differences between other pairs were shown to be non-significant, with an outstandingly high p value (p=.99) for the stop-affricate pair, confirming the similarity observed in Figure 27.

Table 58: Results of Tukey HSD test on V1C ratio in singleton for Italian learners

	diff	lwr	upr	p adj
fricative-affricate	0.4106790	-0.15592862	0.97728658	0.2383408
nasal-affricate	-0.4343482	-1.10626219	0.23756572	0.3362947
stop-affricate	0.0121510	-0.52233464	0.54663663	0.9999249
nasal-fricative	-0.8450272	-1.39668210	-0.29337232	0.0006552
stop-fricative	-0.3985280	-0.77072370	-0.02633227	0.0308273
stop-nasal	0.4464992	-0.07210837	0.96510683	0.1175838

The same results for Japanese native speakers exhibit a different behavior, as, to the exception of the one between nasals and fricatives, no significant difference could be observed between any of the pairs, suggesting a rather similar behavior of the ratio to the preceding vowel for all manners of articulation in native speakers' pronunciation. In contrast, here for Italian learners, it is for fricative consonants only that V1C ratio exhibits a different behavior, when compared with stops and nasals. The higher V1C ratio for fricatives suggests a greater contrast between the duration of preceding vowels and the following fricative consonants.

b. Geminates

Figure 28 below is the graphic representation in boxplots of the distribution of the ratio of the target (geminate) consonant to the preceding vowel in Italian learners' pronunciation. Corresponding numerical values can be found in Table 59.

Table 59: Distribution of V1C ratio in geminates by manner of articulation for Italian learners

Geminate	Min	1st Qu.	Median	Mean	3rd Qu.	Max
Stop	1.083	1.908	2.472	2.732	3.367	8.671
Affricate	0.4079	0.9589	1.3939	1.4045	1.7283	2.3595
Fricative	2.061	2.516	2.940	3.165	3.426	7.022
Nasal	1.293	1.725	2.127	2.376	2.775	3.933

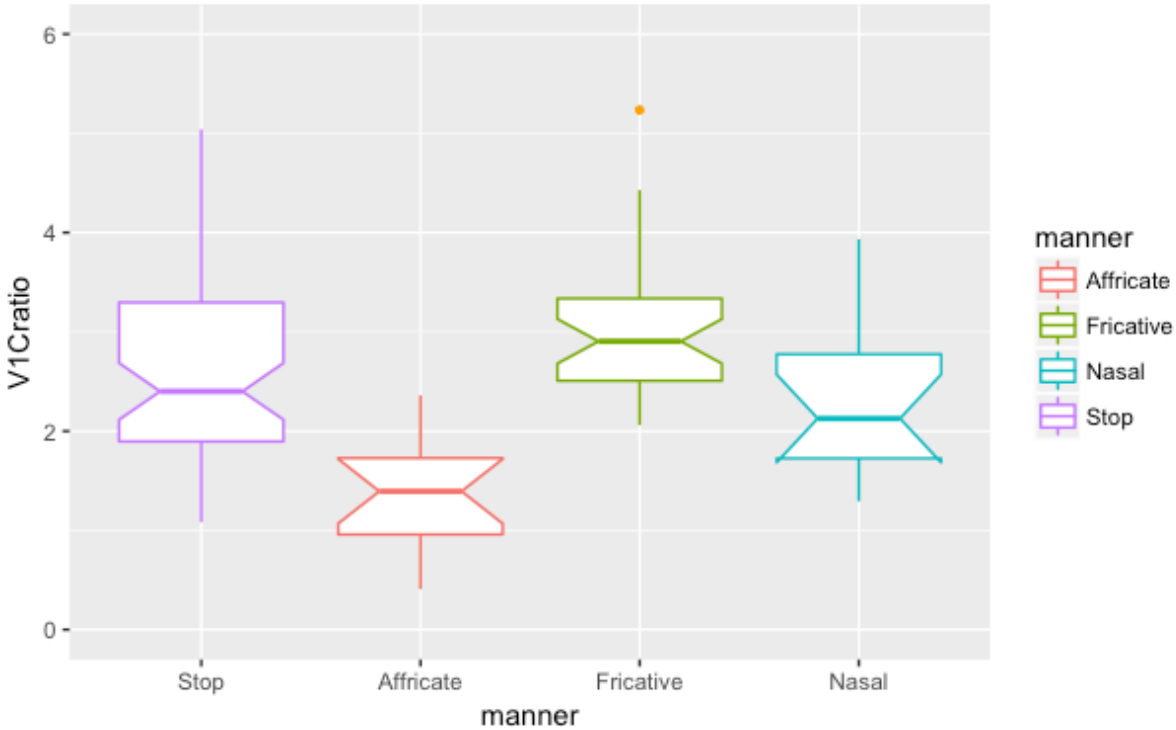


Figure 28: Ratio to the preceding vowel by manner in geminate consonants for Italian learners

The distribution of the ratios for the four manners indicated by the boxes in Figure 28 follows a pattern similar to what was observed in Figure 27 for singletons, but with a greater contrast. We observe the lowest V1C ratio for affricates (M=1.40), and the highest for fricatives (M=3.17). In contrast with Figure 27, notches on the box plots indicate that stops and affricates are most likely from a different population, and that stops, fricatives and nasals are from the same.

The data presented above was tested by conducting a one-way between subjects ANOVA comparing the effect of the manner of articulation on V1C ratio for geminates in stop, fricative, affricate, and nasal conditions (see Table 60). The manner of articulation was shown to significantly affect V1C ratio values [$F(3, 121) = 9.117$, $p < .001$].

Table 60: Results of the one-way ANOVA for V1C ratio in geminates

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
manner	3	32.44	10.813	9.117	1.74e-05 ***
Residuals	121	143.52	1.186		

Post hoc pairwise comparisons were run using a Tukey HSD test which results can be found in Table 61 below. Results show a significant difference for affricates when paired with fricatives ($p < .001$) and with stops ($p < .001$), but lacked significance for nasals ($p = .09$). Similarly, no significant difference could be observed for stops, fricatives and nasals when compared with each other.

Table 61: Results of Tukey HSD test on V1C ratio for Italian learners

	diff	lwr	upr	p adj
fricative-affricate	1.7604756	0.8632857	2.6576655	0.0000072
nasal-affricate	0.9720185	-0.1003285	2.0443656	0.0902234
stop-affricate	1.3279061	0.4883856	2.1674266	0.0004004
nasal-fricative	-0.7884571	-1.6856470	0.1087328	0.1061990
stop-fricative	-0.4325695	-1.0324164	0.1672773	0.2426726
stop-nasal	0.3558875	-0.4836330	1.1954081	0.6875591

The results of the test above allow to confirm the observation made about Figure 28 concerning affricates: they belong to a different population than stops and fricatives. Affricates have a significantly lower ratio, implying less contrast between the consonant and its preceding vowel. No significant difference was found for other manners.

c. Conclusion

The study of the ratio to the preceding vowel in singleton and geminate environments for Italian learners shows the following results: In the singleton environment, fricatives stand out with a significantly higher ratio. However, this difference disappears in the geminate environment where only affricates show a different pattern: their ratio is significantly lower. All other manners of articulation exhibited similar behavior.

Although the results for singletons are similar to those of Japanese native speakers, for geminates, no significant difference was observed between V1C ratios for all manners. In the case of Italian learners, the different behavior of V1C ratio for affricates in geminate environment can be linked with the property of geminates in Italian mentioned above: both closure and frication are lengthened, which implies that there is less lengthening of each segment. As for Japanese, the phonetic implementation of geminate consonants involves only an increase of the closure duration, V1C ratio is similar for stops and affricates in Japanese native speakers' pronunciation. However, for Italian L2 learners, the implementation of consonantal length is reflected in the closure duration to a lesser extent as indicated by the SG ratio (which doesn't include the frication period). This suggests that Italian learners rely on their L1 cues for L2 Japanese production, and that the frication period might be lengthened as well for geminates. This last point will be examined in section 4.2.4.b.

4.2.3. Ratio to the following vowel

a. Singletons

Figure 29 below is the graphic representation of the distribution of the ratio of the target consonant to the following vowel, V2C ratio in Italian learners' pronunciation. Corresponding numerical values appear in Table 62.

Table 62: Distribution of V2C ratio by manner of articulation in singleton for Italian learners

Singleton	Min	1st Qu.	Median	Mean	3rd Qu	Max
Stop	0.2471	0.5836	0.7937	1.0311	1.1843	4.3410
Affricate	0.4092	0.8229	1.0189	1.0935	1.3107	2.1784
Fricative	0.7433	1.4137	1.7386	2.0829	2.5636	5.1154
Nasal	0.3407	0.5039	0.6959	0.6810	0.7832	1.2318

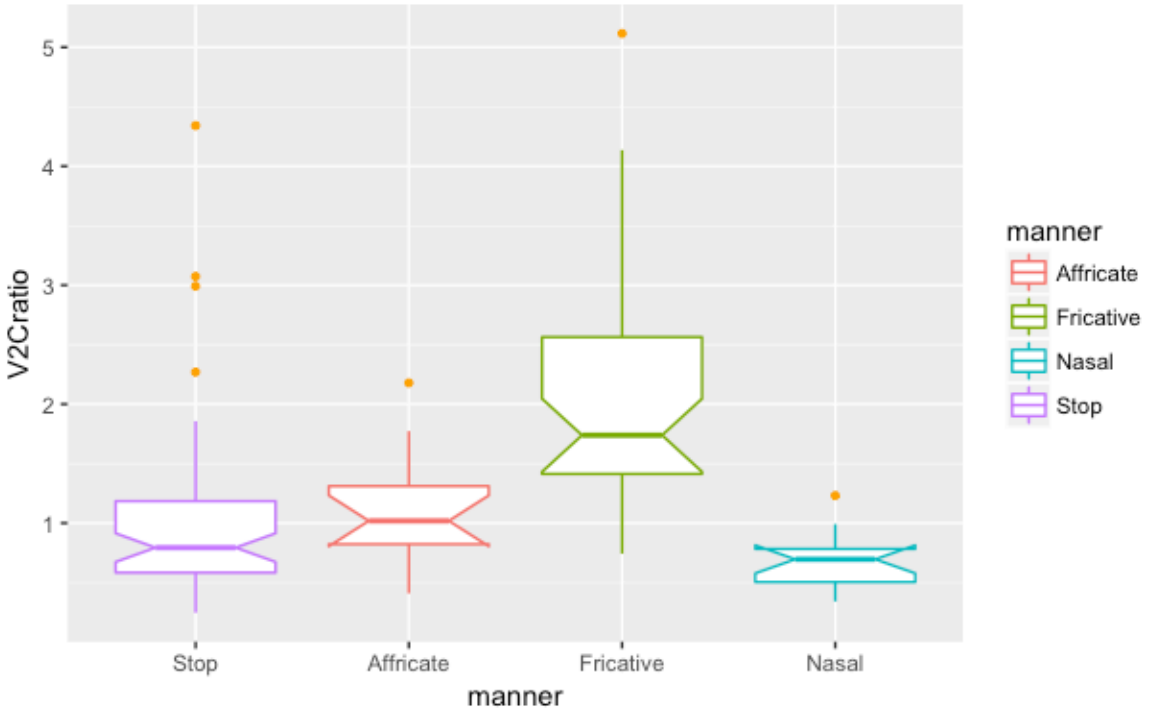


Figure 29: Ratio to the following vowel by manner in singleton for Italian learners

In Figure 29 above, V2C ratio for fricatives clearly stands out with both higher values (M=2.08) and a wider range of variations (*IQR*=1.15). On the other hand, the box plots seem to indicate that stops (M=1.03), affricates (M=1.09) and nasals (M=0.68) follow a different tendency, with lower V2C ratios, and are from the same population.

The significance of the observations above was tested using a one-way between subjects ANOVA, conducted to compare the effect of the manner of articulation on V2C ratio for singletons in stop, fricative, affricate, and nasal conditions (see Table 63). The manner of articulation was shown to be significantly correlated to V2C ratio [$F(3,120)=18.26$, $p < .001$].

Table 63: Results of the one-way ANOVA for V2C ratio in singletons

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
manner	3	31.85	10.617	18.26	7.95e-10 ***
Residuals	120	69.76	0.581		

Post hoc comparisons were conducted by running a Tukey HSD test (see Table 64 below). The difference between fricatives and other manners was shown to be highly significant, as shown by the low *p*-values for the pairwise comparisons with affricates ($p < .001$), nasals ($p < .001$) and stops ($p < .001$). On the other hand, the results confirmed the observations made from Figure 29: No significant difference can be observed between stops, affricates and nasals when compared with each other.

Table 64: Results of Tukey HSD test on V1C ratio for Italian learners

	diff	lwr	upr	p adj
fricative-affricate	1.1221956	0.5015414	1.7428498	0.0000324
nasal-affricate	-0.4891023	-1.2268832	0.2486787	0.3165923
stop-affricate	-0.1528209	-0.7348263	0.4291845	0.9041589
nasal-fricative	-1.6112978	-2.2206046	-1.0019911	0.0000000
stop-fricative	-1.2750165	-1.6820352	-0.8679978	0.0000000
stop-nasal	0.3362813	-0.2336076	0.9061702	0.4214202

The results of the ANOVA and Tukey HSD test above validate the observations made about Figure 29 and Table 62 above. Fricatives follow significantly different patterns with a higher V2C ratio, implying a greater contrast between the singleton consonant and its following vowel. Inversely, stops, affricates and nasal have identical patterns with lower ratios, that is less contrast.

The present findings replicate those of Japanese native speaker, where the same tendency to have a higher V2C ratio for fricatives was observed.

b. Geminates

Figure 30 below is the graphic representation of the distribution of the ratio of the target consonant to the following vowel V2C ratio in Italian learners' pronunciation when

the target consonant is a geminate. Corresponding numerical values are gathered in Table 65.

Table 65: Distribution of V2C ratio by manner of articulation in geminates for Italian learners

Geminate	Min	1st Qu.	Median	Mean	3rd Qu.	Max
Stop	0.4193	1.5689	2.1253	2.2613	2.8528	5.3166
Affricate	0.5450	0.8879	1.2659	1.5080	1.9065	3.2885
Fricative	0.4253	1.9306	2.2232	2.3441	2.6334	4.7587
Nasal	1.113	1.272	1.736	1.832	2.188	3.767

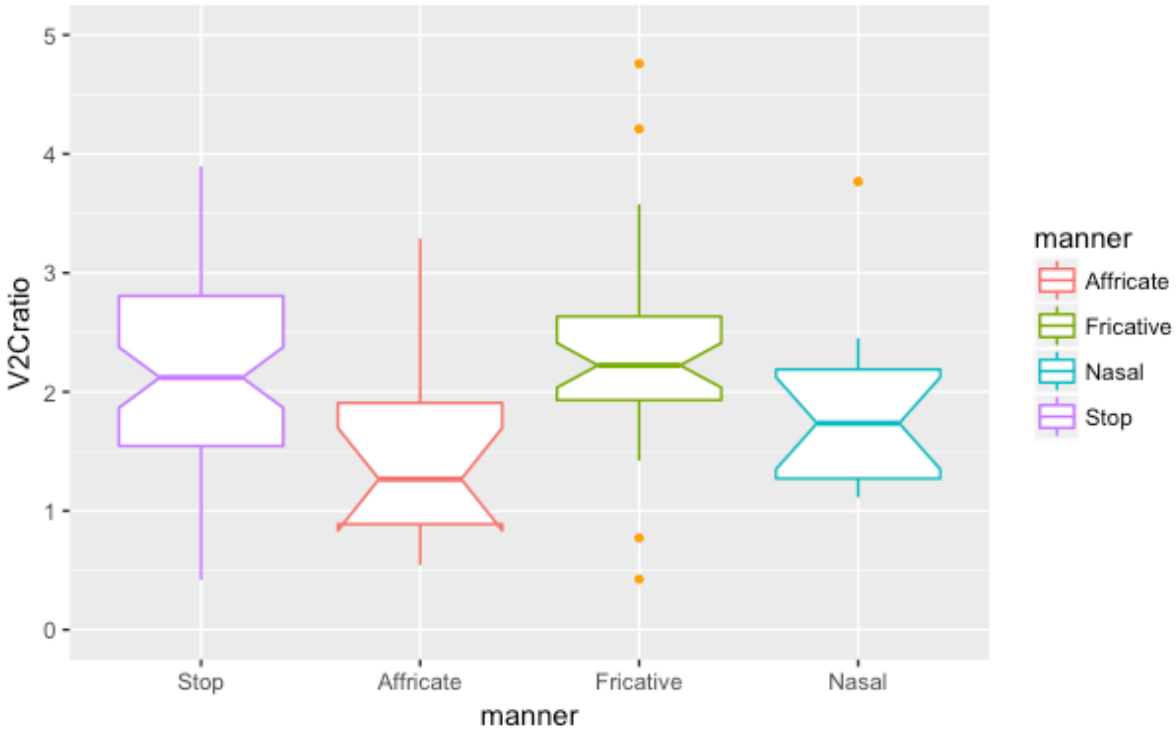


Figure 30: V2C ratio by manner of articulation in geminate consonants for Italian learners

Figure 30 appears to share similarities with Figure 28 in the previous section that presents the distribution of V1C ratio in geminate environment. We observe a low V2C ratio for affricates (M=1.5), suggesting less contrast between the closure and the following vowel durations. This again needs to be put into perspective with the phonetic characteristics of affricate geminates in Italian. Moreover, stops (M=2.26) and fricatives (M=2.34) present

similar mean V2C ratio values, and notches indicate that they belong to the same population, although the distribution of stops has a wider variation range (*IQR*= 1.28). Lastly, nasals have lower V2C ratios (M=1.83), but the notches suggest that they have no significant difference with stops and fricatives.

The observations above were tested using a one-way between subjects ANOVA (see Table 66 below). Results show a statistically significant correlation between the manner of articulation of the geminate consonant and the ratio to the following vowel [$F(3,121) = 4.258$, $p = .006$].

Table 66: Results of the one-way ANOVA for V2C ratio in geminates for Italian learners

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
manner	3	9.28	3.0918	4.258	0.00675 **
Residuals	121	87.86	0.7261		

A Tukey HSD test was used to make post hoc pairwise comparisons which results can be found in Table 67 below. We observe that only the fricative-affricate (*p*=.01) and the stop-affricate (*p*=.01) pairs show a significant difference. Other results indicate that, as observed in Figure 29, sonorants, stops and nasals, belong to the same population. Furthermore, the stop-fricative pair shows an especially high similarity (*p*=.96).

Table 67: Results of Tukey HSD test on V2C ratio in geminates Italian learners

	diff	lwr	upr	p adj
fricative-affricate	0.83607818	0.13410704	1.5380493	0.0126022
nasal-affricate	0.32353084	-0.51548515	1.1625468	0.7470504
stop-affricate	0.75324396	0.09639398	1.4100939	0.0176913
nasal-fricative	-0.51254735	-1.21451849	0.1894238	0.2326053
stop-fricative	-0.08283422	-0.55216092	0.3864925	0.9675878
stop-nasal	0.42971312	-0.22713686	1.0865631	0.3259627

Statistical tests confirm some of the observations on Figure 30 above: Affricates have lower ratios to the following vowel in geminate environment when compared to a fricative

or a stop. No difference could be observed for the other manners suggesting a similar behavior of the durational contrast for them. The present results contrasts with native speakers' data, where fricatives and nasals stand out when compared to the other manners. Affricates and stops in particular had identical patterns.

c. Conclusion

This section provided a comparison of the variations in terms of V2C durational ratios by manners of articulation, looking at singleton and geminate environments separately. What I found is that, although the results for the singleton environment appear to be similar to those of Japanese native speakers, this is not the case in geminate one. For both Italian learners and Japanese native speakers, the fricatives have higher ratio in singleton and are significantly different from other manners. The same pattern was also observed for our French learners. In the case of geminates, however, for Italian learners the only manner that stands out is affricates, with a lower V2C ratio. The differences between all other manners were non-significant.

It appears that for both V1C and V2C in geminate environment, affricates exhibit divergent patterns with less contrast. This is due to the properties of Italian geminates to implement phonetically consonantal length on both closure and frication duration, implying that less lengthening is needed for the consonant closure for Italian learners.

4.2.4. Comparison within each manner of articulation

In the previous section, the data collected from Italian native speakers was analyzed by providing a comparison of the four manners of articulation for V1C, SG and V2C ratio

in singleton and geminate conditions. This section provides a different point of view on the data by comparing singleton and geminate environments separately in stops (section a.), affricates (section b.), fricatives (section c.), and nasals (section d.).

a. Stops

The mean durations for stops in Italian learners' pronunciation are represented in the bar plot in Figure 31 below. The bar on top stands for the singleton environment, and the bottom one for the geminate environment where V1 appears in orange, C in blue and V2 in red. Corresponding values are gathered in Table 68.

Table 68: Relative duration values for stops by Italian learners

	V1	C	V2
Singleton	0.91	1	0.96
Geminate	0.85	2.48	1.06
Mean ratio	0.93	2.48	1.10

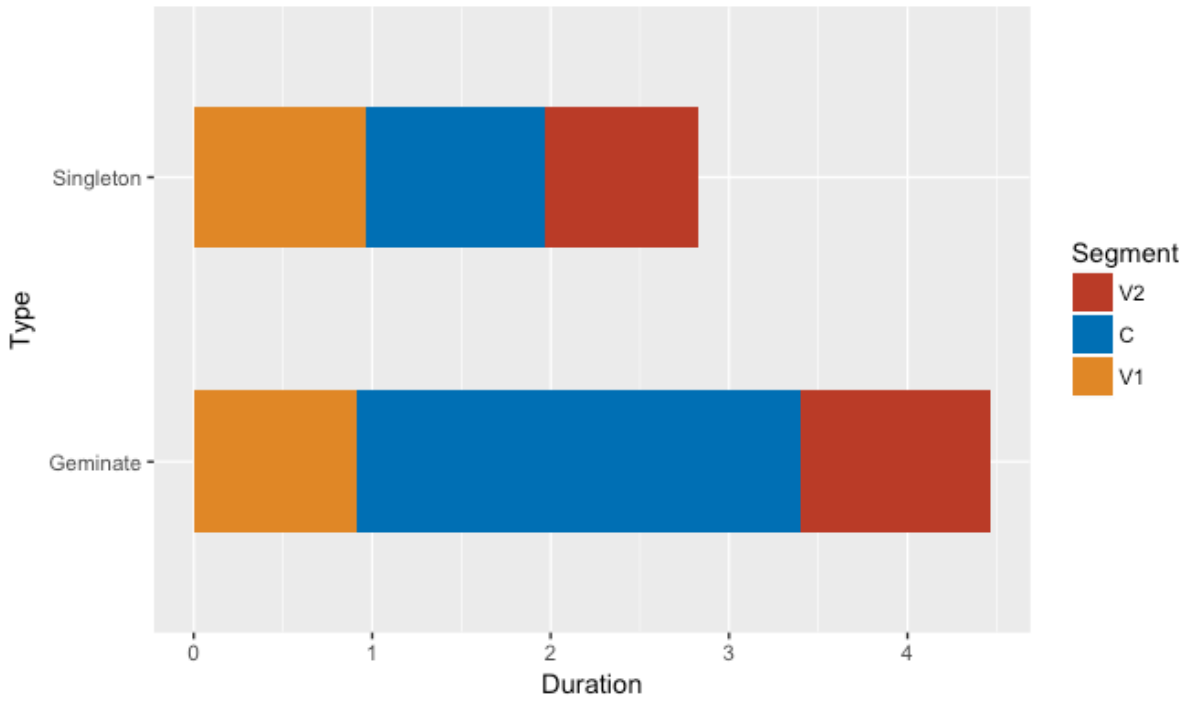


Figure 31: Relative segment mean duration for stops in singleton and geminate consonants by Italian learners

The observation of Figure 31 and Table 68 shows the following tendencies for the pronunciation of the Japanese consonantal length contrast for stops by Italian L2 learners. The consonant ratio for stops is of 2.48, that is, a geminated stop is 2.48 times the duration of a singleton one. This result is consistent with the same experimental results for Japanese native speakers in 2.2.4.a. For vowel durations, a vowel preceding a geminated stop is about 7% shorter, and a vowel following a geminated stop is 10% longer than one before a singleton stop.

These observations were tested using an independent-samples t-test in order to compare the durations of the preceding vowel, the following vowel and the target consonant in singleton and geminate conditions. Results indicate a significant difference for consonantal duration between singleton and geminate populations [$t(192.76) = 9.32$, $p < .001$]. However, the observed variations in terms of vowel duration between the singleton and geminate environments were non-significant for both the preceding [$t(168.55) = 1.2979$, $p = .19$, ns.], and the following vowel [$t(191.66) = -0.71$, $p = .48$]. This indicates that the observed decrease in V1 and increase in V2 between the singleton and geminate environments are no more than tendencies: This result contrasts with native speakers' pronunciation, where increase in V1duration and decrease in V2 duration were shown to be significant. However, the decrease in the preceding vowel, although non-significant, should be put into perspective with data on Italian geminated stops from previous studies (Esposito and Di Benedetto 1999) where a decrease in duration of 25% was observed for V1 before a geminate.

b. Affricates

Figure 32 below presents the relative mean durations of V1 (green), C (orange), the frication period F (blue) and V2 (red) when the target consonant is an affricate, between singleton (top) and geminate (bottom) for Italian learners of Japanese. Corresponding values are gathered in Table 69.

Table 69: Relative mean duration values for affricates by Italian learners

Affricates	V1	C	Frication	V2
Singleton	0.90	1	2.09	0.93
Geminate	1.24	1.52	2.26	1.11
Mean ratio	1.37	1.52	1.07	1.18

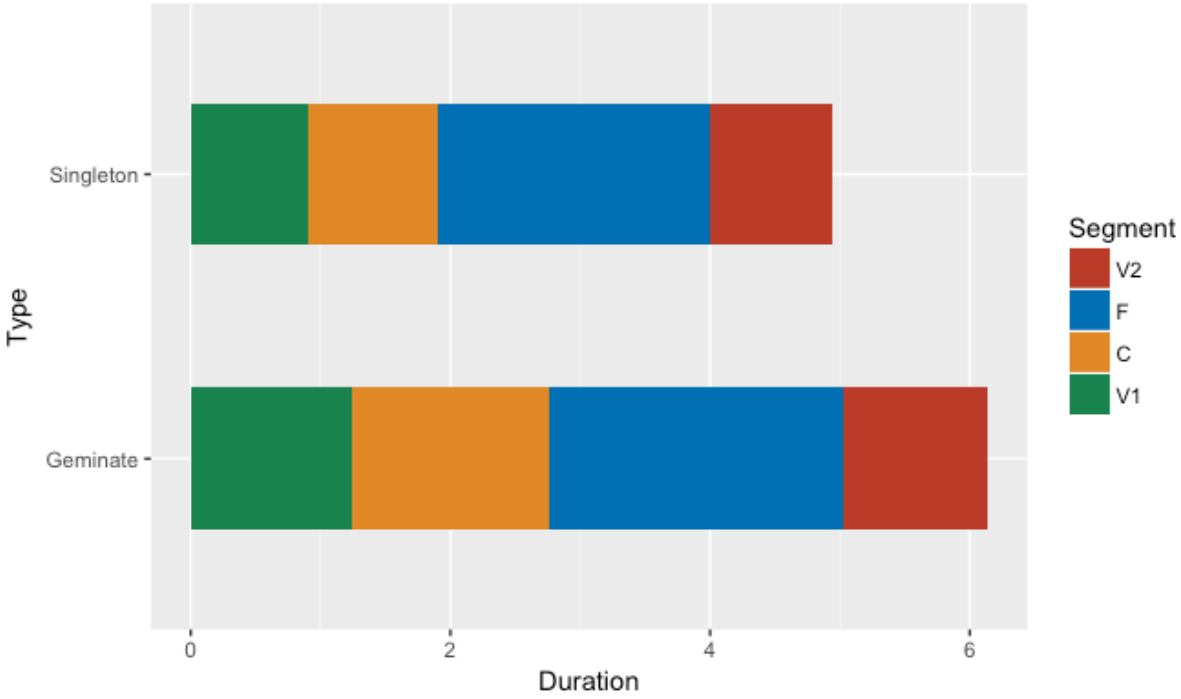


Figure 32: Relative segment duration for affricates in singleton and geminate consonants for Italian learners

Figure 32 and Table 69 indicate an increase in the duration of all segments between singleton and geminate environments. The preceding and following vowels are longer when surrounding a geminate consonant (respectively 137 and 118% longer), and increase is also

observed for the consonant duration (152%), and to a lesser extent, the frication duration (107%).

Several independent samples t-test were conducted in order to test the differences between segment duration in singleton and geminate conditions. Results confirm the significance of the difference between singleton and geminate durations [$t(34.31) = 2.91$, p =.006]. However, no significant difference was found for V1 duration [$t(37.99) = 1.73$, p =.09, ns.], V2 duration [$t(39.54) = 1.34$, p =.1, ns.], and frication duration [$t(40.64 = 1.34$, p =.18 ns.]. These results indicate that there is no significant duration variation between singleton and geminate for V1, V2 and F.

The significance of the difference between the singleton and the geminate duration confirms here again its role as a primary cue in Italian learners' pronunciation, as it is for Japanese native speakers. However, no difference in vowel duration could be observed, a result in contrast with Japanese native speakers'. The absence of difference in frication duration between singleton and geminate contexts is a pattern that was already observed for Japanese native speakers and French learners. However, similarly to French learners, the frication duration in Italian learners' pronunciation is longer than for Japanese native speakers: For Japanese native speakers, the frication is almost the same duration as the closure (93%) for a singleton, and only (38%) of the closure in a geminate. In comparison, for Italian learners it is more than twice the closure duration in singleton and 1.5 times the closure duration in geminate.

c. Fricatives

Figure 33 below presents in a bar plot the durations of V1 (orange), C (blue) and V2 (red) when the target consonant is a fricative, between singleton (top) and geminate (bottom) by Italian learners of Japanese. Corresponding values can be found in Table 70.

Table 70: Mean duration values for fricatives by Italian learners

Fricatives	V1	C	V2
Singleton	0.63	1	0.48
Geminate	0.62	1.99	0.84
Mean ratio	0.98	1.99	1.77

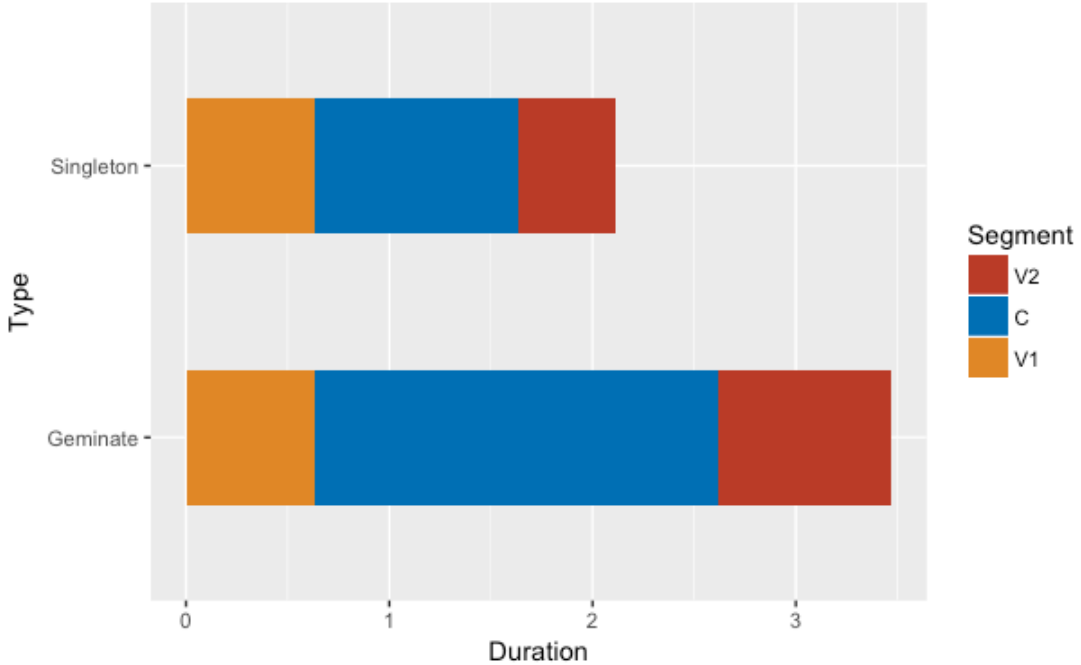


Figure 33: Relative segment duration for fricatives in singleton and geminate consonants for Italian learners

Figure 33 and Table 70 indicate a longer duration for a geminate consonant (199% longer) than for a singleton one. Moreover, the following vowel also exhibits a remarkable increase in duration as a V2 following a geminate is 177% the duration of one following a singleton. On the other hand, V1 doesn't show any increase, and has a tendency to decrease (98%).

Independent samples t-tests were conducted in order to test these observations, and allowed to confirm the significance of all observations above: First, results confirm the significance of the singleton-geminate duration contrast [$t(55.858) = 6.052$, $p < .001$]. Second, the duration of the following vowel V2 in singleton and geminate was also significant [$t(50.315) = 2.8726$, $p = .005$], as well as V1 [$t(55.761) = -2.267$, $p = .02$].

The present results indicate an increase in consonant frication duration between singleton and geminate for fricatives, which is consistent with the primary cue for geminates in Japanese native speakers' pronunciation. Furthermore, the data highlights an increase in V2 and a decrease in V1, which is in contradiction with the patterns observed previously for Japanese native speakers.

d. Nasals

The bar plot in Figure 34 below presents the relative mean durations of V1 (orange), C (blue) and V2 (red) when the target consonant is a nasal, between singleton (top) and geminate (bottom) environments for Italian learners of Japanese. Corresponding numerical values can be found in Table 71.

Table 71: Mean duration values for nasals by Italian learners

Nasals	V1	C	V2
Singleton	1.37	1	1.47
Geminate	1.33	3.17	1.73
Mean ratio	0.96	3.17	1.18

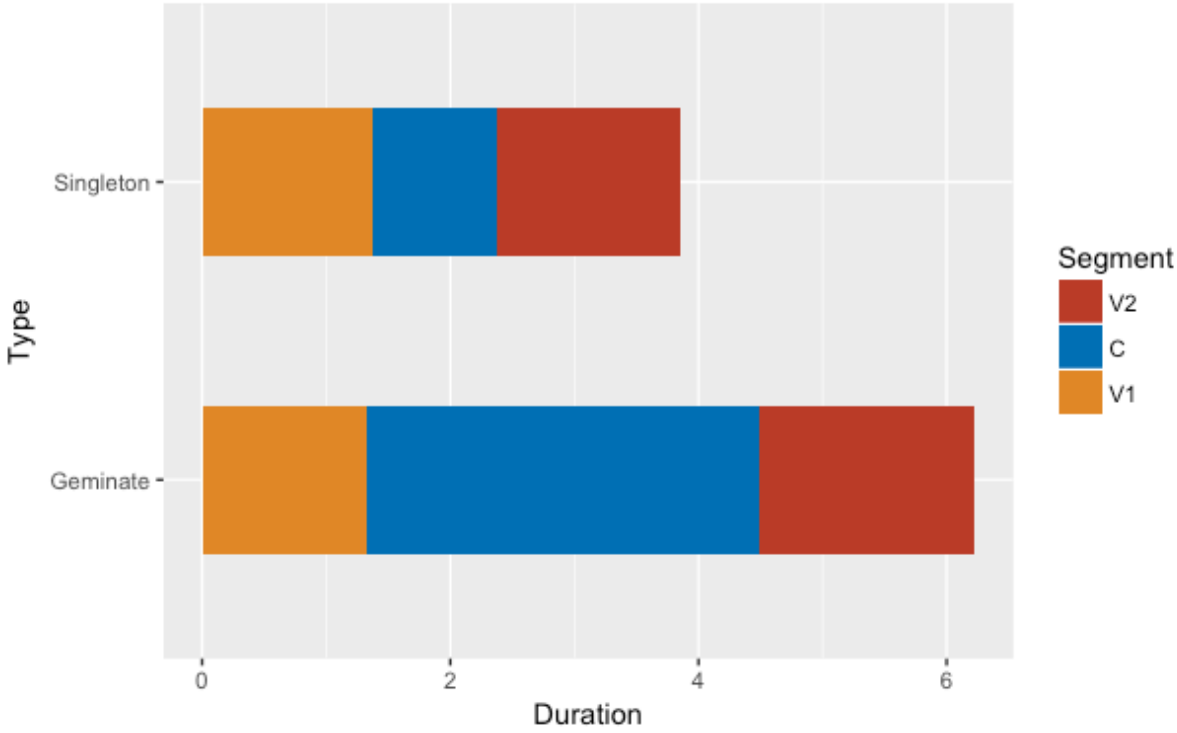


Figure 34: Relative segment duration for nasals in singleton and geminate consonants for Italian learners

The following patterns for Italian learners' pronunciation can be identified from the observation of Figure 34 and Table 71 above. Identically to what was observed for other manners of articulation, geminate consonants are longer (317%) than singletons in nasals. Moreover, the values for V1 indicate that vowel duration decreases between singleton and geminate (96%), and V2 shows a tendency to be longer when following a nasal geminate.

Independent-samples t-test were conducted to compare durational cues for singleton and geminated nasal consonants. The difference between the durations of nasal singletons and geminates was confirmed [$t(14.105) = 6.55$, $p < .001$]. However, the results of the t-tests showed no significant difference for the means of the preceding vowel durations [$t(23.206) = -0.632$, $p = .53$] and the following vowel durations [$t(21.112) = 1.202$, $p = .24$] between the singleton and geminate contexts. The results of the statistical tests suggest

that the duration of V1 and V2 are similar between the two environments, a result which matches those of native speakers for nasals.

e. Conclusion

In this section, the durations of the target segments in singleton and geminate environments were examined further by looking at consonants of each manner of articulation separately. From the investigation of the statistical significance of the durational contrasts observed, we can make the following affirmations about Italian L2 learners' pronunciation of Japanese consonantal length contrast. First, the results confirmed the primary production cue of the singleton-geminate contrast for Italian learners. Similarly to Japanese native speakers in the control group and to French learners, it appears that the primary cue active in Italian learners' pronunciation is also consonant constriction duration: In all manners of articulation, singleton consonants were significantly shorter than geminated one, and ratios consistent with native speakers'. To the exception of fricatives, no significant difference was observed regarding the duration of the preceding and the following vowels between singleton and geminate environments. For fricatives, the preceding vowel was significantly shorter in the geminate environment. Although it was not significant in other cases, it appears that the tendency to a decrease in V1 duration is a pattern observed for all four manners.

4.3. Summary of the results for Italian learners

The fourth section of this chapter was devoted to the analysis of the patterns observed experimentally in Italian learners' pronunciation. In order to identify the production cues active in learners' pronunciation of the consonantal length contrast in Japanese, the investigation focused on global results in section 4.1 before comparing the effect of manner

of articulation on each type of ratio in section 4.2. Specifically, in section 4.2.1 the analysis was conducted in order to compare each ratio type between manners of articulation, while 4.2.2 explored the differences between singleton and geminate condition within each manner of articulation. Findings for each item studied were compared with similar data from the control group of Japanese native speakers and with experimental data from previous studies concerning Italian geminates.

The results of the analyses conducted in the present section suggest the following patterns for of Italian learners' production of Japanese consonantal length contrasts:

(i) The global results indicate that geminate duration is at least twice the singleton duration (SGratio =2.306), confirming constriction duration as the primary acoustic cue.

(ii) Global results showed a small decrease in V1 duration, a secondary cue, but V2 was similar for both conditions.

(iii) The results of the comparisons between and within manners of articulation are summed up in Table 72 and 73 below:

Table 72: Summary of the results of the comparison between manners of articulation for Italian L2 learners

<table>
<tr><th></th><th>V1C</th><th>SG</th><th>V2C</th></tr>
<tr><td>Singleton</td><td>N=S=A≤F</td><td rowspan="2">A=F=S≤N</td><td>S=A=N＜F</td></tr>
<tr><td>Geminate</td><td>A≤N=S=F</td><td>A≤N=S=F</td></tr>
</table>

Table 73: Summary of the results for the comparison within each manner of articulation in Italian learners

<table>
<tr><th></th><th>Stop</th><th>Affricate</th><th>Fricative</th><th>Nasal</th></tr>
<tr><td>V1</td><td colspan="2">V1sing =V1gem</td><td>V1sing＞V1gem</td><td>V1sing =V1gem</td></tr>
<tr><td>C</td><td colspan="4">S＜G</td></tr>
<tr><td>F</td><td>NA</td><td>Fsing=Fgem</td><td>NA</td><td>NA</td></tr>
<tr><td>V2</td><td colspan="2">V2sing=V2gem</td><td>V2sing＜V2gem</td><td>V2sing=V2gem</td></tr>
</table>

The analysis of Italian native speakers' data allows to say that they rely on the same primary production cue as Japanese native speakers for the consonantal length contrast. As reflected in their SG ratio values, a geminate is longer than a singleton, with a longer closure/frication duration for the geminated consonant. However, from the comparison of the present data with results from previous studies about Italian geminates (Argiolas et al. 1995, Giovanardi and Di Benedetto 1998, Esposito and Di Benedetto 1999, Mattei and Di Benedetto 2000, Faluschi and Di Benedetto 2001) it appears that their L1 production cues are active in their L2 pronunciation. Specifically, SG ratio values by manner of articulation are consistent between their L1 and L2 pronunciation, and the duration patterns for affricate consonants were also of interest when compared to Italian phonetic properties. While the primary cue for affricates in Japanese is the closure duration only, in Italian geminates both closure and frication are lengthened, both to a lesser extent than in the case of Japanese. This accounts for the peculiar behavior of affricates in Italian learners' pronunciation: Frication was shown to be longer than for Japanese native speakers in both singleton and geminate, and although there was no significant difference between frication duration between the two environments, the increase of the closure duration was smaller than for native speakers.

Concerning vowel duration, research on Italian phonetics showed that in Italian geminates there is a strong correlation with V1C ratio: namely, the preceding vowel is shorter before a geminate. Japanese geminates behave the opposite way. The productions of the Italian native speakers recorded for this study exhibited interesting patterns. First, the global mean indicates a significant decrease in V1 duration, and when looking at this data by manner of articulation, fricatives also had a significantly shorter preceding vowel. For other manners, although it was not significant, a similar tendency to decrease in V1 duration was also observed.

These results suggest that the duration of the preceding vowel might be a cue in Italian learners' pronunciation, similarly to Japanese native speakers, but in a different way. Namely, the language specific mechanism of temporal compensation observed in Japanese native speakers' pronunciation is not active in Italian learners', and like in their L1, Italian learners tend to have a shorter V1 before a geminate than before a singleton. Further insights on this topic will be provided in the discussion in Chapter 6.

5. ENGLISH L2 LEARNERS

The fifth section of this chapter is devoted to the analysis of the data obtained from the recording of L2 learners of Japanese whose L1 is English. The aim of this last section is to identify some production correlates active in this L2 learner population's pronunciation of the Japanese consonantal length contrast.

Identically to sections 2 to 4, which examined the same items for Japanese native speakers, French L2 learners and Italian L2 learners, in a first subsection will be introduced the general results in terms of consonant and vowel durational cues, before examining in detail the results by manner of articulation in a second sub-section. The third sub-section will present durational data in singleton vs. geminate separately for each manner of articulation. Each section will also include comparisons of the present results for English L2 learners with the results obtained previously (see 2.) for Japanese native speakers.

5.1. General description

5.1.1. Consonant duration

Table 74 below presents mean values for singleton and geminate consonants and distributional values of the singleton geminate ratio for English L2 learners. The experimental mean duration observed for singleton was of 107ms and it was of 200ms for geminate. The comparison of singleton and geminate values using an independent-samples t-test, shows a statistically significant difference between the two populations [$t(180.67) = 8.0749$, $p < .001$]. The mean singleton geminate ratio observed was 2.286, which indicates that a geminate consonant is about 2.3 times its singleton counterpart duration. Figure 35 below is a graphic representation of the distribution of the data for English speaking L2 learners in Table 74. The outliers observed here follow similar patterns to what was observed

for French learners: the tendency is to have higher SG ratios indicating enhancement of the contrast between singleton and geminate closure durations. Speaker EN2F especially exhibits this tendency to overexaggerate contrasts, although she had a high proficiency in both talking and reading, and some of her SG ratios values reach 10.

Table 74: Numerical values for consonants in English learners' production

	Min	1st Qu.	Median	Mean	3rd Qu.	Max
SG ratio	*0.280*	*1.255*	*1.801*	*2.286*	*2.798*	*10.465*
Mean C duration	*singleton*	*107ms*	*geminate*	*200ms*		

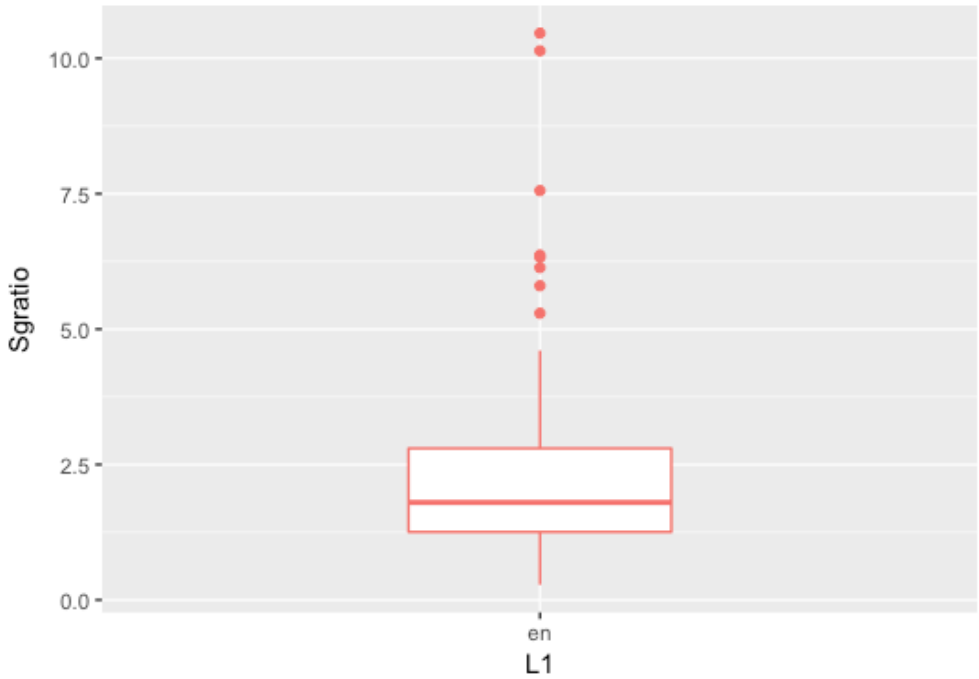


Figure 35: Singleton geminate ratio for English learners

This result duplicates what was observed for all other three language groups before. Although for learners whose L1 is English the mean singleton and geminate duration values are greater than for Japanese native speakers (where singleton was 70ms and geminate 150 ms), the present experimental results for SG ratio are consistent with native speakers'. Indeed, SG ratio values indicate that the average duration of a geminate consonant closure is 2.3 times the duration of a singleton closure, which is consistent with both previous studies

(Beckman 1982, Han 1962, 1994, 1992, Homma 1981, Kawahara 2006, Port et al. 1987 *inter alia*.) and experimental results in this study where the SG ratio is a least 2 for all other speaker groups. These results suggest that the closure/frication duration is the primary acoustic correlate in English-speaking learners' pronunciation of the Japanese consonantal length contrast. Additionally, this indicates that although they have a different speech rate (as shown by the higher values for mean singleton and geminate duration), they are able to maintain a consistent SG ratio.

5.1.2. Vowel duration

This section is devoted to the global results in terms of duration for the preceding and following vowels. The summary of global durational ratios involving vowels for English speaking learners are gathered in Table 75.

Table 75: Mean ratios for vowels in English speaking L2 learners' pronunciation

	Singleton	Geminate
V1C ratio	1.75	3.28
V2C ratio	1.58	2.43

For learners whose L1 is English, in singleton environment, the ratio to the preceding vowel was 1.75 and the ratio to the following vowel was 1.58. This difference between the two populations was tested using an independent sample t-test and was shown non-significant [$t(230.26) = 1.294$, $p = .19$]. This indicates that there is no difference in singleton environment between the contrast of the consonant to its preceding vowel and the contrast of the consonant to its following vowel, that is V1 and V2 are of equivalent durations.

In the geminate environment, ratios to the surrounding vowels show higher values, with a ratio to the preceding vowel of 3.28 and to the following vowel of 2.43. The test with

an independent samples t-test of the ratios in geminate condition indicates a significant difference between V1C and V2C ratios [$t(223.05) = 3.781$, $p < .001$].This suggests that there is a greater contrast between the consonant and its preceding vowel that between the same consonant and its following vowel, that is, an average V1 is shorter than V2.

Table 76 Relative mean segment durations calculated from mean ratios

	V1	C	V2
Singleton	0.57	1	0.63
Geminate	0.69	2.286	0.94
Ratio	1.22	2.286	1.49

Table 76 above presents relative segment durations calculated using the mean SG ratio as well as V1C and V2C mean ratios for singleton and geminates. The table indicates that the preceding vowel ratio is 1.22, suggesting that a vowel preceding a geminate is 22% longer than one preceding a singleton. We also observe a longer following vowel (49%) in a geminate environment when compared to the singleton environment. This is represented graphically in the bar plot in Figure 34 below.

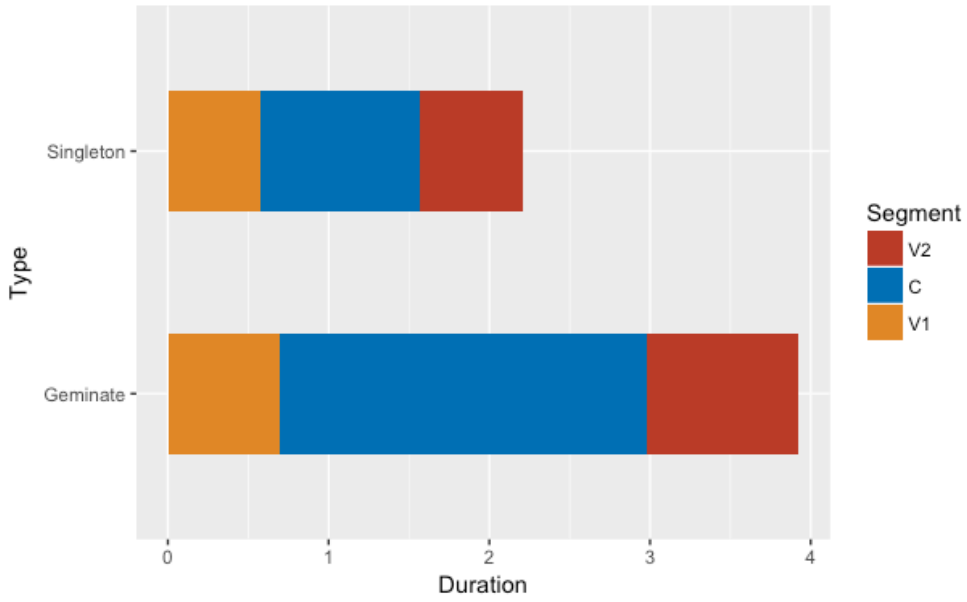


Figure 34: Relative global segment duration in singleton geminates consonants for English speaker learners

Independent samples t-test were used to test the statistical significance of the observations above about Table 76 and Figure 34. The test results show no significant difference for both V1 duration between the singleton and geminate environment [$t(183.74) = 1.192$, $p = .23$, ns.] and V2 duration between the singleton and geminate environment [$t(247.09) = 0.977$, $p = .32$, ns.]. The results of the t-tests indicate that the observed variations in terms of duration for both V1 and V2 between the two environments are no more than tendencies and these vowels are of equivalent durations regardless the environment.

The analysis of the general results for English-speaking Japanese learners, indicates that the primary cue active in their production is the closure/frication duration, similarly to Japanese native speakers. The singleton geminate ratio was of 2.3, which is also consistent with Japanese native speakers' results, both in the present experiment and in previous studies. The experimental results of this study for English-speaking learners are however in contrast with those of previous studies on the same population. Indeed, previous studies (Han 1992, Toda, 1993, 1994) found some evidence for negative transfer in these learners' pronunciation. Namely, their SG ratios were lower than Japanese native speakers' due to mis-interpretation/modification of the syllable structure. In the present study, the results indicate the opposite behavior, with more contrast between singleton and geminate durations than for native speakers. This suggests that learners tend to enhance duration contrasts in their pronunciation of the Japanese consonantal length contrast, and that they have the right interpretation of the syllable structure. A possible explanation for the difference between previous studies and the present experimental results is the level of the participants. Indeed, most of the studies in the literature dealt with lower level learners mostly living in English-speaking countries, while the participants for this dissertation were all living in Japan in an immersion environment and had a high level of proficiency.

Concerning vowel duration, similarly to French L2 learners, no difference was observed for English native speakers between the two environments, which suggests that the duration of the surrounding vowels is not an active production cue in these two learner populations. Durational contrasts will be further investigated in the following section 4.2. based on a comparison of each segment by manner of articulation.

5.2. Results by consonant manner

In this section, I present a detailed analysis of the data obtained from the English native speakers learning Japanese. Each sub-section will be devoted to one of the target ratios (consonant ratio, ratio to the preceding and the following vowel), which will be investigated with regard to their behavior by manner of articulation of the consonant.

5.2.1. Consonantal length

Figure 35 below compares in box plots the singleton geminate ratio distribution with regard to the manner of articulation of the target consonant for English speaking learners. Table 77 contains the corresponding numerical values.

Table 77: Distribution of singleton geminate ratio by manner of articulation for English-speaking learners

	Min	1st Qu.	Median	Mean	3rd Qu	Max
Stop	0.2804	1.0839	1.8486	2.3533	2.7706	10.46
Affricate	0.8004	1.3061	2.1478	2.3167	3.2788	4.4130
Fricative	0.7851	1.1948	1.4721	1.7081	1.9309	6.3674
Nasal	1.508	2.610	3.046	3.361	3.672	7.558

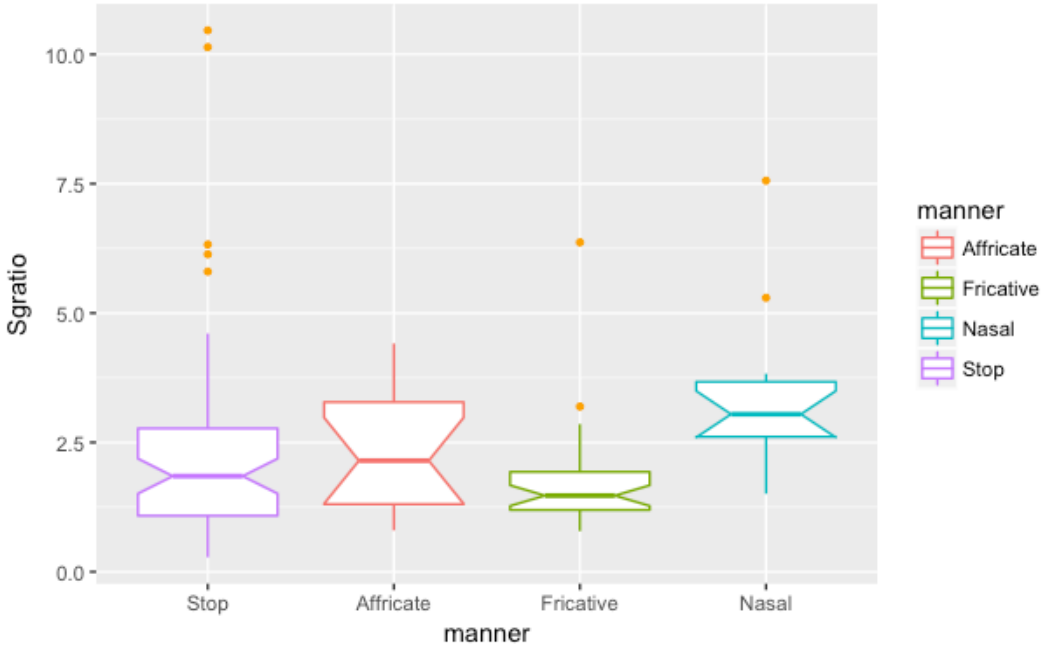


Figure 35: Singleton geminate ratio by manner for English-speaking learners

The observation of Figure 35 and Table 77 above suggests that SG ratios can be divided into three categories according to their manners of articulation. First, stops (M=2.35) and affricates (M=2.32) appear to have similar SG ratios, that is to behave in a similar way regarding the durational contrast between the singleton and the geminate consonant durations. Affricates, however, have a wider variation range (IQR= 1.97) when compared to stops (IQR=1.68). Fricatives exhibit a different behavior, with lower SG ratio values (M=1.71) than stops and affricates, and lastly, SG ratios for nasals show an outstanding difference with the three other manners with the highest values (M=3.36).

A one-way between subjects ANOVA was conducted to test the effect of the manner of articulation on SG ratio in stop, fricative, affricate, and nasal conditions (see results in Table 78 below). The results of the ANOVA indicate a significant effect of manner of articulation on the SG ratio [$F(3, 120) = 3.473$, $p = .01$].

Table 78: One-way ANOVA results

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
manner	3	27.8	9.277	3.473	0.0183 *
Residuals	120	320.5	2.671		

Post hoc pairwise comparisons using the Tukey HSD test (see Table 79) confirm the remarkable similarity of stops and affricates (*p*=.99). Furthermore, to the exception of the nasal-fricative pair (p <.01), no significant difference could be observed between the other manners.

Table 79: Results of the Tukey HSD test on SG ratio for English learners

	diff	lwr	upr	p adj
fricative-affricate	-0.6086324	-1.9607678	0.7435030	0.6451597
nasal-affricate	1.0442864	-0.5649766	2.6537494	0.3330561
stop-affricate	0.0365412	-1.2233991	1.2964815	0.9998444
nasal-fricative	1.6530188	0.2008834	3.0051542	0.0098400
stop-fricative	0.6451736	-0.2634905	1.5538376	0.2554024
stop-nasal	-1.0079452	-2.2677855	0.2520951	0.1642042

The results of the post hoc test confirm the observation on the similarity of stops and affricates, indicating that they behave in an analogous manner in terms of contrast between singleton and geminate duration. The observation of Table 77 and Figure 35 suggested that fricatives have lower SG ratio values, but no significant difference could be observed with stops and affricates. Furthermore, the higher values of nasals' SG ratios were also non-significant when compared to those of stops and affricates. To the exception of the fricative-nasal pair, all observed differences are no more than tendencies and SG ratios follow similar behaviors.

The comparison with Japanese native speakers' results shows that the patterns of SG ratios are different for English speaking learners. In native speakers' pronunciation, a significantly different behavior of fricatives was observed when compared to the other

manners, but although the fricatives SG ratio values for learners were similar to those of native speakers, the difference was non-significant.

5.2.2. Ratio to the preceding vowel

This section analyzes the distribution of the ratio to the preceding vowel for English native speakers learning Japanese in singleton consonants (5.2.2.a.), and geminated ones (5.2.2.b.).

a. Singletons

Figure 36 below accounts for the distribution of the ratio of the target (singleton) consonant to the preceding vowel V1C ratio in English-speaking learners' pronunciation. Corresponding numerical values are gathered in Table 80.

Table 80: Distribution of V1C ratio in singletons by manner of articulation for English speaking learners

Singleton	Min	1st Qu.	Median	Mean	3rd Qu	Max
Stop	0.7981	1.2606	1.6048	1.7007	2.0571	4.6517
Affricate	0.4292	0.8753	1.0530	1.3153	1.2458	3.5500
Fricative	1.063	1.600	1.890	2.345	3.162	4.417
Nasal	0.4723	0.7112	0.9242	0.9721	1.1860	1.7212

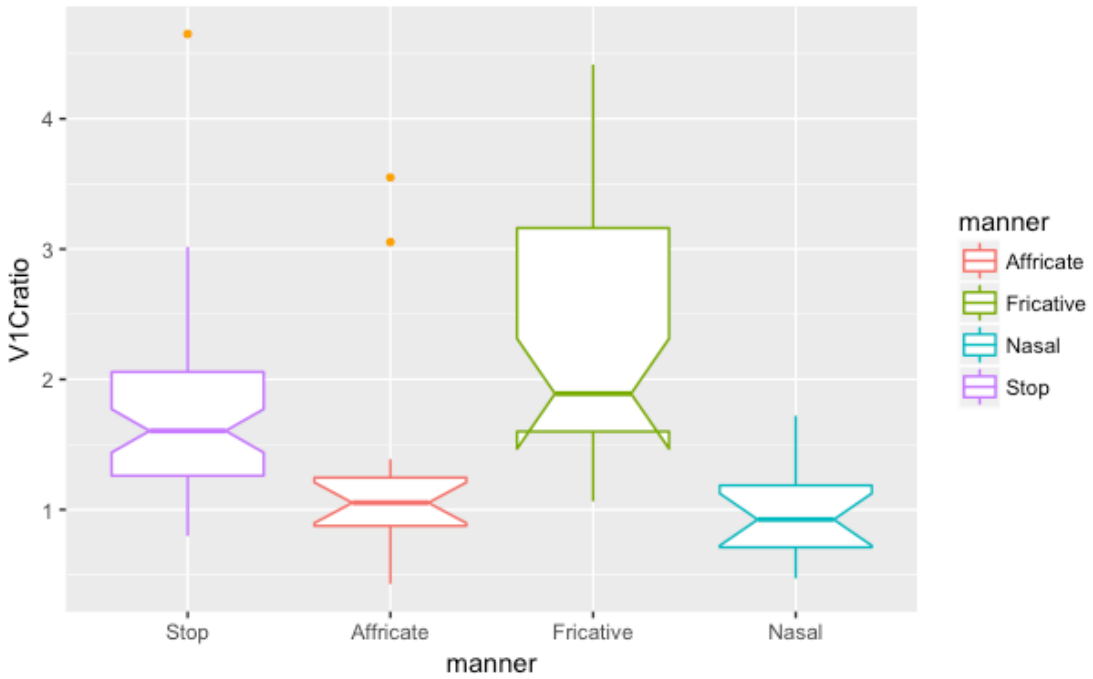


Figure 36: Ratio to the preceding vowel by manner in singleton consonants for English speaking learners

The observation of the data in Figure 36 and Table 80 above suggests that V1C ratios can be divided in two groups. First, as indicated by the notches on the box plot, affricates (M=1.32) and nasals (M= 0.97) have low V1C ratio values and seem to belong to the same population. Secondly, stops (M= 1.70) and fricatives (M=2.35) have higher ratio values, suggesting more contrast between the vowel and the consonant durations. Lastly, V1C ratio for fricatives has an outstandingly high variation range when compared to other manners.

The statistical significance of the observations about Figure 36 and Table 80 above were tested by conducting a one-way between subjects ANOVA, in order to check whether the manner of articulation has a significant effect on V1C ratio for singletons in stop, fricative, affricate, and nasal conditions in English speaking learners' pronunciation. The results, in Table 81 below, show that the manner of articulation significantly affects V1C ratio [$F(3, 117) = 5.865$, $p < .001$] for singletons.

Table 81: Results of the one-way ANOVA for V1C ratio in singletons

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
manner	3	23.29	7.765	13.34	1.57e-07***
Residuals	115	66.96	0.582		

Post hoc pairwise comparisons were made by running a Tukey HSD test (Table 82). Results confirm the significance of fricatives' behavior in terms of V1C ratio. Indeed, fricatives were significantly different from stops ($p < .001$), affricates ($p < .001$) and nasals ($p < .001$). On the other hand, results also shed light on the similarity of affricates when compared to nasals (p= .63), but also with stops (p=.33). A significant difference was also observed between stops and nasals ($p < .01$).

Table 82: Results of Tukey HSD test on V1C ratio in singleton for English speaking learners

	diff	lwr	upr	p adj
fricative-affricate	1.0297616	0.3980494	1.6614738	0.0002530
nasal-affricate	-0.3432500	-1.0951379	0.4086380	0.6343006
stop-affricate	0.3853578	-0.2080180	0.9787336	0.3320382
nasal-fricative	-1.3730116	-2.0047238	-0.7412994	0.0000007
stop-fricative	-0.6444038	-1.0754720	-0.2133357	0.0009324
stop-nasal	0.7286078	0.1252319	1.3219836	0.0094567

The results of the statistical tests above confirm the observations that were made on Figure 36: Fricatives exhibit a significantly different behavior when compared to the other manners with regard to their V1C ratio in singleton environment. That is, the ratio is higher, implying a greater durational contrast between the preceding vowel and the consonant. V1C ratio is also significantly lower for nasals compared to stops, indicating less contrast between the preceding vowel and a nasal consonant. Lastly, results confirmed the similarity of affricates and nasals in terms of durational ratios, but also that their behavior is not different from that of stops.

These results contrast with what was observed for Japanese native speakers where for the same ratio the nasal-fricative pair only exhibited some difference. While in their case

the other manners behave similarly regarding V1C ratio, for English speaking learners, fricatives stand out clearly when compared to other manners.

b. Geminate

The boxplots in Figure 37 present the graphic representation of the distribution of the ratio of the target (geminate) consonant to the preceding vowel when produced by learners of Japanese whose L1 is English. Corresponding numeric values are gathered in Table 83.

Table 83: Distribution of V1C ratio in geminates by manner of articulation for English-speaking learners

Geminate	Min	1st Qu.	Median	Mean	3rd Qu.	Max
Stop	0.5357	1.6575	2.5074	3.0860	3.7248	12.1577
Affricate	0.835	1.461	1.885	2.605	2.950	7.966
Fricative	0.5314	2.6127	3.7785	4.1670	5.6392	11.2593
Nasal	1.526	2.085	2 .732	2.669	3.045	3.874

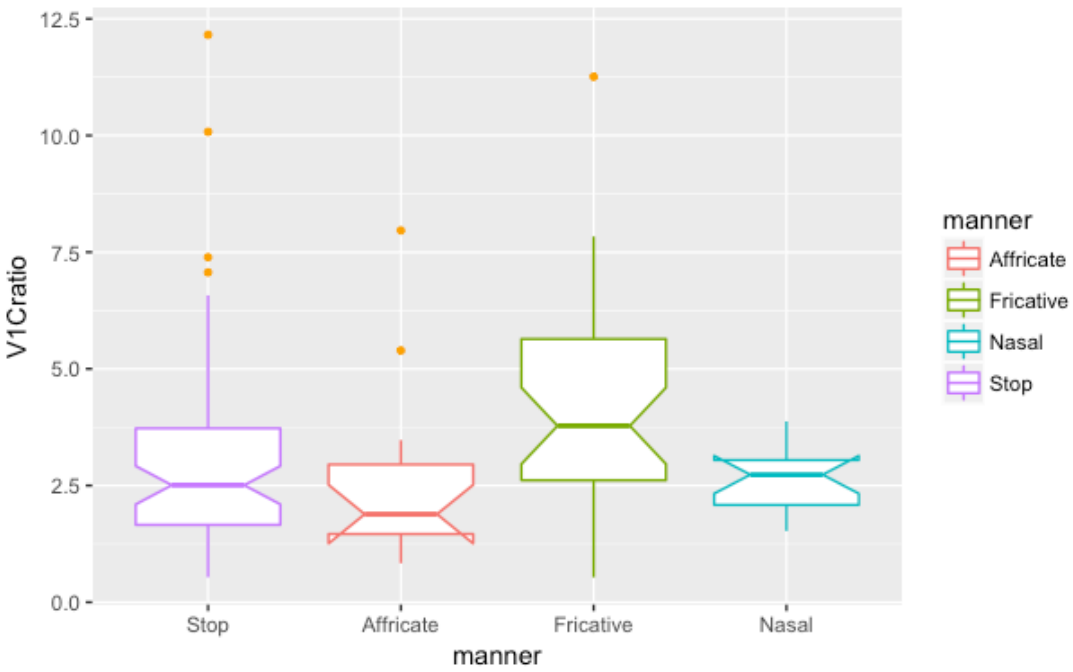


Figure 37: Ratio to the preceding vowel by manner in geminate consonants for English-speaking learners

The first observation that can be made from Figure 37 and Table 83 is the remarkably high values of the mean V1C ratios in geminate environment for all manners when compared with singleton but also with both Japanese native speakers' and other L2 learner groups' data. This suggests a greater contrast between durations of the consonant and its preceding vowel. Secondly, fricatives in Figure 37 stand out with the highest V1C ratio values (M=4.17) when compared to the other three manners. Ratios for stops (M=3.09), affricates (M=2.61) and nasals (M=2.67) appear to have rather similar ratio patterns.

The data presented above was tested by conducting a one-way between subjects ANOVA, which results can be found in table 84 below. The ANOVA compares the effect of the manner of articulation on V1C ratio for geminates in stop, fricative, affricate, and nasal conditions. Results show that the effect of the manner of articulation on V1C ratio is significant but only to a small extent [$F(3, 121) = 3.379$, $p = .02$].

Table 84: Results of the one-way ANOVA for V1C ratio in geminates

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
manner	3	40.7	13.574	3.379	0.0206 *
Residuals	121	486.1	4.017		

Post hoc comparisons were conducted using a Tukey HSD test (Table 85). However, pairwise comparisons indicate a lack of significance of the observations for any of the four manners.

Table 85: Results of Tukey HSD test on V1C ratio in geminate environment

	diff	lwr	upr	p adj
fricative-affricate	1.56211739	-0.09599442	3.22022921	0.0725418
nasal-affricate	0.06454793	-1.90899987	2.03809574	0.9997771
stop-affricate	0.48105503	-1.06173825	2.02384832	0.8485602
nasal-fricative	-1.49756946	-3.15568127	0.16054235	0.0920020
stop-fricative	-1.08106236	-2.19221265	0.03008793	0.0596700
stop-nasal	0.41650710	-1.12628619	1.95930039	0.8956065

The absence of statistical significance in the results of the tests above indicate that the higher ratio values for fricatives observed in Figure 37 are no more than tendencies. Furthermore, it suggests that, for all four manners, V1C ratios in a geminate environment follow similar patterns. A similar result across manners of articulation was observed for Japanese native speakers.

c. Conclusion

The findings in this sub-section exploring the ratio to the preceding vowel for both singleton and geminate environments are as follows. The results indicate that for the singleton environment, fricatives stand out remarkably, with a significantly higher V1C ratio. Inversely, for the geminate environment, the difference that was observed in the graphic representation (Figure 37) was not significant, suggesting that all four manners behave similarly.

5.2.3. Ratio to the following vowel

a. Singletons

The distribution of the ratio of the target consonant (singleton) to the following vowel for the group composed of learners of Japanese whose L1 is English is represented in Figure 38 below. Table 86 presents the corresponding values.

Table 86: Distribution of V2C ratio by manner of articulation in singleton for English speaking learners

Singleton	Min	1st Qu.	Median	Mean	3rd Qu	Max
Stop	0.3161	0.6903	1.0459	1.3973	1.7143	5.4227
Affricate	0.6995	0.8821	0.9800	1.3124	1.1902	4.8136
Fricative	0.6622	1.6844	2.0395	2.3757	2.6991	6.6706
Nasal	0.4090	0.5107	0.6644	0.7054	0.8089	1.4571

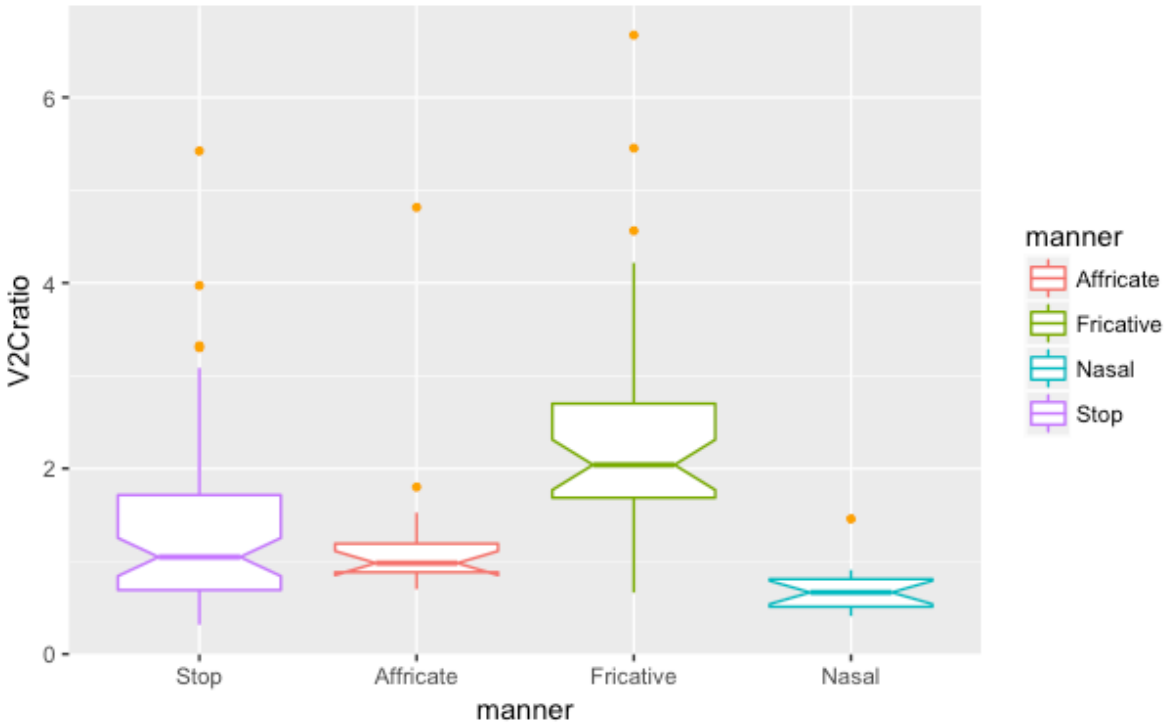


Figure 38: Ratio to the following vowel by manner in singleton for English-speaking learners

The observation of Figure 38 and Table 86 above indicates that fricatives, here again, stand out with higher ratio values (M=2.38), suggesting a greater contrast between the following vowel and the consonant durations. Moreover, stops (M=1.40) and affricates (M=1.31) appear to have similar values, although the box for stop distribution indicates a wider variation range for stops (IQR=1.02) than for affricates (IQR=0.49). Lastly, ratio values for nasals are the lowest (M=0.71).

The significance of the observations about Figure 38 and Table 86 was tested by conducting a one-way between subjects ANOVA in order to compare the effect of the manner of articulation on V2C ratio when C is a singleton, in stop, fricative, affricate, and nasal conditions. According to the results (see Table 87 below), the manner of articulation is significantly correlated with V2C ratio [$F(3,121)=11.12$, $p < .001$].

Table 87: Results of the one-way ANOVA for V2C ratio in singletons

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
manner	3	35.94	11.980	11.12	1.68e-06 ***
Residuals	121	130.31	1.077		

Post hoc comparisons were conducted by running a Tukey HSD test (see Table 88 below). The results give confirmation that the difference between fricatives and other manners is significant, as shown by the low *p*-values for the pairwise comparisons with affricates (p =.008), nasals (p < .001) and stops (p < .001). No significant difference is observed for the other pairs, and affricates show a remarkable similarity with stops (p=.99).

Table 88: Results of Tukey HSD test on V1C ratio for English-speaking learners

	diff	lwr	upr	p adj
fricative-affricate	1.06333756	0.2084453	1.9182298	0.0082886
nasal-affricate	-0.60699715	-1.6287889	0.4147946	0.4125784
stop-affricate	0.08493743	-0.7150043	0.8848791	0.9925724
nasal-fricative	-1.67033471	-2.5252270	-0.8154424	0.0000079
stop-fricative	-0.97840013	-1.5499675	-0.4068328	0.0001081
stop-nasal	0.69193458	-0.1080071	1.4918763	0.1149961

Statistical testing of the observations on Figure 38 and Table 86 confirms the significance of the patterns exhibited by fricative ratio. That is, for fricatives, V2C ratio is significantly higher than for the other manners, suggesting that there is a greater contrast between the duration of a singleton fricative and its following vowel than for other consonant manners. On the other hand, the lower ratio observed for nasals when compared to stops and affricates were non-significant, and results show that there is no difference in the ratio patterns of stops, affricates and nasals. The present findings replicate those for both Japanese native speakers and other learners, where a significantly higher V2C ratio for fricatives was observed.

b. Geminates

Figure 39 below represents graphically the distribution of the ratio of the target consonant to the following vowel (V2C ratio) in the production of learners whose L1 is English, when the target consonant is a geminate. Distributional values are gathered in Table 89.

Table 89: Distribution of V2C ratio by manner of articulation in Japanese geminates for English native speakers

Geminate	Min	1st Qu.	Median	Mean	3rd Qu.	Max
Stop	0.3571	1.5226	2.1278	2.2196	2.7271	5.7319
Affricate	0.3370	0.8116	1.0895	1.8294	1.7908	8.8711
Fricative	0.3047	1.8224	2.7385	3.1643	4.3503	8.2073
Nasal	1.149	1.892	2.071	2.159	2.507	3.375

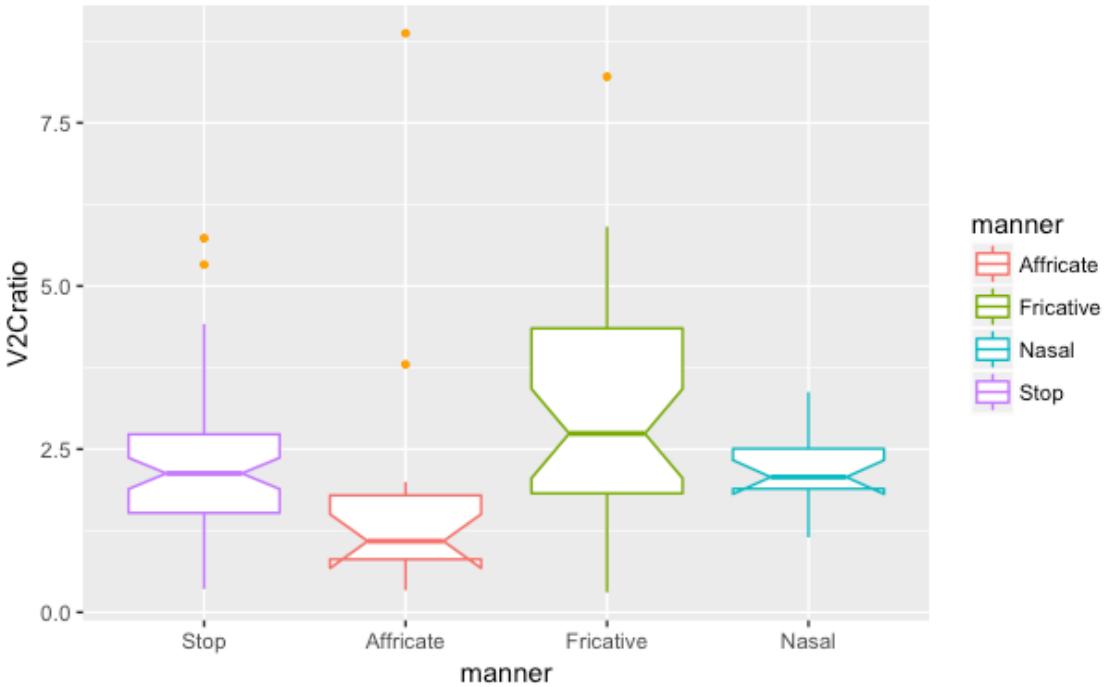


Figure 39: V2C ratio by manner of articulation in geminate consonants for English-speaking learners

In Figure 39 and Table 89 we observe again a higher ratio value for fricatives (M=3.16) when compared with other manners. Inversely, affricates have the lowest V2C ratio values (M=1.83), and stops (M=2.22) and nasals (2.16) present similar ratio values, as indicated by the notches on the boxes, although stops have a wider variation range (IQR=1.20) than nasals (IQR=0.61).

The observations above were tested using a one-way between subjects ANOVA (see Table 90 below). Results show a statistically significant correlation between the manner of articulation of the geminate consonant and the ratio to the following vowel [$F(3,121) = 4.657$, $p = .004$].

Table 90: Results of the one-way ANOVA for V2C ratio in geminates

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
manner	3	27.2	9.066	4.657	0.00408 **
Residuals	121	235.6	1.947		

Post hoc pairwise comparisons were conducted using a Tukey HSD test (see Table 91). The results of the test show a significant difference for fricatives when compared with affricates (p=.01) and with stops (p=.009) only, and the comparison with nasals was non-significant (p=.11). The test shows no other significant difference between any of the other three manners of articulation.

Table 91: Results of Tukey HSD test on V2C ratio in geminates

	diff	lwr	upr	p adj
fricative-affricate	1.33484642	0.1806108	2.4890820	0.0164378
nasal-affricate	0.32908769	-1.0447275	1.7029028	0.9241868
stop-affricate	0.39019515	-0.6837656	1.4641558	0.7798152
nasal-fricative	-1.00575873	-2.1599943	0.1484769	0.1108666
stop-fricative	-0.94465127	-1.7181390	-0.1711635	0.0099316
stop-nasal	0.06110745	-1.0128532	1.1350682	0.9988329

Some of the observations made on Figure 39 above are confirmed by the statistical tests: The difference in ratio patterns for fricatives is significant when compared with stops and affricates. It was however non-significant for the fricative-nasal pair. However, this result indicates that the general tendency for fricatives is to have a higher V2C ratio, that is, more contrast between the geminate consonant and the following vowel duration. On the other hand, the lower ratio values observed for affricates were non-significant, and there was no difference in the behavior of stops, affricates and nasals.

c. Conclusion

This section provided a comparison of the variations in terms of V2C ratios by manners of articulation by looking at singleton and geminate environments separately. The general observation that can be made about the pronunciation of L2 learners whose L1 is English, is the tendency for fricatives to stand out compared to other manners of articulation. Similarly to what was observed for the ratio to the preceding vowel, for the following vowel the ratio was significantly higher for the singleton environment. Namely, the contrast between the vowel and the fricative (singleton) consonant was greater than for other consonant manners. For the geminate environment however, the same tendency was observed but was less significant as it was confirmed only for the difference with stops and affricates. Lastly, no significant difference was observed between the patterns of stops and affricates, suggesting a similar behavior for the two manners, which was also the case in Japanese native speakers' productions.

5.2.4. Comparison within each manner of articulation

After the comparison of each of the durational ratio patterns for SG, V1C and V2C ratios in singleton and geminate conditions in the previous section, this section looks at the data recorded from English native speakers with a different point of view: The durational contrasts between singleton and geminate environments will be compared for stops, affricates, fricatives and nasals separately.

a. Stops

The bar plot in Figure 40 below represents the mean durations for stops in the pronunciation of the Japanese consonantal length contrast by L2 learners whose L1 is

English. The bar on top stands for the singleton environment, and the bottom one for the geminate environment where V1 appears in orange, C in blue and V2 in red. Corresponding values are gathered in Table 92.

Table 92: Relative duration values for stops by English speaking learners

	V1	C	V2
Singleton	0.59	1	0.72
Geminate	0.76	2.35	1.06
Mean ratio	1.30	2.35	1.48

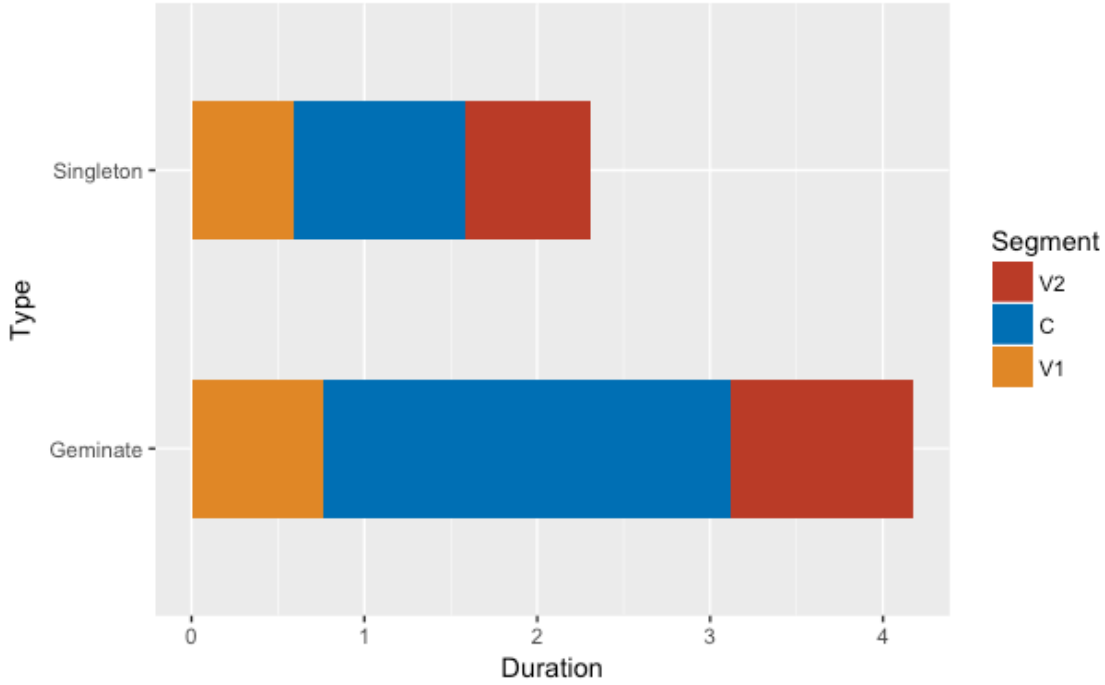


Figure 40: Relative segment mean duration for stops in Japanese singleton and geminate consonants by English-speaking learners

The observation of Figure 40 and Table 92 indicates the following tendencies for the pronunciation of the Japanese consonantal length contrast for stops by English-speaking learners. The ratio for stops is of 2.35, that is, the closure of a geminated stop is 2.35 times the duration of the closure for its short counterpart. This result is consistent with the same experimental results for Japanese native speakers in 2.2.4.a. Preceding and following vowel durations also show a tendency to increase between the singleton and the geminate

environment, as a vowel preceding a geminated stop is 1.3 times longer and one following a geminated stop is 1.48 times longer than when the consonant is a singleton.

These observations were tested using an independent-samples t-test in order to compare the durations of the preceding vowel, the following vowel and the target consonant in singleton and geminate conditions. The results indicate that the difference in consonant duration between singleton and geminate environments is statistically significant [$t(78.404) = 5.3376$, $p < .001$].

However, the variations observed in terms of vowel duration were non-significant for both the preceding [$t(79.133) = 1.5582$, $p = .12$, ns.], and the following vowel [$t(108.25) = -0.59983$, $p = .55$, ns.].

These results indicate that the increase in vowel duration for V1 and V2 between singleton and geminate environments are no more than tendencies. Moreover, although the consonant duration appears to be an acoustic correlate in the production of the consonantal length contrast for stops, the analysis of the present data suggests that this is not the case for the duration of the surrounding vowels. This is also in contrast with Japanese native speakers' pronunciation, where an increase in preceding vowel duration was observed.

b. Affricates

Figure 41 below presents the relative mean durations of V1 (green), C (orange), the frication period F (blue) and V2 (red) when the target consonant is an affricate, between singleton (top) and geminate (bottom) for English-speaking L2 leaners. Corresponding values are gathered in Table 93.

Table 93: Relative mean duration values for affricates by English speaking learners

Affricates	V1	C	Frication	V2
Singleton	0.76	1	2 .14	0.76
Geminate	0.89	2.32	1.85	1.27
Mean ratio	1.17	2.32	0.87	1.66

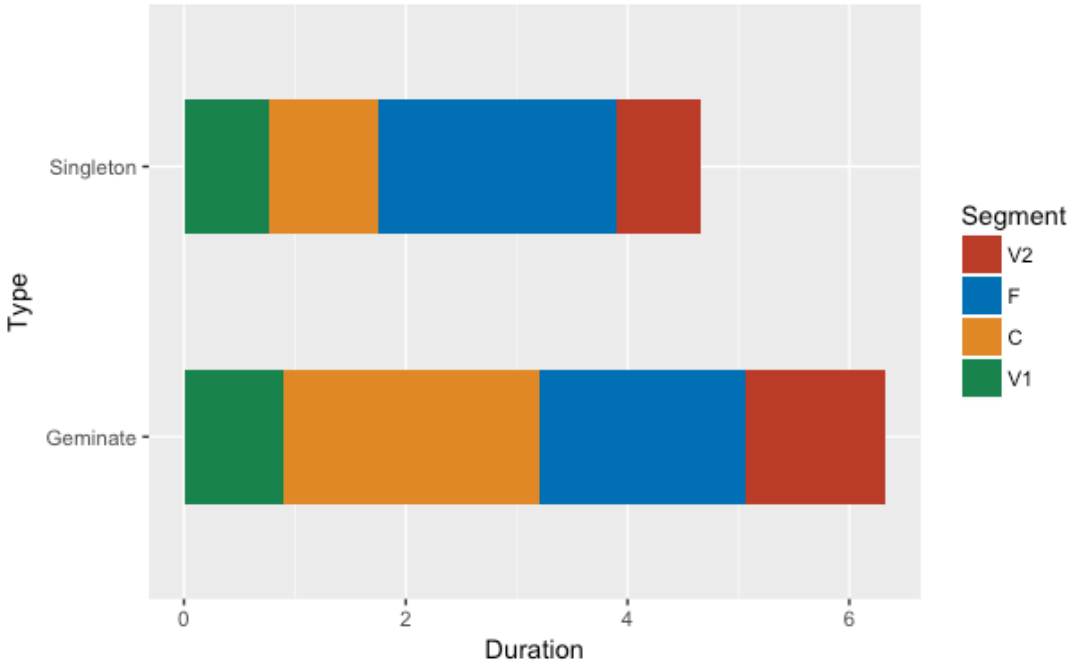


Figure 41: Relative segment duration for affricates in singleton and geminate consonants for English speaking learners

The data presented in Figure 41 and Table 93 above indicates that a geminated affricate consonant has a closure 2.32 times longer than in its shorter counterpart. Furthermore, an increase is also observed in vowel durations with a V1 that is 17% longer and a V2 that is 66% longer when in a geminate context. The duration of the frication part in the consonant follows a different pattern as a decrease in frication duration (-13%) is observed between the singleton and the geminate environments.

Several independent samples t-test were conducted in order to test the differences between segment duration in singleton and geminate conditions. Results confirm the significance of the difference between singleton and geminate durations [$t(14.733) = 3.0884$

, p =.007], and the increase in the following vowel duration was also significant [t(15.77) = 2.642 , p =.01]. However, no significant difference could be found for V1 duration [t(-24.831) = 0.218 , p =.82, ns.], and frication duration [t(35.531) = 0.78 , p =.44, ns.] between singleton and geminate environments.

The present results confirm the use of consonant closure duration as the primary acoustic cue for the Japanese consonantal length contrast, as it was the case for the same data from Japanese native speakers. However, the patterns of frication duration differ from those of Japanese native speakers' pronunciation. Although for both English and Japanese native speakers no significant variation was observed for frication duration between the singleton and geminate environments, frication duration is remarkably longer in learners' pronunciation. Indeed, the results indicate a frication duration of more than twice the closure duration in singleton, while in native speakers' pronunciaiton it is about the same duration. Concerning vowel duration, no significant difference was observed for V1, indicating that the increase in V1 duration used as a production cue by Japanese native speakers is not active in English speaking learners.

c. Fricatives

Durational contrasts between the singleton and geminate environments for fricatives are represented in the bar plot in Figure 42 below. V1 duration appears in orange, C duration in blue and V2 in red, with the upper bar standing for singleton and the lower for geminate environment. Corresponding values can be found in Table 94.

Table 94: Mean duration values for fricatives by English speaking L2 learners

Fricatives	V1	C	V2
Singleton	0.43	1	0.42
Geminate	0.41	1.71	0.54
Mean ratio	0.96	1.71	1.28

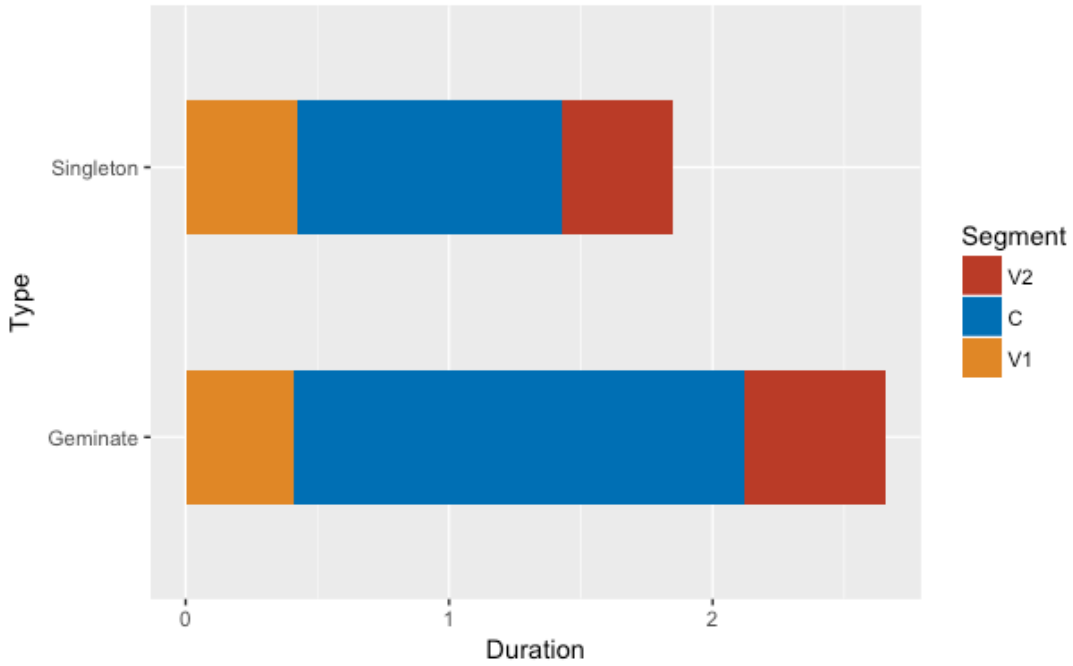


Figure 42: Relative segment duration for fricatives in singleton and geminate consonants for English-speaking learners

Figure 42 and Table 94 indicate a longer duration of the frication period for a geminate fricative consonant (171%) than for a singleton one. The following vowel V2 also shows an increase in duration (128%), while the data for the preceding vowel indicates a slight tendency to a decrease (96%) in duration.

Independent samples t-tests were conducted in order to test these observations. Results allowed to confirm the significance of the singleton-geminate durational contrast [$t(54.655) = 4.144$, $p < .001$]. However both the increase in duration observed for V2 [$t(63.323) = 0.99$, $p = .32$, ns.], and the slight decrease in V1 [$t(59.985) = -0.623$, $p = .53$, ns.] were non-significant, indicating that these are no more than tendencies.

The present results, indicate an increase in consonant frication duration between singleton and geminate for fricatives, which is consistent with the primary production cue for fricatives geminates in Japanese native speakers' pronunciation. However, no significant variations could be observed in the duration of the surrounding vowels, suggesting here

again that learners do not rely on vowel duration for production of the singleton geminate contrast.

d. Nasals

The bar plot in Figure 43 below presents the relative mean durations of V1 (orange), C (blue) and V2 (red) when the target consonant is a nasal, between singleton (top) and geminate (bottom) environments for learners of Japanese whose L1 is English. Corresponding numerical values can be found in Table 95.

Table 95: Mean duration values for nasals by English-speaking learners

Nasals	V1	C	V2
Singleton	1.02	1	1.42
Geminate	1.23	3.36	1.56
Mean ratio	1.19	3.36	1.09

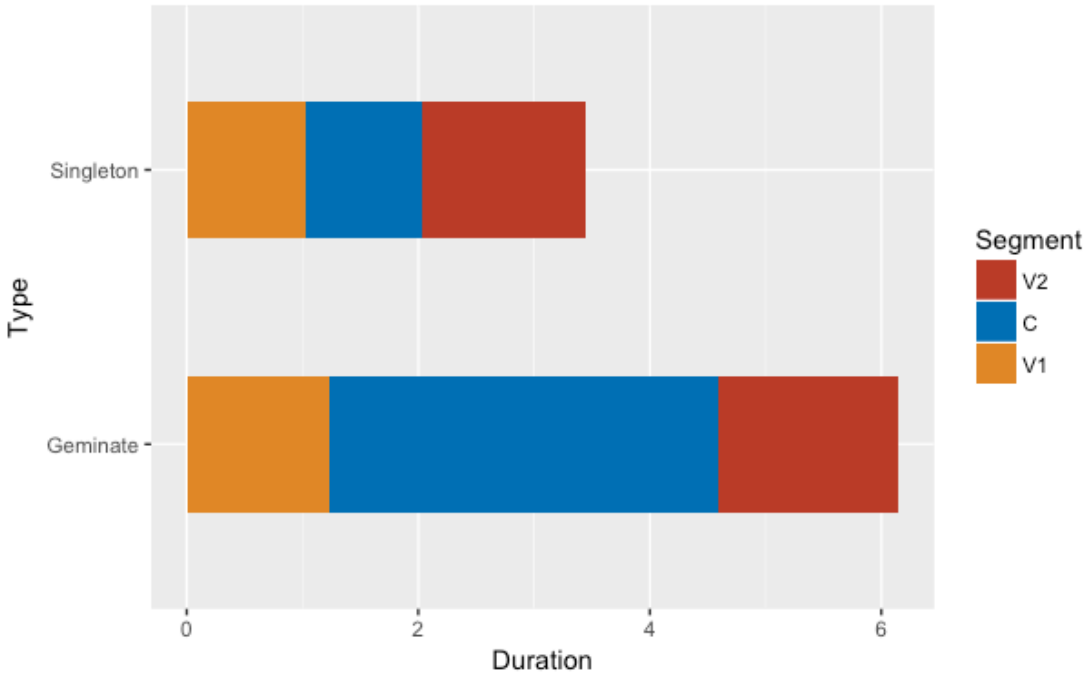


Figure 43: Relative segment duration for nasals in singleton and geminate consonants for English-speaking learners

The observation of Figure 43 and Table 95 above allows the identification of a general tendency to an increase in segment duration between the singleton and geminate environment in this learner population. Nasal geminate are more than three times longer (336%) than singletons. Furthermore, the values for V1 and V2 indicate an increase in duration when before a geminate (119%), and when following a geminate but to a lesser extent (109%).

The observations above were tested by conducting several independent-samples t-tests, which confirm the difference between the consonant duration in singleton and geminate environments [$t(15.658) = 7.549$, $p < .001$]. However, both the increase in V1 duration [$t(25.728) = 0.511$, $p = .61$, ns.], and the one in V2 duration [$t(15.36) = 0.632$, $p = .53$, ns.] were non-significant. The results of the statistical tests suggest that the duration of V1 and V2 are similar between the two environments, a result which matches those of native speakers for nasals.

e. Conclusion

This section investigated further the durations of the target segments by comparing them between the singleton and geminate contexts separately for each manner of articulation. The statistical significance of all observations on the data was tested and the results of the statistical testing allows to make the following affirmations concerning the pronunciation of Japanese consonantal length contrast by English native speakers: First, it was confirmed that in this learner population the primary production cue for the singleton-geminate contrast is the consonant constriction duration, similarly to Japanese native speakers and to the other L2 learner groups examined in previous sections. This is shown by the significant difference in the duration of geminates compared to singleton consonants,

and the durational ratio that is consistent with native speakers': a geminate is a least twice a singleton duration.

For vowel duration, no difference could be observed for V1 between singleton and geminate for any of the four manners of articulation. The following vowels had a similar pattern to the exception of V2 for affricates which showed a tendency to increase when following a geminate consonant.

5.3. Summary

The fifth section of this chapter was devoted to the analysis of the patterns observed experimentally in the pronunciation of L2 learners whose L1 is English. In order to identify the production cues active in these learners' pronunciation of the consonantal length contrast in Japanese, the investigation focused on global results in section 5.1 before comparing the effect of manner of articulation on each type of ratio in section 5.2. Specifically, in section 5.2.1 the analysis was conducted in order to compare each ratio type between manners of articulation, while 5.2.2 explored durational correlates in singleton and geminate context within each manner of articulation. Findings for each item studied were compared with similar data from the control group of Japanese native speakers.

The results of the analyses conducted in the present section suggest the following patterns for the production of Japanese consonantal length contrasts by this learner population:

(i) The global results indicate that geminate duration is at least twice the singleton duration (SGratio =2.28), which confirms the role of constriction duration as the primary acoustic correlate for gemination.

(ii) Global results show that there is no significant variation in V1 and V2 duration between the two environments.

(iii) The results of the comparisons between and within manners of articulation are summed up in Table 96 and 97 below, where S stands for stops, A for affricates, F for fricatives and N for nasals.

Table 96: Summary of the results of the comparison between manners of articulation for English-speaking L2 learners

	V1C	SG	V2C
Singleton	N≤S=A＜F	S=A=F=N (N＜F)	S=A=N＜F
Geminate	S=A=N＜F		S=A=N≤F

Table 97: Summary of the results for the comparison within each manner of articulation in English-speaking learners

	Stop	Affricate	Fricative	Nasal
V1	V1sing =V1gem			
C	S＜G			
F	NA	Fsing=Fgem	NA	NA
V2	V2sing=V2gem	V2sing＜V2gem	V2sing=V2gem	

From the analysis of L2 learners of Japanese whose L1 is English, we can say that they rely on the same primary production cue as Japanese native speakers for the consonant length contrast. This is reflected in their SG ratio values, showing that the closure/ frication duration of geminate consonants is a least twice the duration of their singleton counterparts. The only exception was for fricatives which had lower ratio values, but this characteristic was also observed in Japanese native speakers' pronunciation

In previous results on English native speakers by Han (1992), geminates were twice the duration of a singleton, a result which was similar to those of the pronunciation of sequences of identical vowels (e.g. cat tail) in their L1, and that Han attributed to negative L1 transfer. Similar results were also observed in Toda (1994), and she claims that learners

interpret the syllable structure as a sequence of identical consonants VC-CV instead of a long consonant VC:V and modify it accordingly. In the present study, however, the SG ratio found for English speaking learners was greater than for Japanese native speakers, with inversely an overexaggeration of the singleton geminate contrast in learners' production, and suggesting that they interpret the syllable structure correctly.

The patterns for the durations of the surrounding vowels replicate those observed for French learners as to one exception there was no difference in terms of V1 duration between singleton and geminate context, as well as for V2 duration between singleton and geminate. While the Japanese native speakers in this experiment use V1 duration as a secondary acoustic cue for the phonetic implementation of the consonantal length contrast, the present results suggest that this is not the case for English speaking L2 learners.

6. SUMMARY OF CHAPTER 6

In order to provide an answer to the third hypothesis of this dissertation, the present chapter presented the results obtained from the detailed investigation of the data recorded for the four speaker groups in the production experiment. This chapter introduces results on the pronunciation of the consonant quantity contrast in Japanese for each speaker group separately in the following order: The data from the control group composed of Japanese native speakers was introduced first in order to compare it with the same data for second language learners in the sub-sections that follows. The three following sub-sections present the results for French, Italian and English-speaking L2 learners of Japanese. For each of the learner groups, general results on the production of the consonantal length contrast come first, followed by a detailed analysis looking especially at the variations in terms of durational contrasts between the singleton and geminate environments when comparing manners of articulation: stop, affricate, fricative and nasal. Specifically, I looked at durations and durational ratios for the target consonant as well as its surrounding vowels V1 and V2 between the singleton and geminate environments. Statistical skews were tested in order to ensure of the significance of the results.

The third hypothesis of this dissertation is reproduced below:

Hypothesis 3: There is no difference between L2 learners and Japanese native speakers in the use of durational cues for consonantal length production.

Data analysis allowed to shed light on the following characteristics of learners' pronunciation of the consonantal length contrast: First, all three learner groups appear to successfully make use of consonantal length and SG ratio to distinguish a short consonant from a long one. This suggest that the primary cue for Japanese native speakers is also active

in learners' pronunciation. Secondly, durational properties for the preceding and following vowels exhibited patterns that diverge from those observed for native speakers. Namely, although native speakers use a language-specific timing control reflected in vowel durations in order to phonetically implement and maintain the contrast between singleton and geminate, it appears that learners are mostly limited to consonantal length. In the case of French and English native speakers, the absence of variations in vowel duration between the singleton and geminate environments strongly suggests that this is not an active cue in their pronunciation. For Italian learners, the situation is more complex, as they exhibit a propensity to shorten the vowel preceding a geminate consonant, a property observed in their L1.

In sum, the present results show that only some of the durational cues used by native speakers are also used by learners in the pronunciation of the consonantal length contrast. Consequently, the third hypothesis cannot be validated. Moreover, it appears that the pronunciation of French and English learners has similar characteristics, which are different from Italian learners. In sum, the productions cues for learners are different from those of Japanese native speakers, but differences were also observed among the three learner groups. This will be discussed further in the next chapter.

CHAPTER 7: DISSCUSSION

Based on the results of the analysis of the experiment data presented in Chapter 5 and 6, the present chapter proposes to discuss their significance and implications.

1. CONSISTENCY OF THE RESULTS FOR JAPANESE NATIVE SPEAKERS

The production by Japanese native speakers of the consonantal length contrast in our data replicates the results from previous studies (Beckman 1982, Han 1962, 1994, 1992, Homma 1981, Kawahara 2006, Port et al. 1987 *inter alia*.) and confirms the durational production cues in native production. Indeed, in the present data, durational ratios are consistent with the same ratios in the studies cited above: The singleton/geminate ratio shows that the closure/frication duration in a geminate is at least twice the closure duration in its singleton counterpart, confirming the closure/frication duration as the primary acoustical cue for the production of the consonantal length contrast. However, the SG ratio values found in our experimental data appear to be lower than those of previous studies, although consistent[38]. A possible explanation is that these values might be due to the influence of the experimental setting, but do not however have a negative influence on the

[38] In our case SG ratio for Japanese native speakers is closer to 2, while it is closer to 3 most studies in the literature.

significance of the same results for learners as these are based on the same experiment contents and methodology.

Concerning secondary durational cues, the durational ratios observed with surrounding vowels indicate that the duration compensatory mechanism observed in previous studies is also active in our experiment: In line with previous studies (Fukui 1978, Han 1994, Hirata 2007, Idemaru and Guion 2008, Kawahara 2006 *inter alia.*), we observe that the vowel preceding the target consonant is in general longer when before a geminate in Japanese native speaker pronunciation. However, the tendency for vowels following a geminate to be shorter in Japanese native speakers' production (Han 1994, Hirata 2007, Idemaru and Guion 2008 *inter alia.*), although observed, was observed only for geminated stops in the present experiment. This is however not inconsistent with previous findings as Hirata (2007) claims that this decrease in following vowel duration in a geminate environment is less consistent than what is observed for the preceding vowel duration.

2. Fricatives and Affricates, Language-specific and Universal Properties

The analysis of our data for all four speaker groups sheds light on the remarkable status of fricative consonants. Indeed, regardless whether the data was taken from Japanese native speakers or from L2 learners, fricative consonants followed durational patterns that stand out when compared to the other manners. Namely, the general tendency observed for fricatives is to have a significantly lower singleton-geminate ratio, that is less contrast between the singleton and the geminate consonant durations. This was also reflected in the ratios to the preceding and following vowels: Results indicate that they have higher values in general than the other manners, that is, a greater contrast between the consonant duration and the duration of the surrounding vowels. The behavior of both SG, V1C and V2C ratio

values taken all together suggests that the consonant itself is longer for a fricative than for other manners.

The fact that this tendency for fricative consonants appears to be shared by all four speaker groups regardless their L1, suggests that these results are to be related to universal (articulatory) properties of fricative consonants rather than to some language specific cues. Previous studies affirm that fricative singletons are longer than stops (closure, Lehiste 1970). This is the case in Japanese as observed by Beckman (1982), Campbell (1999) and Port et al. (1987) among others, and in Italian (Giovanardi and Di Benedetto 1998). Giovanardi and Di Benedetto (1998). Kawahara (2015) affirms that the［-continuant］feature of stop consonants is responsible for an inherently shorter duration than fricative consonants in general. That is, the contrast between singleton and geminate fricatives is less straightforward and a logical consequence of a lower SG ratio, is that the difference is more difficult to perceive (Kawahara 2015).

In terms of second language acquisition and teaching it has the following implications: Although fricative quantity contrasts have been claimed to be more difficult than stops to perceive for both native speakers and learners (Hardison and Motohashi-Saigo 2010, Toda 1998, 2003), I suggest that in terms of production the situation might be different. A first argument that supports this claim is the crucial role of universal acoustic/articulatory properties of fricatives in learners' pronunciation shown by the present results: Regardless the L1 less contrast was observed for fricatives between singleton and geminates. If a less straightforward contrast is crosslinguistically an inherent property of [+continuant] phonemes, then there should be no need for acquisition of a specific timing for these phonemes when compared to stops. Secondly, the contrast between singleton and geminate in [+continuant] phonemes being less straightforward and therefore more difficult to

perceive, it can be expected that native speakers will be less sensible to potential errors in learners' speech (i.e. higher comprehensibility). Lastly, as fricatives and stops have different inherent properties with regard to continuancy, they might require a different acquisition process. This can be extended to nasals that also have the same [+continuant] feature. Indeed, [-continuant] phonemes are inherently characterized by an absence of acoustic signal for both singleton and geminate, while for [+continuant] ones, they will be continuous sounds with different durations. It seems challenging for both teachers to explain, and for learners to understand an absence of acoustic signal. In sum this suggests that, contrary to previous claims in perception studies, the production of length contrasts including a [+continuant] consonants are easier to acquire.

Now looking at affricate consonants in our data, their patterns are also of interest. The literature on Japanese affricate geminates (Oba, Brown and Handke 2009, Kawahara 2015), although rare, points out the similar behavior of durational cues for stops and affricates. Indeed, their results show that the primary acoustic correlate of affricate gemination is the closure duration, and that no variation is observed for the frication duration. The results of the present experiment for Japanese native speakers were consistent with previous studies' results. It was also the case for French and English native speaker groups, in which no significant difference in durational ratios could be observed between stops and affricates, indicating a similar behavior. For Italian learners however, the ratio for affricates was significantly lower than for other language groups. This is illustrated in Table 1 below.

Table 1: Mean SG ratio in stops vs. affricates for the four language groups

	Japanese	Italian	French	English
Stop	2.12	2.4	2.2	2.35
Affricate	2.22	1.61	2.13	2.31

The results in Table 1 above should be put into perspective with the property of Italian geminates to lengthen both the closure of the stop part and the frication period of the fricative part. Both the lower values exhibited by affricate consonants for SG ratio, and for V1C and V2C ratios in geminate environment only, suggest that the lengthening of the closure part of the consonant is less important than for other manners. This constitutes a piece of evidence for L1 negative transfer for Italian learners, who apply their language-specific durational cues for affricates to Japanese affricates even if these actually require the use of different production cues. However, the results for the frication period in Chapter 6 showed no significant variation in terms of duration between singleton and geminate environments for Italian learners, indicating that either L1 transfer is not active on frication duration, or the L2 durational cue is only partly acquired. The different behavior of French and English learners on the one hand, and Italian learners on the other hand will be discussed further in section 4 of this chapter.

3. Incomplete acquisition of the consonantal length contrast

In the production of the consonant durational contrast for the three learner groups, the singleton-geminate ratio indicated that the primary acoustic cue for all groups is the closure/frication duration (see mean SG ratios reproduced in Table 97 below). Learners are able to make a distinction between a singleton and a geminate consonant in their production (singleton and geminate closure/frication durations were significantly different from each other for all three groups). Namely, their phonetic implementation of the phonemic consonantal length contrast in Japanese lies in a difference in terms of duration of the closure/frication duration.

In general, previous studies on English learners of Japanese (Han 1992, Toda 1997 *inter alia*.) researchers found lower SG ratios for learners when compared to native speakers, which was claimed to be underdifferenciation due to L1 negative transfer. What is responsible for this underdifferenciation phenomenon, according to these authors is, on the one hand an insufficient geminate duration that does not allow to maintain the contrast (Han 1992), and on the other hand for Toda (1997) it's the longer singleton duration when compared to the geminate one. In sum, Han (1992) and Toda (1997) argue that learners, unlike native speakers, are not able to maintain the ratio and therefore a consistent moraic timing across speech rate. These two studies also suggest that English learners have difficulties in interpreting the syllable structure and modify it in order to have a sequence of identical consonants (VC-CV) and not a long consonant (VC:V).

However, results of the present experiment show different tendencies. In opposition to what was observed in previous studies cited above, SG ratios for learners are higher than for Japanese native speakers (see Table 1 below), indicating that learners are aware of the consonant durational contrast and tend to use overexaggeration, that is enhancement of the contrast, as a production strategy. It also appears that they do not seem to have problems with syllable structure. Furthermore, the higher ratio values for learners are not irrelevant values for SG ratios in general when compared to those observed in the literature. Although singletons (see Table 2) are longer in learners' pronunciation than in native speakers', this merely is more than an effect of speech rate[39], as geminates are also found to be longer. This suggests that learners have acquired, to a certain extent, the moraic timing, as they are able to maintain a consistent SG ratio across speech rate.

[39] The observed speech rate was lower in general for learners than for Japanese native speakers in this experiment.

Table 2: Mean SG ratios for the four speaker groups

	Japanese	French	Italian	English
Mean SG ratio	2.07	2.35	2.31	2.29
Mean raw S/G durations (ms)	70/150	90/180	96/190	107/200

The analysis of the durational ratios involving vowels surrounding the target consonant sheds light on some other characteristics of the three learner groups' pronunciation. The literature indicates that in Japanese native speakers' production, the duration of the preceding and following vowels is a secondary acoustic correlate for the consonant durational contrast: a vowel preceding a geminate is longer (Fukui 1978, Han 1994, Hirata 2007, Idemaru and Guion 2008, Kawahara 2006 *inter alia.*), and one following a geminate tends to be shorter (Han 1994, Hirata 2007, Idemaru and Guion 2008 *inter alia.*). Although the results for Japanese native speakers support previous studies' claim for preceding vowels and to a lesser extent for following vowels, this is not the case in learners' data. In French and English native speakers' pronunciation, results indicate no significant variations in terms of duration for both preceding and following vowels between singleton and geminate environment, which suggests that in contrast with Japanese native speakers, surrounding vowel durations are not active durational correlates in their pronunciation. On the other hand, for Italian native speakers, results suggest that they rely on the preceding vowel duration to phonetically implement the consonantal length contrast in Japanese. However, the observed tendency is to a decrease in their vowel durations, contrary to native speakers for who an increase is observed. Although vowel duration appears to be a production cue for Italian native speakers, they use it in a different way than Japanese native speakers. In sum, the results allowed to identify the following cues for the four speaker groups.

Table 3: Production durational cues for the four L1 groups

	V1 duration	C duration	V2 duration
Japanese	+	+	- (+?)
Italian	+	+	-
French	-	+	-
English	-	+	-

The role of L1 timing and phonetic cues has been demonstrated in the production of Japanese geminates by Korean learners, for who the identification of geminate consonants is based on consonant quality (phonetic characteristics) and not duration (Min 1987, 2007, Horigome 1999). Indeed, Korean learners exhibit a tendency to identify geminates as Korean tense stops with a resyllabification as closed syllables, where the consonant becomes a coda, leading to a shortened vowel duration (Min 2007). This pattern seems consistent with the production of Italian learners, whose L1 is also syllable-timed and where geminates are analyzed as heterosyllabic (Lopocaro 1990) with a shorter preceding vowel duration, which explains a shorter vowel duration in their L2 as well. Inversely, for learners whose L1 is French, another syllable-timed language, the vowels preceding geminate consonants were not shortened, which suggests that geminate consonants might be interpreted as tense onsets instead. Although their L1 has a different type of timing (i.e. stress-timed), English-speaking learners behave as French leaners, which suggests a similar type of interpretation of the syllable structure for these two populations.

All together these findings suggest that the four learner groups have acquired the phonological categories for short and long consonants (i.e. they are able to distinguish them and maintain consistent ratio). However, the results concerning the surrounding vowel durations indicate that they are not yet able to phonetically implement these categories with a native-like (and specific to Japanese) control of timing, that is they still need to acquire

native-like phonetic implementation strategies. This result supports Mah and Archilbald (2002)'s claim that acquisition of native-like pronunciation of new segment contrasts requires two distinct processes: building phonological representations and acquisition of accurate language phonetic implementation strategies, which are specific to Japanese (Lahiri and Hankamer 1998, Esposito and Di Benedetto 1999). In the present case, we postulate that learners have acquired the former, but not the second.

3. L1 INFLUENCE

The crucial role of the influence of L1 in L2 phonological acquisition has been pointed out by a wide range of studies, which interpret differences or similarities in phonological properties between L1 and L2 as predictors for errors and interlanguage formation patterns (Eckman 2004, Eckman and Iverson 2012). In particular, research based on empirical evidence propose models that shed light on the relationship between a learner's L1 phonological properties and his/her abilities in terms of perception and production (phonetic implementation) of L2 sounds. Among these: The Feature Competition Model (FCM, Hancin-Bhatt 1994), the Perceptual Assimilation Model (PAM, Best 1995), the Speech Learning Model (SLM, Flege 1995). The present sub-section, based on Flege's SLM that will be introduced more in details below, aims at using our experimental results to modelize L2 acquisition of durational contrasts, with regard to the phonological properties of a learners' L1.

In this sub-section, in order to ease the comprehension as the discussion involves the three learner groups, the expressions "source language" and "target language" will be used instead of L1 and L2. Source language is defined as the L1 of the learners, that is Italian for

Italian learners, French for the group of French learners and English for the group of learners whose L1 is English. Target language on the other hand refers to the L2 common to all these language groups: Japanese.

3.1. Phonological representation and phonetic implementation

In the preceding sub-section was introduced Mah and Archibald's (2002) view of the acquisition of the pronunciation of new segment contrasts. They claim that it requires two distinct processes: First, the building of phonological representations, and second, the acquisition of accurate language-specific phonetic implementation strategies. Building upon their claim, we make the postulate that in the acquisition of a new segment contrast, the building of the phonological representations (i.e. categories required for a phonemic contrast) is easier for learners whose source language has a similar contrast.

In the present case, Italian learners, who have a similar contrast in their source language, have an advantage when compared to native speakers of languages who don't, owing to the fact they don't need to build a new phonological category for long consonants as they already have one available. We also expected French learners, whose source language has, to some extent, a distinction between short and long consonants, to perform better than English native speakers. However, our results indicate that all learners from all L1 groups are able to make a clear difference between singleton and geminate in their pronunciation, that is, they have succeeded in building a phonological category for long consonants, regardless the phonological properties of their source language (see also section 3 above). The nature of the present experiment (cross-sectional) makes it inherently difficult to make any claim concerning the acquisition process that participants went through for the consonantal length contrast. We can only presume that at an earlier stage of acquisition,

Italian native speakers had an advantage in acquiring separate phonological representations for the singleton-geminate contrast. Yet, it appears that at the intermediate level, which was the condition for participant recruitment, learners from all three L1 groups had mastered the phonological representations of the phonemic contrast between singleton and geminate consonant. Findings from Chapter 4 on production accuracy may however provide some pieces of evidence of the advantage that the presence of the consonantal length contrast in one's source language represents for the target language acquisition. Indeed, Chapter 4 results show a higher durational accuracy for Italian and French than for English learners.

Concerning phonetic implementation of the contrast, as mentioned in section 2 of this chapter, my results suggest that learners from all learner groups have not yet acquired the language specific timing control required for a native-like phonetic implementation. The detailed analysis of the data for each group provided in Chapter 5, sheds light on the difficulties that learners encounter when it comes to phonetic implementation of the consonantal length contrast. In French and English-speaking learners of Japanese we generally observe an absence of any correlation with the surrounding vowels durations and the consonant nature: that is, both V1 and V2 show no significant variations in terms of duration across the singleton and the geminate environments. For Italian learners, their durational ratios appear to follow different patterns. Indeed, we could observe a tendency to have a shorter V1 before a geminate consonant, a peculiar behavior for affricates[40], and although it was not statistically significant, a tendency for SG ratio values to match those observed in their source language in previous studies (Argiolas et al.1995, Giovanardi and Di Benedetto 1998, Esposito and Di Benedetto 1999, Mattei and Di Benedetto 2000, Faluschi and Di Benedetto 2001).

[40] The behavior of affricates discussed in section 2 of this chapter.

What we suggest from this data, is that Italian learners of Japanese rely on their source language timing correlates for phonetic implementation of the consonantal length contrast in their target language, and that therefore, production durational cues of the target language are not acquired. Gemination being mostly irrelevant phonemically in English and French[41], the lack of data prevents us from comparing our results with the patterns in their source language. However, what we notice is that their use of timing control differs both from Italian learners' and from Japanese native speakers'. Although they appear to rely on the same primary acoustic correlate (i.e. closure/frication duration), they do not use surrounding vowel durations. This indicates that they rely only partly on the production cues of the target language, and suggests incomplete acquisition. The present data doesn't allow us to know whether this is a final stage of their acquisition, but the model presented in 3.2. bellow postulates that this is only an intermediate stage and that acquisition is possible for these learners with appropriate instruction.

3.2. Modelization

In Flege's Speech Learning Model (1987, 1995, 2005), the acquisition of an L2 phonological system is subject to the influence of a learners' L1 in the following way: As our brains are optimized for L1 phonological categories, when learning of a second language, L2 phonemes that are "similar" to the learners' L1 phonemes are classified into a L1 phonological category. On the other hand, in the case of L2 phonemes that are categorized as "new", it is necessary to create a new category to classify and process them. Flege (1987, 1995, 2005) affirms that this makes an accurate pronunciation of similar sounds more

[41] The results of a perceptual experiment in Guillemot (2018) suggests that French native speakers don't have separate phonemic categories for singleton and geminate consonants in French.

challenging for learners as they tend to be assimilated to L1 phonological categories making the distinction arduous. A logical consequence is that, inversely, phonemes that are "new" for the learner will be easier to acquire. The principles of the Speech Learning Model summarized above are schematized in Figure 1.

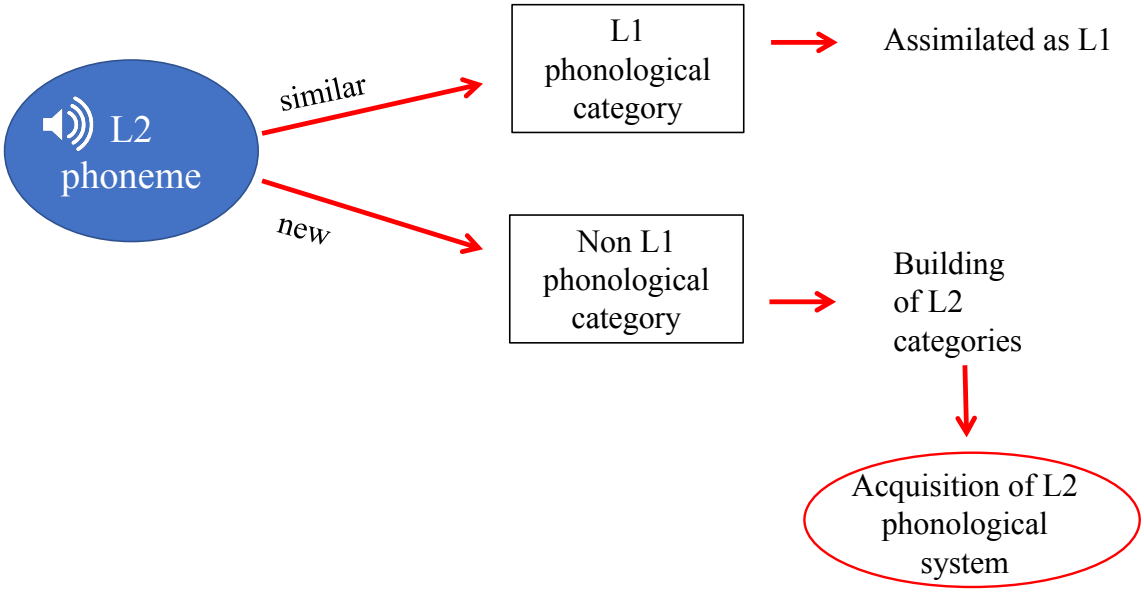


Figure 1: Speech Learning Model (Flege 1987, 1995, 2005)

Building upon both Flege's Speech Learning Model and Mah and Archibald (2002)'s two steps for segment contrast acquisition we propose a theoretical model to account for our experimental results on the acquisition of consonantal length contrast in Japanese. The present model differs from Flege's in the way it links phonology and phonetics in the acquisition process: It is not limited to the acquisition in terms of phonological consideration but also includes how this is phonetically reflected in the pronunciation.

The first assumption is that the building of phonological representations is closely related to the identification of a contrastive segment of the target language as "similar" or "new" compared to the source language categories. Indeed, the building of a new phonological category can occur only in a case in which the segment is identified as "new", that is, contrastive.

The second assumption is that phonetic implementation follows from the first assumption above: The accuracy of phonetic implementation of the contrast in the target language depends on the success in building a new phonological category for the contrastive segment. Namely, an identification as "similar" leads to the use of source language cues, while an identification as "new" leads to the building of not only a new phonological category but also new acoustic cues.

This model is presented in Figure 2 below, where SL stands for "source language" and TL for "target language".

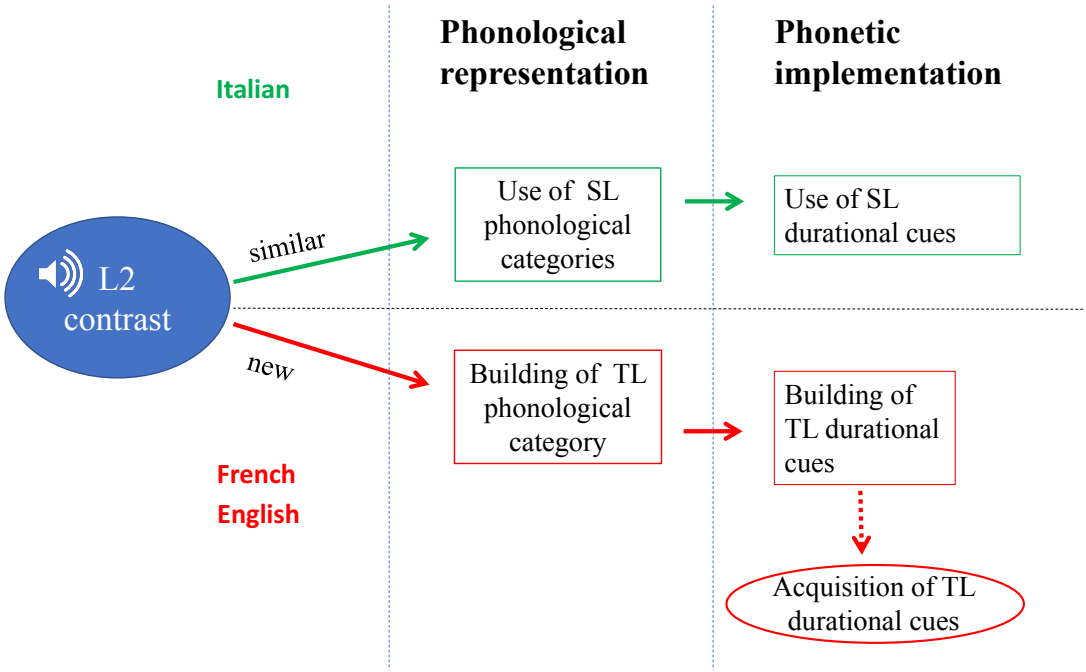


Figure 2: SL influence in Phonological category building and phonetic implementation of TL contrasts

Applied to the present data and length contrasts, we can account to our results in the following way:

We suggest that having a consonantal length contrast in their source language is an advantage for Italian learners (in green in Figure 2) when it comes to phonemic representations: they don't need to create a new phonological category as the phonemic

distinction between short and long consonant is already available for them. In their case, a Japanese long consonant will be identified as “similar” and assimilated to the long consonant phonological category of their source language. Consequently, we can expect that even at early stages of their acquisition of Japanese, the production of a contrast between short and long consonants in Japanese does not constitute a challenge for Italian learners as it follows from a source language process. A logical consequence of this is a higher accuracy for Italian learners (cf. results for accuracy). On the other hand, owing to the absence of a phonological representation for long consonants (as opposed to short ones existing in their source language), French and English learners will need to build a new phonological representation for geminates and may therefore experience a disadvantage at the early stages of acquisition when compared to Italian learners.

However, according to the prediction of the model above, the accurate acquisition of the language specific timing control necessary for phonetic implementation of the Japanese consonantal length contrast will be more challenging for Italian learners than for other learners. Indeed, English and French learners will build directly target language phonemic categories, which are associated with target language phonetic cues, while Italian learners are using those of their source language. This is confirmed in our results by the tendency observed for Italian learners to rely on their source language cues (V1 duration, SG ratio values, affricate patterns), while French and English learners have partially acquired durational cues (SG ratio is contrastive but not related with surrounding vowels durations).

In sum, our model suggests that:

(i) In phonological representation building: Italian > French, English

(ii) In phonetic implementation: French, English > Italian

When it comes to language teaching, it follows from the present model that Italian, English and French native speakers should not be dealt with in a similar way when learning Japanese, and more specifically the consonantal length contrast. This point will be further developed in the conclusion to this dissertation (Chapter 8).

CHAPTER 8: CONCLUSION

1. Summary of the dissertation

This dissertation provided an experimental study of the pronunciation of the consonantal length contrast in Japanese by learners whose native languages have different phonological properties with regard to timing and to the presence/absence of such a contrast. As such, it explores the role of L1 influence on L2 production. In particular, the items examined were the effect on L1 influence on L2 accuracy and on L2 production cues, and results allowed to identify different cues for different L1 phonological properties.

After the introduction, Chapter 2 provided a review of the literature pertaining to the issues tackled in this dissertation. Geminate consonants in Japanese are found in all lexical strata and have phonologically a special status, as they constitute one of the two segments allowed as codas in Japanese phonotactics. They also have a high functional load, as shown by the many minimal pairs in which the contrast is involved, and the variety of morpho-phonological and phonological processes such as preservation of prosodic/syllable preferred structures, in which it plays a fundamental role. In terms of phonetics, the primary acoustic correlate for the contrast between singleton and geminate consonants is the closure/frication duration of the consonant. In general, the singleton-geminate value ratio is comprised between 2 and 3 for native speakers. Secondary correlates include a longer preceding vowel, and a shorter following vowel when in a geminate environment.

Although the acquisition of geminate consonants is crucial for achieving an efficient communication with Japanese native speakers, it is well-known for being challenging for L2 learners, especially when their native languages don't have such a contrast and are stress or syllable-timed. It appears therefore that a specific attention is needed for this contrast in language teaching and accordingly, this topic has gathered much attention in Japanese L2 acquisition research. Among the many factors examined by these works, the importance of L1 influence stands out as the main factor to consider for this contrast. However, it appears that the existing studies focus mainly on native speakers of English or of Asian languages such as Chinese and Korean. Clearly, there is a lack of data for native speakers of other languages, and accordingly one of the goals of the present dissertation is to provide data for two understudied languages in Japanese acquisition: French and Italian.

The third sub-section of the literature review dealt with the status of the consonantal length contrast in the three languages that were chosen as targets for the native language of the L2 learners in the present study. First, geminate consonants in English are not contrastive, and only emerge phonetically as a result of identical consonant sequences at morpheme/word boundaries. Inversely, Italian is well-known for having a consonantal length contrast. Lastly, the situation is more complex for French, as in addition to identical consonant sequences (similar to English), coexist in the language stylistic geminates and some rare cases of phonemic gemination even though their reality in native perception is questionable.

The third chapter of this dissertation introduced the goals and hypotheses investigated. The primary goal of this dissertation is to provide some production data for the consonantal length contrast by L2 learners and in particular to identify language specific difficulties and production cues. Secondary goals are to provide data on under-studied learner groups, and to link the results observed to possible improvement in teaching methods.

The three hypotheses formulated for this dissertation are reproduced below:

Hypothesis 1: There is no difference in terms of accuracy between all three groups of learners in their pronunciation of L2 Japanese geminates.

Hypothesis 2: There is no difference in terms of accuracy between manners of articulation in all three learner groups' pronunciation of L2 Japanese geminates.

Hypothesis 3: There is no difference between L2 learners and Japanese native speakers in the use of durational cues for consonantal length production.

Chapter 4 describes the methodological considerations for the procedures and the design of the experiment conducted in order to collect production data from the three learner groups. A total of 25 L2 learners and 8 Japanese native speakers (control group) participated in reading tasks aiming at evaluating their pronunciation skills. Among the tasks that learners were asked to perform, one was a proficiency test made for the purpose of this dissertation and that allows to evaluate, based on native judgement, the learners' level without relying on their writing and reading skills but only on pronunciation.

The results of the analysis of the experimental data is presented in Chapters 5 and 6. Chapter 5 deals with the two first hypotheses and focusses on learners' accuracy. In the present experiment, I used durational accuracy to measure learners' accuracy, a range of acceptable values for the singleton-geminate ratio based on Japanese native speakers' pronunciation. The results indicated that Italian learners were the most accurate, and English the least. No significant difference was observed between French and Italian learners in terms of accuracy. Following from these results, the first null hypothesis was not validated as a difference was observed in terms of accuracy between the three learner groups. Concerning manner of articulation however, no significant difference could be observed between stop, affricates, fricatives and nasals, and the second hypothesis was validated.

Chapter 6 provided a detailed account to the patterns observed in Japanese native speakers (section 2), French L2 learners (section 3), Italian L2 learners (section 4), and English L2 learners (section 5). The results for Japanese native speakers were consistent with those of previous studies and confirmed the closure/frication duration as the primary cue, and vowel duration as the secondary cue. For learners, however, the situation was different. The analysis of the data allowed to identify different cues depending on the learner group: First for English and French native speakers, the results indicated a similar pattern with the closure/duration as a primary cue, but no significant difference for preceding and following vowel durations. However, for Italian learners in addition to the closure/frication duration as the primary cue, the results indicated that the duration of the preceding vowel was correlated with gemination, but in a different way than for Japanese native speakers, as their V1s tended to be shorter. This, as well as the behavior of affricates for Italian learners and the distribution of their SG ratios, suggests that they rely on their L1 production cues for L2 phonetic implementation. In sum, although all speaker groups had the closure/frication duration as the primary acoustic correlate for gemination, differences could be observed in the use of vowel duration as secondary cues, which implies that the third null hypothesis cannot be validated.

The results from Chapter 5 and 6 were discussed in Chapter 7. In particular, I discussed the influence of the learners' L1s on the results and proposed a theoretical model for the acquisition of the consonant length contrast that can be generalized to other contrasts (i.e. vowel length contrast). The claim in Chapter 7 is that building of phonological representations (i.e. phonemic categories) of the L2 phoneme inventory should be separated from the phonetic implementation (i.e. acquisition of native production cues). In our results, all learners were able to make a distinction in their pronunciation between a singleton and a

geminate consonant and the ratios were consistent with those of Japanese native speakers, which constitutes a piece of evidence for the fact they were able to build different phonemic categories for short and long consonant. However, the other production cues (i.e. vowel durations) were different for Italian learners on the one hand and French and English-speaking learners on the other hand. This suggests that differences appear in phonetic implementation. In the present case, we postulate that Italian learners, who have a consonantal length contrast in their L1, don't need to build phonological representations because these are already available for them. However, when it comes to phonetic implementation, owing to the fact they are using L1 phonological representations, they rely on their L1 cues. For English and French native speakers on the other hand the absence of contrastive gemination in their L1 makes it more challenging to create separate phonemic categories, but they do not suffer from the influence of a phonetic conditioning by some L1 cues. In sum, phonological category building is easier for learners who have the contrast in their L1, but phonetic implementation of a native-like language specific timing is more challenging for them.

The results also showed a higher SG ratio for learners when compared to previous studies, which suggests a tendency for learners to enhance the singleton-geminate contrast though overexaggeration. Lastly, we discussed the case of fricative consonants that appeared to follow patterns based on universal properties rather than language-specific ones, and of affricates, for which L1 influence was especially salient in Italian learners' pronunciation.

2. Implications of the dissertation

The present dissertation contributes to the field of second language acquisition research by providing empirical data on the production of the Japanese consonantal length contrast

by two understudied learner populations. The data collected allowed to identify some production cues active in their pronunciation, and the comparison of the four languages targeted to examine the specific influence of specific native language phonology on L2 speech.

The main issue addressed in this dissertation is the influence of L1 phonological contrast on learners' L2 pronunciation. Specifically, in this regard, the languages targeted in the present case compared the influence on L2 acquisition of (i) a presence/absence of geminate consonants (Italian and French vs. English), and (ii) a phonemic or non-phonemic gemination (Italian vs. French and English). What our results indicate is that the existence of geminate consonants in a language is not enough to constitute an advantage in terms of L2 acquisition by itself: they have to be contrastive, that is, phonemic. Therefore, we propose to group English and French together, in opposition with Italian learners.

What these results imply for language teaching is that pronunciation instruction needs to be done in a different way for the two groups: Italian learners will not encounter the same needs and difficulties as French or English learners. For Italian learners, it appears that instruction on the presence of a contrast itself is not necessary and should be omitted, in order to focus more on a phonetic training. In this regard, learners would need explicit instruction on native cues and mora timing, with phonetic training using waveforms for example. Such a training is used in Motohashi-Saigo and Hardisson (2009), and their results indicated the effectiveness of trainings based on auditory-visual explicit input for L2 perception and production of durational contrasts. In the case of French and English native speakers, inversely, the teaching of the consonantal length contrast needs to start with explicit instruction on the contrast itself to ease the building of phonological representations for short and long consonants. In this purpose, the use of Identification/Discrimination

training (Shinohara and Iverson 2018) might constitute a useful tool to ease the building of phonemic categories.

In sum, the focus of instruction should be on phonetic implementation for Italian learners, and phonemic category building for the others. Furthermore, this is not limited to these learners and this contrast in particular. This should be extended to all learners of Japanese whose L1 belongs to one of these two types: language with and language without phonemic length contrasts. Also, this might be extended to vowel length contrasts in Japanese. It would be of interest to investigate whether this postulate holds cross-lingusitically, that is, if for example Japanese learners of Italian behave differently from English and French learners in production. Previous studies on perception suggest that this is the case (Sadakata et al. 2014, Tsukada et al. 2014, Tsukada et al. 2018), and a recent production study on Arabic geminates shows that Japanese learners outperform English learners (Aldossari and Rafat 2018).

However, one point that needs to be questioned is whether, in the phonetic implementation, a native-like timing control of the Japanese consonantal length contrast is a necessary component of Japanese L2 acquisition. That is, whether it has enough influence on Japanese native speakers' perception of learners' intelligibility, comprehensibility and naturalness to be required for communication with native speakers. This might constitute an interesting follow-up study to this dissertation, as recent results by Lee et al. (2018) suggest that in the case of Japanese geminate consonants, native-like timing control is related to comprehensibility. In the present study, the productions of Italian learners had the highest accuracy when rated in terms of absolute durational ranges. However, the rating of the same productions using native speaker judgment might lead to a different result, as previous perception studies on Japanese native speakers indicate a correlation between preceding

vowel length and geminate perception (Arai and Kawagoe 1998, Kingston et al. 2009, Ofuka 2003): Consonants tend to be more perceived as geminates when the vowel is longer. Their findings suggest that Italian learners' production might be perceived as less accurate because of their tendency to use native cues, that is, shorter vowels, in their pronunciation of the consonantal length contrast. In sum, to the question of the necessity of a native-like timing control, we postulate that it is necessary, owing to the fact that, in contrast with only segmental items, the consonantal length contrast is closely related to the timing of the language.

Another point that needs to be explored is whether the acquisition of phonetic implementation of the native-like timing control in question is even possible. According to Flege (1995, 2005)'s Speech Learning Model, the critical period hypothesis is not valid because the access to the acquisition capacity remains the same along a learner's life-span, and under this assumption the acquisition of the present timing control is possible. Furthermore, the present results also suggest that acquisition is possible, with for example the influence of L1 that could be observed only on the closure part of affricate consonants for Italian learners, but only to a lesser extent on frication noise. To the question of the possibility of the acquisition of such a timing, here again, our postulate is that yes, it seems possible. The two issues mentioned above need to be tested in follow-up studies and it appears that specific training tools might be required for acquisition of native-like timing in Japanese.

The literature on second language speech acquisition presented in the introduction of this dissertation pointed out two major points of view: one giving to L1 influence a central role, and another affirming that L1 influence alone was not enough to account for the

observed patterns and making use of universal principles. In the results of this dissertation, both target language cues (closure duration) and source language cues (shorter V1 for Italian learners) were observed in learners' production, providing evidence for the influence of L1 on learners' interlanguage. The role of individual variations and of the quality and quantity of the input were also indicated by the fact that the oral proficiency score, evaluated by native speakers, showed no correlation with the time spent studying Japanese or the time spent in Japan. That is, for a similar instruction time and for a similar amount of time spent in Japan, the output in terms of proficiency differs among learners, possibly due to the quality of the input and individual skills. Moreover, the behavior of fricatives for example also suggested the importance of universal properties of consonants, here the [+continuant] feature of the consonant. In sum, this dissertation is consistent with previous studies and shows a major role of L1 influence, but also some other factors like individual variations, quality of the input or universal properties contributing to learner language.

Recently, the population of immigrants in Japan is growing significantly (18% increase between 2016 and 2017, Japanese Ministry of Health, Labour and Welfare 2017), with the emergence of new groups. In addition to the traditional Chinese, Brazilian or Korean nationals, the Japanese Ministry of Health, Labour and Welfare announced for example in its 2017 annual report a tremendous increase in the Vietnamese (+40%) and Nepali (+31%) populations. With the Japanese population decline, these immigrants expect (and are expected) to contribute to the workforce in various domains, and therefore have a great need for Japanese education and sufficient proficiency. In this regard, the diversification of the immigrant population in Japan brings out new issues for Japanese language teaching, especially for pronunciation as a foreign accent is what native speakers notice first, thus having a substantial influence on their employment possibilities and social integration. As a

consequence, there is an increasing demand for efficient teaching methods optimized for these populations, and which would allow them to acquire quickly the required competences to be operational for work. And this even more because their L1s are not major languages that are taught in Japan (vs. English, Korean, French, Chinese).

Most of the literature on Japanese L2 learners has been dealing with Chinese, Korean or English native speakers, and accordingly teaching methods are adapted to them. However, the situation in Japan increases the need for L2 acquisition studies targeting new immigrant populations. Native speakers of Vietnamese, Nepali, Burmese for example should be the focus of future speech acquisition research, and follow-up studies using this dissertation methodology on these new immigrant population might contribute to the field and when applied to teaching methods, benefit to the community and their social welfare.

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CONSENT FORM

Purpose of Study

The purpose of the study is to investigate the pronunciation of Japanese by learners of Japanese as a second language whose mother tongue is English, French or Italian. You were selected as a possible participant because you are either a native speaker of Japanese or a native speaker of one of the target languages and a learner of Japanese. We ask that you read this form and ask any questions that you may have before agreeing to be in the study.

Description of the Study Procedures

If you agree to be in this study, you will be asked to do the following things:

1. Read aloud a short text in Japanese
2. Do a listening task using a computer
3. Respond orally to some simple grammar problems

Tasks 1. and 3. will be recorded for the purpose of the study. After the experiment you will be asked to answer a simple questionnaire concerning your history of Japanese education. The expected total duration of the experiment is about 30 minutes.

Risks and Benefits of Being in this Study

There are no reasonable foreseeable (or expected) risks in this study. The participation to this study is volunteer.

Confidentiality

This study is anonymous. We will not be collecting or retaining any information about your identity. The records of this study will be kept strictly confidential. We will not include any information in any report we may publish that would make it possible to identify you.

Right to Refuse or Withdraw

The decision to participate in this study is entirely up to you. You may refuse to take part in the study *at any time*. Your decision will not result in any loss or benefits. You have the right not to answer any single question, as well as to withdraw completely from the interview at any point during the process; additionally, you have the right to request that the interviewer not use any of your interview material. However, all data and material published before the date of your withdrawal will continue to be used.

Right to Ask Questions and Report Concerns

You have the right to ask questions about this research study and to have those questions answered before, during or after the research. If you have any further questions about the study, at any time feel free to contact me. (Céleste Guillemot, by email celeste.guillemot@gmail.com or by phone 080-7957-6374)

Consent

Your signature below indicates that you have decided to volunteer as a research participant for this study, and that you have read and understood the information provided above.

Subject's Name (print): _____

Subject's Signature: _____ Date: _____

(Researcher)
International Christian University
Graduate School of Arts and Sciences
Céleste Guillemot, Ph.D Candidate

(Research Advisor)
International Christian University
Associate Professor, Lee Seunghun

/ /

FORMULAIRE DE CONSENTEMENT

But de l'étude
Cette étude porte sur la prononciation du japonais par ses apprenants de langue maternelles anglaise, française ou italienne. Vous avez été sélectionné comme potentiel participant pour cette étude car vous êtes soit un locuteur natif du japonais, soit un apprenant du japonais et natif des langues cibles.

Description des procédures
Dans le cas ou vous acceptez de participer à cette étude, il vous sera demandé d'effectuer les tâches suivantes :

1. Lire à voix haute un court texte en japonais
2. Faire un exercice d'écoute sur ordinateur
3. Répondre à l'oral a de simples problèmes grammaticaux

Les tâches 1. et 3. seront enregistrées pour leur utilisation dans l'étude. Après ces exercices, il vous sera demandé de répondre à un questionnaire concernant votre apprentissage du japonais. La durée totale attendue de l'étude est d'environ 30 minutes.

Risques et bénéfices
Cette étude ne comprend aucun risque connu. De plus la participation est sur la base du volontariat.

Confidentialité
Cette étude est anonyme. Aucune information concernant votre identité ne sera conservée et les données personnelles récoltées seront strictement confidentielles. Enfin, aucune information qui permettrait de vous identifier ne sera publiée.

Droit de rétraction
Vous seul pouvez décider de participer ou non à cette étude. Vous avez à tout moment la possibilité de vous rétracter et cette décision ne résultera en aucunes pénalités. Vous avez également le droit de refuser de répondre à une ou plusieurs question(s) comme de vous retirer de l'étude dans son ensemble à n'importe quelle étape. Enfin, vous avez à tout moment le droit de refuser au chercheur l'utilisation des données vous concernant. Cependant, tout document ou donnée publiée avant la date de votre rétraction ne pourra être retirée.

Questions et plaintes
Vous avez le droit de poser toutes les questions qui vous semblent nécessaires avant, pendant ou après votre participation à l'étude. Si vous avez plus de questions, n'hésitez pas a me contacter (Céleste Guillemot, par courriel celeste.guillemot@gmail.com ou par téléphone 080-7957-6374).

Consentement
J'ai lu et compris les informations ci-dessus et je décide de me porter volontaire pour cette étude.

Nom du sujet : _____

Signature : _____

Date : _____

(Chercheur)
Céleste Guillemot
Doctorante,
International Christian University
Département des arts et sciences

(Superviseur)
Seunghun Lee
Maître de conférence
International Christian University

被験者の方へ　　年　　月　　日

外国人二言語学習者の日本語の発音に関する実験的研究

参加同意書

研究の目的

この研究は、外国人日本語学習者の日本語の発音を検討することを目的としています。日本語母語話者の発音との比較により、外国人日本語の発音の特徴をより細かく把握し、教授方法の改善に向けて分析します。
実験開始前にこの説明をお読みいただき、ご協力いただける場合には、参加同意書に署名をお願いいたします。

実験方法

本実験において、三つのタスクに参加していただきます。
1. 短い文書を読んでいただきます。
2. パソコンを使用したリスニング問題を解いていただきます。
3. 簡単な文法の練習問題を口頭で解いていただきます。

1と3番のタスクは録音させていただきます。実験後に、簡単なアンケートをご記入いただきます。所要時間は、前後の説明時間も含めて３０分時間程度です。

個人情報とデータの取扱い

取得したデータや個人情報は、研究目的以外には使用しません。データの保管には万全を期し外部へは漏洩しません。データには番号付けを行うとともに匿名化しますので、専門学会、学術専門誌、学内研究会等を通じて研究発表する際も個人情報は守秘されます。

実験対象者の権利について

この研究に参加するか否かは自由意志で決定してください。また、一度同意した後でいつでも同意を取り消すことができ、それによる不利益はありません。匿名化番号を破棄するとともに、それまでに得られたデータや解析結果を破棄し、それ以降の研究には一切使用いたしません。但し、取り消し要求された時点で公表済みの解析結果がある場合は、このデータを破棄できませんのでご承知おきください。

実験に参加することによる利益と不利益

本研究に参加することによる費用の負担はありません。参加されなくても不利益を受けることは全くありません。また、ボランティアでの参加を前提とするため謝礼の支払いはありません。

以上、何かご不明な点がありましたら遠慮なくお尋ねください。
本研究へのご理解とご協力に深く感謝いたします。

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参加同意書

私は、以上の説明を理解し、本研究に参加することに同意します。

年　　月　　日

所 属: _____

氏 名: _____

Demographic questionnaire ID: (L1_No_M/F)

Age : ……

Sex : (Circle the appropriate answer)

Male Female I do not want to answer

Native Language (s): ……

Languages (other than Japanese):

……

……

Stays in foreign countries if any (more than 6 months):

……

……

Are you experiencing any hearing or speech impairment?

Yes No

---

1. What is your level in the institution where you're currently studying Japanese in? (Circle the appropriate answer)

beginner high beginner low intermediate high intermediate advanced

2. How long and where have you been studying Japanese?

……

……

……

3. Why did you choose to learn Japanese?

……

……

4. How often do you use Japanese in everyday life? (Circle the appropriate answer)

never sometimes often everyday

5. In which occasion(s)? (Circle all that apply)

at school at work with friends with my family when going out

6. Do you often do any of the following in Japanese? (Circle all that apply)

Read: manga books newspapers Internet
Listen to: music radio
Watch:TV shows dramas movies anime

7. How would you rate your Japanese proficiency? (Circle the appropriate answer)

	Poor	→	→	→	→	Very good
Overall level	0	1	2	3	4	5
Writing	0	1	2	3	4	5
Reading	0	1	2	3	4	5
Listening	0	1	2	3	4	5
Speaking	0	1	2	3	4	5
Pronunciation	0	1	2	3	4	5

8. Circle the appropriate answer.

	False	→		→		True
I have no problem understanding what Japanese speakers say.	0	1	2	3	4	5
Japanese native speakers understand my Japanese.	0	1	2	3	4	5
I feel comfortable when speaking in Japanese with Japanese people.	0	1	2	3	4	5
I'm used to speak in Japanese in front of other people.	0	1	2	3	4	5
I think I have a foreign accent when I speak in Japanese.	0	1	2	3	4	5
I sometimes feel frustrated because Japanese speakers don't understand what I'm saying.	0	1	2	3	4	5

9. List your stays in Japan (more than 6 months):

……

……

……

10. Do you have any Japanese language certificate or diploma? (JLPT, school certificates…)

……

……

11. Did you have any exposure to Japanese prior age 5?

Yes No

12. Did you have any access to Japanese native speakers when younger?

Yes No

13. Have you ever taken any Japanese pronunciation class?

Yes No

Thank you very much！

If you have any questions or comments, if there is any information you wish to add please feel free to use the blank space below.

アンケート

ID: (L1_No_M/F)

・**年齢**：……

・**性別**（適当な物に〇をつけて下さい）

男性　　女性　　答えたくありません

・**あなたの母語は何ですか？**（適当な物に〇をつけて下さい）

日本語　　その他：……

・**出身地**：……

・**日本語以外に習った/話せる言語**（あればご記入下さい）：

……

・**外国に（６ヶ月以上）住んだことはありますか？**（あればご記入下さい）

……

・あなたは聴覚障害や発話障害を持っていますか？

はい　　いいえ

今日は自転車で広いデパートへ買い物に行きました。ビルの地下１階から９階までお店が沢山あります。屋根に一本の旗がそっと揺れています。洋服屋でセールをやっていたので、ワンピースとキャミソールを一着ずつ買いました。ワンピースはベージュで、肩に緑の葉っぱとリボンが付いています。次に、文房具屋で、青いペン、雑誌と消しゴムを買った時、店員さんに飴をもらいました。病気で一緒に行けなかった娘に子供服とおもちゃの売り場で大好きな象のぬいぐるみを買ってあげました。そして、北陸新幹線の切符を買いました。来週は夫と娘と三人で金沢を旅行する予定です。その後は、美容院に予約を取りに行ったら、ずっと会えていなかった友達に偶然会いました。昔二人で中国へ留学したことは、一生の思い出です。二人で牛乳入りの紅茶を飲みながら、学校で好きだった授業の話に夢中になりました。帰る時は、外は雨が降っていました。傘は持っていなくて、そのままじゃちょっと帰りづらかったので、バーでビールを飲みながら雨が止むのを待ちました。

１．娘(むすめ)はまた遅(おそ)い時間(じかん)にこっそり帰(かえ)って来(き)て、がっかりしました。

２．この六(むっ)つの音(おと)から、一致(いっち)していないものを探(さが)しましょう。

３．千年前(せんねんまえ)からバナナの葉(は)っぱで石鹸(せっけん)を作(つ)っている工場(こうじょう)についてのエッセイを必死(ひっし)に書(か)いています。

４．夫(おっと)は毎日(まいにち)朝(あさ)から筋肉(きんにく)のトレーニングをしてから、日記(にっき)を書(か)いている。

５．卒業式(そつぎょうしき)のレセプションにむけて、服(ふく)と靴(くつ)を決(き)めましょう。

６．このテーブルに赤(あか)い石(いし)が六個(ろっこ)もあった。

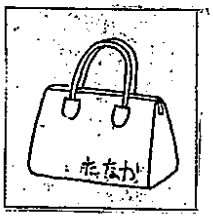
７．観光案内窓口(かんこうあんないまどぐち)の女性(じょせい)はミニスカートをはいている。

８．日本で一番好(いちばんす)きな所(ところ)では、山(やま)には雪(ゆき)がいつもうっすらと積(つ)もっている。

９．ブックカバーをあっさり捨(す)てた。

１０．パパとは世間話(せけんばなし)しかしない。

問題１
例：



→　この　カバンは　田中さんの　です。

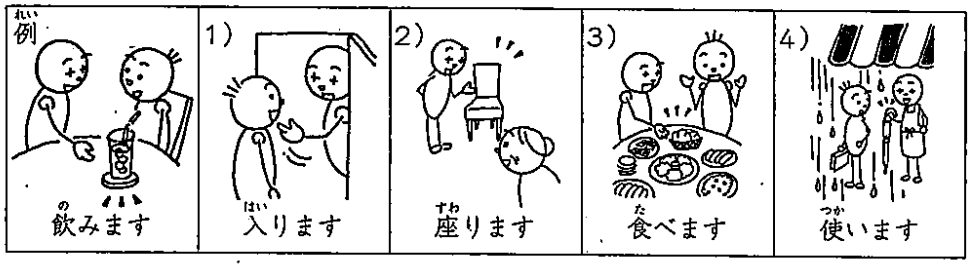
1）

2）

3）

例：→　どうぞ　飲んで　ください。

1）→　　2）→　　3）→　　4）→



問題２

例：海　は　きれい　でしたか？

→　いいえ、あまり　きれい　では　ありませんでした。

１）天気は　良かった　ですか。

いいえ、…

２）田中さんと　いっしょに　パーティーに　行きましたか。

はい、…

３）この　女の子は　日本人ですか。

はい、…

４）あなたは　けっこん　していますか。

いいえ、…

５）先週の　まつりは　たのしかったですか。

はい、…

６）この　喫茶店の　コーヒーは　おいしいかったですか。

いいえ、…

７）先生は　みんなの　かおを　覚えていましたか。

はい、…

８）この　パンは　８００円ですか。

いいえ、…

Praat MFC Experiment script "Quasi-continuous grading scale" (modified from Munro 2017) used for the Proficiency test (shortened version)

```
"ooTextFile"
"Collection" 2

"ExperimentMFC 7" "comprehensibility"
blank while playing? <no>
stimuli are sounds? <yes>
stimuliFileNameHead = ""
stimulusFileNameTail = ".wav"
stimulusCarrierBefore ""
stimulusCarrierAfter ""
InitialSilenceDuration 0.5 seconds
MedialSilenceDuration 0.8 seconds ! inter-stimulus interval
FinalSilenceDuration 0 seconds
NumberOfDifferentStimuli = 99

"EN11" ""
"EN12" ""
"EN13" ""
[…]
"JP83" ""

numberOfReplicationsPerStimulus = 1
breakAfterEvery = 25
randomize = <PermuteBalancedNoDoublets>
startText = "The sentences that follow have been recorded from Japanese native
speakers
and learners of Japanese.
Listen to each sentence and decide how difficult it is to understand.
Then give it a rating by clicking on the bar on the screen.
Click on the RIGHT for 'easy to understand.'
Click on the LEFT for 'difficult to understand.'

Click to begin."
runText = "

<–Very Difficult
Very Easy–>

How difficult to understand is this sentence?
                                                                    "
pauseText = "You can have a short break if you like. Click to proceed."
endText = "Thank you for your responses. Now lets proceed to the next part of the
experiment"
maximumNumberOfReplays = 3
replaybutton = 0.40 0.60 0.75 0.85 "Play again" ""
okbutton = 0 0 0 0 "" ""
oopsbutton = 0 0 0 0 "" ""
responsesAreSounds? <no> "" "" "" "" 0 0 0
numberOfDifferentResponses = 1024
0.01238      0.013332381  0.5   0.54  ""          9     ""    "1"
0.013332381  0.014284762  0.5   0.54  ""          10    ""    "2"
0.014284762  0.015237143  0.5   0.54  ""          11    ""    "3"
0.015237143  0.016189523  0.5   0.54  ""          12    ""    "4"
0.016189523  0.017141904  0.5   0.54  ""          13    ""    "5"
0.017141904  0.018094285  0.5   0.54  ""          14    ""    "6"
0.018094285  0.019046666  0.5   0.54  ""          15    ""    "7"
[…]
0.983808477  0.984760857  0.5   0.54  ""          1029  ""    "1021"
0.984760857  0.985713238  0.5   0.54  ""          1030  ""    "1022"
0.985713238  0.986665619  0.5   0.54  ""          1031  ""    "1023"
0.986665619  0.987618     0.5   0.54  ""          1032  ""    "1024"
numberOfGoodnessCategories = 0
```

```
"ExperimentMFC 6" "foreign accentedness"
blank while playing? <no>
stimuli are sounds? <yes>
stimuliFileNameHead = ""
stimulusFileNameTail = ".wav"
stimulusCarrierBefore ""
stimulusCarrierAfter ""
InitialSilenceDuration 0.5 seconds
MedialSilenceDuration 0.8 seconds ! inter-stimulus interval
FinalSilenceDuration 0 seconds
NumberOfDifferentStimuli = 99

"EN11" ""
"EN12" ""
"EN13" ""
[…]
"JP83" ""
numberOfReplicationsPerStimulus = 1
breakAfterEvery = 25
randomize = <PermuteBalancedNoDoublets>
startText = "Now I would like you to decide how much you can hear
a foreign accent in these sentences.
Give a rating to each sentence by clicking on the bar on the screen.
Click on the RIGHT for 'no accent.'
Click on the LEFT for 'heavily accented.'

Click to begin."
runText = "

<- Heavily accented
No accent->

How much foreign accent do you hear in this sentence?
                                                                "
pauseText = "You can have a short break if you like. Click to proceed."
endText = "This is the end of the experiment. Thank you for your responses."
maximumNumberOfReplays = 3
replaybutton = 0.40 0.60 0.75 0.85 "Play again" ""
okbutton = 0 0 0 0 "" ""
oopsbutton = 0 0 0 0 "" ""
responsesAreSounds? <no> "" "" "" "" 0 0 0
numberOfDifferentResponses = 1024
0.01238      0.013332381  0.5   0.54  ""          9     ""    "1"
0.013332381  0.014284762  0.5   0.54  ""          10    ""    "2"
0.014284762  0.015237143  0.5   0.54  ""          11    ""    "3"
0.015237143  0.016189523  0.5   0.54  ""          12    ""    "4"
0.016189523  0.017141904  0.5   0.54  ""          13    ""    "5"
0.017141904  0.018094285  0.5   0.54  ""          14    ""    "6"
0.018094285  0.019046666  0.5   0.54  ""          15    ""    "7"
[…]
0.983808477  0.984760857  0.5   0.54  ""          1029  ""    "1021"
0.984760857  0.985713238  0.5   0.54  ""          1030  ""    "1022"
0.985713238  0.986665619  0.5   0.54  ""          1031  ""    "1023"
0.986665619  0.987618     0.5   0.54  ""          1032  ""    "1024"
numberOfGoodnessCategories = 0
```

Praat script used to calculate the durations of the segments in the sound files.

```
# This script will calculate the durations of all labeled segments in a TextGrid
object.
# The results will be save in a text file, each line containing the label text and
the
# duration of the corresponding segment..
# A TextGrid object needs to be selected in the Object list.
#
# This script is distributed under the GNU General Public License.
# Copyright 12.3.2002 Mietta Liennes

# ask the user for the tier number
	form Calculate durations of labeled segments
	comment Which tier of the TextGrid object would you like to analyse?
	integer Tier 1
	comment Where do you want to save the results?
	text textfile durations.txt
endform

# check how many intervals there are in the selected tier:
numberOfIntervals = Get number of intervals... tier

# loop through all the intervals
for interval from 1 to numberOfIntervals
	label$ = Get label of interval... tier interval
	# if the interval has some text as a label, then calculate the duration.
	if label$ <> ""
		start = Get starting point... tier interval
		end = Get end point... tier interval
		duration = end - start
		# append the label and the duration to the end of the text file,
separated with a tab:
		resultline$ = "'label$'	'duration''newline$'"
		fileappend "'textfile$'" 'resultline$'
	endif
endfor
```