Bilingual phonological development: a case study of Japanese-English bilingual acquisition

by

© Yuka Katayama

A thesis submitted to the

School of Graduate Studies

in partial fulfillment of the requirements of the degree of

Master of Arts

Department of Linguistics

Memorial University of Newfoundland

December 2021

St. John’s, Newfoundland and Labrador

Abstract

Despite many decades of modern research on child language acquisition, our understanding of how humans acquire languages is still incomplete and, as such, subject to theoretical debates. Particularly, concerning the process of language acquisition in bilingual children, there are two opposite views within the scientific literature; some scholars support the view that certain properties of one of the two languages of these children may affect the acquisition of the other language, while other scholars do not find any evidence for such phenomenon. In this thesis, we examine how a Japanese-English bilingual child, code-named Naoki, developed consonants and consonant clusters in word-initial syllable onsets, word-final syllable codas as well as word-medial geminates and coda-onset clusters. The results from this longitudinal study suggest that while Naoki displayed high accuracy in his productions of syllable onsets in both Japanese and English, his development of syllable codas in both languages was affected by the Japanese constraints on sound distributions within this position.

Summary

Although there has been much research, especially since the 1940s, on how children learn their mother tongue, the mechanism of human language learning is still not well understood. This is particularly true concerning children who are learning two languages in parallel, for whom academic research suggests two different analyses. Some researchers suggest that certain properties of one of the child's languages can affect the development of their other language, either in positive or in negative ways. Meanwhile, other researchers have not found evidence for such effects, and claim that the two languages of a bilingual child function largely independent of one another. In this thesis, we examine how a child, code-named Naoki, who is learning Japanese and English in parallel, develops sounds and sound sequences at the beginning and end of words as well as sound sequences in the middle of words. The results suggest that while Naoki did well in producing sounds at the beginning words in both Japanese and English, his development of sounds at the end of English words appears to function in ways similar to what we would expect from Japanese but not English monolingual learners. This effect yielded a slower development of some English sounds at the end of words, and at the end of syllables found in the middle of words.

Acknowledgements

Being far away from home and working for this degree, I had to get over so many tough challenges. Especially, everything became even tougher after the pandemic hit. However, there had always been constant and kind support from warm-hearted people around me, and I was able to conquer challenges with them. I would like to express how grateful I am to these people.

ありがとう to my dad and my mom. I really appreciate that you both allowed me to study for three years in this far-away place. Especially you must have been very worried during the pandemic. I also went through homesickness so many times, but now I got over a lot of things and I was able to improve a lot. Thank you for your constant support.

A big thanks to my partner Ellan, for your support all the time. Engaging in all the work during the pandemic was very very tough, especially with other things going on around me, as you know. But you were always next to me and you always reminded me how far I have progressed, and how much I improved. Thanks to that, I could always motivate myself. Arigatou, and I love you.

Thank you to my graduate fellows, for sharing a lot of fun times. I always enjoyed chatting with you all, and that gave me a lot of energy. I had a lot of struggle at the end of thesis work, but just seeing you guys cheered me up and I could push myself. I will miss you all, but we will see each other again!

Thank you all at the Department of Linguistics. You all literally supported me for everything, from my work to my life. Now, I am glad to be able to show you all that I got to this point. I will miss you all.

Thank you to all who worked on Naoki's data for this research. Without you, it would have been hard to make this research as it is now. I appreciate it a lot.

Thank you to reviewers for taking your time to examine my thesis. I appreciate all the feedback and constructive comments that you gave, as they will undoubtedly improve this work.

Finally, the biggest thank you to my supervisor, Dr. Yvan Rose. Since I started my program at MUN, I have faced a lot of challenges both in my work and my life, as you know. Many things were not easy. But whenever I was going through those situations, you did everything you could do to support me and cheer me up. I almost gave up on myself at some points, but you never gave up on me. Now, I got to this point finally. I am stronger now. I cannot explain how grateful I am right now. You were like my father here. Thank you so much for everything.

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

Outside of a handful of descriptive studies, many of which are under the scope of behaviourism (e.g. Piaget 1955; Piaget 1971), modern studies of language acquisition began in earnest with Jakobson (1941), a seminal work which has had a great impact on studies on phonological development to this day. Shortly after, in parallel with the rise of cognitive science in general and the advent of the generative theory in linguistics (Chomsky 1957), the field of language acquisition consolidated from what was initially an interdisciplinary field into a focus area in linguistic research. However, in spite of 70 years of fruitful research since, we have yet to develop a satisfactory model of how humans acquire language systems. This is especially true concerning the acquisition of multiple languages at once, which brings its own set of additional questions and challenges. Bilingual development must indeed combine the process of language acquisition with the types of variations that are inherent to multilingual environments, for example how the properties of each ambient language may interact with one another, both during the learning process and beyond.

One major focus of studies of bilingual development is whether the two languages that bilingual children are acquiring interact with one another and, if so, what types of interactions can be seen between then. Many case studies have been conducted so far to address these questions, which have interestingly yielded two opposite views of bilingual development: some scholars claim that the two languages of a bilingual learner never interact with one another (Paradis & Genesee 1996; Mishina-Mori 2002), while others posit that properties of either of the two languages may affect the other through

development, and beyond (Major 1992; Yip & Matthews 2000; Almeida et al. 2012; Kehoe 2018). In this thesis, we attempt to address this debate by contributing new transcription data of an already existing case study of a child, code-named Naoki, learning Japanese and English in a multilingual environment. We offer a series of systematic descriptions, in each of Naoki's languages, of the acquisition of consonants in word-initial syllable onsets and onset clusters, word-final syllable codas as well as word-medial geminates and coda-onset consonant clusters. While the current work is much more descriptive than a theoretical exploration, it offers a few hypotheses concerning asymmetries observed in the data. In particular, we suggest that the child's development of syllable codas (word-finally, word-medially in coda-onset clusters, and as part of the syllabification of geminate consonants) is influenced by pressures imposed by the phonological grammar of Japanese, in particular the phonotactic restrictions that Japanese imposes on consonants syllabified post-vocalically, within syllable codas (especially, Itô 1986).

The thesis is outlined as follows: we summarize past research results and related issues in Chapter 2, where we also look at case studies documenting language interactions, or lack thereof, from morphosyntactic and phonological perspectives. As part of this summary, we introduce five interaction patterns suggested so far within the literature. We then describe our current research in Chapter 3, which builds on a comparison of the development of Japanese and English consonants and consonant clusters. In Chapter 4, we describe Naoki's development of consonants and clusters in the two languages. Finally, in Chapter 5, we discuss the language interaction patterns that, as the data suggest, arose from interactions between the learner's two developing systems.

Chapter 2: Background

In this chapter, we summarize previous studies of language development by bilingual children. In section 1, we provide an overview of current knowledge on bilingual children's language development, as they are discussed by De Houwer (1995) and Meisel (2007), and discuss its relevance to models of language acquisition. We then focus more specifically on findings about language transfer from morphosyntactic and phonological perspectives, in section 2, where we compare different perspectives on the notion of transfer, in particular concerning the five possible language interaction patterns suggested through this literature. Finally, in section 3, we highlight the significance of the current research.

1. The relevance of bilingual language development studies

According to De Houwer (1995: 220), studying bilingual children can be helpful in two main areas: to obtain more data for analyzing child language acquisition generally, and to address misconceptions that raising children as bilingual speakers can have negative effects linguistically or otherwise. De Houwer highlights previous studies showing that bilingual children's linguistic awareness develops earlier than in monolingual children (Levy 1985; Clyne 1987). Building on this, she suggests that bilingual children could be better at structural analysis of their language input, as they can use one language's properties to compare against that of their other language(s) (Hakuta & Diaz 1985; Pléh, Jarovinskij & Balajan 1987; Meisel 1990b; Goodz, Legaré & Bilodeau 1987). This, in turn, opens up research opportunities, for example to determine whether some phenomena are language-specific or apply cross-linguistically (De Houwer 1987a: 53).

De Houwer also suggests that analyzing language development in bilingual children may help uncover effects of language input on acquisition, considering that the linguistic environment of each bilingual child varies depending on the linguistic makeup of their households (De Houwer 1995: 223). Finally, returning to misconceptions that prevail within societies about language development in bilingual children, De Houwer points out that analyzing the speech productions of these children can help determine how and to what extent a learner can attain two languages without mixing the codes, or whether external influences such as bilingual education may affect children's development more generally (De Houwer 1995: 230).

More specifically, De Houwer (1995) addresses relationships between the two languages of bilingual children, and what is known so far about how bilingual children select their language of production. Firstly, she points out that beyond considering what is the native language of bilingual children's parents or what is the main language in their community, it is important to understand how much bilingual children are exposed to each of the two languages they are acquiring, and how parents educate children using code switching. The language environment for bilingual children can indeed vary widely, and research has so far been inconclusive as to whether mixing languages in input is positively or negatively correlated with measures of success in child learners (Idiazábal 1984; Goodz, Bilodeau & Légaré 1988). More studies are thus required in this field, in order to understand all the variables that may affect bilingual development (De Houwer 1995:223-30).

Concerning potential connections between the two languages of bilingual children, there is however controversy as to whether children separate the two languages or develop a hybrid system that can encode both source languages. On the one hand, Volterra & Taeschner (1978) suggest that there is a systematic stage of mixed language in bilingual children at an early point. On the other hand, some studies on morphosyntactic development instead suggest that children acquire the two languages independently of one another (Meisel & Mahlau 1988; Meisel 1989). However, as De Houwer states, there is not enough data to fully support this claim, and the evidence available is at times unclear. In this regard, she suggests that bilingual studies always include comparisons with monolingual children's language development, for each of the two languages of the bilingual learner, as a way to distinguish between language-specific patterns and interactions between the two systems (De Houwer 1995: 242). Together, her suggestions aim at uncovering what could be defined as "normal" language development in bilingual children (De Houwer 1995: 248–49).

Meisel (2007) also addresses background issues in bilingual language acquisition, based on studies of syntactic development. According to Meisel, many studies agree that bilingual children can acquire two languages to the same extent as monolingual children of each language, an observation which supports the view that these children develop two separate language systems from an early point, at the beginning of the acquisition process (Jekat 1985; Quay 1995; Meisel 1986; Meisel 1989; Genesee 1989; De Houwer 1990; Köppe 1996). This position leads Meisel to suggest that studies should focus on what factors can possibly disrupt the development of grammatical properties for each of the bilingual child's two languages (Meisel 2007: 27). Evidence for

this comes from studies highlighting interactions between a bilingual learner's two languages. These studies suggest two main factors as potential causes for those interactions: (1) the structural properties of each of the languages, and (2) language dominance. The former builds on the idea that transfer occurs when given properties of one of the languages are ambiguous, leading children to compensate for these properties with their counterparts in the other language (Hulk & Müller 2000; Müller & Hulk 2001; see also Yip & Matthews 2000, discussed in the next section). Building on these studies, Meisel suggests that only certain grammatical properties can be influenced by language interaction, in line with Hulk & Müller (2000), Müller & Hulk (2001), and Yip & Matthews (2000). However, Meisel claims that this hypothesis must be tested against more explicit evidence, calling for more studies focusing on the topic of structural interaction between languages (Meisel 2007: 41).

In sum, from the main issues highlighted by De Houwer (1995) and Meisel (2007) summarized above, it appears that the process of language development by bilingual children is generally ill-understood, and needs more investigation. Studies on this topic should also ideally document different language learning situations, which together can reveal as many types of structural interactions as possible, or else verify the absence of such interactions between the bilingual learner's two linguistic systems. We turn to the topic of language interactions more specifically in the next section.

2. Language interactions

In this section, we discuss background studies on language interactions. Section 2.1 looks at the five possible language interaction patterns suggested in the literature.

Section 2.2 summarizes the findings from morphosyntactic bilingual development. We then compare these with the results obtained from bilingual phonological development, in section 2.3.

2.1 Interaction patterns

In their study of syntactic acquisition in French-English bilingual children, Paradis & Genesee (1996) propose the notions of transfer, acceleration, and delay for categorizing types of language interaction in bilingual children. Paradis & Genesee build on the premise that bilingual children at the age of two have separate language systems for each language, as suggested in several previous studies of syntactic development in bilingual children (Kaiser 1994; Meisel 1989; Meisel 1990; Parodi 1990). Paradis & Genesee hypothesize that, given these two language systems, there might be some interaction between the two languages during the course of development. They propose three interaction patterns, as follows: transfer is the movement of grammatical elements between the two languages; acceleration is the earlier emergence of a grammatical property in one or both languages compared to the emergence of the same property in monolingual learners of either language; and delay is the slower acquisition of certain grammatical properties compared to their development by monolinguals (Paradis & Genesee 1996: 3–4). In addition to these three interaction patterns, two more possibilities were proposed concerning bilingual phonological development specifically. The first of them is called fusion, as suggested by Queen (2001), whereby phonological properties appear in a child's production in both languages, and those properties are similar to, but not the same, as properties in either of the developing languages. Finally, a "different order of acquisition" was proposed by Lleó (2006), a pattern which

corresponds to neither language but emerges from their interaction during the development process. In the next two sections, we discuss observations about these patterns in morphosyntactic and phonological development, respectively.

2.2 Evidence from morphosyntactic development

As described above, five main interaction patterns have been proposed in the study of bilingual children's language development. Studies in different sub-fields have attempted to verify the validity of these patterns. When it comes to morphosyntactic development, different studies offer at times different perspectives; while some studies claim that language interactions do occur, others rule out their existence.

Yip & Matthews (2000) support the interaction view. They studied a Cantonese-English learning child's development of *wh*-in-situ interrogatives, null objects, and prenominal relatives. Yip & Matthews focused on the fact that the grammatical rules of these three elements show clear differences between the two languages: for the *wh*-in-situ interrogatives, while *wh*- elements are moved to the sentence-initial position in English, they remain in the same position in Cantonese. With regard to null objects, while pronouns in English typically follow transitive verbs, Cantonese transitive verbs do not require them. Finally, concerning prenominal relatives, English modifiers are positioned after nouns, while the order is completely the opposite in Cantonese. Overall, the child studied by Yip & Matthews showed almost the same developmental path as monolingual Cantonese child learners, in all of the three grammatical elements, while his development of English was clearly affected by the grammar of Cantonese.

Other evidence of language interaction was reported in the study by Müller & Hulk (2001), who studied the development of "object omission" in three children who are learning one Germanic and one Romance language, namely German-French, Dutch-French, and German-Italian. The general result of this study is that the children omitted objects as frequently as monolingual children do in each of the two Germanic languages, which is rather frequently, especially when compared to monolingual children of each of the Romance languages. Thus, Müller & Hulk conclude that the development of the children's Romance languages was influenced by their Germanic languages.

Contrary to the claims summarized above, other studies suggest that there is no language interaction in bilingual children's morphosyntactic development. Paradis & Genesee (1996), for example, who started with the hypothesis that transfer, acceleration, and delay may affect bilingual development, found no such interactions based on their own study of French-English bilingual children. Paradis & Genesee specifically focused on the development of finite verbs, negation, and pronominal subjects, and observed that the bilingual children they studied did not differ from monolingual children in developing the two languages: French-English speaking children developed both of their languages similarly to monolingual children learning each of these languages.

This "no transfer" view of morphosyntactic acquisition in bilingual children is also supported in the observation of Japanese-English speaking bilingual children by Mishina-Mori (2002), who specifically focused on potential acceleration effects. The study looks at the production of past tense and negation in two Japanese-English

bilingual children who are between two and three years old, living in the USA, whose mothers are native speakers of Japanese and whose fathers are native speakers of English. The result shows no evidence of acceleration; the children displayed the same paths as monolingual children in terms of their acquisition of past tense and negation in each language.

In sum, the evidence for language interactions at the morphosyntactic level in bilingual children is inconclusive at this stage; some studies suggest that transfer can take place between the two languages that bilingual children are developing, while others make a completely opposite claim, reporting no interaction. The bilingual children documented in these latter studies behave similarly to monolingual children in each of their two languages.

2.3 Evidence from phonological development

Contrary to studies of morphosyntactic development, studies of bilingual children's phonological development so far reveal a more straightforward perspective: according to these studies, the two languages that bilingual children are developing do interact with each other in significant ways.

In her comparison of German-Spanish bilingual and monolingual children of each language, Kehoe (2018) attempted to see if there is any interaction between the two languages in the development of rhotics in bilingual children. She focused on German [ʁ], a voiced uvular approximant, Spanish [ɾ] and [r], a voiced alveolar tap and a voiced alveolar trill respectively, by considering the notions of transfer, acceleration, and delay put forth by Paradis & Genesee (1996). For the German data, Kehoe focused on

[ʁ] in the singleton onsets of stressed syllables and in complex onsets; for the Spanish data, she focused on [ɾ] in complex onsets and in word-medial singleton onset positions, and on [r] in word-initial and word-medial singleton onsets. Additionally, the bilingual children's development of /l/ in complex onsets was described, in order to determine whether potential differences in the acquisition of /r/ in this position (i.e. German [ʁ] and Spanish [ɾ]), compared to monolingual children, could be unique to rhotics or generalized to other consonants. Kehoe analyzed the phonological productions of children aged between two and three years. The results show that there was a delay in the acquisition of German [ʁ] and Spanish [r], while acceleration was seen in the acquisition of Spanish [ɾ]. Specifically, by position, the delay affecting German [ʁ] was seen in complex onsets, and Spanish [r] in both positions mentioned above, while Spanish [ɾ] acceleration was observed in both positions specified above. Concerning the comparison between rhotics and laterals in complex onsets, while German monolingual children acquired the two consonants at the same time, bilingual children acquired laterals faster than rhotics. As for Spanish development, both monolingual and bilingual children acquired laterals earlier than rhotics. From these results, Kehoe suggests that the difference seen between monolingual and bilingual children is unique to rhotics, and that these findings might be the result of phonological assimilation between the two systems of the bilingual children (Kehoe 2018: 728).

Almeida et al. (2012) also investigated transfer, acceleration, and delay, by specifically looking at a Portuguese-French learning child's development of complex onsets and word-medial codas. For the complex onsets, Almeida et al. studied the combinations of

plosive and rhotic, plosive and lateral, fricative and rhotic, and fricative and lateral sequences. For each of these clusters, Almeida et al. also considered the facts that French-learning monolingual children learn the ClV combination first and the CrV second (dos Santos 2007; Kehoe et al. 2008), while Portuguese-learning monolingual children follow the opposite order (Almeida & Freitas 2010) and tend to show vowel epenthesis between the two consonants of the cluster (Freitas 2003), which is virtually undocumented outside of a few specific cases among French monolingual children (Rose 2000; dos Santos 2007; Kehoe et al. 2008). The bilingual child showed the results represented in the figures below:

	fl	pl	fɾ	kl	pɾ	kɾ
2;04	X					
2;06		X				
2;10			X			
3;00				X		
3;03					X	
3;06						X

Table 1: Developmental order of complex onsets in Portuguese (adapted from Almeida et al. 2012: 46)

	fl	pʁ	kl	kʁ	fʁ	pl	tʁ
2;04	X						
2;10		X					
2;11			X				
3;01				X			
3;03					X	X	
3;08							X

Table 2: Developmental order of complex onsets in French (adapted from Almeida et al. 2012: 46)

First is the general observation that the child developed her clusters in both languages during approximately the same time period. Second, the child did not go through a stage of vowel epenthesis in her development of either language. There are also some common facts observed in both languages: (1) the first consonant cluster the child acquired is /fl/, while the last one is /tr/, which the child did not master during the recorded period in Portuguese; (2) the child also generally developed ClV sequences before CrV ones.

The bilingual child studied by Almeida et al. (2012) showed almost the same path as French monolingual children, and vowel epenthesis was absent in her Portuguese development. From this, Almeida et al. suggest that the child's French development had an accelerating effect on her Portuguese development.

Concerning the word-medial codas, the authors emphasize that most consonants can appear in this position in French (Dell 1995), where they develop during same time period (Rose 2000; dos Santos 2007). In Portuguese, only three consonants, [s], [ɾ], and [ɬ], are possible in this position (Mateus & Andrade 2000), where fricative codas are acquired earlier than liquids (Freitas 1997; Correia 2004).

The child acquired fricative codas earlier than liquid codas in both languages, and French plosives were acquired later than any other consonant. This order, given that French monolinguals acquire almost all consonants at the same time (e.g. Rose 2000), suggests that the development of French plosives was delayed.

In sum, Almeida et al. (2012) reported on both acceleration and delay effects based on a single case study. They emphasize that the development of whole syllables, or certain properties within the syllable, can be affected by interactions between the two languages that bilingual children are developing, and that these interactions can take place in either direction. They also suggest that this observation may be limited to balanced bilingual children; concerning bilingual children with a clear language dominance, Almeida et al. follow the suggestion by Paradis (2001) that this factor alone may determine the direction of language interactions.

Studies of language interaction in bilingual children's phonological development are not limited to the two studies mentioned above. Many other studies reported such interactions, both in children's productions (e.g. Keshavarz & Ingram 2002; Fabiano-Smith & Barlow 2010) and in terms of the children's awareness of phonological structure (e.g. Liu & Kager 2016; Lin, Cheng & Wang 2018). In a recent discussion from a psycholinguistic point of view, Lleó (2016) considers two more types of language interactions, in addition to the acceleration, delay, and transfer effects suggested by Paradis & Genesee (1996). Although Paradis & Genesee concluded that these hypothetical effects do not manifest themselves in bilingual children's morphosyntactic acquisition, Lleó (2016) confirms that these effects are all robustly attested in the context of bilingual phonological acquisition, as evidenced by Lleó et al. (2003), Lleó & Rakow (2003), and Lleó & Rakow (2006). In addition, Lleó (2016) considers fusion, suggested by Queen (2001), and a "different order of acquisition" (Lleó 2006). Queen describes fusion in her study of intonation patterns in German-Turkish bilingual children as those patterns which share similarities with certain properties of the two developing languages,

yet do not exist in either (Queen 2001:56). For example, her study shows that bilingual children produced the rising intonational patterns of L*HH% and L%H%",[1] the former being similar to the German rise pattern and the latter close to the Turkish rise pattern, yet neither of which exists in German nor in Turkish. Nonetheless, both of the patterns were seen in both of the languages produced by the bilingual children. Hence the term "fusion" employed by Queen (2001), which Lleó (2016) lists as another type of language interaction.

The "different order of acquisition" proposed by Lleó (2006) can be defined by any different order in the acquisition of specific properties of speech exhibited by bilinguals which differs from that displayed by monolingual children in both of the bilingual's languages. For example, Lleó reports that German-Spanish bilingual children first acquire monosyllables and then trisyllables, while Spanish monolingual children acquire these properties in a completely opposite way. As Lleó (2016) points out:

> [...] the crucial difference is that it generally involves both phenomena at the same time: that is, bilinguals show acceleration of monosyllables and delay of trisyllables. (Lleó 2016: 13)

In sum, given that the five phenomena of acceleration, delay, transfer, fusion, and different orders of acquisition have been evidenced in studies of the phonological development of bilingual children such as those mentioned so far, it is important to look further into these patterns by investigating bilingual children in the context of different language learning situations. By observing a Japanese-English bilingual child, we

1 "H" is a high and "L" is a low tonal morphemes, "*" stands for accent tones and "%" stands for boundary tones (Queen 2001: 61)

propose to see how these types of interactions may reveal themselves between the two languages of this individual learner.

3. Significance of current research

The current research offers one more step towards our understanding of bilingual children's phonological development, considering that previous studies mainly concentrated on the development of European languages, which are also typologically close to one another (Kehoe 2002; Lleó 2006). In fact, there are very few previous studies on the phonological development of bilingual children who are developing English and Japanese, and those studies are mostly focusing on the development of phonological awareness (Otake & Yamamoto 2001; Sakakibara 2016). Thus, observing development in those typologically distant languages by specifically focusing on their differences in consonants, syllable structure, and language-specific elements which are described in the earlier sections, and seeing how these elements interact between Japanese and English, offers new light on patterns of interaction and, more generally, form a basis for further research in this field.

Chapter 3: Methodology

Based on the previous studies outlined above, and in order to obtain further results for bilingual children's language development, which is one of the central aims highlighted by both De Houwer (1995) and Meisel (2007), we propose to study the phonological development of a Japanese-English learning child, following a longitudinal, corpus-based research design. For this study, we concentrate exclusively on the child's development of consonants and consonant clusters, leaving for further research issues such as the child's development of vowel, pitch accent (especially for Japanese) or stress accent (especially for English).

1. Participant

The case study focuses on a bilingual Japanese-English learning child code-named Naoki, who was acquiring his two languages in parallel. The child grew up in northern Virginia in the USA as an only child, and his parents are native speakers of Japanese. Because of this background, he was exposed to Japanese at home, and to English-speaking environments in his daycare centre as well as other situations such as when English speaking visitors were coming to his home (Ota 1998).

2. Differences between Japanese and English

In order to establish the developmental stages exhibited in Naoki's speech, it is necessary to look at the distinctive characteristics of each language. In the descriptions below, we focus specifically on differences relevant to consonants, including language-specific phonological patterns present in each of the two languages, including consonant clusters.

2.1 Japanese consonants

The table below shows the consonant inventory of Japanese (Labrune 2012).

	Labial	Alveolar	Post-Alveolar	Palatal	Velar	Uvular	Glottal
Plosive	p b	t d			k g		
Nasal	m	n					
Fricative		s z	ʃ ʒ	ç			h
Affricate		ʣ	ʧ ʤ				
Liquid		ɾ					
Glide	w			j		ɴ	

Table 3: Japanese consonant inventory (adapted from Labrune 2012: 59)

One important detail to note is that the consonants listed above are only phonemic ones; some of these consonants have allophones conditioned by the ambient vowels, as shown below in (1).

(1) Consonantal allophones in Japanese (adapted from Labrune 2012: 62-69)

a. Allophones of /t/

/t/ → [t] / _ a, e, o

→ [ʧ] / _ i

→ [ʦ] / _ ɯ

b. Allophones of /s/

/s/ → [s] / _ a, e, ɯ, o

→ [ʃ] / _ i

c. Allophones of /h/

/h/ → [h] /_ a, e, o

→ [ç] / _ i

→ [ɸ] / _ ɯ

d. Allophones of /d/ in word-initial position

/d/ → [d] / _ a, e, o

→ [ʒ], [ʤ] / _ i

→ [z], [ʤ] / _ ɯ

e. Allophones of /d/ in word-medial position

/d/ → [d] / _ a, e, o

→ [ʒ] / _ i

→ [z] / _ ɯ

f. Allophones of /z/ on the word-initial position or after /ɴ/

/z/ → [z], [ʣ] / _a, e, ɯ, o

→ [ʒ] ([ʤ]) / _ i

g. Allophones of /z/ in word-medial position

/z/ → [z] /_ a, e, ɯ, o

→ [ʒ], [ʤ] / _ i

→ [ʤ] /_ ɯ (occasionally)

h. Allophones of /n/

/n/ → [n] / _ a, e, ɯ, o

→ [ɲ] / _ i

Please note that, while [ʧ], [ʃ], [ç], and [ʒ](or [ʤ]) are considered as allophones of /t/, /s/, /h/, /d/ and /z/ when they precede the vowel [i], as shown above, they are phonemes when they are positioned before the vowels [a], [ɯ], or [o]. We look at the details of these phonemic patterns in the next section.

2.1.1 Yoon

Yoon are consonant sequences, or palatalized consonants, realized in Japanese as consonant+/j/. The consonants which precede /j/ are typically /k/, /g/, /t/, /s/, /z/, and /h/, and either [a], [ɯ], or [o] follow /j/. This CjV structure is monomoraic. While

/kj/ and /gj/ are pronounced as [kj] and [gj], /tj/, /sj/, /zj/, and /hj/ are produced as [tʃ], [ʃ], [ʒ] (or [ʤ]), and [ç j], respectively (Labrune 2012), as shown below in (2).

(2) Realization of yoon in Japanese

a.	*kyou*	[kjo:]	‘today’
b.	*gyouza*	[gjo:za]	‘dumpling’
c.	*chairo*	[tʃairo]	‘brown’
d.	*shouko*	[ʃo:ko]	‘evidence’
e.	josei	[ʤosei]	‘woman’
f.	*hyaku*	[çjakɯ]	‘one hundred’

In the next two sections, we explore additional properties of Japanese phonotactics.

2.1.2 Syllabic nasal /ɴ/

As part of its phonemic inventory, Japanese displays the uvular nasal consonant /ɴ/, realized as such in word-final position, but in most cases as a nasal consonant which shares the place of articulation of the following consonants or assimilates with surrounding vowels (Saito 2018), as seen below in (3). This is also the only consonant, aside from geminates, which may appear in the coda position of syllables in Japanese (Otake et al. 1993: 262).

(3) Realization of /ɴ/ in Japanese (adapted from Labrune 2012: 134)

a. Before labial consonants except /w/

i.	*kiɴpatsu*	[kimpatsɯ]	‘blond’
ii.	*biɴbou*	[bimbo:]	‘poor’
iii.	*geɴmai*	[gemmai]	‘whole rice’

b. Before alveolar consonants except /s/, /z/, and /ɾ/

i.	*hon̲ten*	[hon̲teɴ]	‘main shop’
ii.	*ton̲da*	[ton̲da]	‘flew’
iii.	*san̲’nen*	[san̲neɴ]	‘three years’

c. Before velar consonants

i.	*kan̲kei*	[kaŋ̲ke:]	‘relation’
ii.	*kan̲gae*	[kaŋ̲gae]	‘thought (noun)’

d. Before /h/, /s/, /z/

i.	*san̲hujinka*	[saũ̲ɸɯʒiŋka]	‘gynaecology’
ii.	*sen̲sei*	[seũ̲se:] [seã̲se:]	‘professor’
iii.	*kan̲ji*	[kaũ̲ʒi] [kaã̲ʒi]	‘Chinese character’

e. Before a pause

i.	*hon̲*	[hoɴ]	‘book’

f. Before /w/, /y/, and a vowel

i.	*kan̲wa*	[kaã̲wa]	‘sino-Japanese’
ii.	*sen̲’you*	[seẽ̲jo:]	‘exclusive use’
iii.	*on̲’in*	[oĩ̲iɴ]	‘phonology’
iv.	*nan̲’ou*	[naã̲o:]	‘Southern Europe’

g. Before /ɾ/

i.	*en̲ryo*	[eũ̲ɾjo], [eẽ̲ɾjo], [eɴ̲ɾjo]	‘reserve, discretion’

2.1.3 Gemination

Gemination is characterized by the delayed release of word-medial consonants in Japanese, and is mostly restricted to the voiceless obstruent consonants /p/, /t/, /k/, and /s/. Gemination for the voiced counterparts of these consonants normally occurs only in loanwords. Gemination of the nasal consonant /ɴ/ is also common, however unlike obstruent consonants /p/, /t/, /k/, and /s/, it is realized as /ɴ/+nasal consonant, rather than a delayed release of /ɴ/. As for the other consonants,

gemination almost never manifests itself with /r/ or /h/, and never occurs with /j/ or /w/ (Labrune 2012). Shown below in (4) is the realization of gemination with the position highlighted, except for those rare cases of gemination for /r/ and /h/. In the context of this thesis, geminates are symbolically represented as a sequence of two identical consonants.

(4) Realization of gemination in Japanese (adapted from Labrune 2012: 136)

a. Before a voiceless obstruent

i.	*kappa*	[kappa]	‘kappa (river imp)’
ii.	*motto*	[motto]	‘more’
iii.	*kissaten*	[kissaten]	‘coffee shop’
iv.	*hassha*	[haʃʃa]	‘departure’
v.	*matcha*	[matʃtʃa]	‘green matcha tea’
vi.	*sekken*	[sekken]	‘soap’

b. Before a voiced obstruent

i.	*baggu*	[baggɯ]	‘bag’
ii.	*guzzu*	[gɯzzɯ]	‘goods’

c. Before a nasal consonant

i.	*sanma*	[samma]	‘saury fish’
ii.	*konnan*	[konnan]	‘difficulty’
iii.	*kinniku*	[kiɲɲikɯ]	‘muscle’

2.2 English consonants

When comparing the Japanese consonant inventory specified above with the English one shown below, the first observation is that English has more consonants than Japanese in its phonemic inventory.

	Labial	Labio-dental	Dental	Alveolar	Retroflex	Post-Alveolar	Palatal	Velar	Glottal
Plosive	p b			t d				k g	
Nasal	m			n				ŋ	
Fricative		f v	θ ð	s z		ʃ ʒ			h
Affricate						ʧ ʤ			
Lateral				l					
Rhotic					ɹ				
Glide	w						j		

Table 4: English consonant inventory (adapted from Jensen 1993:28)

Noticeable in this inventory is the presence of labio-dental and dental consonants, which do not exist in Japanese. Also, while English has two types of liquid consonants, namely /l/ and /ɹ/, Japanese has only one liquid consonant, /ɾ/, and monolingual Japanese native speakers typically show difficulty in distinguishing English /l/ from /ɹ/ (Logan, Lively & Pisoni 1991).

2.3 Consonant clusters

Assuming that the glide is nuclear in CjV sequences (e.g. Lawrence 2004), tautosyllabic consonant clusters do not exist in Japanese, a language where prosodic units are structured by mora, where only CV, CjV, or V syllables are typically attested. Other than a single vowel, only the syllabic nasal /ɴ/, the first half of a geminate, and the lengthening of vowels can take one mora within the syllable rhyme (Labrune 2012: 143). Thus, in consonant clusters or after word-final consonants of loanwords, vowel epenthesis generally occurs. For example, the English word *cream* ([kɹiːm]), is pronounced [kɯ̟ɾiːmɯ̟], where the vowel [ɯ] is inserted between the consonants of [k] and [ɾ], and in word final position, after [m] (Tsujimura 1996: 226).

In contrast to this, English syllables can display consonant clusters both in syllable onsets and codas, and tri-consonant clusters are possible as well. According to McLeod et al. (2001), children start to acquire consonant clusters at around the age of two.

3. The data

The data comes from a longitudinal corpus developed by Mitsuhiko Ota (Ota 1998) available on PhonBank (https://phonbank.talkbank.org). Ota recorded Naoki's speech productions every two or three weeks, from the child's age of 1;7.15 to 2;7.0, for 30 minutes in an English-speaking-only environment and 30 minutes in a Japanese-speaking-only environment. No particular interaction structure was imposed during the sessions, which focused on Naoki's interests at the time of recording. An English native speaker interacted with him in the English-speaking context and, for the Japanese-speaking sessions, Ota himself and/or the child's parents interacted with him. The child's utterances were recorded on cassette tapes, later digitized, and were partly transcribed into IPA form by Ota. Originally, the corpus contained 19 sessions per language (38 in total), but due to missing audio recordings or session files, 18 sessions per language (36 in total) were examined. However, this should not affect our assessment of the overall timeline of Naoki's development. In the current study, all of these 36 data sessions were transcribed into IPA form, following the method described below.[2]

4. Data editing

The original dataset contributed by Ota was edited using the Phon software program (Rose et al. 2006; Rose & MacWhinney 2014), where the recordings of the English-only sessions were transcribed into IPA by an English native speaker, and the Japanese-only

2 We are indebted to Dr. Ota for his generous contribution of the original dataset to the CHILDES and PhonBank databases. Without his work, none of ours would have been possible.

sessions by a Japanese native speaker, both working within the Speech Sciences and Language Acquisition Laboratory at Memorial University. After this step, the software used an algorithm to assign syllable structure annotations to the target (model) and actual productions. These structures are broken down into onset, nucleus, and coda positions. Phon also provides an alignment between the target and actual utterances, on a phone-by-phone basis. In the rare cases when the alignment supplied by Phon is incorrect, they have to be corrected manually, through the program's graphical user interface. After verification of these annotations, the corpus was ready for analysis.

5. Data analysis

Using the Phon software, we assessed the development of Naoki's productions of consonants and consonant clusters in word-initial syllable onsets and word-final syllable codas, word-medial geminates, and coda-onset clusters (where relevant, based on each language), by comparing them with the target (model) forms, which correspond to adult renditions of the same words and word combinations. Due to their arbitrary and variable nature across languages, onomatopoeia were excluded from our analysis. Below we describe the child's phonological development in each of his two languages, both qualitatively and quantitatively. We then compare the development of each language against one another. Through this process, we investigate whether we can observe any interaction between the child's two systems. As we will see, such interactions are most evident in the development of Naoki's syllable codas.

Chapter 4: Data description

1. Introduction

In this chapter, we describe Naoki's development of phones and clusters in both Japanese and English. We extracted these data from the corpus via Phon queries, and we report on them both qualitatively and quantitatively. We illustrate the longitudinal patterns of each phone and cluster type through the use of bar graphs, which present the proportions of accurate productions, substitution, and deletion patterns for each session throughout the recorded period.

We separated the data of Naoki's productions by language, in order to observe any differences between his development of Japanese versus English. For singletons, we further grouped consonants by those attested in both languages and those unique to one of the two languages, in order to verify whether there was an effect of one language onto the other. As we describe later, while Naoki was generally proficient at consonants/clusters in word-initial position, he showed deletions and voicing errors in word-final position as well as word-medial syllable codas in both languages.

In the next section, we begin with the general overview of Naoki's word inventory in each language.

2. General observations

Looking at Naoki's word inventory without babbles of each language throughout the recorded period, we observed differences in developmental patterns between the two languages. In total, Naoki produced 4620 word tokens in the Japanese sessions, and 7910 in the English sessions.

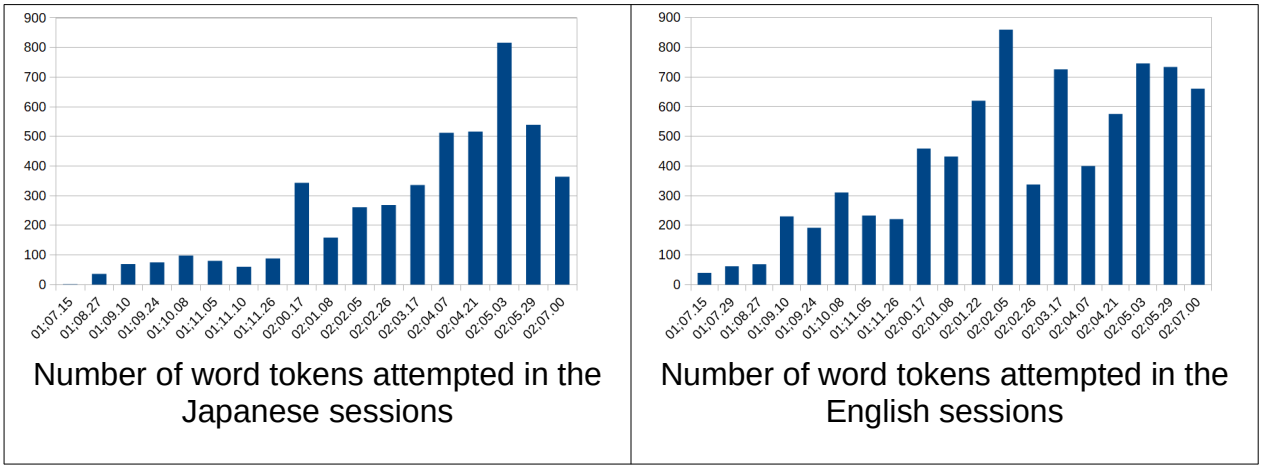

Figure 1: Number of word tokens attempted by Naoki in the Japanese and the English sessions

In the Japanese sessions, there was a period characterized by relatively few attempts at the beginning of the recorded period, between 01;07.15 and 01;11.26, inclusively. Considering that the number of tokens Naoki produced during this period was much smaller than in the subsequent sessions, it is possible that he was avoiding producing some words that he considered difficult to pronounce, although we have no way to independently verify this possibility. From 02;00.17, Naoki started to increase his number of attempts. Although the amount of productions reached the highest at 02;05.03, with 816 tokens, all the other sessions between 02;00.17 and 02:07.00 had relatively fewer productions, roughly between 300 and 500 tokens each.

With regard to Naoki's word inventory in English, similar to Japanese, there was a period when relatively few attempts at English words were made at the beginning of the recorded period. However, this period was shorter with the English sessions than the Japanese ones, lasting only for the first three sessions between 01;07.15 and 01;08.27, inclusively. Again, it is possible that Naoki was avoiding some words that contained difficult phones to pronounce. He then started increasing his number of attempts, from 01;09.10 onward, the amount of productions reaching over 600 in six sessions, with the largest number, 860 tokens, recorded at 02;02.05. Considering the earlier increase and higher amount of productions in the English sessions than in Japanese ones, it is possible that Naoki generally considered English words to be easier to pronounce than Japanese words. Interestingly, however, it is far from clear whether the child was dominant in English at all. As we will see below, there is indeed little evidence of English dominance in his production patterns.

3. Singleton onsets in word-initial position

In this section, we discuss Naoki's development of singleton onsets in word-initial position in both languages. He was overall proficient at producing obstruent plosives, nasals, and glides, for which most of the target consonants are attested in both languages. For these consonants, Naoki showed accurate productions early on, and his productions were generally stable throughout the recorded period.

In contrast to this, Naoki showed various production patterns in his attempts at fricatives, affricates, and liquids. There was a general tendency that while he showed accurate and stable productions for consonants which are attested in both languages, he showed

unstable or only few productions for consonants which are only attested in either one of the two languages.

3.1 Obstruent plosives

With regard to obstruent plosives, Naoki mostly made accurate productions for all the consonants throughout the recorded period in both languages.

3.1.1 /p/, /b/, /t/, /d/, /k/, and /g/

Naoki's productions of /p/, /b/, /t/, /d/, /k/, and /g/ were overall very accurate throughout the recorded period, in both of his languages.

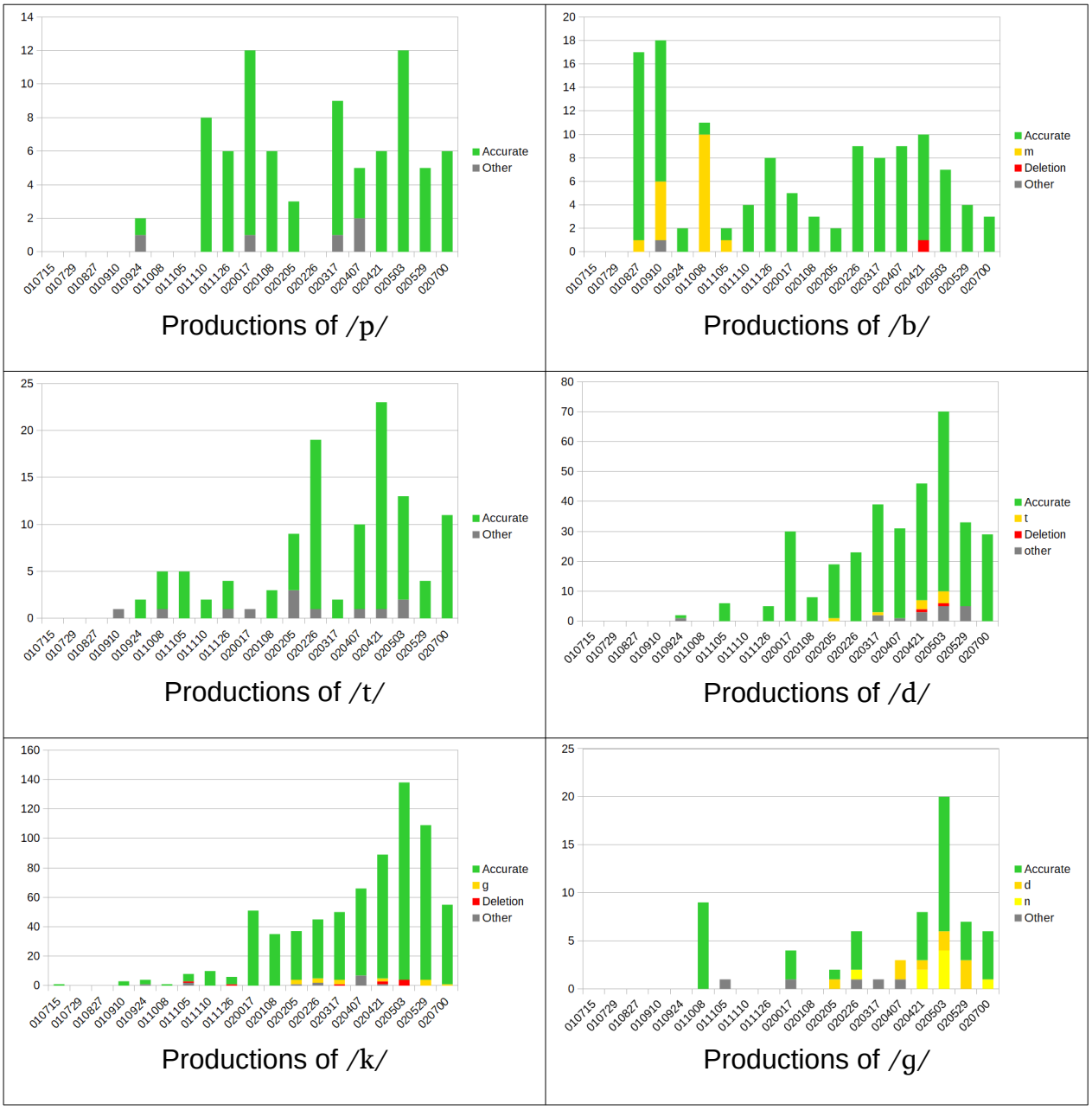

Figure 2: Naoki's productions of /p/, /b/, /t/, /d/, /k/, and /g/ in word-initial onset position in Japanese

In the Japanese sessions, there were some substitutions affecting Naoki's productions of /b/, /d/, and /g/, which occurred in only specific words; the substitution to [m] in his development of /b/ only occurred in the word *Baikinman* /baikimmaɴ/ → [maikimmam] (a cartoon character). As for the devoicing in his development of /d/, it occurred

predominantly in the Japanese copula *da*. Finally, the substitutions to [d] and [n] in his development of /g/ were only observed in the Japanese particle *ga* /ga/→[da], [na]. These types of idiosyncratic behaviours, where a child produces inaccurate productions only in specific words, do not always conform to the phonological grammar, and are instead considered as lexical exceptions (Rose 2014). Therefore, we do not consider the substitutions described above to be representative of Naoki's phonological development. Aside from these substitutions and other minor issues, Naoki was good at producing obstruent plosives in word-initial position in Japanese. We can thus claim that Naoki had acquired the target consonants by 01;09.24.

Naoki's productions of obstruent plosives in word-initial position were similarly accurate in English, as we can see in Figure 3:

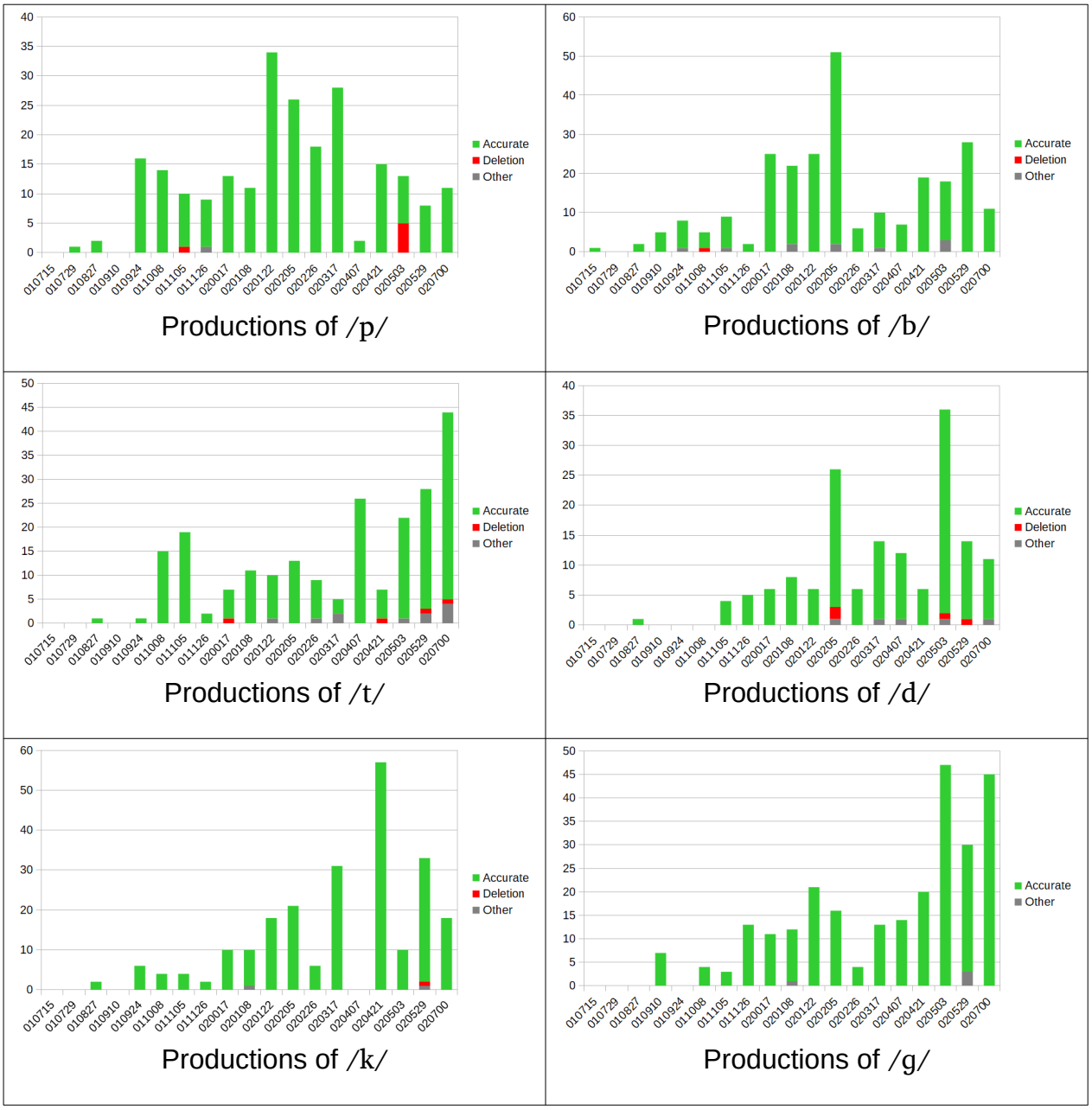

Figure 3: Naoki's productions of /p/, /b/, /t/, /d/, /k/, and /g/ in word-initial onset position in English

Naoki started to produce these consonants in English slightly earlier than in Japanese, at around 01;08.27, in line with his generally higher lexical productivity in this language reported above. From this point, his productions were already accurate. We can thus

claim that Naoki had acquired the obstruent plosives in word-initial position in English by 01;08.27.

3.1.2 Summary of obstruent plosives in word-initial onset position

In summary, Naoki's productions of all the obstruent plosives in word-initial position were generally adult-like throughout the recorded period, despite a few lexical exceptions in Japanese. In the next section, we consider Naoki's development of fricatives.

3.2 Fricatives

Compared to obstruent plosives, Naoki's fricatives showed noticeable variation in their development. There was also a tendency that his productions of consonants which are attested in both languages were very accurate, while his productions of consonants which are unique to either one of the languages tended to be either inaccurate, inconsistent, or completely avoided.

3.2.1 Fricatives attested in both languages

3.2.1.1 /s/, /ʃ/, and /h/

Naoki showed similar developmental patterns for /s/, /ʃ/, and /h/. We consider that his productions of these consonants were mostly adult-like throughout the recorded period, in both languages.

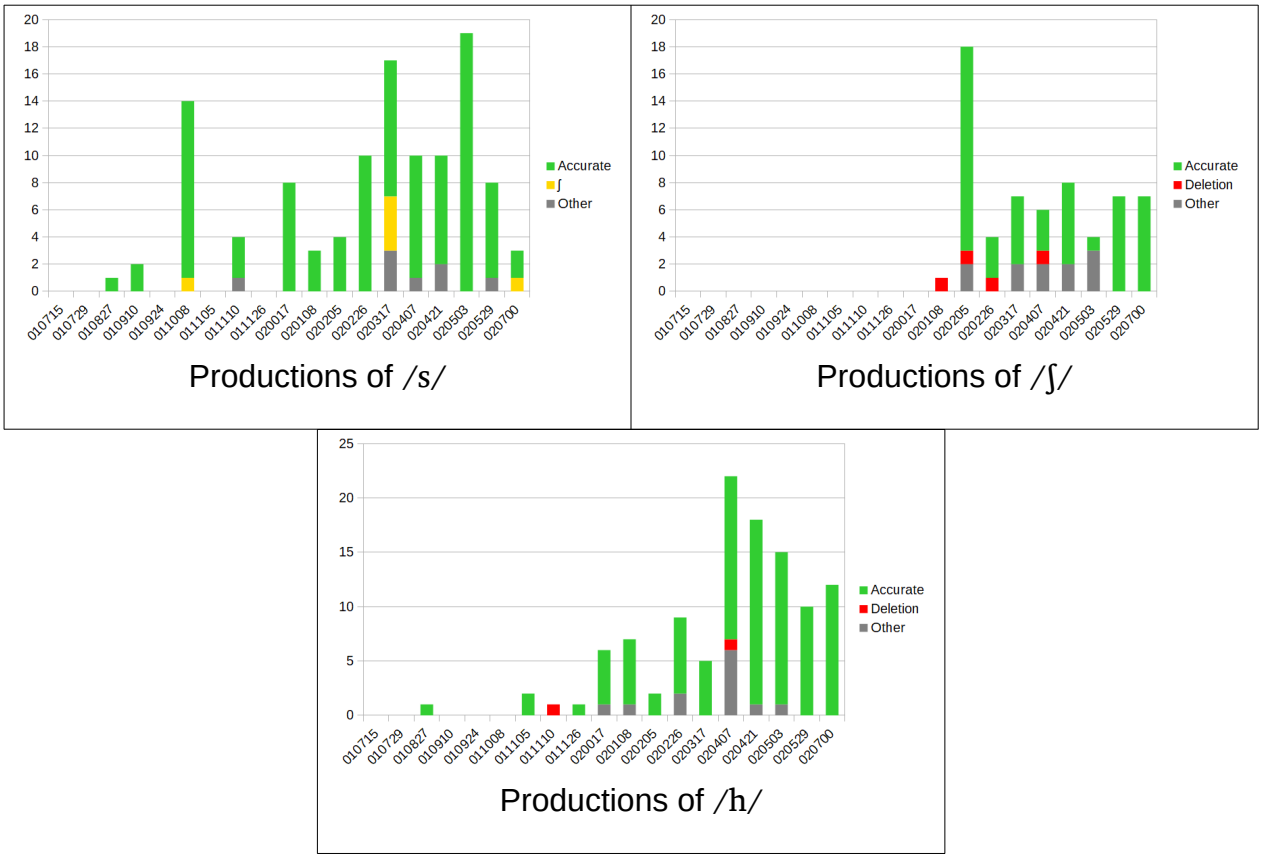

Figure 4: Naoki's productions of /s/, /ʃ/, and /h/ in word-initial onset position in Japanese

In the Japanese sessions, Naoki showed occasional substitutions to [ʃ] in his productions of /s/. At 02;03.17 particularly, there was a lexical exception pattern, where all substitutions happened in the word *soojiki* (/soːʒiki/→[ʃoʊʒuki] 'vacuum cleaner'). For his development of /ʃ/, the substitutions occurred with variable consonants such as [t], [s], and [ʧ] in unsystematic ways. Deletions all occurred in the same word, *shitteru* (e.g./ʃitteɾɯ/→[tteɾɯ] 'know'), with one of these examples being in the conjugated form, *shitte.* Finally, the substitutions in Naoki's productions of /h/, observed at 02;04.07, were mostly with [k] in different words, such as in *haitchatta* /haitʃʧatta/→[kʊʧɛta] 'entered', *hora* /hoɾa/→[koɾa] 'see', and *hoshi* /hoʃi/→[kɯʃi] 'star'. Aside from these and other minor inaccurate productions, Naoki was proficient at

producing the target consonants. We can thus conclude that Naoki had generally acquired these consonants by 01;08.27.

Naoki's productions of /s/, /ʃ/, and /h/ in English in the word-initial onset position showed similar results as those in Japanese, with a few deletions.

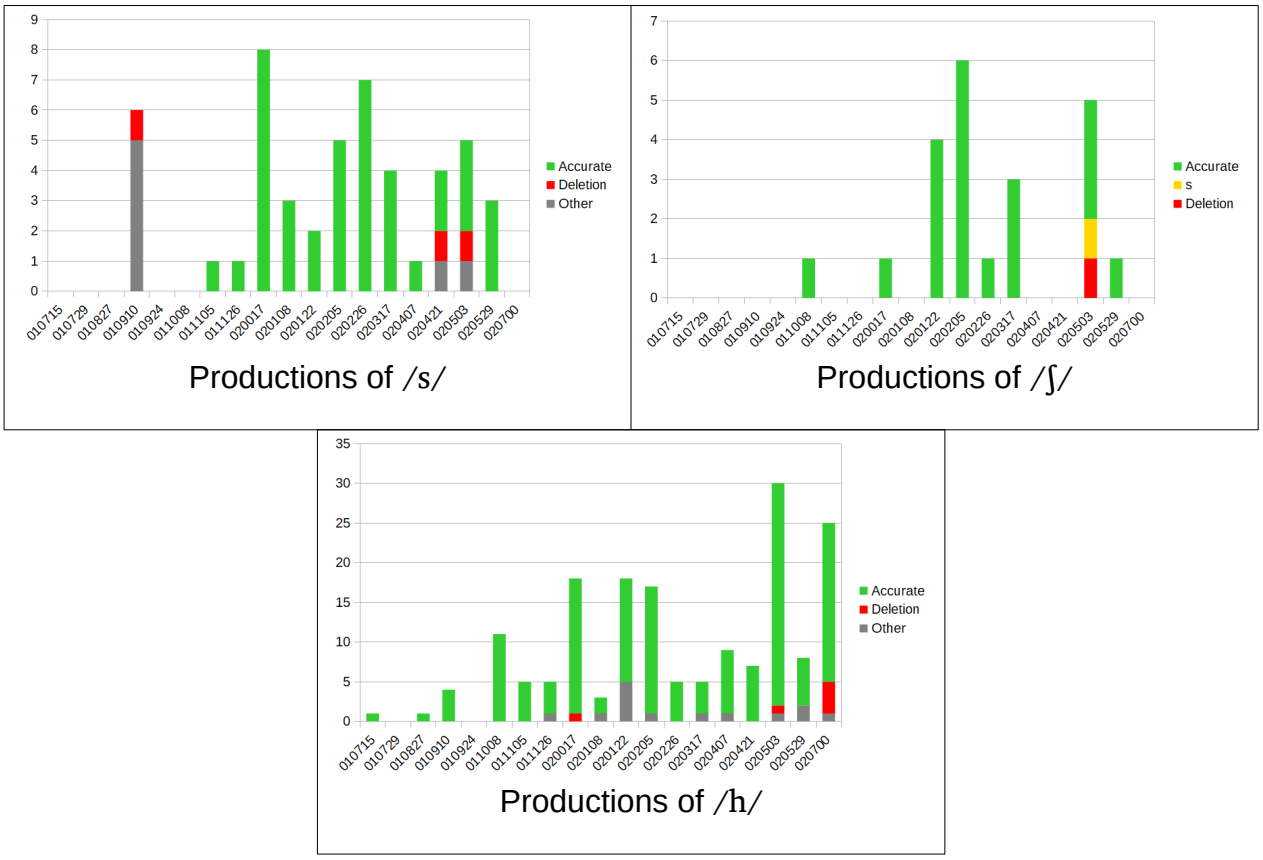

Figure 5: Naoki's productions of /s/, /ʃ/, and /h/ in word-initial onset position in English

In the first session recording attempts at /s/, all the substitutions occurred in one word, *circle* (e.g. /ˈsʌɹkəl/→[ˈkokə]), suggesting an early pattern of consonant harmony affecting the fricative in this particular word. There were deletions and substitutions seen at 02;04.21 and 02;05.03, and all occurred in the word *see*, except for the deletion at 02;04.21. Regarding Naoki's productions of /ʃ/, there were only one deletion and one

substitution, respectively, at 02;05.03, occurring in the same word, *sheep* /ˈʃiːp/→[ˈiːp], [ˈsiːp]. Finally, in his productions of /h/, the substitutions seen at 02;01.22 were mostly with [k], in the word *helicopter* (e.g /ˈhɛlɪˌkɑptəɹ/→[ˈkʌɹɪˌkɑdə]). Out of four deletions observed in 02;07.00, two were in a cartoon character's name, Henrietta (e.g. /hɛnɹiː ˈɛtə/→[ˌɛɹiːˈɛta]). However, Naoki was generally accurate with this word; these two examples were thus not representative of his more general phonological productive abilities. Aside from these and other minor unsystematic productions, Naoki was able to produce the target consonants. We can thus conclude that Naoki had acquired the target fricatives /s/, /ʃ/, and /h/ in English by 01;10.08.

3.2.1.2 /z/

Unlike in English, the Japanese /z/ in word-initial position can be produced as both [z] and [ʣ] (Labrune 2012: 64), and there is a general tendency (but no phonological rule) among native speakers whereby [z] is produced when /z/ is in intervocalic position (Saito 2018). For the observation of Naoki's development, due to the difficulty in predicting which phone is to be applied given this relatively free variation, both [z] and [ʣ] phones are considered accurate regardless of the surrounding phones.

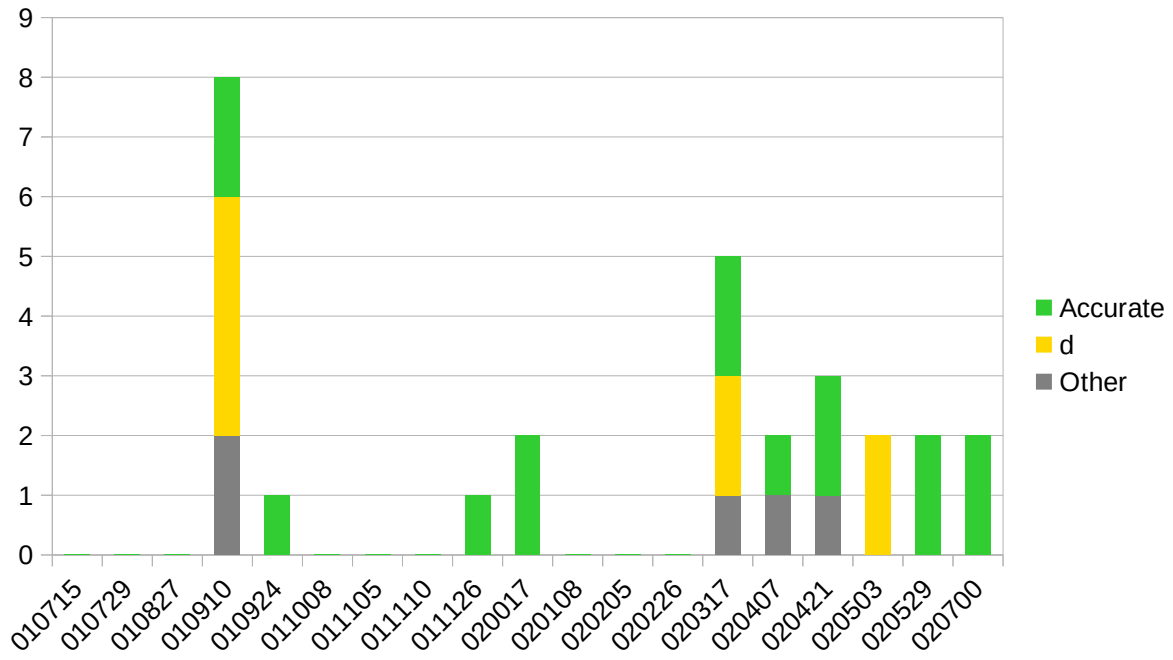

Figure 6: Naoki's productions of /z/ in word-initial onset position in Japanese

In spite of this analytical flexibility, Naoki's productions of /z/ in Japanese were not very stable. Most of the time, he only uttered the word *zoo-san*, where most of the substitutions were with [d] (e.g. /zoːsaɴ/→[doːsaɴ] 'elephant'), and half of the other substitutions involved either [ʒ] or [s].

In English, Naoki only made one attempt at /z/ in word-initial position during the recorded period, at 02;01.08, which was accurate. Because of the insufficient data, it is difficult to judge when he actually acquired /z/ in English.

3.2.1.3 /ʒ/

In Japanese, /ʒ/ can be produced as either [ʒ] or [ʤ] in the word-initial onset position. However, similar to the relationship between [z] and [ʣ] described in the preceding section, there is no strict phonological rules about the environment where [ʒ] or [ʤ]

should occur (Saito 2018: 89). Thus, in the chart below, both [ʒ] and [ʤ] are considered to be accurate productions.

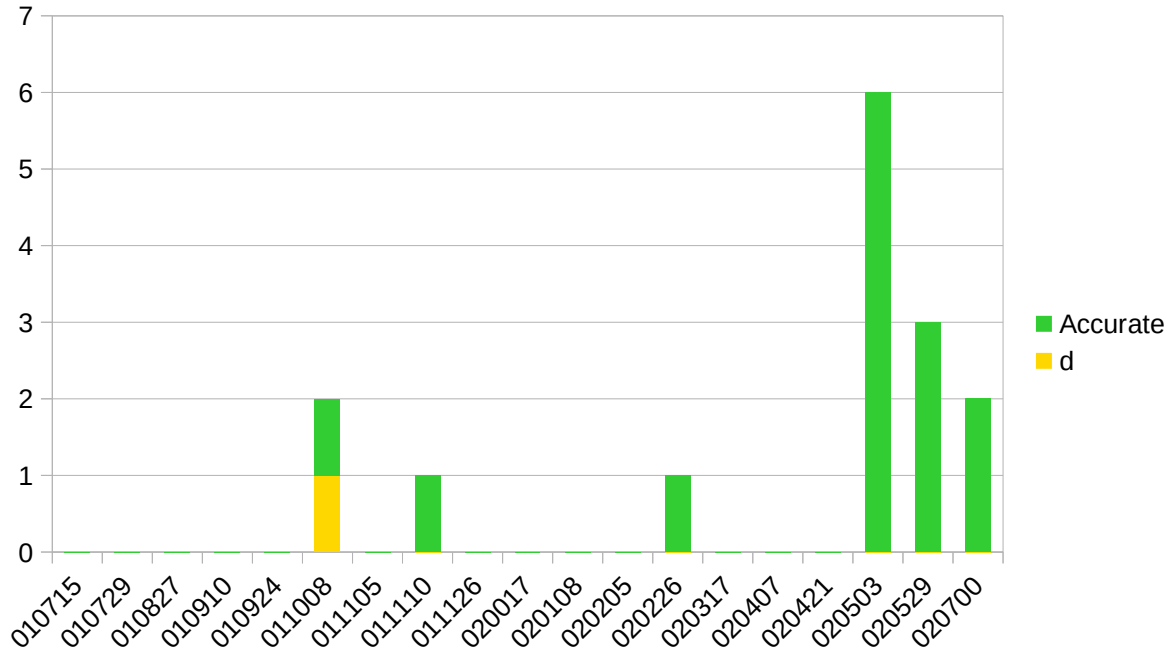

Figure 7: Naoki's productions of /ʒ/ in word-initial onset position in Japanese

In Japanese, Naoki showed accurate productions of /ʒ/ after his attempt recorded at 01;10.08. He substituted the target consonant with [d] only once, in the word *juusu* /ʒɯːsɯ/→[dɯːsɯ] 'juice'. Thus, considering the amount of accurate productions, we can claim that he had acquired /ʒ/ in Japanese by 01;10.08 or shortly thereafter. In English, Naoki did not make any attempt at /ʒ/.

3.2.2 Fricatives attested only in Japanese

3.2.2.1 [ɸ]

Naoki's productions of [ɸ], an allophone of /h/, were overall very accurate, although there were only 14 attempts recorded throughout the observation period.

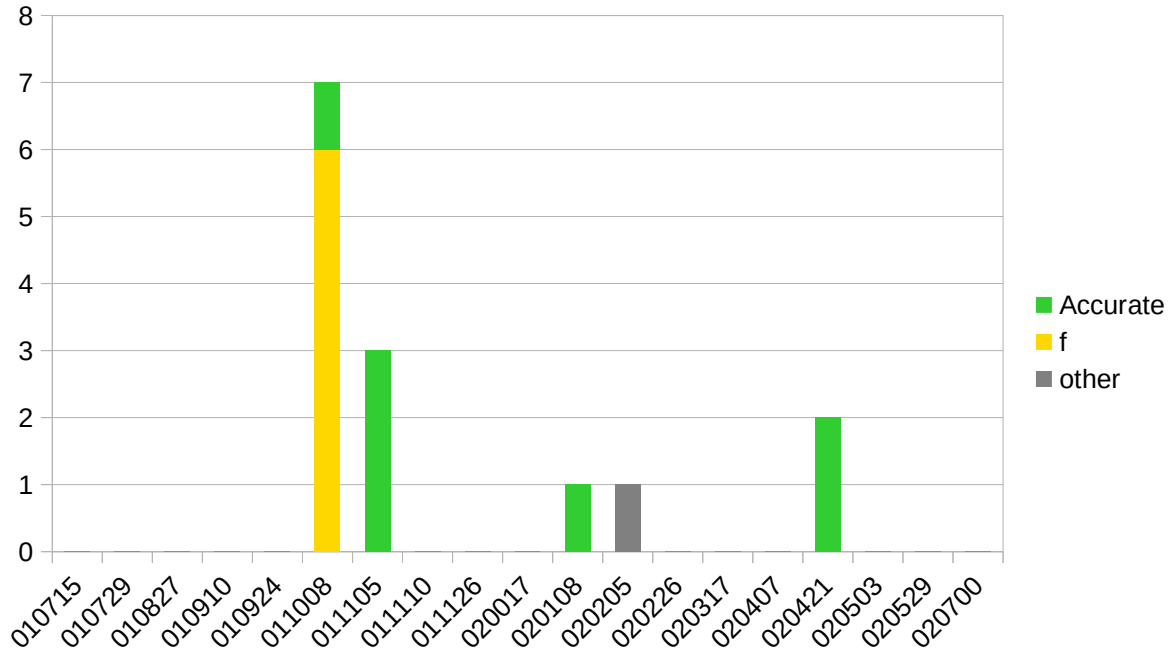

Figure 8: Naoki's productions of [ɸ] in word-initial onset position in Japanese

Naoki substituted [ɸ] with [f] at 01;10.08 in a majority of cases, but this only occurred in a TV show character's name *Fado* (e.g. /ɸado/→[fada]). After this session, his productions were mostly accurate. We can thus claim that Naoki had acquired [ɸ] by 01;11.05.

3.2.2.2 /ç/

Naoki's productions of /ç/ were unstable throughout the recorded period.

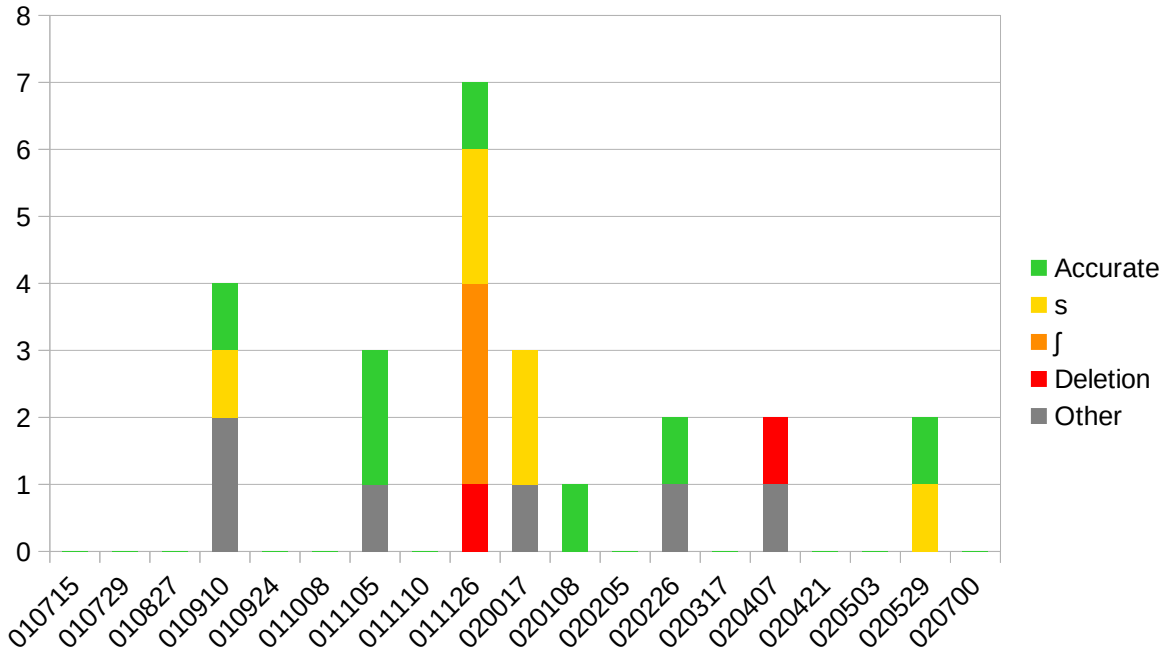

Figure 9: Naoki's productions of /ç/ in word-initial onset position in Japanese

The substitution with [s] occurred many times in the word *hito* (e.g. /çito/ → [sto] 'person'), whereas the substitution with [ʃ] occurred only in the word *hikooki* (e.g. /çikoːki/ → [ʃkoːki] 'airplane'). The deletions, which were attested at 01;11.26 and 02;04.07, were both in the word *hitotsu* (e.g. /çitotsɯ/ → [itatstsɯ] 'one'). In sum, Naoki's productions of /ç/ were inconsistent, also with each substitution or deletion mostly occurring in unique words.

3.2.3 Fricatives attested only in English

3.2.3.1 /f/

Naoki's productions of /f/ were mostly accurate and stable throughout the recorded period.

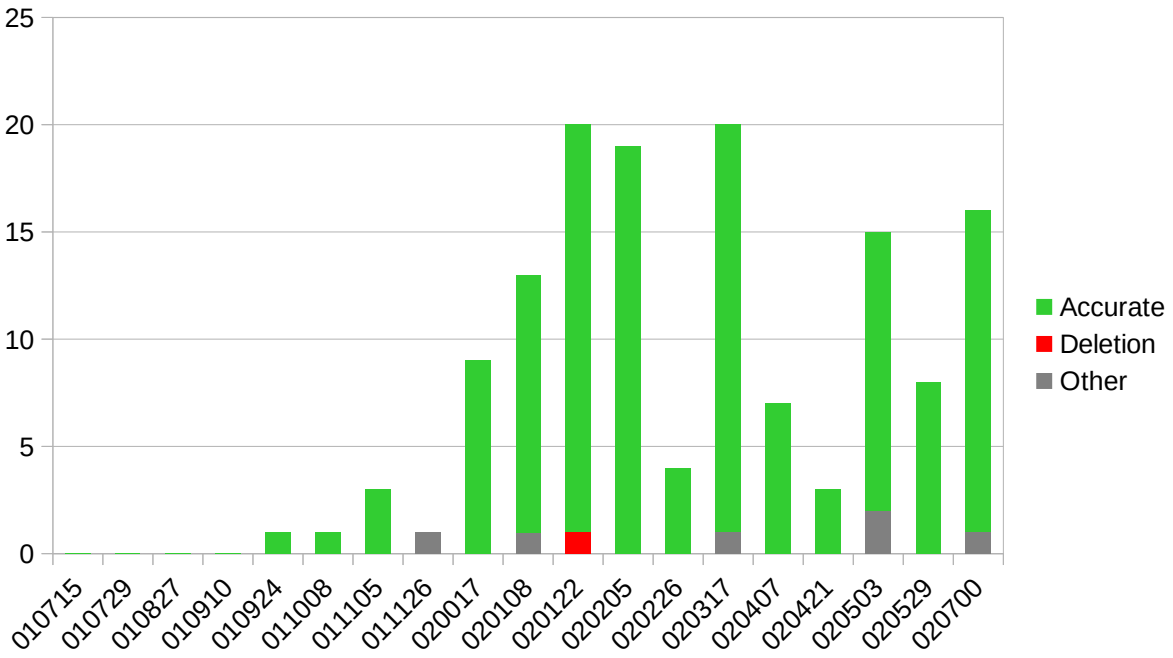

Figure 10: Naoki's productions of /f/ in word-initial onset position in English

Naoki only showed unsystematic substitutions six times, to [p], [v], [t], and [h], and only displayed a single deletion. From these observations, we can conclude that Naoki had acquired /f/ by 01;09.24.

3.2.3.2 /v/ and /θ/

Naoki only attempted /v/ and /θ/ twice each throughout the recorded period. For /v/, he made attempts at 01;09.24 and 02;01.08. He substituted the target consonant with [k] in the word *vegetables* /ˈvɛʤtəbəlz/→[ˈkiːtubu] in his first attempt, and pronounced it accurately in the second attempt. As for /θ/, he attempted it at 02;01.08 and 02;07.00. He substituted the target consonant with [p] in his first attempt in the word *thing* /ˈθɪŋ/→[ˈpɪnt], and he pronounced the word *think* accurately in his second attempt. Overall, because of the small number of productions, it is difficult to judge when exactly Naoki acquired these consonants.

3.2.3.3 /ð/

Naoki substituted /ð/ to [d] throughout the recorded period.

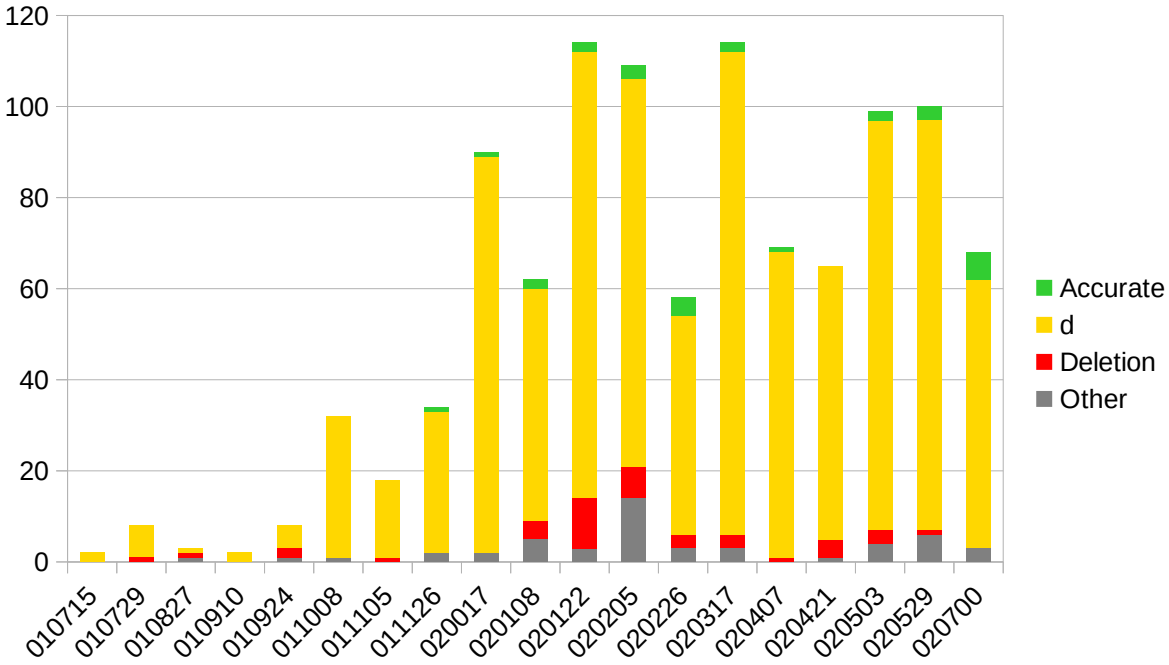

Figure 11: Naoki's productions of /ð/ in word-initial onset position in English

Mostly, his attempts only occurred in function words such as *the, this, that,* and *there,* and substitutions and deletions occurred in these words too. Overall, he had difficulties while producing the target consonant, which resulted in mostly consistent productions of [d].

3.2.4 Summary of fricatives in word-initial onset position

In summary, Naoki showed more variable results in his development of fricatives, compared to his productions of plosives. He displayed a better performance with consonants which are attested in both languages, such as /s/, /ʃ/, and /h/, while the opposite is true for consonants that are attested only in either one of the languages, such as /ç/ in Japanese, and /θ/ and /ð/ in English, for which Naoki showed either few

productions, inconsistency, or substitutions throughout the data. In the next section, we describe Naoki's development of affricates.

3.3 Affricates

Naoki's production of affricates showed a tendency similar to that of fricatives; while he showed mastery at producing /ʧ/, which is attested in both languages, his productions of consonants only found in one of the languages were, similar to what we saw with fricatives, either inconsistent, or the number of productions was too small to offer conclusive evidence.

3.3.1 Affricate attested in both languages: /ʧ/

Naoki's attempts at /ʧ/ in both languages were mostly accurate.

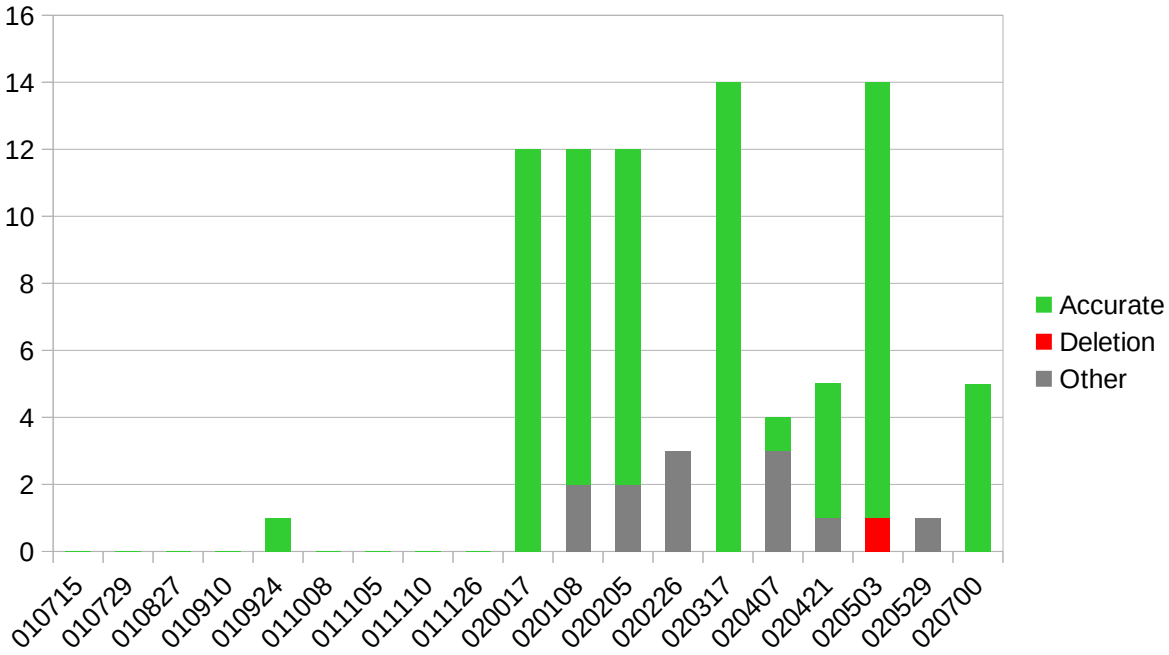

Figure 12: Naoki's productions of /ʧ/ in word-initial onset position in Japanese

In the Japanese sessions, the substitutions observed between 02;01.08 and 02;05.29 were all with alveolars such as [t], [ʒ], [ʦ], and so on. Despite this, most of his productions were accurate. We can thus claim that Naoki had acquired [ʧ] by 01;09.24, if not before.

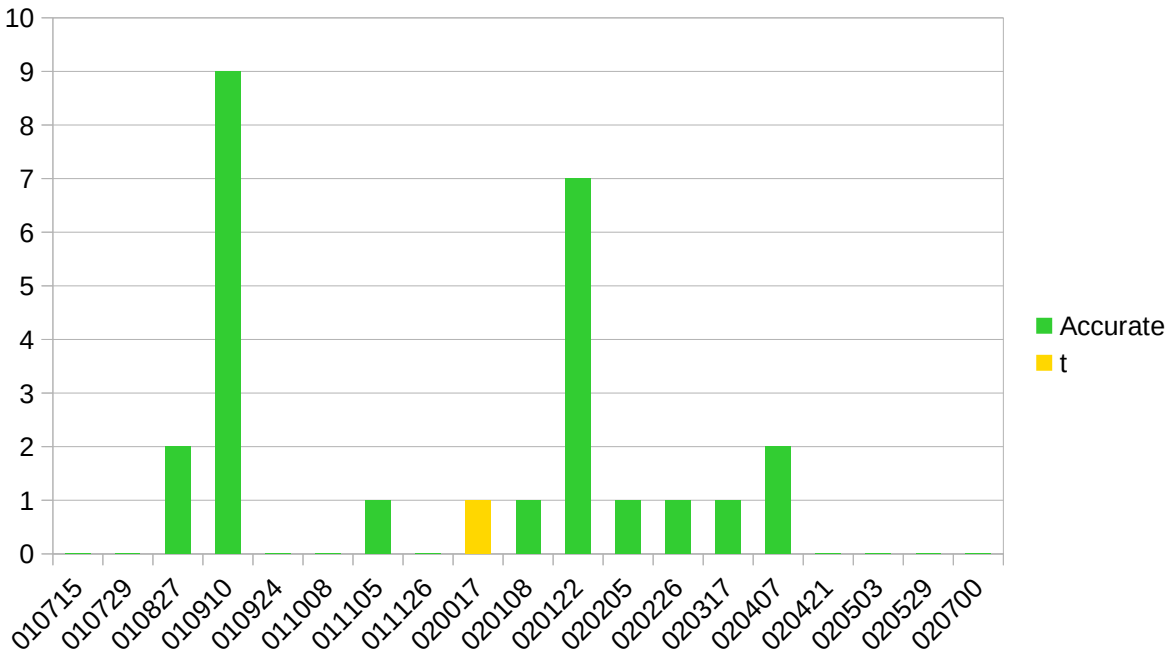

Figure 13: Naoki's productions of /ʧ/ in word-initial onset position in English

In the English sessions, there was only one substitution at 02;00.17, with [t]. We can conclude from these data that Naoki had acquired /ʧ/ in English by 01;08.27, if not before.

3.3.2 Affricate attested only in Japanese: [ʦ]

Throughout the recorded period, Naoki's productions of [ʦ] were mostly inaccurate and unstable.

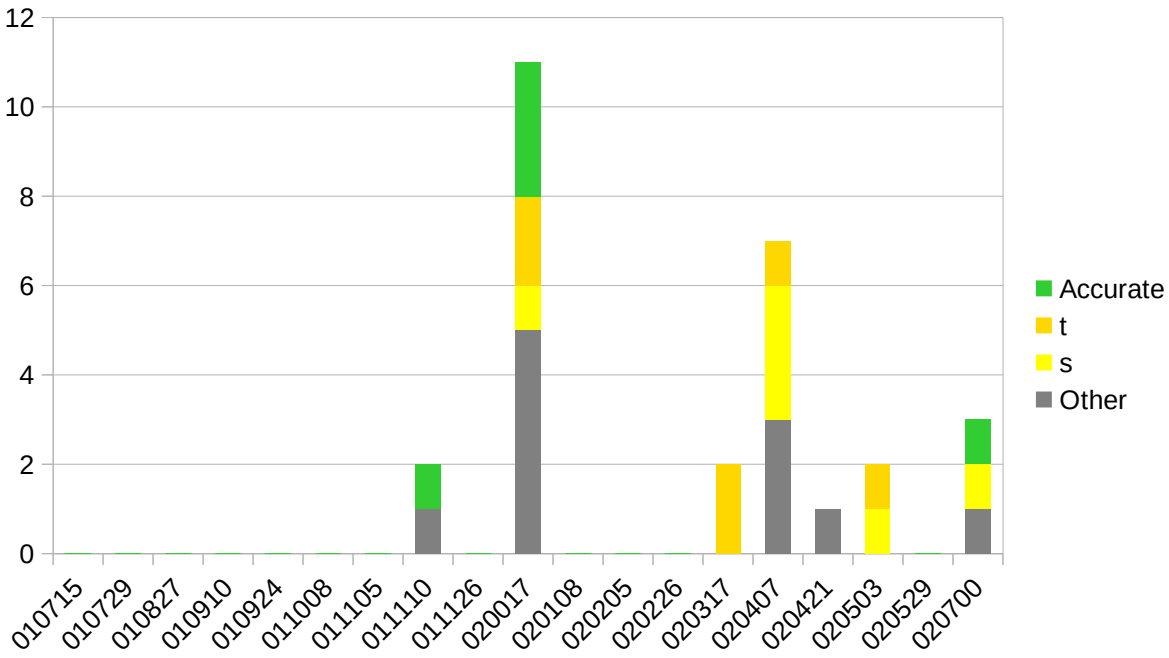

Figure 14: Naoki's productions of [ʦ] in word-initial onset position in Japanese

In most of the sessions where Naoki made attempts at this affricate, there were substitutions with [t] and/or [s]. These substitutions occurred in various words and in unsystematic ways. The other substitutions were mostly with coronals: [d], [z], [ʒ], [ʧ], [ʤ], as well as with [k]. In sum, there is no evidence that Naoki had acquired [ʦ] by the end of the recorded period.

3.3.3 Affricate attested only in English: /ʤ/

Naoki attempted /ʤ/ only eight times throughout the recorded period. Out of these, five were produced accurately. There was one case of deletion at 02;04.21, and two substitutions: with [z], at 01;09.10, and with [ʧ], at 01;11.05. Overall, it is difficult to judge whether he acquired the target consonant during the course of the observation period, considering the small number of attempts recorded.

3.3.4 Summary of affricates in word-initial onset position

Overall, the evidence suggests relatively early mastery of /tʃ/, which is attested in both languages, but poor performance with all of the other affricates, which are attested only in either one of the languages. Naoki's productions of [ʦ] in Japanese were inconsistent throughout the recorded period, and he only showed few productions of /ʤ/ in English. In the next section, we look at his development of nasals.

3.4 Nasals

Similar to obstruent plosives in word-initial onsets, Naoki's productions of nasals in this position were very accurate in both languages throughout the recorded period.

3.4.1 Nasals attested in both languages: /m/ and /n/

Naoki was very proficient at /m/ and /n/ in both languages.

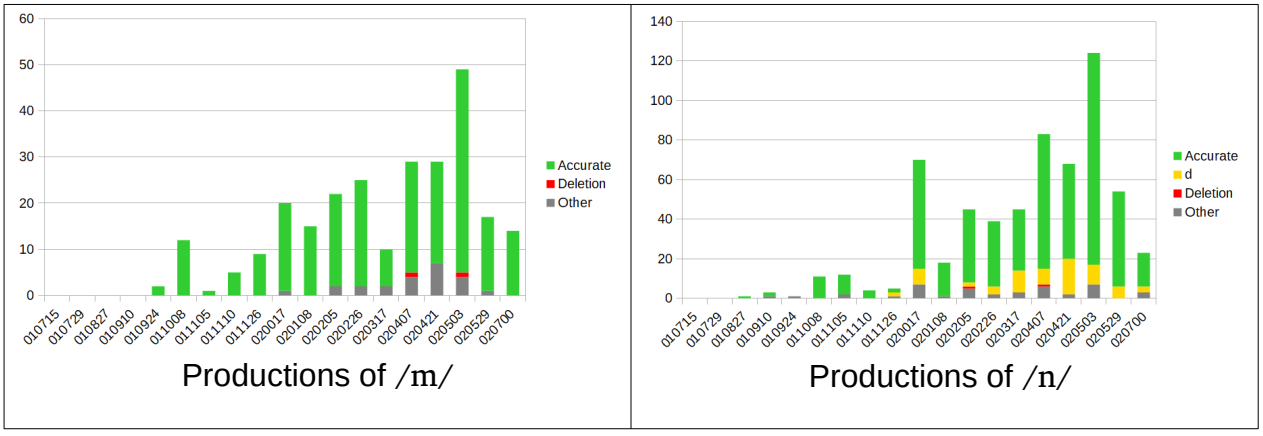

Figure 15: Naoki's productions of /m/ and /n/ in word-initial onset position in Japanese

In the Japanese sessions, there were a few substitutions in his productions of /m/, particularly between 02;02.05 and 02;05.03. However, these occurred in unsystematic ways and resulted in various consonants ([b], [d], [h], [n], and [w]). As for his attempts at /n/, there were substitutions to [d], from 01;11.26 until the end of the

recorded period. These substitutions also did not show any systematic pattern. In spite of these inaccurate productions, Naoki's attempts at /m/ and /n/ in word-initial position in Japanese were mostly adult-like. We can thus claim that Naoki had acquired these consonants by 01;10.08.

Naoki showed more accuracy in his productions of /m/ and /n/ in English than in Japanese.

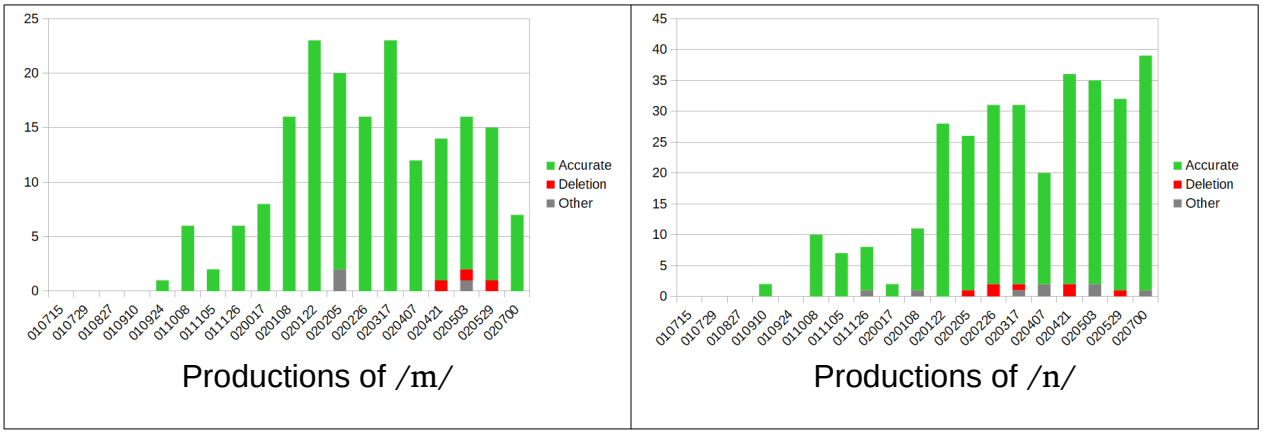

Figure 16: Naoki's productions of /m/ and /n/ in word-initial onset position in English

Between 02;04.21 and 02;05.29, there were a handful of deletions as well as substitutions to [p], [b], and [h] in Naoki's attempts at /m/, which occurred across different words. The deletions in his attempts at /n/, which were observed between 02;02.05 and 02;05.29, occurred in the word *no* most of the times (e.g. /ˈnoʊ/→[oʊ]). Except for these minor issues, Naoki's productions were very accurate throughout the recorded period. We can thus conclude that he had acquired these consonants by 01;10.08.

3.4.2 Nasal attested only in Japanese: [ɲ]

Naoki attempted [ɲ], an allophone of /n/, 45 times in total, fewer than the other nasal consonants. He also began his attempts at [ɲ] much later than he began to attempt the other nasals. However, his productions were overall very accurate.

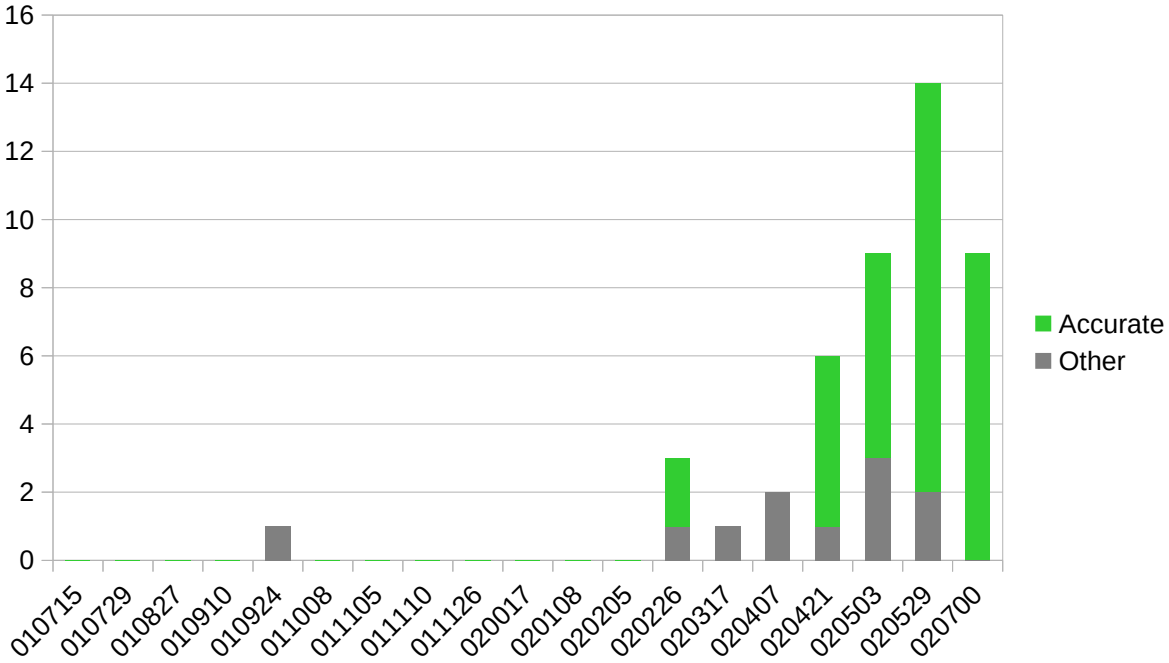

Figure 17: Naoki's productions of [ɲ] in word-initial onset position in Japanese

The substitutions between 02;02.26 and 02;05.29 occurred mostly in *ni* 'two' and *ni* (Japanese particle), and involved other alveolar consonants ([d], [n], [l], [ɾ]; e.g. /ɲi/→[ɾi]). Overall, the amount of accurate productions increased toward the end of the recorded period; we can claim from the available data that Naoki had acquired /ɲ/ by 02;04.21, or potentially earlier.

3.4.3 Summary of nasals in word-initial onset position

In summary, Naoki was very proficient at all the nasals in both languages, and acquired all of them during the recorded period. While he started to attempt /ɲ/, which is only

attested in Japanese, later than the other nasals, which are attested in both languages, there were overall no major problems for him to produce all the nasals. Furthermore, of the small amount of inaccurate productions recorded throughout the data, many examples came from specific words in functional categories. In the next section, we look at Naoki's productions of liquids.

3.5 Liquids

Naoki's productions of liquid consonants showed different results by language. It took a sizeable amount of time for him to learn the Japanese liquid /ɾ/, while he could generally produce English liquids throughout the recorded period.

3.5.1 Liquid attested only in Japanese: /ɾ/

Naoki's productions of /ɾ/ were not stable until the last few sessions. At 01;09.10 and 02;00.17, he substituted the target consonant with [ɹ] a total of six times. However, the substitutions only occurred in very specific words: at 01;09.10, he attempted *raion*, with the substitution pattern of /ɾaioɴ/→[ʊɹæɪɹo] 'lion'. At 02;00.17, he only attempted *Remonchan* (a cartoon character), for which more than half of the occurrences displayed substitutions with [ɹ] (e.g. /ɾemonʧaɴ/→[ɹeːmonʧa]).

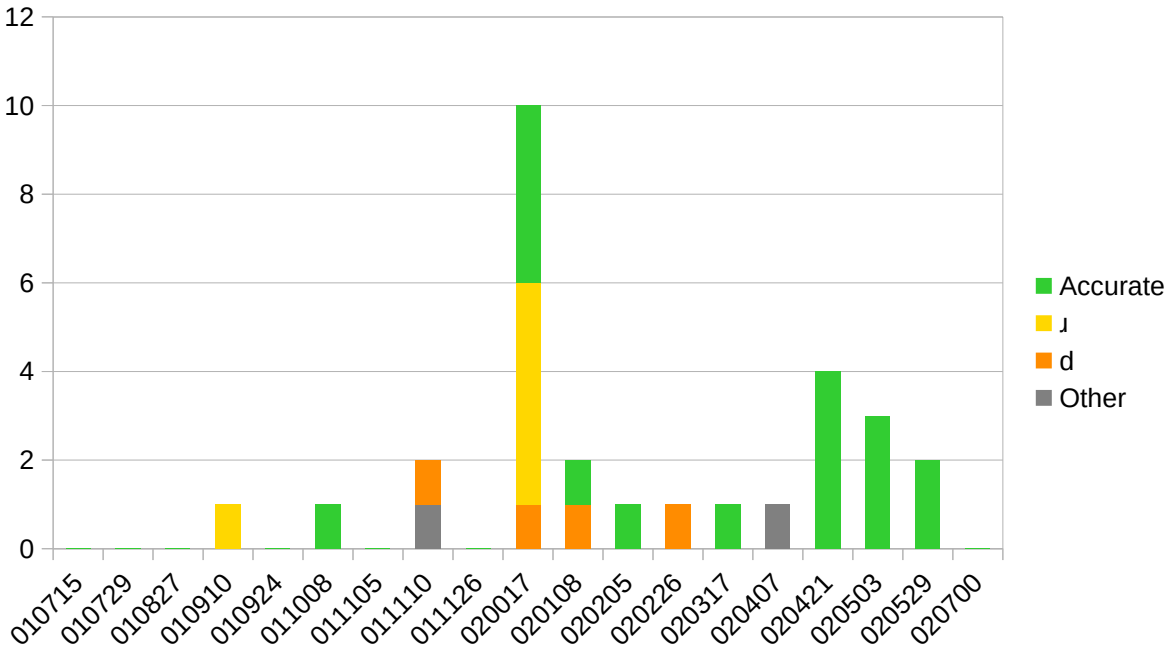

Figure 18: Naoki's productions of /ɾ/ in word-initial onset position in Japanese

The substitutions with [d], by contrast, all occurred in different words, for instance *Resshii* /ɾeʃʃiː/→[deːʃiː] (a cartoon character) and *roku* /ɾokɯ/→[dokɯ] 'six'. Finally, the "Other" substitutions were with [j] and [w]. Overall, aside from the lexical exception where Naoki substituted [ɹ] for /ɾ/, he began to produce /ɾ/ more accurately at 02;00.17, which we take as the age of mastery.

3.5.2 Liquids attested only in English: /l/ and /ɹ/

Compared to his productions of Japanese /ɾ/, Naoki's productions of /l/ and /ɹ/ were more stable throughout the recorded period.

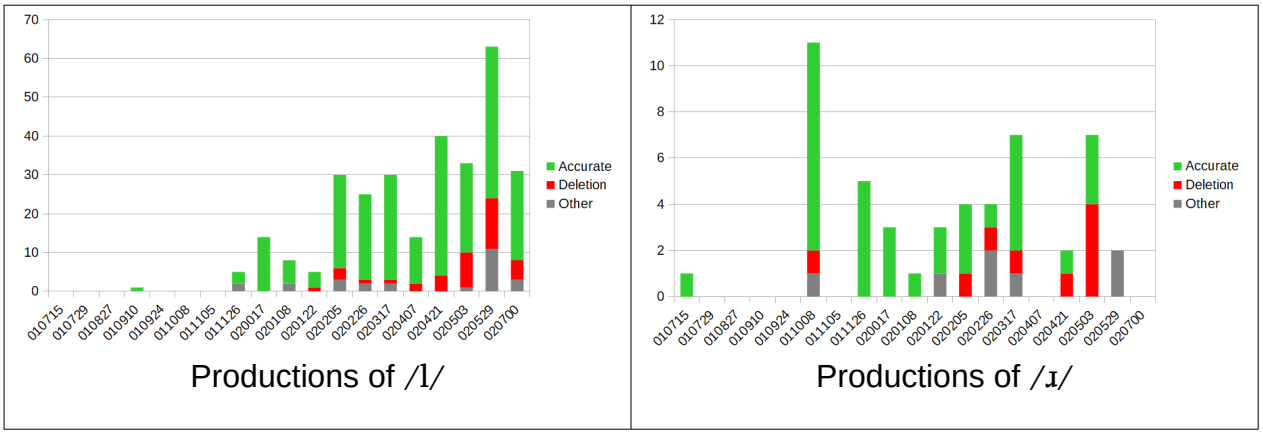

Figure 19: Naoki's productions of /l/ and /ɹ/ in word-initial onset position in English

In his productions of /l/, a larger amount of deletions were observed at 02;05.29, which occurred in the word *look* (/ˈlʊk/→[ˈʊk]) 12 times out of 13 total deletions. Nonetheless, accurate productions also occurred 28 times in this word, out of 39 total accurate productions for the session. Regarding his attempts at /ɹ/, there were some inaccurate productions at 02;02.26, 02;03.17, and 02;05.03, which we can consider as lexical exceptions. In these sessions, out of six deletions, five occurred in the word *right* (e.g. /ˈɹaɪt/→[ˈaɪ]). Of the three substitutions between 02;02.26 and 02;03.17, two were to [w], both in the word *red* (/ˈɹɛd/→[ˈwɛd]), and once to [v] in the word *right* (/ˈɹaɪt/→[ˈvaɪ]). Aside from these deletions and substitutions, Naoki's productions of the target consonants were generally adult-like. We can thus conclude that Naoki had acquired liquids in word-initial onset position in English by 01;11.08.

3.5.3 Summary of liquids in word-initial onset position

In summary, while Naoki displayed a certain amount of inaccurate productions for all the liquid consonants, he still acquired the ability to produce these consonants during the observation period. However, he generally made many more attempts at English liquids

than Japanese /ɾ/, and he was more proficient at producing the former. In the next section, we turn to Naoki's development of glides in word-initial position.

3.6 Glides: /w/ and /j/

Naoki's production of /w/ and /j/ in Japanese were adult-like from his first attempts, and generally remained so throughout the recorded period.

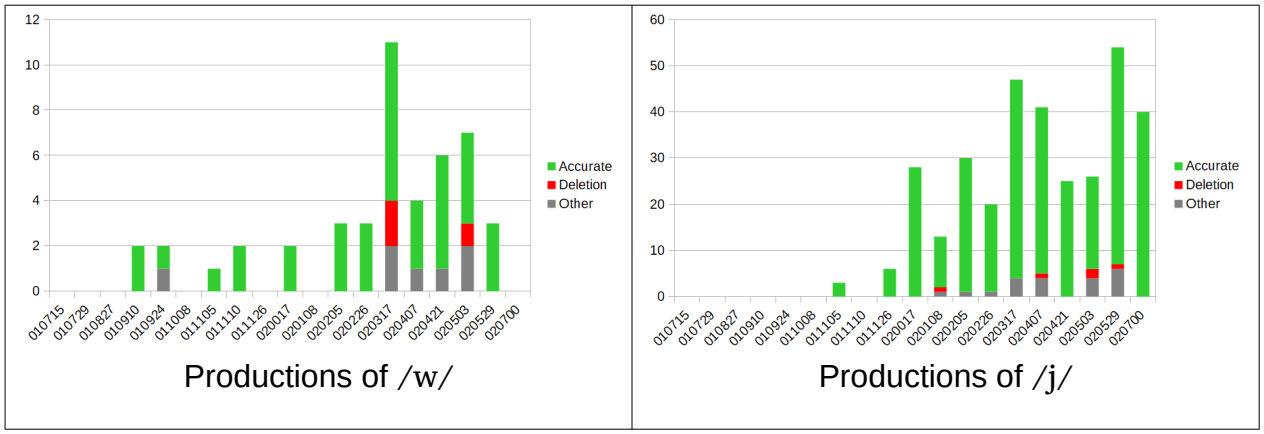

Figure 20: Naoki's productions of /w/ and /j/ in word-initial onset position in Japanese

The deletions and substitutions observed in his productions of /w/ all occurred in the particle *wa,* which we take as a lexical exception. The few substitutions and deletions recorded in his productions of /j/ took place in unsystematic ways, with Naoki sometimes showing difficulty producing the specific word *yatte* ('doing'), as /jatte/→[tte], or [ʒatte]. Aside from these few inaccurate productions, Naoki was very proficient at producing both of the target glides. We can thus claim that he had acquired glides in word-initial position in Japanese by 01;09.10.

Naoki's glides in English were also mostly accurate, with productions away from the targets observed only in specific words.

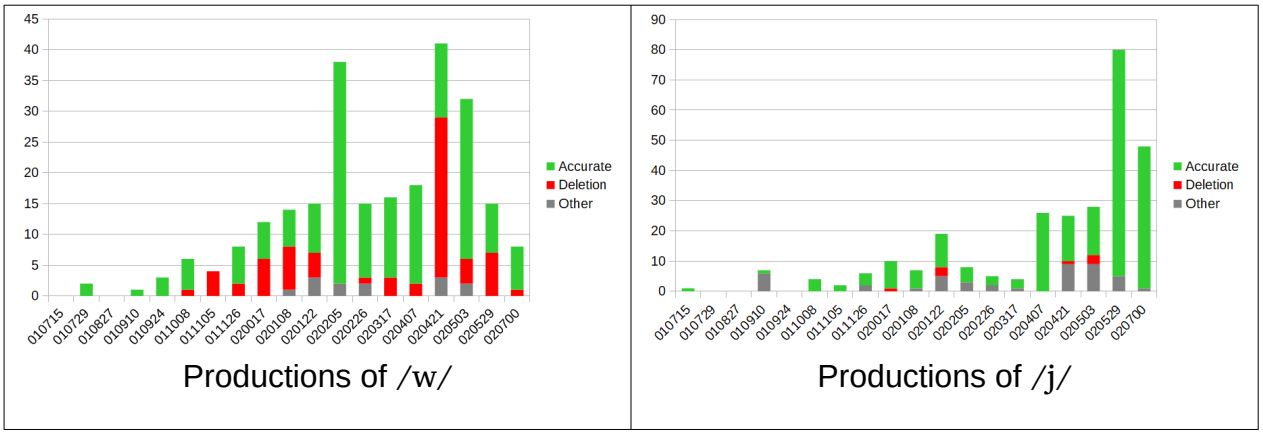

Figure 21: Naoki's productions of /w/ and /j/ in word-initial onset position in English

In Naoki's productions of /w/ in English, almost all of the deletions were attested in the words *whoops* and *whoopsie.* For example, at 02;04.21, all of the deletions were found in these two words. However, due to the similarity of these two words to onomatopoeia, and given the arbitrary nature of their phonological forms, it is also possible that the target form for Naoki did not have /w/ in word-initial position ([ˈʊps], [ˈʊpsiː]). Except for this and other minor inaccurate productions, Naoki was indeed very good at producing glides in English throughout the recorded period. We can thus claim that Naoki had acquired glides in word-initial position in English by 01;10.08 or before. In the next section, we summarize Naoki's development of all the consonants in the word-initial onset position.

3.7 Summary of singleton onsets in word-initial position

In summary, despite Naoki's difficulty with producing some fricatives, affricates, and liquids, he showed stable and consistent productions for the remainder of the target consonants, which he acquired during the recorded period. The tables below present Naoki's predominant production pattern by age in each language. The background shadow indicates the age Naoki had acquired each consonant. When two production

patterns occurred with relatively equal frequency at the same age, they are both indicated, and separated by a slash (/).

Legend	
D	Deletion
O	Minor substitution pattern(s) shown as *other* in graphs
VAR	Variable productions
✓	Accurate
-	No production

		010715	010729	010827	010910	010924	011008	011105	011110	011126	020017	020108	020205	020226	020317	020407	020421	020503	020529	020700
Obstruent plosive	/p/	-	-	-	-	✓	-	-	✓	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓
	/b/	-	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	/t/	-	-	-	O	✓	✓	✓	✓	✓	O	✓	✓	✓	✓	✓	✓	✓	✓	✓
	/d/	-	-	-	-	✓	-	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	/k/	✓	-	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	/g/	-	-	-	-	-	✓	O	-	-	✓	-	✓/ [d]	✓	O	[d]	✓	✓	✓/ [d]	✓
Fricative	[ɸ]	-	-	-	-	-	[f]	✓	-	-	-	✓	O	-	-	-	✓	-	-	-
	/s/	-	-	✓	✓	-	✓	-	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	/z/	-	-	-	[d]	✓	-	-	-	✓	✓	-	-	-	-	✓/ [d]	✓	[d]	✓	✓
	/ʃ/	-	-	-	-	-	-	-	-	-	-	D	✓	✓	✓	✓	✓	O	✓	✓
	/ʒ/	-	-	-	-	-	✓/ [d]	-	✓	-	-	-	-	✓	-	-	-	✓	✓	✓
	/ç/	-	-	-	O	-	-	✓	-	[ʃ]	[s]	✓	-	✓/O	-	D/O	-	-	✓/ [s]	-
	/h/	-	-	✓	-	-	-	✓	D	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Affricate	[ʦ]	-	-	-	-	-	-	-	✓/O	-	O	-	-	-	[t]	[s]/ O	O	[t]/ [s]	-	✓/ [s]
	/ʧ/	-	-	-	-	✓	-	-	-	-	✓	✓	✓	O	✓	✓	✓	✓	O	✓
Nasal	/m/	-	-	-	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	/n/	-	-	✓	✓	O	✓	✓	✓	✓/ [d]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	[ɲ]	-	-	-	-	O	-	-	-	-	-	-	-	✓	O	O	✓	✓	✓	✓
Liquid	/ɾ/	-	-	-	[ɪ]	-	✓	-	[d]/ S	-	✓	✓/ [d]	✓	[d]	✓	O	✓	✓	✓	-
Glide	/w/	-	-	-	✓	✓/O	-	✓	✓	-	✓	-	✓	✓	✓	✓	✓	✓	✓	-
	/j/	-	-	-	-	-	-	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 5: Timeline of Naoki's development of singletons in word-initial onset position in Japanese

As can be seen above, Naoki acquired most of the consonants in Japanese at an early point, between 01;08.27 and 01;10.08. He first acquired /s/ and /h/ at 01;08.27, followed by glides at 01;09.10, obstruent plosives and the affricate /tʃ/ at 01;09.24, and nasal /m/ and /n/ as well as fricative /ʒ/ at 01;10.08. These consonants generally showed accurate productions throughout the recorded period.

Moving forward, he acquired [ɸ] at 01;11.05, /ɾ/ at 02;00.17, /ʃ/ at 02;02.05, and /ɲ/ at 02;04.21. All of these consonants except /ʃ/ are attested only in Japanese. These consonants did not display major issues, but his initial attempts at them, or the time periods when he showed increasing numbers of attempts at them, were generally later than for all the consonants he acquired earlier. The remainder of the consonants, /z/, /ç/, and [ʦ], showed inconsistency with frequent substitutions, and Naoki did not acquire them during the recorded period.

Compared to the Japanese consonants, Naoki appears to have acquired his consonants in English during a tighter time frame, as he acquired most of his consonants in this language between 01;08.27 and 01;10.08.

		010715	010729	010827	010910	010924	011008	011105	011126	020017	020108	020122	020205	020226	020317	020407	020421	020503	020529	020700
Obstruent plosive	/p/	-	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	/b/	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	/t/	-	-	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	/d/	-	-	✓	-	-	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	/k/	-	-	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	✓	✓	✓	✓
	/g/	-	-	-	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Fricative	/f/	-	-	-	-	✓	✓	✓	O	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	/v/	-	-	-	-	[k]	-	-	-	-	✓	-	-	-	-	-	-	-	-	-
	/θ/	-	-	-	-	-	-	-	-	-	[p]	-	-	-	-	-	-	-	-	✓
	/ð/	[d]	[d]	[d]	[d]	[d]	[d]	[d]	[d]	[d]	[d]	[d]	[d]	[d]	[d]	[d]	[d]	[d]	[d]	[d]
	/s/	-	-	-	O	-	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	/z/	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-
	/ʃ/	-	-	-	-	-	✓	-	-	✓	-	✓	✓	✓	✓	-	-	✓	✓	-
	/h/	✓	-	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Affricate	/ʧ/	-	-	✓	✓	-	-	✓	-	[t]	✓	✓	✓	✓	✓	✓	-	-	-	-
	/ʤ/	-	-	-	[z]	-	-	✓	-	-	-	-	-	-	-	-	D	-	-	✓
Nasal	/m/	-	-	-	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	/n/	-	-	-	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Liquid	/l/	-	-	-	✓	-	-	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	/ɹ/	✓	-	-	-	-	✓	-	✓	✓	✓	✓	✓	✓	✓	-	✓	✓	O	-
Glide	/w/	-	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	/j/	✓	-	-	O	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 6: Timeline of Naoki's development of singletons in word-initial onset position in English

In the English sessions, Naoki acquired obstruent plosives and /ʧ/ at 01;08.27, /f/ at 01;09.24, and the fricatives /s/, /ʃ/, and /h/ as well as nasals, liquids, and glides at 01;10.08. He generally showed more consistency and stability in his productions in the English sessions than in the Japanese ones. While Naoki acquired most of the counterparts of these consonants in the Japanese sessions within the same age range, between 01;08.27 and 01;10.08, the difference we can see here is that while Naoki had acquired liquid /ɾ/ in Japanese later than this period, at 02;00.17, he had acquired liquids in English during the earlier period. This observation falls in line with previous

research on the development of rhotics, where taps (and trills) indeed seem to be acquired late cross-linguistically (Bernhardt & Stemberger 2018; Rose & Penney 2021).

The remainder of the consonants, most of which are only attested in English, showed inaccurate or insufficient numbers of attempts. Naoki constantly substituted /ð/ to [d] throughout the recorded period, and did not make many attempts at the fricatives /v/, /θ/, and /z/, or at the affricate /ʤ/.

This concludes our description of Naoki's development of singleton onsets in word-initial position in Japanese and English. In the next section, we turn to Naoki's development of singleton codas in word-final position.

4. Singleton codas in word-final position

Unlike the overall adult-like productions of singleton onsets described above, Naoki showed difficulties with producing singleton codas in word-final position in both languages. Two main patterns are observed: deletion and voicing errors. We observed frequent deletions affecting almost all of the consonants, and Naoki devoiced virtually all the target voiced obstruents in this position.

In the next sections, we look at these patterns in more detail, starting with obstruent plosives. Recall from section 2.1.2 of Chapter 3 that, in Japanese, only /ɴ/ can appear in word-final coda position. Thus, obstruent plosives, fricatives, affricates as well as liquids will only be relevant to the development of Naoki's English. Anticipating on these descriptions, we later attribute Naoki's general difficulties in word-final codas to this phonotactic difference between the two languages.

4.1 Obstruent plosives

For obstruent plosives, Naoki was still in his developmental stage for most of the target consonants. All of the consonants, except /k/, showed frequent deletions, and voiced consonants showed frequent devoicing throughout the recorded period.

4.1.1 /p/, /b/, /t/, /d/, and /g/

Naoki's attempts at /p/, /b/, /t/, /d/, and /g/ in word-final position displayed very frequent deletions, as well as devoicing of voiced targets.

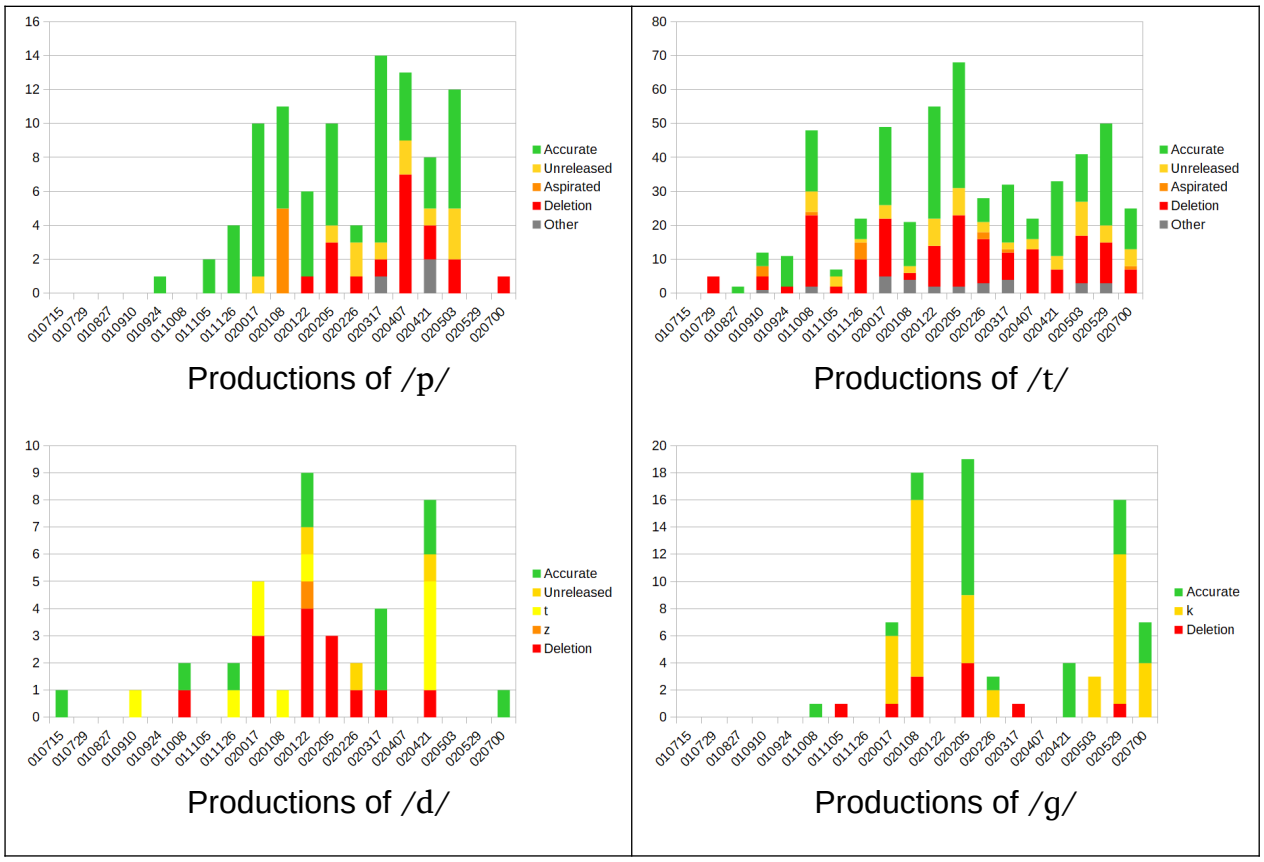

Figure 22: Naoki's productions of /p/, /t/, /d/, and /g/ in word-final coda position in English

Deletions typically occurred when the target consonants were in sentence-final position, or in sentence-medial position followed by other consonants. Devoicing affected all of

the target voiced consonants (/b/, /d/, and /g/). For /b/, Naoki only made attempts eight times during the observation period, uniquely with the word *crab,* starting at 02;00.17*,* out of which two showed devoicing (e.g. /ˈkɹæb/→[ˈkɹʊp]). In his attempts at /d/, devoicing only occurred in the specific words *good* (e.g. /gəd/→[gʊt]) and *side* (e.g. /ˈsaɪd/→[ˈsaɪt]). Devoicing of /g/ occurred in unsystematic ways. While devoicing was present, there were no voiced productions in Naoki's attempts at /p/ and /t/. Also, the majority of these two consonants were unaspirated, which is considered accurate in this position, alongside occasional aspirated or unreleased consonants. In sum, with frequent deletions or devoicing, Naoki was still in his developmental stage of the target consonants.

4.1.2 /k/

In contrast to the other obstruent plosives above, Naoki's productions of /k/ were very accurate and stable throughout the recorded period.

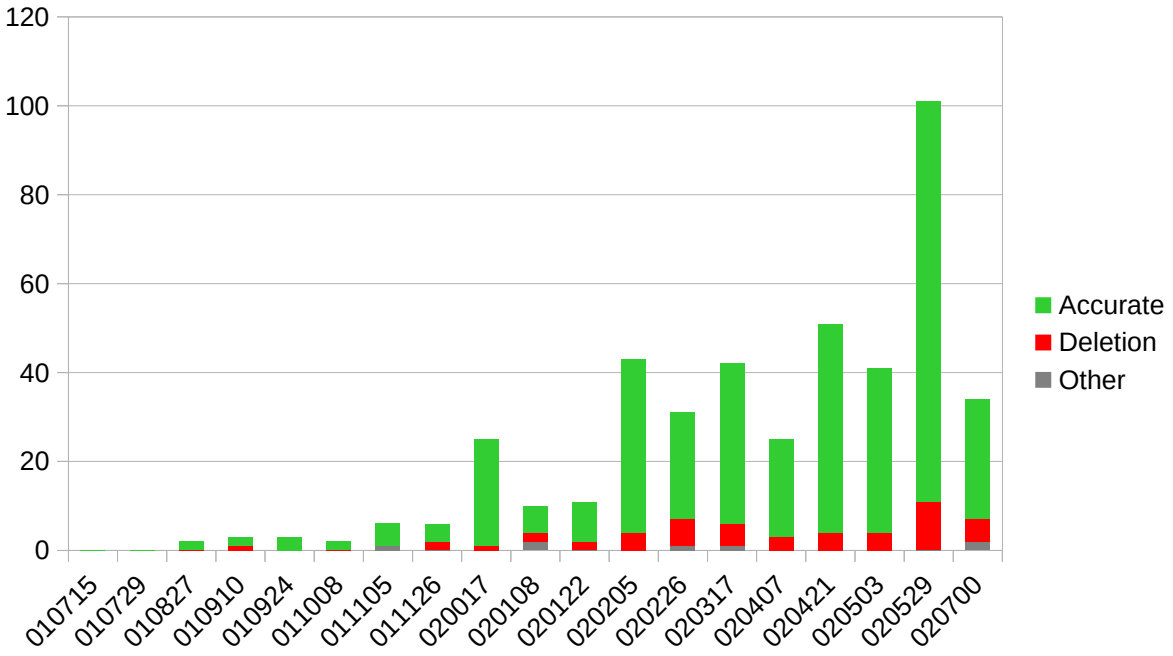

Figure 23: Naoki's productions of /k/ in word-final coda position in English

There were occasional deletions, around half of which occurred in the word *look* (e.g. /ˈlʊk/→[ˈlʊ]). However, Naoki showed more accuracy than deletion in this word. Considering the overall number of accurate productions, we can conclude that Naoki had acquired /k/ in the word-final coda position by 01;08.27.

4.1.3 Summary of obstruent plosives in word-final coda position

In sum, we saw two notable production patterns in Naoki's development of obstruent plosives. The first is frequent deletions, which were especially observed with /p/, /t/, and /d/. As we will see in subsequent sections, frequent deletion is a recurring pattern observed in Naoki's development of consonants in word-final coda position. We further discuss those deletion patterns in section 4.6. Secondly, devoicing was observed for all of the voiced consonants (/b/, /d/, /g/). This suggests that the child had at least acquired the place and the manner of articulation of these consonants. In contrast to

this, Naoki showed early proficiency at /k/, which he maintained throughout the recorded period. In the next section, we look at Naoki's productions of fricatives in word-final coda position.

4.2 Fricatives

Naoki generally showed different production patterns between voiced and voiceless fricatives. While his productions of voiceless consonants, except for /θ/, were adult-like throughout the recorded period, his productions of voiced consonants showed devoicing, similar to his productions of voiced plosives described earlier, as well as some deletions.

4.2.1 /f/, /s/, /ʃ/, and /θ/

Naoki's attempts at /f/, /s/, and /ʃ/ in word-final coda position were almost always adult-like, virtually across all ages where data are available, while there was only limited data for /θ/.

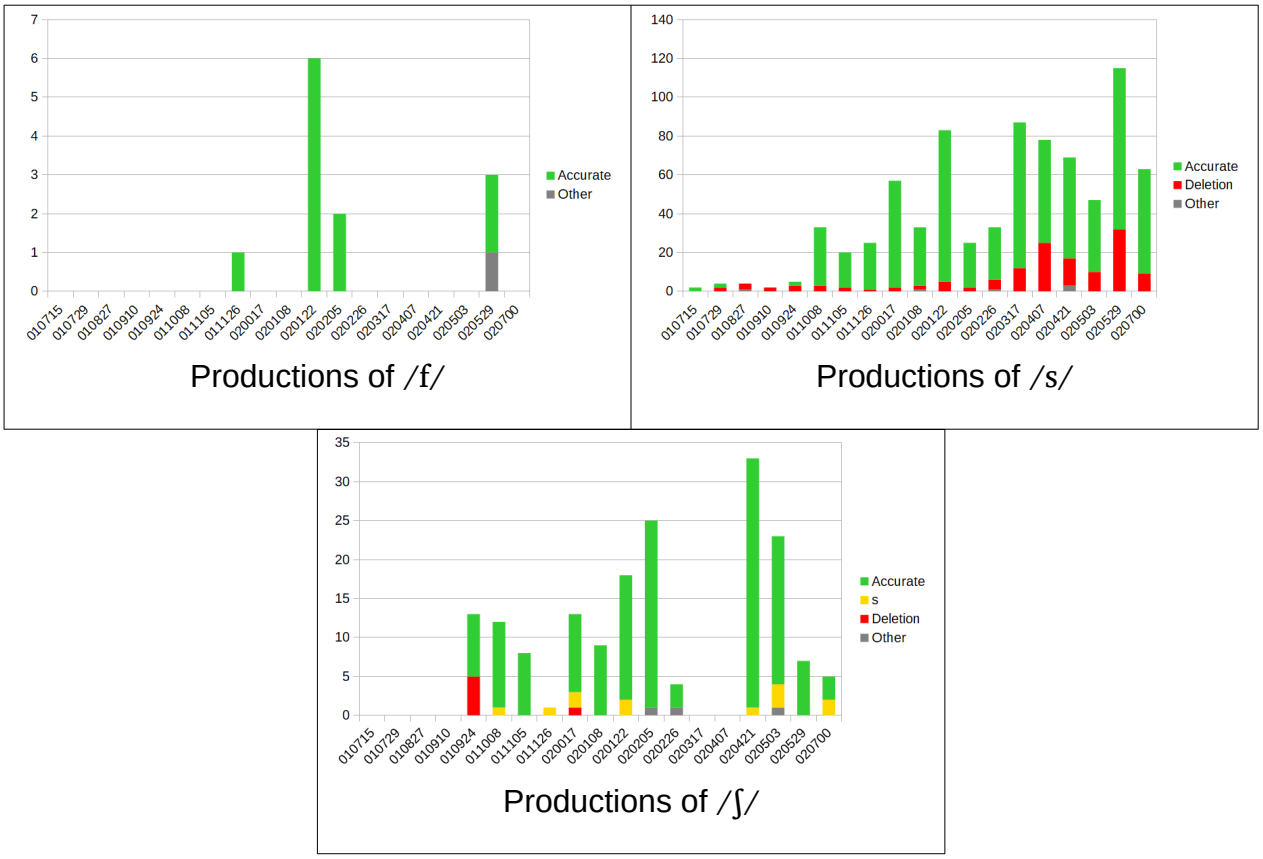

Figure 24: Naoki's productions of /f/, /s/, and /ʃ/ in word-final coda position in English

Concerning his productions of /s/, most of Naoki's attempts came from the word *this*, for which he also showed sporadic deletions. With regard to his productions of /ʃ/, Naoki substituted the target consonant with [s] 12 times, with seven of these substitutions occurring in the word *push* /ˈpʊʃ/→[ˈpʊs]. However, Naoki still showed 61 accurate productions, out of 73 total attempts at this word. The deletions observed at 01;09.24 also mostly occurred in this same word. Finally, Naoki only attempted /θ/ twice during the recorded period, both at 02;00.17. He made attempts at this consonant in the word *with* both times, each of which resulted in deletion of the target consonant: /ˈwɪθ/→[ˈwʌ]. In sum, aside from /θ/, Naoki was overall good at producing /f/, /s/, and /ʃ/. We can thus conclude that he had acquired these three fricatives by 01;10.08.

4.2.2 /v/ and /z/

Similar to the voiced obstruent plosives in word-final position mentioned earlier, Naoki's productions of /v/ and /z/ showed devoicing as well as some deletions.

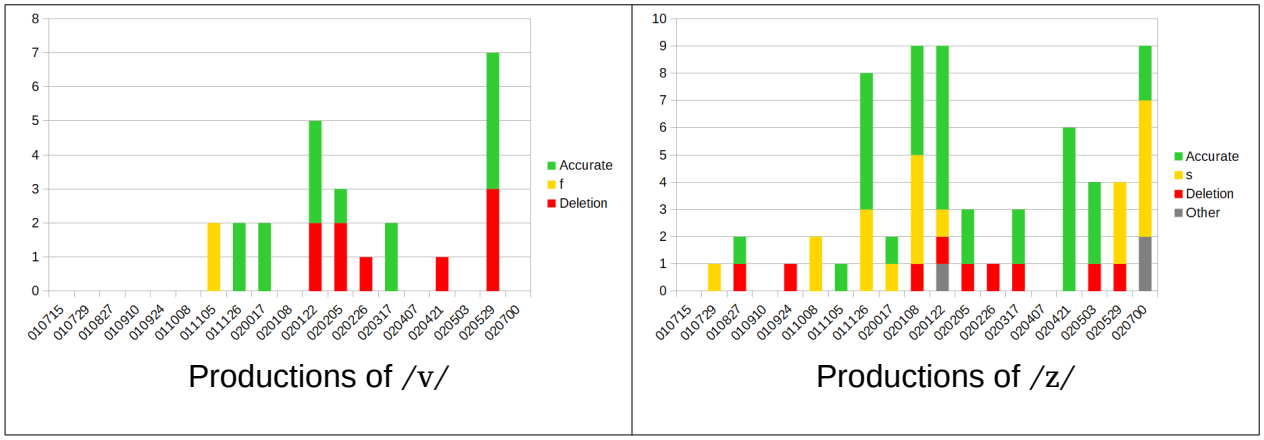

Figure 25: Naoki's productions of /v/ and /z/ in word-final coda position in English

Naoki devoiced /v/ in the word *five* twice (e.g. /ˈfaɪv/→[ˈfaɪf]), while devoicing of /z/ occurred sporadically across a number of different words (e.g. /ˈnoʊz/→[ˈnʊs]). As for the nine deletions of /v/, they predominantly occurred in the specific words *five* (three times) and *of* (five times). However, accurate productions also occurred in these two words, twice in the word *five* and four times in *of*. With regard to deletions of /z/, they occurred four times in the word *is* out of nine total deletions, although Naoki showed more accurate productions than deletions in this word. The other five deletions occurred in four different words. With these results, we conclude that Naoki was still in his developmental stage of /v/ and /z/ in word-final codas by the end of the observation period.

4.2.3 Summary of fricatives in word-final coda position

In summary, while Naoki was proficient at the voiceless consonants /f/, /s/, and /ʃ/ throughout the recorded period, he devoiced /v/ and /z/, and also showed some deletions. In the next section, we look at Naoki's productions of affricates.

4.3 Affricates: /tʃ/ and /ʤ/

Concerning affricates, Naoki only made very few attempts at each of /tʃ/ and /ʤ/ in word-final coda position. Regarding /tʃ/, Naoki only made six attempts during the recorded period, starting at 01;10.08. Out of these, four were accurate, and the other two were substituted with [s] and [ʃ], respectively. Because of data scarcity, it is unclear whether or not he had acquired /tʃ/ during the observation period. As for /ʤ/, Naoki only attempted it seven times. From his first attempt at 01;11.26, he only uttered the word *page,* where he devoiced the target consonant in all of his attempts (*page* /ˈpeɪʤ/→[ˈpitʃ]), which is consistent with the results we obtained from voiced plosives and fricatives described above. In the next section, we look at Naoki's development of nasals in word-final coda position.

4.4 Nasals

In word-final coda position, Naoki had difficulty producing nasals in general. Overall, his productions in English showed more consistency than those in Japanese, although he only acquired /m/ in English during the recorded period.

4.4.1 Consonants attested in both languages

4.4.1.1 /m/

Starting with Naoki's attempts at [m] in Japanese, an allophone of /N/, and /m/ in English, we observe some deletions in both languages.

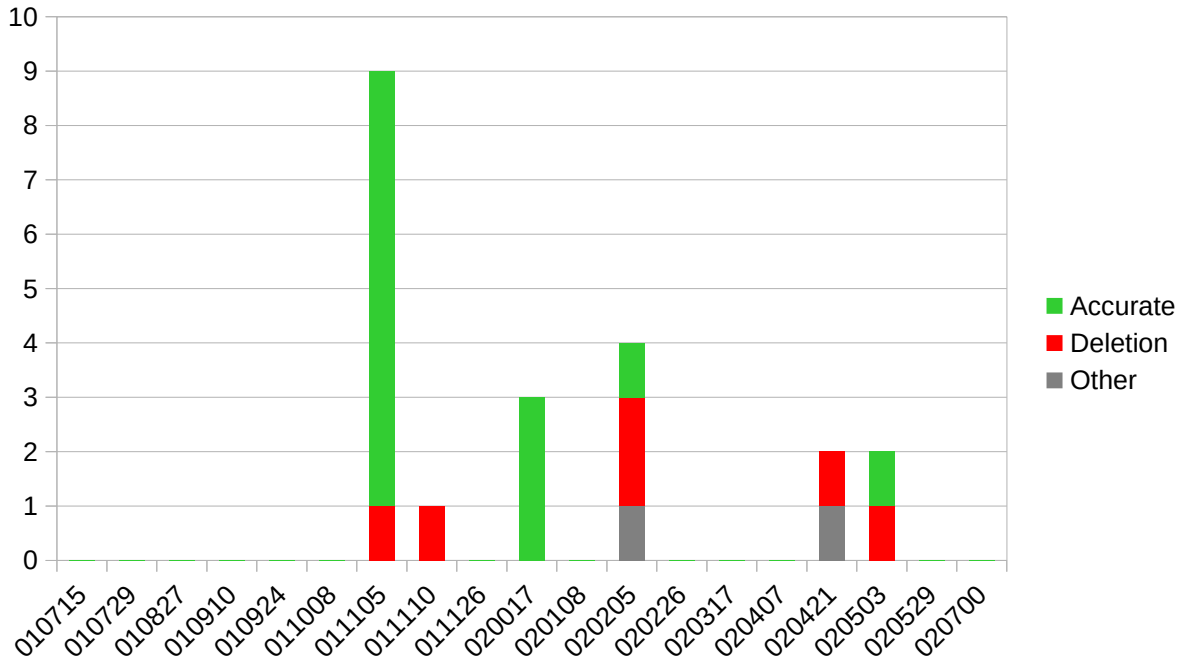

Figure 26: Naoki's productions of [m] in word-final coda position in Japanese

In the Japanese sessions, deletions were observed six times, out of 21 total attempts, and their occurrences were not systematic. The other substitutions were with [ŋ] and [ã], and occurred only once each.

Naoki's attempts at /m/ in word-final coda position in English showed more accuracy compared to those in Japanese, however with noticeable deletions as well.

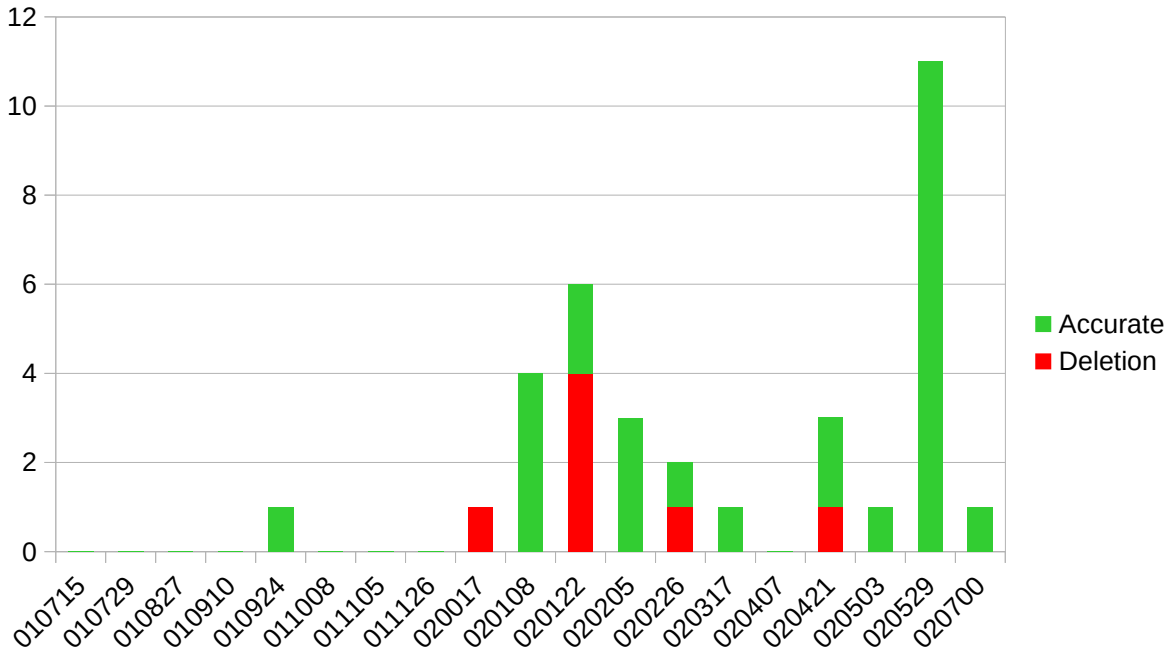

Figure 27: Naoki's productions of /m/ in word-final coda position in English

Out of seven deletions, four occurred in *I'm* (e.g. /ˈaɪm/→[ˈeɪ]). The other three deletions each occurred in different words, and were random in appearance. All of the other productions were accurate. We can tentatively conclude that Naoki had acquired the target consonant by 01;09.24.

4.4.1.2 /n/ and /ŋ/

Concerning /n/ and /ŋ/, we observe an intriguing asymmetry between the two languages. In Naoki's productions of [n] and [ŋ] in word-final coda position in Japanese, both of which are allophones of /N/, there were frequent deletions.[3] In contrast to this, his productions of /n/ and /ŋ/ in English frequently involved substitutions to [N].

3 While it is possible that nasalization of a preceding vowel may have occurred (see section 2.1.2 of Chapter 3), rather than an observable nasal closure, this detail should not detract us away from the observation that Naoki had more difficulties producing these final consonants. The same applies to our discussion of [N] in section 4.4.2.

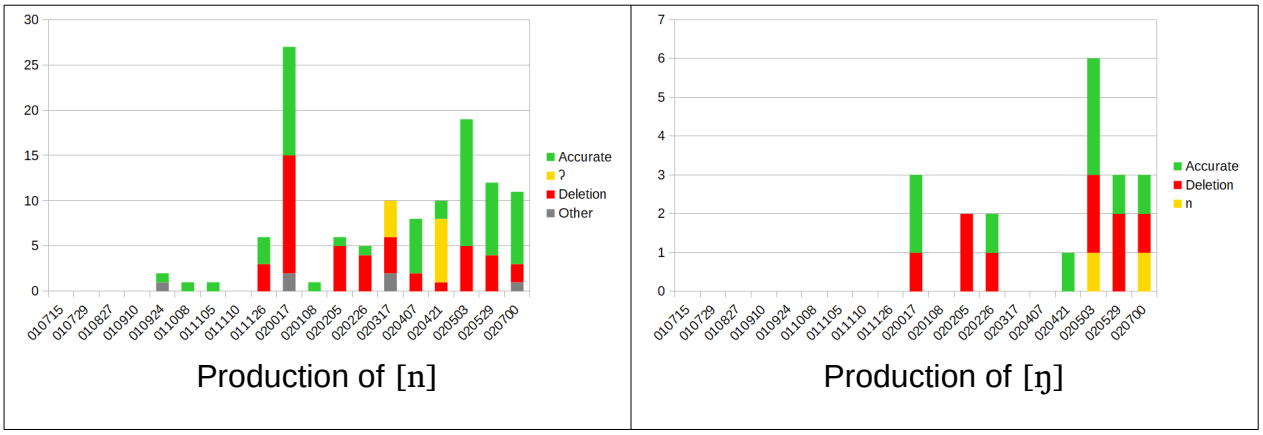

Figure 28: Naoki's productions of [n] and [ŋ] in word-final coda position in Japanese

In the Japanese sessions, deletions were observed in most of the sessions and were in appearance random, from around 01;11.26 until the end of the recorded period. The occasional substitutions to [ʔ] in Naoki's attempts at [n] occurred when the target consonant was followed by *da* (either a copula or the ending of adjectives): /hen da/→[heʔ da]. Overall, while Naoki was still in his developmental stage of [ŋ], he had acquired [n] by 02;04.07.

With regard to Naoki's productions in English, the substitutions to [ɴ] took place in variable and unsystematic ways; accurate productions and substitutions were indeed observed across similar phonological environments. Further, deletions were observed in every session for both of the target consonants, which mostly occurred when these consonants were in sentence final position or they were followed by other consonants. We return to this observation below in section 4.6.

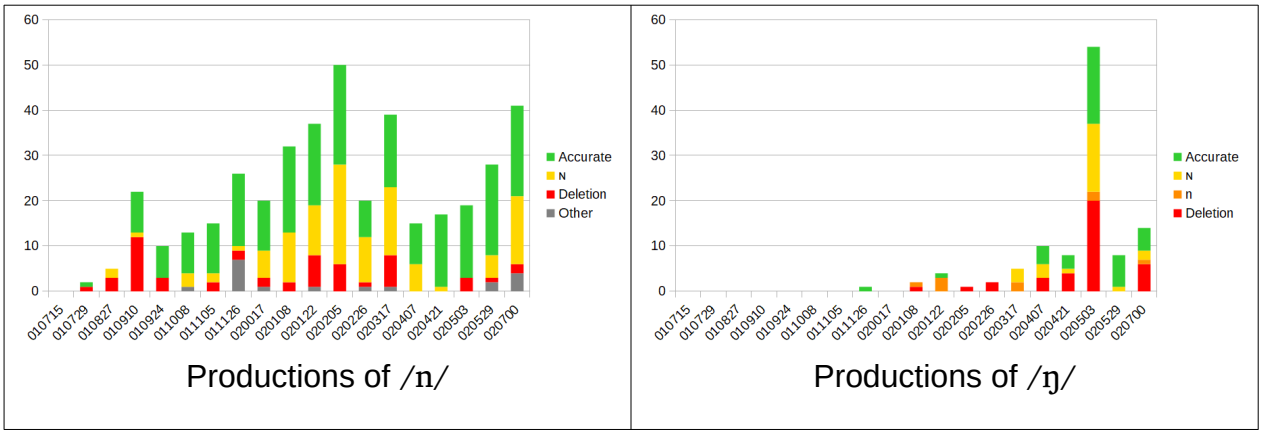

Figure 29: Naoki's productions of /n/ and /ŋ/ in word-final coda position in English

To summarize, in spite of the large amount of substitutions to [N] and deletions, we can claim that Naoki had acquired /n/ in the word-final coda position in English by 02;04.21, while he was still in the developmental stage of /ŋ/ in the same position.

4.4.2 Nasal attested only in Japanese: [N]

Turning now to Naoki's [N], we observe that around half of his attempts at this consonant resulted in accurate productions.

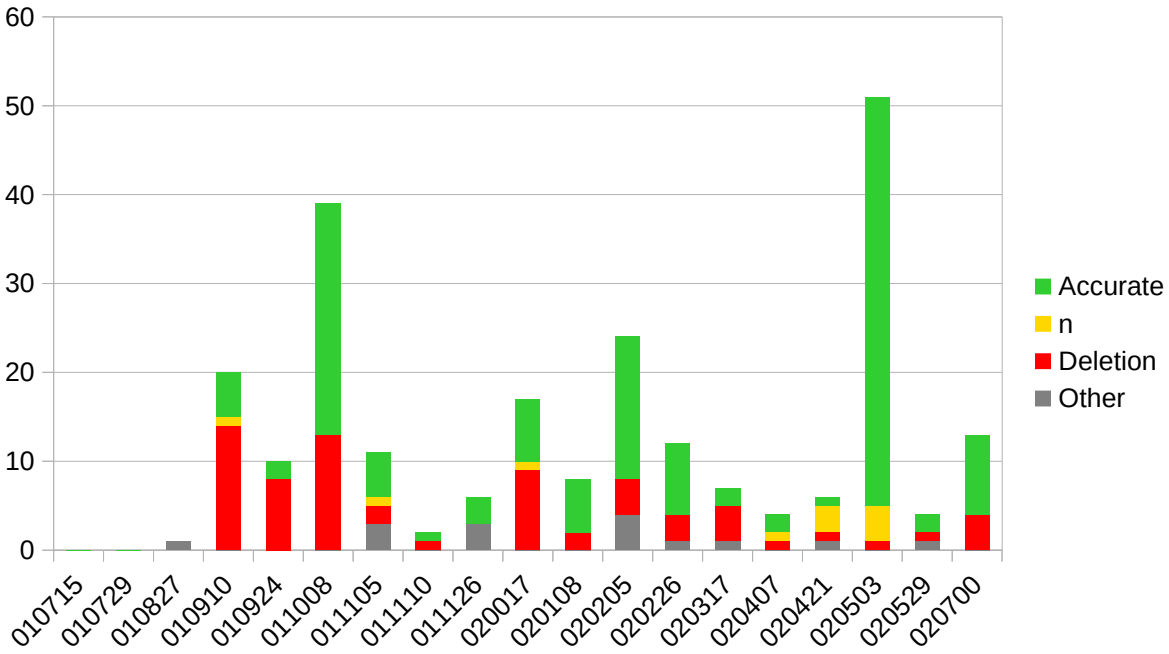

Figure 30: Naoki's productions of [ɴ] in word-final coda position in Japanese

There were also frequent deletions, which were often seen when the target consonant was in sentence-final position or sentence-medial position when followed by other consonants, as we discuss further in section 4.6 below. Naoki also substituted the target consonant with [n] occasionally, which was mostly observed in sentence-final position in various words. Despite these deletions and substitutions, Naoki improved his productions from 02;05.03. We can thus conclude that he had acquired Japanese [ɴ] by this age.

4.4.3 Summary of nasals in the word-final coda position

In summary, the productions of most of the nasals in both languages displayed frequent deletions or substitutions. For the labial nasal /m/, while Naoki acquired it in English, he was still in the developmental stage in Japanese. For the remainder of the nasals (/n/, /ŋ/), Naoki was able to pronounce the targets accurately in both languages from an

early point, although he also showed a variety of inaccurate productions, in particular frequent deletions in Japanese, and substitutions to [N] in English. Yet, Naoki arguably acquired /n/ in both languages and [N] in Japanese, during the course of the observation period. In the next section, we look at Naoki's productions of liquids in word-final coda position.

4.5 Liquids

Naoki's attempts at liquid consonants displayed a sizeable amount of deletions throughout the recorded period. While there were consistently more accurate productions in his development of /ɹ/, the amount of deletions differed session by session concerning his development of /l/.

4.5.1 /l/

We begin with Naoki's productions of /l/ in word-final coda position.

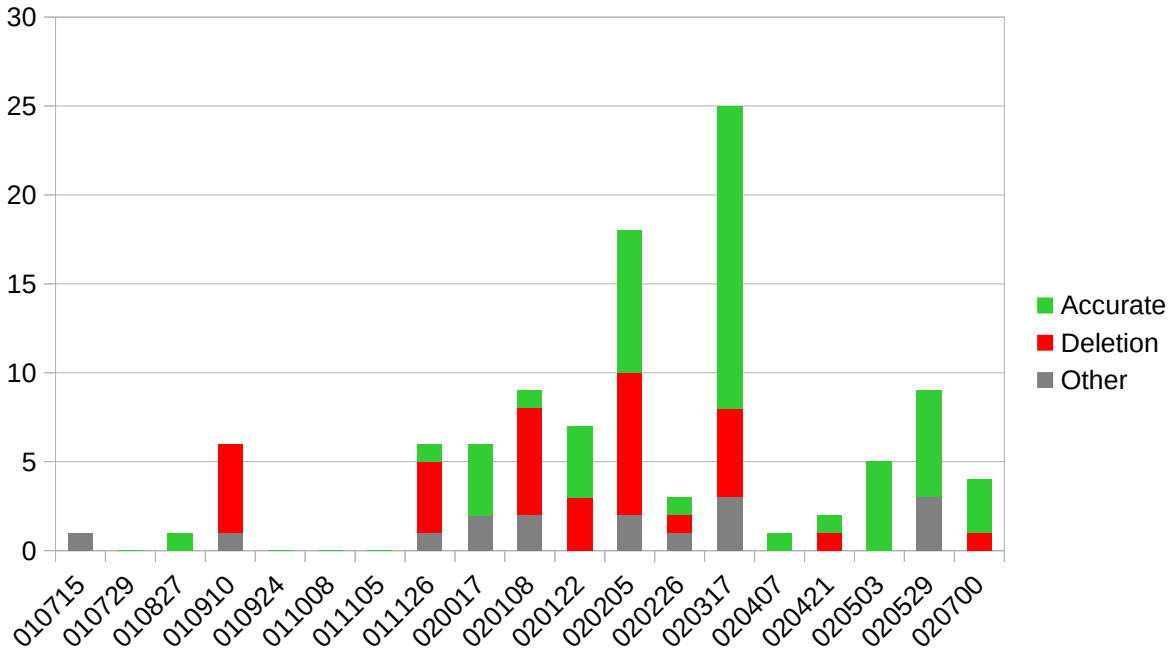

Figure 31: Naoki's productions of /l/ in word-final coda position in English

Naoki deleted the target consonant predominantly between 01;09.10 and 02;03.17. During this period, he mostly produced the words *ball*, *fall*, and *all*, both accurately and with deletions occurring occasionally. The substitutions predominantly took the form of liquid vocalization; out of 16 substitutions in total, eight were with [ʊ], and four were with [ɪ]. These vocalizations occurred mostly in the two words *ball* (/ˈbɑl/→[ˈboʊ]) and *fall* (e.g. /ˈfɑl/→[ˈfoʊ], [foɪ]), six and four times, respectively. Overall, the ratio of accurate productions increased from 02;03.17 onward. We can thus conclude that Naoki had acquired the target consonant by this age.

4.5.2 /ɹ/

Naoki was overall very proficient at producing /ɹ/ in word-final coda position, throughout the recorded period.

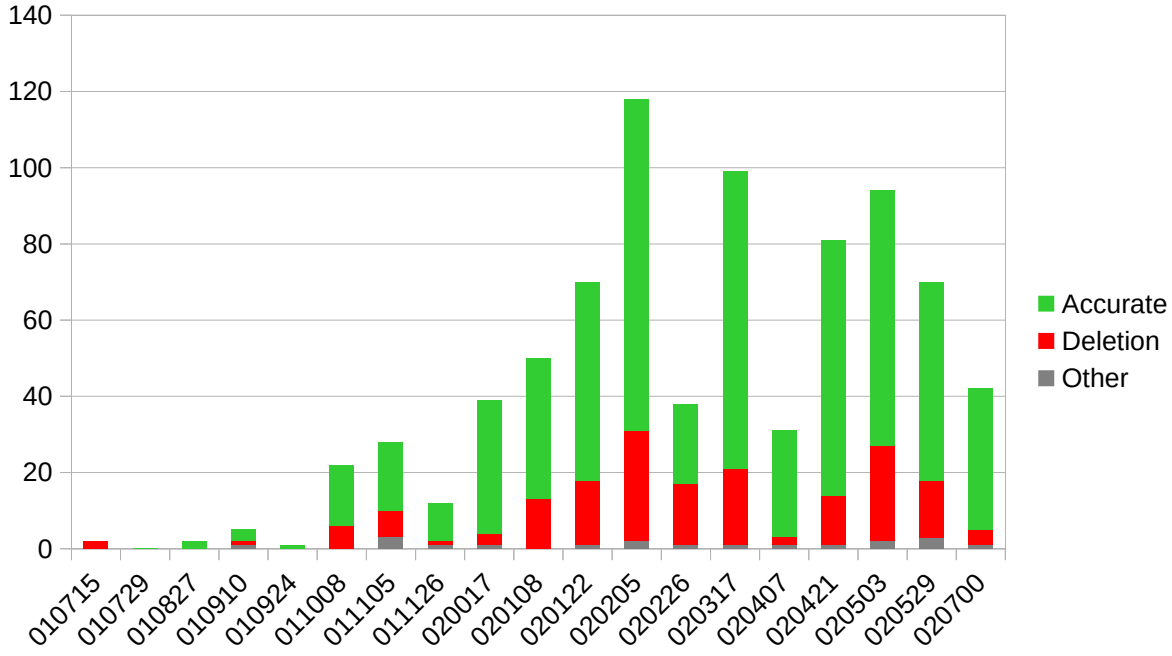

Figure 32: Naoki's productions of /ɹ/ in word-final coda position in English

In almost all the sessions, there were sporadic deletions, none of which can be predicted from the larger phonological context. Despite these deletions, his productions were most of the time adult-like. We can claim that Naoki had acquired /ɹ/ in this position by 01;08.27.

4.5.3 Summary of liquids in word-final coda position

In sum, while the target lateral and rhotic consonants in word-final codas frequently underwent deletion, Naoki acquired both of them during the recorded period. He was especially proficient at producing /ɹ/, for which he showed accurate productions more than deletions, in contrast to /l/, especially during the first few sessions. In the next section, we look at Naoki's intriguing performance observed in some consonants in word-final coda position.

4.6 Segmental behaviours by context

In the development of English consonants in word-final coda position described above, we observed an overall weak and variable performance over time. In this section, we look at the behaviours of three consonants in particular, /p/, /t/, and /n/, by comparing attempts at these consonants across three different phonological contexts: sentence-final (Final), sentence-medial followed by a consonant in the onset of the following word (Medial+C), and sentence-medial followed by a vowel-initial word (Medial+V), as shown in the table below:

Context	Example
Final	Look at tha**t̲**. /ˈlʊk ˈæt ˈðæ**t̲**/
Medial+C	‘How abou**t̲ th**ere?’ /ˈhaʊ əˈbaʊ**t̲** ˈðɛɹ/
Medial+V	Wanna pu**t̲ i**nside. /ˈwɑnə ˈpʊ**t̲** ˌɪnˈsaɪd/

Table 7: Examples of phonological contexts for /t/ in coda position

The data discussed come from four representative sessions for which we have attempts at these consonants in sufficient numbers to engage in the small investigation that follows: 02;02.05, 02;02.26, 02;03.17, and 02;04.07. The graph below shows Naoki’s performance at producing /p/, /t/, and /n/ across the three different contexts. *Produced* refers to ‘aspirated’, ‘unaspirated’ or ‘unreleased’ productions for /p/ and /t/, and to [ɴ] or [n] for /n/.

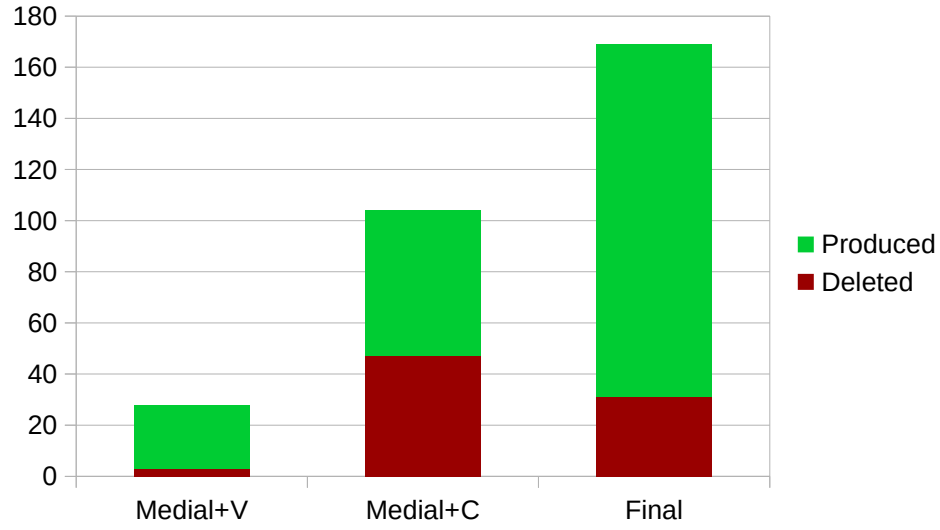

Figure 33: Total amount of productions and deletions in English /p/, /t/, and /n/ by position, observed between 02;02.05 and 02;04.07

As we can see in this chart, overall, Naoki showed more deletions when the target consonants were followed by a consonant within the utterance, or when it was in

sentence-final position, while he had fewer problems when the target consonants were followed by a vowel. Naoki especially had difficulties when these target consonants were followed by another consonant, in particular in the case of /p/ and /t/, where the amounts of deletion even exceeded that of production.

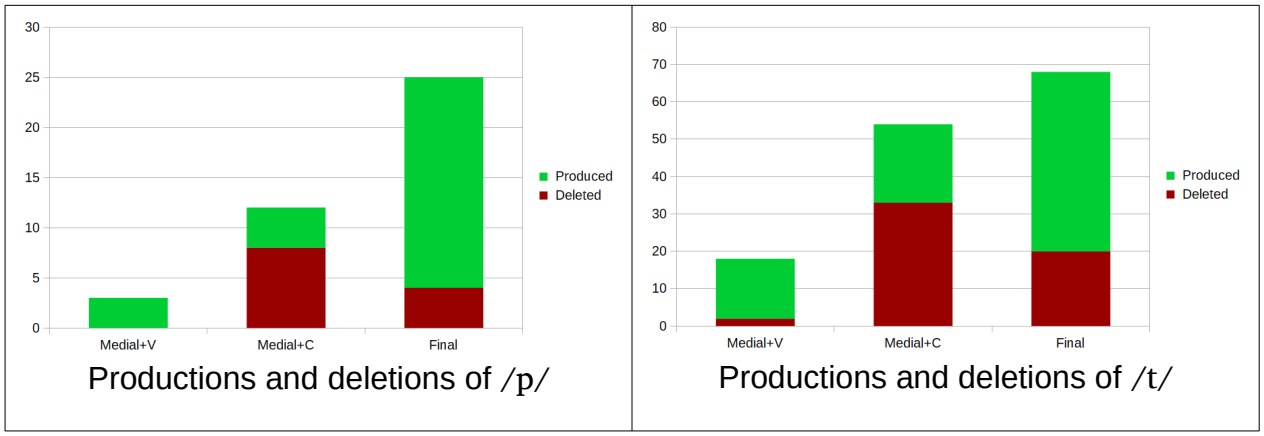

Figure 34: The amount of productions and deletions of English /p/ and /t/ by position, observed between 02;02.05 and 02;04.07

Compared to the deletions in /p/ and /t/, Naoki had markedly fewer difficulties with /n/.

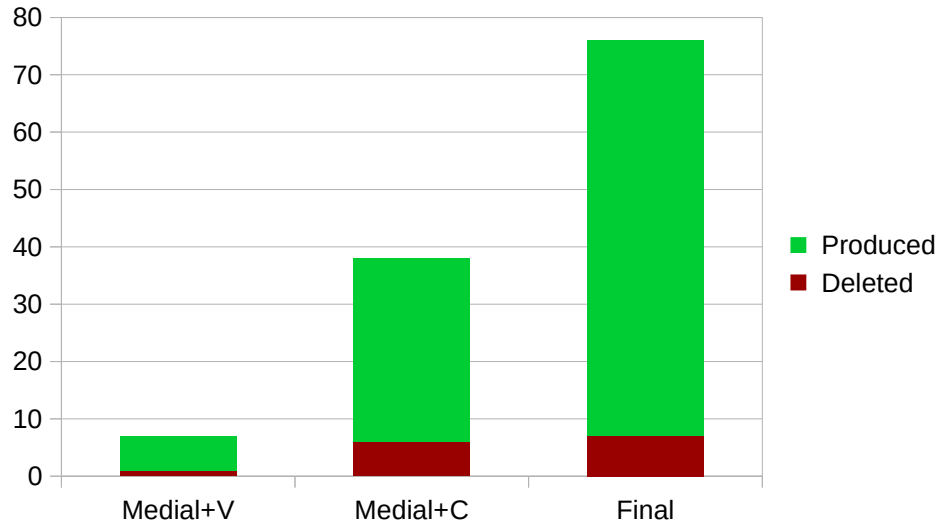

Figure 35: The amount of productions and deletions of English /n/ by position, observed between 02;02.05 and 02;04.07

Similar to his productions of /p/ and /t/, Naoki showed deletions more often when the target nasal was followed by another consonant within the utterance, or when it was in sentence-final position. However, the proportion of /n/ deletions was much smaller compared to the other two consonants.

As we discuss in section 3 of Chapter 5, these results suggest some tensions between the English and Japanese phonological systems; while English allows all target consonants except /h/ to appear in the coda position, this is not true for Japanese (Cruttenden 2014; Labrune 2012). It is thus possible that this positional pattern of deletion we observe in the data just above is reflective of pressures from the child's Japanese phonological constraints on to his English productions.

4.7 Summary of singleton codas in word-final position

In summary, Naoki generally showed difficulty with producing singleton codas in both languages, unlike his productions of consonants in onset position, for which he was overall much more proficient. In coda position, the major issues observed are deletions in both languages, and devoicing in English obstruents.

Looking specifically at productions of nasals in the Japanese sessions first, while Naoki started to show accurate productions at around 01;10.08, these productions were very unstable throughout the recorded period, as summarized in the table below.

		010715	010729	010827	010910	010924	011008	011105	011110	011126	020017	020108	020205	020226	020317	020407	020421	020503	020529	020700
/ɴ/	[m]	-	-	-	-	-	-	✓	D	-	✓	-	D	-	-	-	D	✓/D	-	-
	[n]	-	-	-	-	✓	✓	✓	-	✓/D	✓/D	✓	D	D	D/ [ʔ]	✓	[ʔ]	✓	✓	✓
	[ŋ]	-	-	-	-	-	-	-	-	-	✓	-	D	✓/D	-	-	✓	✓/D	D	VAR
	[ɴ]	-	-	O	D	D	✓	✓	✓/D	✓	D	✓	✓	✓	D	✓	[n]	✓	✓	✓

Table 8: Timeline of Naoki's development of nasals in word-final coda position in Japanese

Given these frequent deletions, Naoki only acquired [n] and [ɴ] on the late side of the recorded period, at around 02;04.07 and 02;05.03, respectively.

Naoki's English productions also showed very similar results with frequent deletions. Out of the 19 different consonants he attempted in word-final singleton codas, he only acquired eight during the recorded period.

		010715	010729	010827	010910	010924	011008	011105	011126	020017	020108	020122	020205	020226	020317	020407	020421	020503	020529	020700
Obstruent plosive	/p/	-	-	-	-	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	D	✓/D	✓	-	D
	/b/	✓	-	-	-	-	-	-	-	✓/ dV	✓	-	D	-	-	-	-	✓/ dV	✓	✓
	/t/	-	D	✓	✓/D	✓	✓/D	✓	✓/D	✓/D	✓	✓	✓	D	✓	D	✓/D	✓/D	✓	✓
	/d/	✓	-	-	dV	-	✓/D	-	✓	D	dV	D	D	✓/D	✓	-	dV	-	-	✓
	/k/	-	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	/g/	-	-	-	-	-	✓	D	-	dV	dV	-	✓	dV	D	-	✓	dV	dV	dV
Fricative	/f/	-	-	-	-	-	-	-	✓	-	-	✓	✓	-	-	-	-	-	✓	-
	/v/	-	-	-	-	-	-	dV	✓	✓	-	✓/D	D	D	✓	-	D	-	✓/D	-
	/θ/	-	-	-	-	-	-	-	-	D	-	-	-	-	-	-	-	-	-	--
	/s/	✓	✓/D	D	O	D	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	/z/	-	dV	✓/D	-	D	dV	✓	✓	✓/ dV	✓/ dV	✓	✓	D	✓	-	✓	✓	dV	dV
	/ʃ/	-	-	-	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-	✓	✓	✓	✓
Affricate	/ʧ/	-	-	-	-	-	[s]	-	✓	-	-	-	[ʃ]	-	✓	-	-	✓	✓	-
	/ʤ/	-	-	-	-	-	-	-	dV	dV	-	dV	-	-	-	-	-	-	-	-
Nasal	/m/	-	-	-	-	✓	-	-	-	D	✓	D	✓	✓/D	✓	-	✓	✓	✓	✓
	/n/	-	✓/D	D/ [ɴ]	D	✓	✓	✓	✓	✓/ [ɴ]	✓/ [ɴ]	✓/ [ɴ]	✓/ [ɴ]	✓/ [ɴ]	✓/ [ɴ]	✓/ [ɴ]	✓	✓	✓	✓/ [ɴ]
	/ŋ/								✓	-	D/ [n]	[n]	D	D	[ɴ]	VAR	✓/D	VAR	✓	✓/D
Liquid	/l/	O	-	✓	D	-	-	-	D	✓	D	✓/D	✓/D	✓/D	✓	✓	✓/D	✓	✓	✓
	/ɹ/	D	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓/D	✓	✓	✓	✓	✓	✓

Table 9: Timeline of Naoki's development of singletons in word-final coda position in English (dV = Devoicing)

As we discussed in 4.6, the cases of deletion occurred much more often when the target consonants were in sentence-final or sentence-medial position when followed by another consonant, which we suggest was caused by differences in phonological constraints between Japanese and English. We return to this hypothesis below in Chapter 5. This concludes our description of singleton codas. In the next section, we look at Naoki's development of consonant sequences in word-initial position in Japanese.

5. Consonant sequences (yoon) in word-initial position in Japanese

Concerning the yoon context, Naoki only attempted /bj/ and /kj/, once and three times, respectively, during the recorded period. With regard to /bj/, we observe vowel epenthesis with [i] at 02;04.21: *byooki* /bjoːki/→[bijoʊgɯ] 'disease'. As for his three attempts at /kj/, Naoki pronounced all of them differently: he produced [ʃ] at 02;02.26 (*kyoo* /kjoː/→[ʃoː] 'today'), produced /kj/ accurately at 02;04.07 in the same word, and vowel epenthesis was observed with [i] at 02;05.29 (*kyuu* /kjɯː/→[kijɯː] 'nine'). Based on these results, we can tentatively conclude that Naoki had not yet acquired this phonological context. In the next section, we look at Naoki's development of complex onsets in word-initial position in English.

6. Complex onsets in word-initial position in English

Naoki's attempts at complex onsets in word-initial position in English were overall very successful, however with some specific consonants showing inconsistent patterning. Naoki's attempts at /bɹ/, /kɹ/, /gɹ/, and /fɹ/ were mostly accurate, but /tɹ/ showed C2 substitution, sometimes occurring at the same time as other inaccurate productions, and /θɹ/ showed frequent C1 substitution to [f]. Naoki's attempts at s+consonant clusters showed C1 deletion, specifically in /sp/, /st/, and /sk/ clusters, yet Naoki acquired the former two during the recorded period. In the next section, we begin our description with obstruent+l clusters.

6.1 Obstruent+l (excluding s-initial) clusters: /pl/, /bl/, /kl/, and /fl/

Naoki attempted /pl/, /bl/, /kl/, and /fl/ clusters 135 times in total, most of which were accurate. He made the majority of his attempts around the middle of the recorded

period, between 01;11.26 and 02;04.07. He occasionally showed C2 deletion in his attempts at /pl/ and /bl/ clusters.

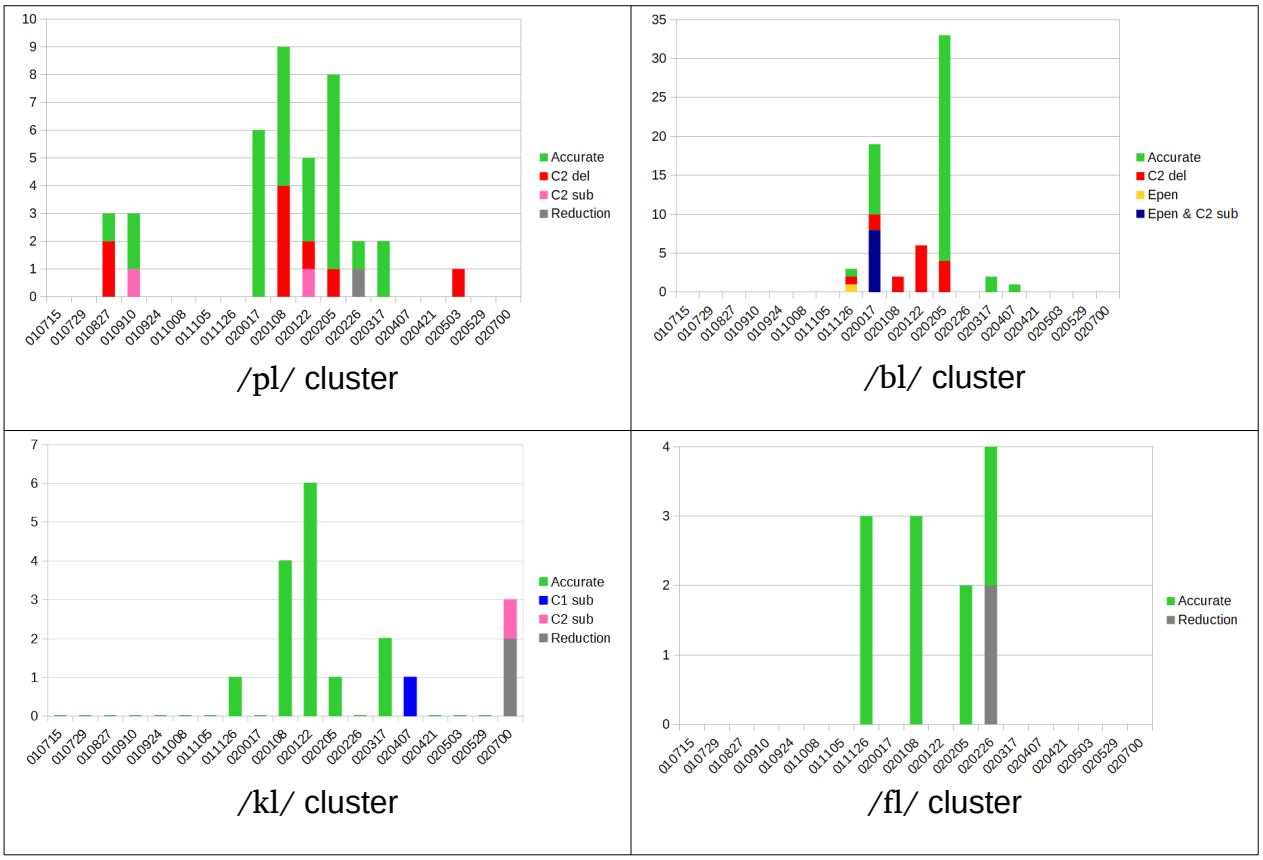

Figure 36: Naoki's productions of /pl/, /bl/, /kl/, and /fl/ clusters in word-initial onset position in English

In his attempts at /pl/ clusters, deletions were seen in the word *plane* /ˈpleɪn/→[ˈpeɪn], which is also a word that he attempted very often throughout the recorded period. Concerning /bl/ clusters, the majority of his attempts occurred in the word *blue*, and all the C2 deletions occurred in this word as well: *blue* /ˈbluː/→[ˈbuː]. Despite these cases of C2 deletion and a few other inaccurate instances, Naoki's productions were mostly adult-like, which also parallels his productions of /l/ in word-initial singleton onset position. Based on the data available, we can claim that he had acquired this

phonological context by 01;11.26. In the next section, we turn to Naoki's attempts at obstruent+ɹ clusters.

6.2 Obstruent +ɹ (excluding *s*-initial) clusters

Naoki's productions of obstruent+ɹ clusters showed more variation than the obstruent+l context described above. First, his development of /bɹ/, /kɹ/, /gɹ/, and /fɹ/ clusters showed similar patterns; his attempts tended to start around the middle of the recorded period, from which his productions were mostly adult-like, and thus we can conclude that he had acquired all of these clusters. Second, his development of the /tɹ/ cluster showed inconsistency. C2 deletions are observed in more than half of the sessions, sometimes with other inaccurate productions occurring at the same time. Finally, his productions of the /θɹ/ cluster were mostly inaccurate, with frequent C1 substitution.

6.2.1 /pɹ/, /bɹ/, /kɹ/, /gɹ/, and /fɹ/

Naoki attempted /pɹ/, /bɹ/, /kɹ/, /gɹ/, and /fɹ/ clusters 191 times in total. His productions of these clusters were mostly accurate. Since Naoki made only four attempts at /pɹ/, the graph for this cluster is not included in the figure below.

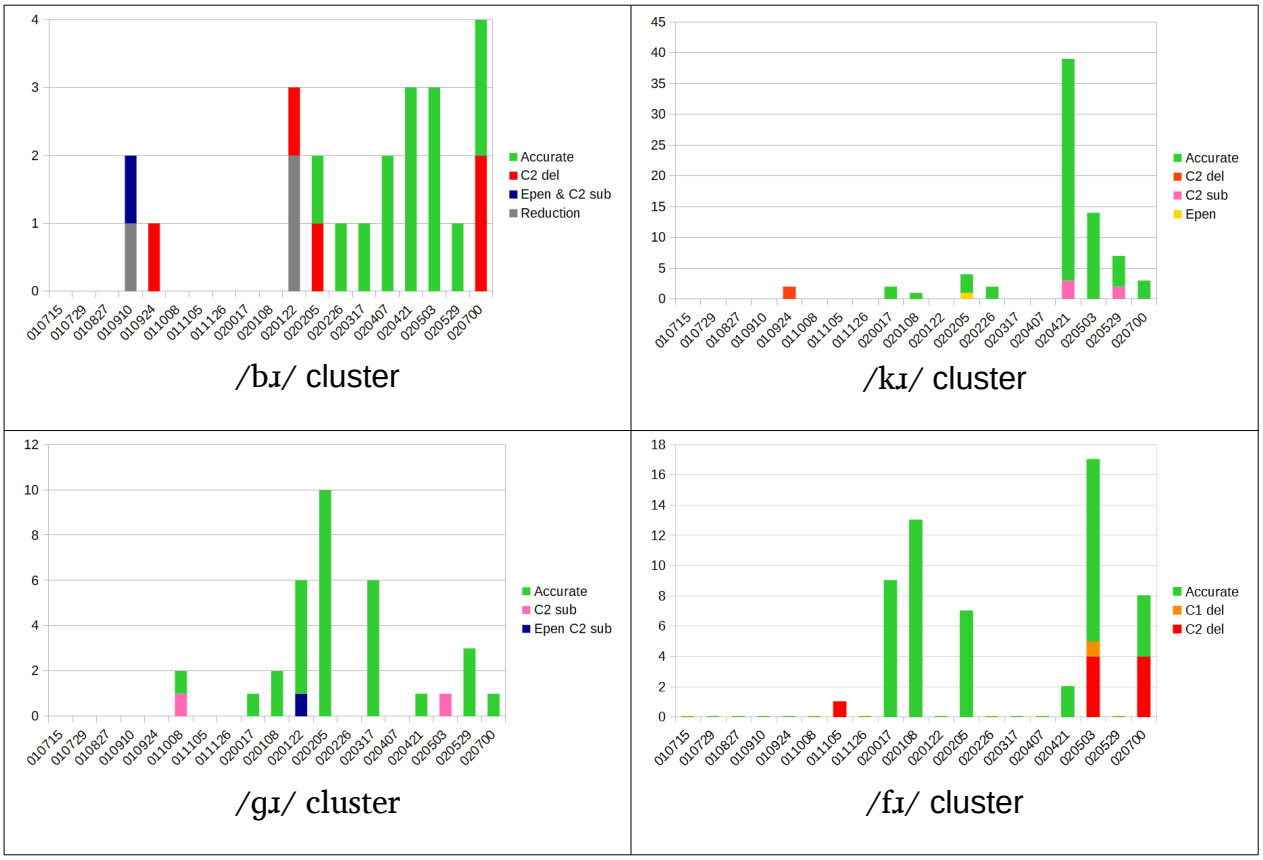

Figure 37: Naoki's productions of /bɹ/, /kɹ/, /gɹ/, and /fɹ/clusters in word-initial onset position in English

Similar to what we observed in his development of singleton onsets, Naoki's overall productivity tended to increase from 02;00.17, and there were already adult-like cluster productions at this point. There were also occasional C2 deletions, which specifically occurred in /bɹ/ and /fɹ/ clusters. In his productions of /bɹ/, any words except *broken*, which was accurately produced throughout the recorded period, tended to result in C2 deletion (e.g. *brown* /ˈbɹaʊn/→[ˈbaʊn], and *bring* /ˈbɹɪŋ/→[ˈbɪn]). Regarding Naoki's productions of /fɹ/, C2 deletion only occurred in the word *friend(s)* /ˈfɹɛnz/→[ˈfɛns]. Aside from these examples and a few other inaccurate outcomes, Naoki's productions at /bɹ/, /kɹ/, /gɹ/, and /fɹ/ were mostly adult-like. We can thus claim that he had generally acquired these clusters by 02;00.17. As for the /pɹ/ cluster, Naoki only made

four attempts, two of which were recorded at 01;11.05 and which resulted in full deletion (*propeller* /pɹəˈpɛləɹ/→ [ˈpeloʊ]), and the remainder two were accurate, both made at 02;02.05 in the word *present.* Because of the scarcity of the data, we cannot judge when Naoki acquired this cluster; the data merely suggest acquisition of this cluster by 02;02.05.

6.2.2 /tɹ/ and /dɹ/

Naoki's attempts at the /tɹ/ and /dɹ/ clusters were unstable throughout the recorded period, also with occasional C2 substitutions. For /tɹ/, C2 substitutions sometimes occurred at the same time as other errors, such as with C1 substitution and/or vowel epenthesis. Regardless of other errors, or the words in which they occurred, C2 substitutions were mostly with [w] (e.g. *truck* /ˈtɹʌk/→[ˈtwʌk]), with a substitution which was sometimes seen in the singleton /ɹ/ in onset position as well, as described in section 3.5.2. In addition to C2 substitution, vowel epenthesis occurred eight times in the word *train*, out of nine occurrences in total (e.g. /ˈtɹeɪn/ → [ˈʧuweɪ]).

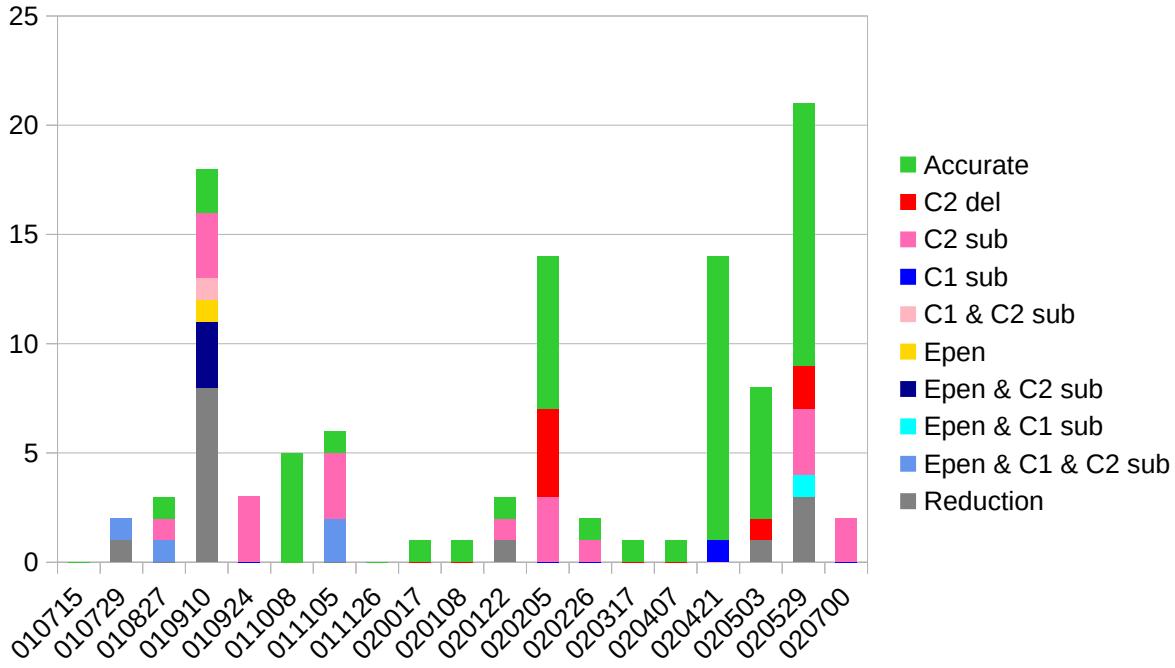

Figure 38: Naoki's productions of /tɹ/ cluster in word-initial onset position in English

The accuracy of Naoki's productions increased toward the end of the recorded period. We can infer from this that he had acquired /tɹ/ cluster in word-initial onset position by 02;04.21.

Concerning the /dɹ/ cluster, Naoki only attempted it six times in total throughout the recorded period. While four productions were accurate, all of which were made at 02;04.07 in the word *drink,* Naoki showed the same C2 substitution pattern as we saw with /tɹ/ once at 02;02.26, where he substituted the C2 /ɹ/ to [w]: *dragon* /ˈdɹægən/→[ˈdwægən]. Naoki made another attempt at 02;05.29, where he deleted C2: *drive* /ˈdɹaɪv/→[ˈdaɪv]. Overall, because of the scarcity of the data, it is hard for us to judge whether Naoki had acquired the /dɹ/ cluster or not during the recorded period.

6.2.3 /θɹ/

In contrast to all of the other C+liquid clusters, Naoki's attempts at the /θɹ/ cluster predominantly showed C1 substitutions.

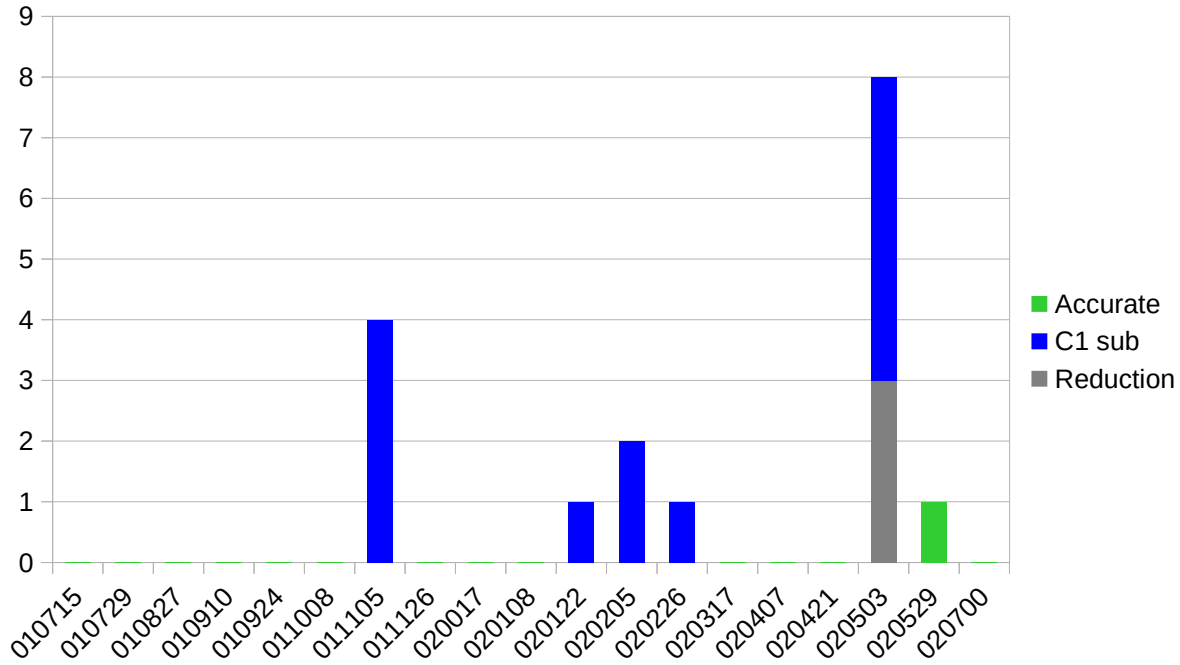

Figure 39: Naoki's productions of /θɹ/ cluster in word-initial onset position in English

Out of the 17 attempts in total, C1 substitution occurred 13 times, with [f] as the primary substitute (e.g. *three* /ˈθɹiː/→[ˈfɹiː]). Naoki also reduced the cluster to [f] at 02;05.03 (*three* /ˈθɹiː/→[ˈfiː]). These two patterns confirm that there was a tendency for Naoki to substitute [θ] to labials, considering that he was also substituting the singleton /θ/ in word-initial position to [p], as described in 3.2.3.2. In sum, Naoki was still developing /θɹ/, with noticeable issues with the place of articulation of /θ/.

6.2.4 Summary of obstruent+ɹ (excluding s-initial) clusters

In summary, Naoki was proficient at producing /bɹ/, /kɹ/, /gɹ/, and /fɹ/ clusters. However, his productions of the /tɹ/ cluster showed inconsistency with C2 substitutions

to [w] and occasional vowel epenthesis, and his /θɹ/ cluster showed C1 substitution with [f] throughout the recorded period. In the next section, we describe Naoki's development of obstruent+w clusters

6.3 Obstruent+w (excluding *s*-initial) clusters

Concerning obstruent+w clusters, Naoki made attempts at /tw/ and /kw/ only four times in total. He attempted /tw/ once at 02;01.22, and /kw/ three times between 01;01.05 and 02;02.26, all of which were accurate. However, because of the scarcity of data, it is difficult for us to judge when Naoki actually acquired the target clusters. In the next section, we turn to Naoki's attempts at s+consonant clusters.

6.4 *s*+consonant clusters

Naoki's productions of s+consonant clusters showed developmental patterns different from the other clusters described above (e.g. Barlow 1997 and Goad & Rose 2004 for similar observations in the context of monolingual first language acquisition). In his development of /sp/, /st/, and /sk/ clusters, there were C1 deletions observed until later in the recorded period. Unlike the other consonant clusters described above, where inaccurate productions mostly occurred in particular words, these C1 deletions occurred across a range of word forms. Naoki also attempted /sm/, /sl/, /sn/, and /sw/ clusters, each of which only a few times in total. We thus cannot fully depict his development of these clusters.

6.4.1 /sp/, /st/, and /sk/

Naoki's attempted /sp/, /st/, and /sk/ clusters a total of 104 times. In these productions, there were occasional C1 deletions. Since Naoki only attempted /sk/ once, the graph of this cluster is not included in the figure below.

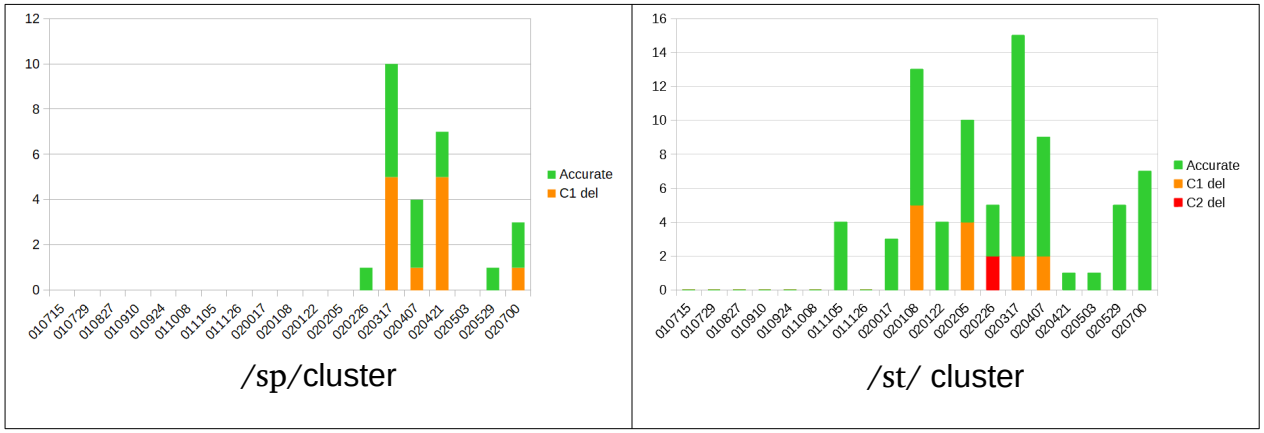

Figure 40: Naoki's productions of /sp/ and /st/ clusters in word-initial onset position in English

The C1 deletions were observed mainly between 02;01.08 and 02;04.21, and, as mentioned already, occurred across different words, and also in unsystematic ways. After the period of C1 deletions, his productions were more accurate. With regard to /sk/, Naoki made only one attempt, at 02;05.29, in which he deleted C1 in the word *sky* (/ˈskaɪ/→[ˈkaɪ]). From these results, we can claim that Naoki had acquired /sp/ and /st/ clusters by at least 02;05.29, while no conclusion can be drawn for /sk/ clusters.

6.4.2 /sm/, /sn/, /sl/, and /sw/

Naoki attempted /sm/ and /sl/ clusters four times each, and /sn/ and /sw/ clusters twice each. His productions of /sm/ and /sn/ clusters displayed vowel epenthesis, once in /sm/ at 02;05.03 (*small* /ˈsmɑl/→[ˈsəmɑl]), and also once in /sn/ at 02;00.17 (*snake*

/ˈsneɪk/→[ˈsʌneɪk]). The remainder of the productions of these clusters were accurate. With regard to /sl/ and /sw/ clusters, Naoki showed C2 substitutions. He only made attempts at /sl/ in the word *sleep(ing).* He made three out of these four attempts at 02;03.17, one resulting in an accurate production, one with C2 deletion, and the last one with C2 substitution to [w]. He made another attempt at 02;04.07 with an accurate production. Concerning his attempts at the /sw/ cluster, Naoki made one accurate production at 02;00.17, while there was a C2 substitution to [v] at 02;02.26; *swimming* /ˈswɪmɪŋ/→[ˈsvɪmi]. Overall, we lack data for these clusters, but based on the available occurences, we can tentatively conclude that Naoki was still in his developmental stage for s+sonorant clusters.

6.4.3 Summary of s+consonant clusters

In summary, Naoki acquired /sp/ and /st/ clusters during the course of the observation period, after showing unsystematic C1 deletions at first, while he made few attempts at the other s+consonant clusters, which he generally did not produce accurately. In the following section, we summarize Naoki's productions of complex onsets.

6.5 Summary of complex onsets in word-initial position in English

In summary, Naoki showed proficiency in most of the clusters that had sufficient data, while he had difficulties producing /tɹ/, in the form of C2 substitution, and /θɹ/, in the form of C1 deletion, as shown in the table below.

Legend	
E	Epenthesis of vowel between clusters
D1	C1 deletion
D2	C2 deletion
FD	Full deletion of cluster
S1	C1 substitution
S2	C2 substitution
CS	Substitution of both C1 and C2
R	Cluster reduction to a phone not present in cluster
&	More than one production pattern occurring at the same time

		010715	010729	010827	010910	010924	011008	011105	011126	020017	020108	020122	020205	020226	020317	020407	020421	020503	020529	020700
Obstruent+l	/pl/	-	-	D2	✓	-	-	-	-	✓/D2	✓	✓	✓	✓/R	✓	-	-	D2	-	-
	/bl/	✓	-	-	-	-	-	-	VAR	VAR	D2	D2	✓	-	✓	✓	-	-	-	-
	/kl/	-	-	-	-	-	-	-	✓	-	✓	✓	✓	-	✓	S1	-	-	-	R
	/fl/	✓	-	-	-	-	-	-	✓	-	✓	-	✓	✓/R	-	-	-	-	-	-
Obstruent+ɹ	/pɹ/	-	-	-	-	-	-	FD	-	-	-	-	✓	-	-	-	-	-	-	-
	/bɹ/	-	-	-	E&S2/ R	D2	-	-	-	-	-	R	✓/D2	✓	✓	✓	✓	✓	✓	✓/D2
	/tɹ/	-	E&CS	VAR	R	S2	✓	S2/ E&CS	-	✓	✓	VAR	VAR	✓/S2	✓	✓	✓	✓	✓	S2
	/dɹ/	-	-	-	-	-	-	-	-	-	-	-	-	S2	-	✓	-	-	D2	-
	/kɹ/	-	-	-	-	D2	-	-	-	✓	✓	-	✓	✓	-	-	✓	✓	✓	✓
	/gɹ/	-	-	-	-	-	✓/S2	-	-	✓	✓	✓	✓	-	✓	-	✓	S2	✓	✓
	/fɹ/	-	-	-	-	-	-	D2	-	✓	✓	-	✓	-	-	-	✓	✓	-	✓
	/θɹ/	-	-	-	-	-	-	D1	-	-	-	D1	D1	D1	-	-	-	D1	✓	-
Obstruent+w	/tw/	-	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-
	/kw/	-	-	-	-	-	-	✓	-	-	-	-	-	✓	-	-	-	-	-	-
s+consonanr	/sp/	-	-	-	-	-	-	-	-	-	-	-	-	✓	✓/D1	✓	D1	-	✓	✓
	/st/	-	-	-	-	-	-	✓	-	✓	✓	✓	✓/D1	✓/D2	✓	✓	✓	✓	✓	✓
	/sk/	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	D1	-
	/sm/	-	-	-	-	-	-	-	-	-	-	-	✓	✓	-	-	-	✓/E	-	-
	/sn/	-	-	-	-	-	-	-	-	✓/E	-	-	-	-	-	-	-	-	-	-
	/sl/	-	-	-	-	-	-	-	-	-	-	VAR	-	-	-	✓	-	-	-	-
	/sw/	-	-	-	-	-	-	-	-	✓	-	-	-	S2	-	-	-	-	-	-

Table 10: Timeline of Naoki's development of complex onsets in word-initial onset position in English

Unlike his productions of singleton onsets, the earliest point Naoki showed acquisition was in the middle of the recorded period, at 01;11.26 for obstruent+l clusters. He then acquired more than half of obstruent+ɹ clusters, /kɹ/, /gɹ/, /fɹ/ at 02;00.17, /bɹ/ at 02;02.26, and /tɹ/ at 02;04.21. These clusters were then followed by two s+consonant clusters, specifically /sp/ and /st/, at 02;05.29. While he generally showed later acquisition of onset clusters than singleton onsets, Naoki did not show consistent patterns such as the deletions and voicing errors observed in singleton codas. In the next section, we turn to our description of Naoki's development of coda-onset sequences in Japanese.

7. Coda-onset sequences in Japanese

In this section, we discuss Naoki's development of geminates and nasal+consonant sequences. For geminates, he showed consistent patterns of degemination, also with voicing and/or substitution affecting some target consonants. Concerning nasal+consonant sequences, Naoki showed C1 deletion consistently, which bears similarity to the deletion pattern we saw in his productions of singleton codas in word-final position.

7.1 Geminates

Degemination affected all of the geminates Naoki attempted, in particular in the context of geminate plosives. Naoki also showed a combination of degemination and voicing occasionally in his attempts at geminate plosives and affricates. In his attempts at nasal geminates, he showed both degemination and substitution, which occurred especially frequently in his productions of /mm/, produced as [w].

7.1.1 Obstruent plosives

Regarding obstruent plosive geminates, Naoki attempted /pp/, /tt/, and /kk/ 383 times in total. Until 02;04.21, Naoki predominantly degeminated these targets.

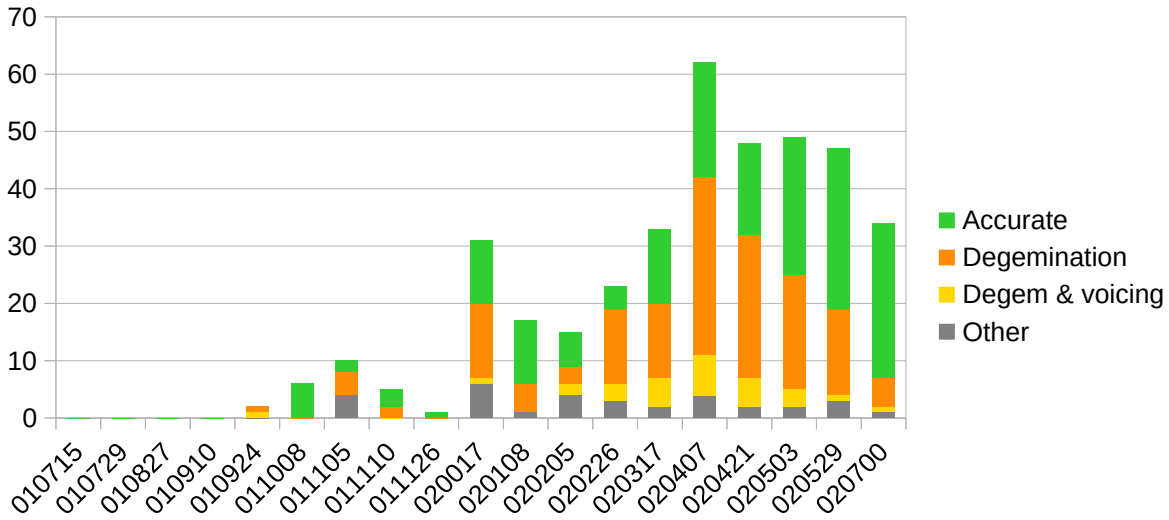

Figure 41: Naoki's productions of geminates of obstruent plosives in Japanese

In addition to degemination, Naoki also showed voicing errors, similar to what we saw in singleton obstruents in word-final position (e.g. /atta/→[ada] 'found it'). However, aside from these issues, the place and manner of articulation in his productions were generally accurate. Geminate production became more accurate toward the end of the recorded period, as Naoki showed a high number of accurate productions at 02;07.00. We thus conclude that Naoki had acquired /pp/, /tt/, and /kk/ by this age.

7.1.2 Fricatives

Turning now to geminate fricatives, Naoki only attempted [ʃʃ], showing accurate productions in more than half of the few forms he attempted.

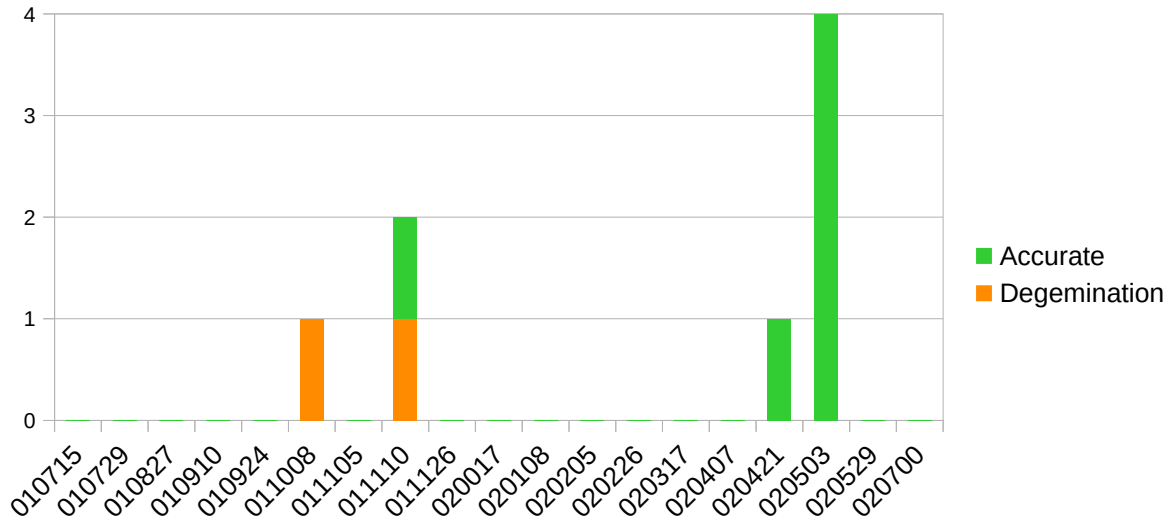

Figure 42: Naoki's productions of geminate of /ʃʃ/ in Japanese

At 01;10.08 and 01;11.10, Naoki only produced the cartoon character's name *Resshii*, for which there was one accurate production, and the remainder showed degemination (/ɾeʃʃiː/→[ɾeʃiː]). At 02;04.21 and 02;05.03, he produced this target geminate accurately five times in total. We can thus conclude that Naoki had acquired the geminate /ʃʃ/ in Japanese by this age or before, something we cannot verify precisely due to data scarcity.

7.1.3 Affricates

Naoki attempted the affricates [tsts] and /ʧʧ/ twice and 196 times, respectively. Similar to what we saw in his attempts at geminate plosives, he was mostly accurate in the place and manner of articulation of the target geminates, but displayed difficulties with voicing and geminate duration.

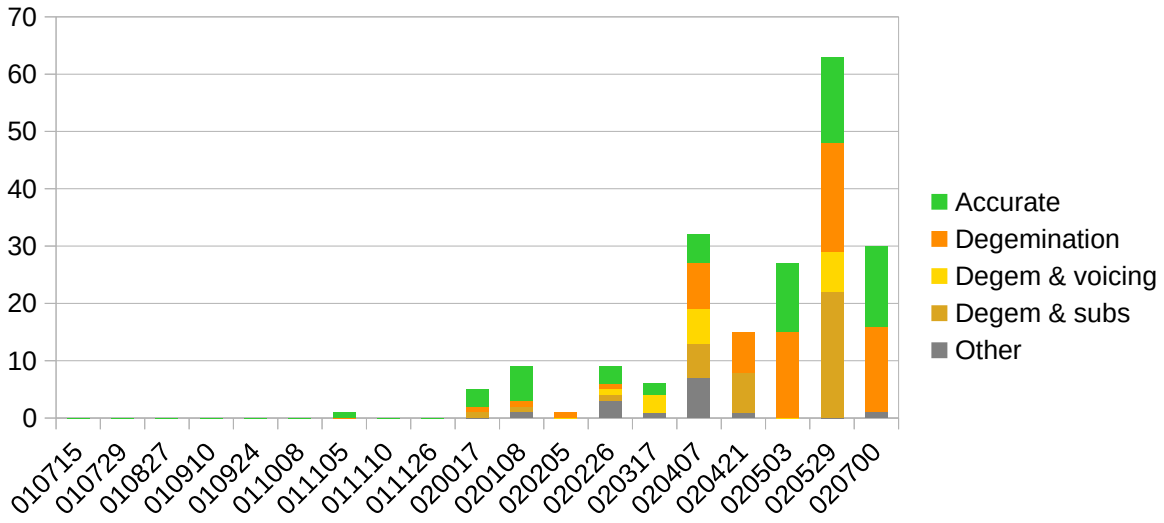

Figure 43: Naoki's productions of geminates of affricates in Japanese

Throughout the recorded period, Naoki produced the word *kotchi* 'here' more than half the time in his attempts at /ʧʧ/, with both accurate and inaccurate productions seen in this word in unsystematic ways. Regarding degemination and substitutions, observed 38 times in total, Naoki mostly substituted /ʧʧ/ to [ʒ] and [d], 17 times and 10 times respectively. From these results, we consider that Naoki was still in his developmental stage for geminate affricates.

7.1.4 Nasals

Naoki made attempts at [nn], [mm], and [ɲɲ] nasal geminates 199 times in total. Apart from frequent degemination, consistent with the patterning of other geminates, Naoki produced instances of degemination and substitutions 29 times during the recorded period.

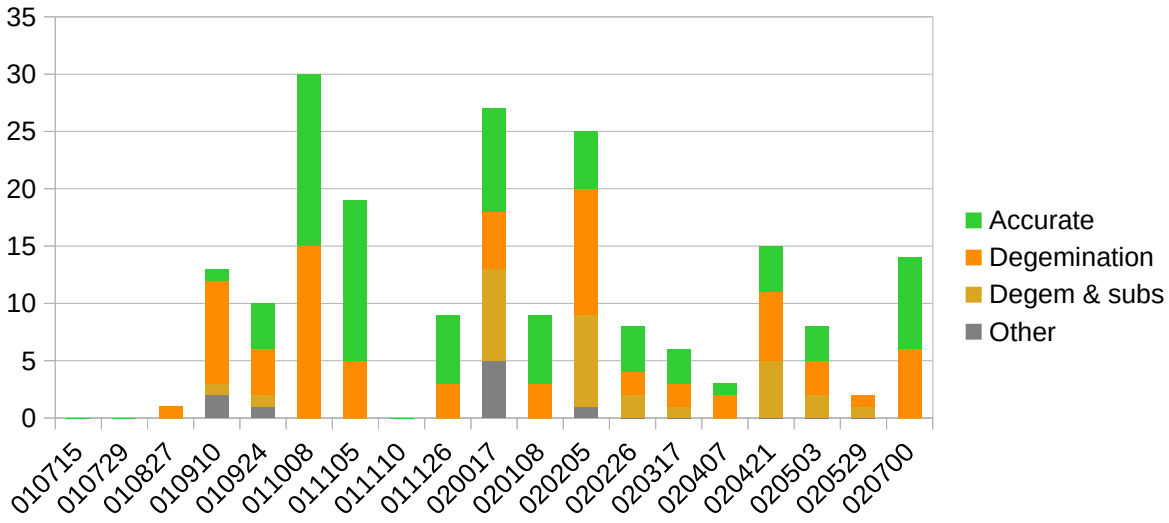

Figure 44: Naoki's productions of geminates of nasals in Japanese

Unlike the voicing errors previously observed in geminate obstruents, Naoki frequently changed the manner of articulation when attempting the target nasal geminates. For example, out of the 29 occurrences of degemination and substitution, Naoki substituted /mm/ with [w] 18 times. This occurred most of the time in the cartoon characters' names of *Anpanman* (/ampammaɴ/ → [apawa]) and *Kareepanman* (/kaɾeːpammaɴ/→[koɾʊpawa]). However, we do not consider this as a lexical exception, considering that Naoki predominantly attempted these words and another character's name *Baikinman* throughout the recorded period, and we observed both accurate productions and degeminations in these words. We rather assume that this substitution was caused by the process of compounding the words *anpan/kareepan+man* (red bean bun/curry bun+hero).[4] More generally, we can claim that Naoki was still in his developmental stage of nasal geminates in Japanese.

4 Whether this substitution was directly related to compounding in this form cannot be verified.

7.1.5 Summary of geminates

In summary, Naoki showed a consistent degemination pattern in all types of geminates. In his attempts at obstruent plosives, it was a predominant pattern. He also showed degemination and voicing patterns for obstruent plosives and affricates. This indicates that although he had issues with the length of gemination and voicing errors, he had already acquired the place and manner of articulation of these consonants. Concerning nasals, in addition to the consistent degemination pattern, Naoki tended to substitute [w] for /mm/. This, unlike geminate obstruents, shows a change in manner of articulation, which we assume was caused as part of a process of word compounding. Overall, Naoki ended up acquiring obstruent plosive geminates, as well as /ʃʃ/, an allophone of /s/. In the next section, we turn to Naoki's development of nasal+consonant sequences.

7.2 Nasal+consonant sequences

For nasal+consonant sequences (i.e. /ɴ/+consonant), Naoki attempted [mp], [mb], [nt], [nd], [nʒ], [ntʃ], [ŋk], and [ŋg]. Overall, he showed more C1 deletions than accurate productions, also with occasional C1 substitutions.

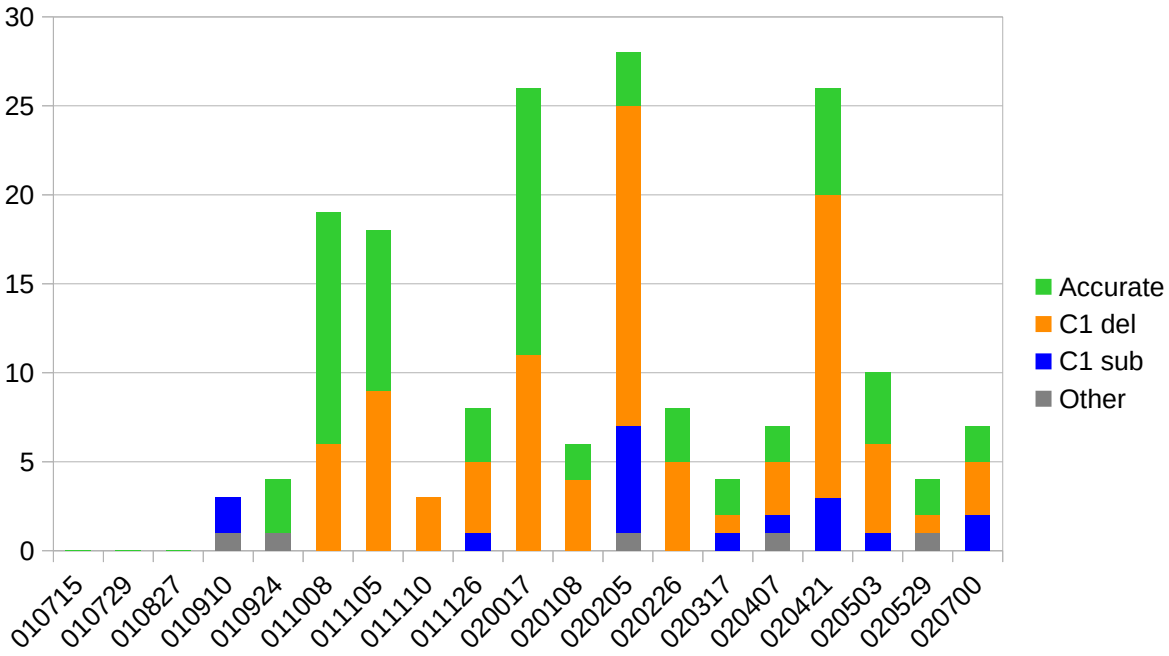

Figure 45: Naoki's productions of nasal+consonant sequences in Japanese

The deletion of C1 in coda position shows parallels with the predominant pattern of deletions Naoki displayed in his attempts at singleton codas, described in section 4.6. Concerning C1 substitutions, this process took the form of C2 gemination most of the time. For example, at 02;02.05, Naoki produced [pp] twice in his attempt at [mp]; *Anpanman* /ampammaɴ/ → [appamə] (a cartoon character). From these results, we consider that Naoki was still in his developmental stage of nasal+consonant sequences in coda-onset position in Japanese.

7.3 Summary of coda-onset sequences in Japanese

In summary, Naoki's showed consistent degemination in his attempts at geminates, and C1 deletion in his attempts at nasal+consonant sequences. The table below shows Naoki's overall developmental pattern of the geminates.

Legend	
dG	Degemination
S	Substitution
V	Voicing

	010715	010729	010827	010910	010924	011008	011105	011110	011126	020017	020108	020205	020226	020317	020407	020421	020503	020529	020700
Obs.plosive	-	-	-	-	dG	✓	dG	✓	✓	✓/dG	✓	VAR	dG	✓/dG	dG	dG	✓/dG	✓/dG	✓
Fricative	-	-	-	-	-	dG	-	✓/dG	-	-	-	-	-	-	-	✓	✓	-	-
Affricate	-	-	-	-	-	-	✓	-	-	✓	✓	dG	✓	dG&V	VAR	dG/ dG&S	✓/dG	VAR	✓/dG
Nasal	-	-	dG	dG	✓/dG	✓/dG	✓	-	✓	✓/ dG&S	✓	dG/ dG&S	VAR	✓/dG	dG	VAR	VAR	dG/ dG&S	✓/dG

Table 11: Timeline of Naoki's development of geminates in Japanese

Again, in addition to degemination, a pattern of voicing was often seen for obstruent plosives, while degemination and substitution was the frequent pattern in his attempts at nasal geminates. The former indicates that Naoki already had mastered the place and manner of articulation of obstruents, while latter can be related to a compounding process in a specific word. Given these inaccurate productions, Naoki acquired geminates of obstruent plosives and /ʃʃ/ quite late in the recorded period, at 02;07.00 and 02;04.21 respectively, while he was in his developmental stage for the remainder of the target geminates.

Concerning nasal+consonant sequences, the predominant C1 deletion pattern is consistent with the deletion pattern Naoki showed in his attempts at singleton codas, which confirms that he had major issues producing codas whether in singleton positions or as part of heterosyllabic clusters.

	010715	010729	010827	010910	010924	011008	011105	011110	011126	020017	020108	020205	020226	020317	020407	020421	020503	020529	020700
Nasal+C	-	-	-	S1	✓	✓	✓/ D1	D1	✓/ D1	✓/ D1	D1	D1	D1	VAR	✓/ D1	D1	✓/ D1	D1	VAR

Table 12: Timeline of Naoki's development of coda-onset sequences in Japanese

The C1 deletion as a dominant pattern lasted until the end of the recorded period, which indicates that Naoki was still in his developmental stage of the target sequence. In the next section, we move on to our description of coda-onset clusters in English.

8. Coda-onset clusters in English

Similar to nasal+consonant sequences in Japanese, described in 7.2, Naoki showed C1 deletion as a dominant production pattern in coda-onset clusters in English. We again associate this to the deletion pattern he produced in word-final codas. In addition to this, Naoki displayed occasional C2 deletions in his attempts at nasal+consonant clusters, and vocalization and voicing errors in liquid+consonant clusters.

8.1 Obstruent+consonant clusters

For obstruent+consonant clusters, Naoki attempted /pt/, /ts/, /dn/, /kʧ/, /kn/, /sʃ/, /sm/, and /ʤt/,[5] with a total of 58 attempts. C1 deletions were the leading pattern until 02;04.21.

5 Naoki also attempted /ps/ 33 times, most of which were accurate throughout the recorded period. However, considering that 29 occurrences were in the exclamation *whoopsie*, which is similar in nature to an onomatopoeia, it is difficult to judge whether Naoki truly acquired the target phonology or if it is the product of lexical exception (see also section 3.6 about this word). Thus, /ps/ is not included in our analysis.

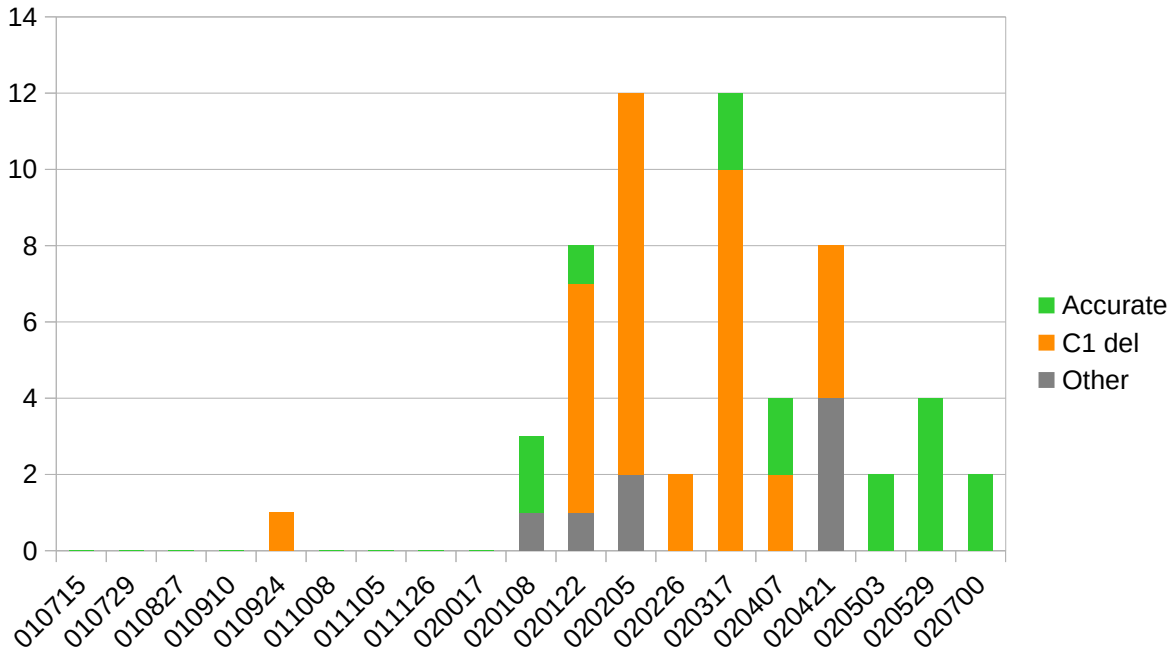

Figure 46: Naoki's productions of obstruent+consonant clusters in coda-onset position in English

From 02;05.03 onward, Naoki started to show accurate productions only. This suggests that he had acquired obstruent+consonant clusters in coda-onset position by this age.

8.2 Nasal+consonant clusters

Naoki attempted /mb/, /ns/, /nʤ/, /nɹ/, /ŋk/, and /ŋg/ for nasal+consonant clusters, 38 times in total.

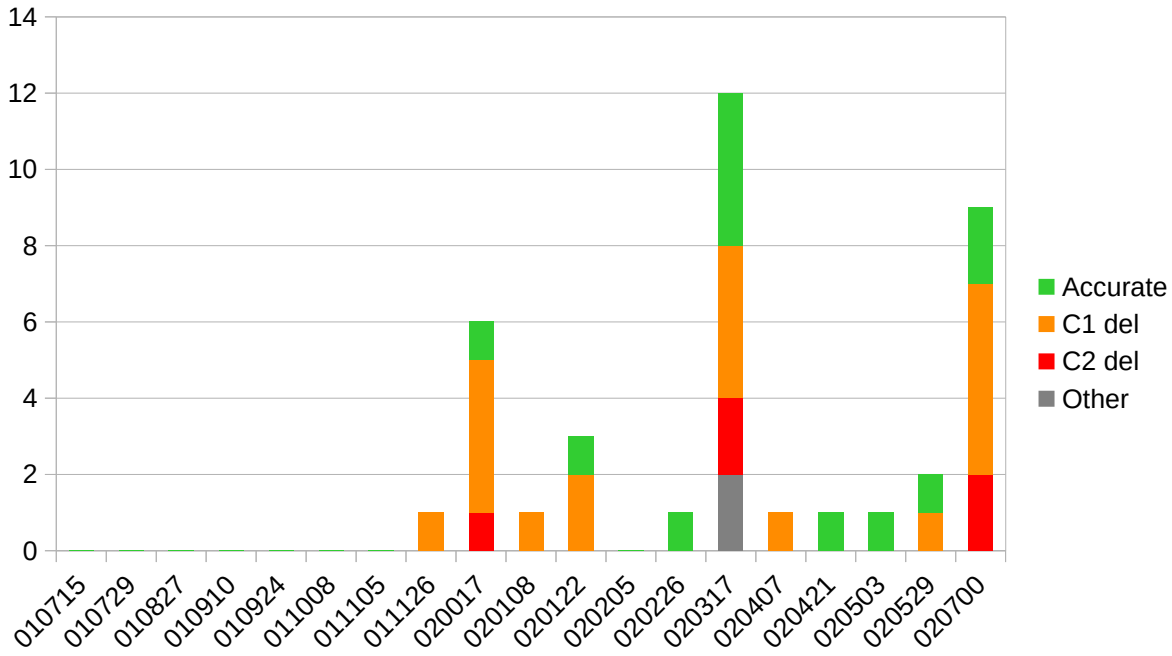

Figure 47: Naoki's productions of nasal+consonant clusters in coda-onset position in English

Beside the consistent C1 deletion pattern, Naoki also occasionally showed C2 deletions, particularly in /mb/ and /ŋg/ (e.g. /ˈsʌmbədiː/→[ˈsʌməɹ]). Considering these results, we conclude that he was still in his developmental stage of nasal+consonant clusters in coda-onset position in English.

8.3 Liquid+consonant clusters

Naoki attempted /lf/, /lm/, /lɹ/, /ɹp/, /ɹt/, /ɹd/, /ɹk/, /ɹf/, /ɹs/, and /ɹn/ for liquid+consonant clusters. Aside from C1 deletion, as seen previously, we observed occasional C1 vocalization or voicing of C2 in his productions of these clusters.

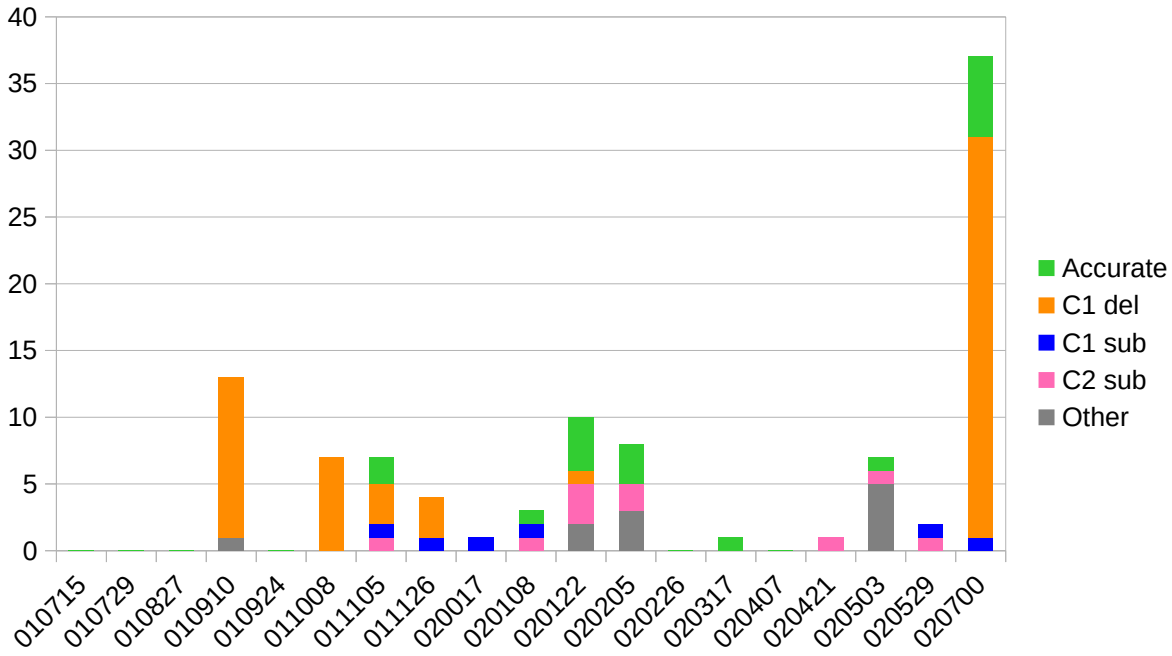

Figure 48: Naoki's productions of liquid+consonant clusters in coda-onset position in English

We observed C1 vocalization in /lf/, /lm/, /lɹ/, /ɹp/, and /ɹn/, where the first consonant was substituted to either [ʊ] or [ɪ] (e.g. /ˈpʌɹpəl/→[ˈtoʊpə]). Furthermore, Naoki showed a voicing error, similar to that seen in singleton obstruents in coda position, where C2 voicing occurred when the consonant was a voiceless obstruent, specifically /ɹp/ (once out of five attempts), /ɹt/ (twice out of nine attempts), and /ɹf/ (once out of one attempt). From these results, we consider that Naoki was still in his developmental stage of liquid+consonant clusters in coda-onset position in English.

8.4 Summary of coda-onset clusters in English

In summary, Naoki showed C1 deletion as a predominant production pattern for all the coda-onset clusters in English, which is consistent with his productions of singleton codas and nasal+consonant sequences in Japanese, as presented in the table below.

	010715	010729	010827	010910	010924	011008	011105	011126	020017	020108	020122	020205	020226	020317	020407	020421	020503	020529	020700
Obstruent+C	-	-	-	-	D1	-	-	-	-	✓	D1	D1	D1	D1	✓/ D1	D1	✓	✓	✓
Nasal+C	-	-	-	-	-	-	-	D1	D1	D1	D1	-	✓	✓/ D1	D1	✓	✓	✓/ D1	D1
Liquid + C	-	-	-	D1	-	VAR	D1	-	D1	VAR	✓/S2	S2	-	✓	-	S2	VAR	S1/ S2	D1

Table 13: Timeline of Naoki's development of coda-onset clusters in English

Also, specifically in his attempts at liquid+consonant clusters, Naoki showed C1 vocalization and C2 voicing, the latter of which resembles the voicing errors he showed in singleton obstruents in coda position. By the end of the recorded period, Naoki had only acquired obstruent+consonant clusters, at 02;05.03. This concludes our description of Naoki's development of coda-onset clusters in English. We now move onto the next chapter, where we summarize all the descriptions, and briefly discuss our main findings.

Chapter 5: Discussion

1. Introduction

In this chapter, we summarize the main findings from the previous chapter, and offer a discussion of Naoki's developmental patterns. As we will see, Naoki's phonological development, especially in syllable codas, appears to have been largely affected by the phonological constraints of Japanese. This is in contrast with the fact, noted in section 2 of Chapter 4, that Naoki showed slightly higher productivity in using English words than Japanese words in the recorded sessions; his behaviours are indeed suggestive of a Japanese monolingual child who was learning English as a second language.

2. Summary of observations

In this section, we summarize the main observations from the previous chapter. First, for the singleton onsets in word-initial position, Naoki generally showed adult-like productions in both languages throughout the recorded period. The exceptions were particularly those obstruents which are attested only in either of the languages, such as /ç/ and [ʦ] in Japanese, and /v/, /θ/, and /ð/ in English. His attempts at these consonants generally showed inaccurate productions, or yielded too few data to draw any reliable conclusion. Aside from these and a few other consonants, Naoki had acquired most of the consonants during the recorded period.

Concerning Naoki's attempts at singleton codas in word-final position, he showed two noteworthy behaviours in English: deletion and voicing errors. With regard to deletion, we observed them across all manners of articulation. As for voicing errors, Naoki particularly showed devoicing of target voiced obstruents. Concerning his attempts at

nasal codas in Japanese, he also showed frequent deletions. By the end of the recorded period, he had only acquired approximately half of the target consonants in this position.

Turning to complex onsets in English, Naoki was generally proficient at them, similar to his general performance at singleton onsets. He only showed difficulty with producing /tɹ/ and /θɹ/, and he also showed occasional C1 deletion in s+consonant clusters. However, he acquired most of the target clusters during the period documented in the corpus.

With regard to geminates in Japanese, Naoki showed generalized degemination and also voicing errors, similar to what we saw in his attempts at singleton codas in English. Overall, he acquired geminates of obstruent plosives only. As for coda-onset sequences, he showed C1 deletion as a predominant pattern, consistent with his productions of singleton codas.

Finally, for coda-onset clusters in English, C1 deletion was again a predominant pattern, similar to his productions of word-final codas. He also showed errors in voicing, a general pattern affecting his productions of obstruent codas across all positions.

From these results, it is evident that deletion was a major issue in coda position, in both of his target languages. As discussed in 4.6 of Chapter 4, this deletion pattern was more prominent when the target phone in coda position was a non-nasal consonant. Furthermore, as our consideration of productions in context within the utterance showed, Naoki displayed more deletions when the target codas were in sentence-medial position when followed by another consonant, or sentence-final position.

3. Discussion

At first glance, we had a general impression that Naoki was an English-dominant bilingual child. The main reason for this came from the fact that he appeared to be more productive in English than in Japanese, as we saw in section 2 of Chapter 4. Also, he showed more accurate production of singleton onsets in English. However, looking at his productions of singleton codas, we began to question this assumption; we saw constraints related to the Japanese phonological system affecting his productions of coda consonants in English.

Recall that we saw deletions in almost all the coda consonants in English, and also in Japanese nasal codas. Also, Naoki substituted nasals /n/ and /ŋ/ in English to [N] very frequently. These results suggest an effect of the phonological constraints of the Japanese coda. This can be rationalized by the concept of prosodic licensing discussed by Itô (1986) in her analysis of Japanese phonotactics. In short, all phonological units belong to a higher prosodic structure, where they must conform to specific constraints in order to be licensed and, thus, phonetically realized in spoken forms.

Itô and Mester (1993) further analyzed issues in prosodic licensing in Japanese, where they describe a constraint which disallows phonological units with a consonantal place of articulation to be realized in coda position. Because of this, /N/ is the only possible consonant to appear in this position, as it is suggested that it is a placeless consonant (e.g. Itô 1986; Nasukawa 1998). In light of this, Naoki's productions of coda consonants in both of his languages suggest a transfer effect from Japanese to English, given that

the target phones in coda position were frequently deleted, despite the lack of restriction on place or manner of articulation in coda position in adult English.

Further evidence of Naoki's application of Japanese phonological constraints could be seen in the fact that Naoki showed fewer deletions when a target coda consonant was followed by a vowel. This is indeed possible given that a word-final coda can be resyllabified in the onset of the following word, thereby escaping constraints on coda licensing.

These deletion patterns observed in coda position were also similar to those found in Japanese monolingual acquisition. Typically, monolingual Japanese children delete /ɴ/, with occasional lengthening of the preceding vowel, in the early development of this consonant (e.g. Kazama 2000; Ota 2003). As such, these deletion patterns Naoki showed in codas in English partially match the developmental pattern of /ɴ/ by monolingual Japanese children, although we did not observe vowel lengthening before codas in Naoki's productions.

In contrast, by comparing Naoki's coda development with that of English monolingual children, we also see an effect of delay in his acquisition of some English obstruents. Recall from section 2.3 of Chapter 2 that we looked at the development of word-medial codas of a Portuguese-French learning child from the study of Almeida et al. (2012). In this study, despite the fact that French monolingual children acquire almost all consonants in this position at the same time, the child acquired plosives later than the other consonants. Almeida et al. suggest that this is an effect of the child's Portuguese

phonological constraints, as plosives are not allowed in coda position in this language. Therefore, the child's development of plosives in French was delayed. Similar to this, we suggest that Japanese coda constraints caused Naoki's delayed acquisition of English voiceless plosives and voiced obstruents. While monolingual English-learning children generally acquire voiceless plosives first, followed by voiceless fricatives and nasals, voiced obstruents, and finally liquids (Bernhardt & Stemberger 1998; Kehoe & Stoel-Gammon 2001), Naoki did not acquire voiceless plosives nor voiced obstruents during the documented period.

Together, these observations suggest that Naoki was more akin to a monolingual Japanese child who was learning English as his second language; another interpretation would be that he was learning both languages in parallel, however with a clear dominance effect coming from his Japanese system.

4. Limitations and conclusion

Through this thesis, we are contributing to research on child phonological development in a multilingual context. Building on the recorded and partially transcribed corpus documenting Naoki's development of his Japanese and English languages originally contributed by Dr. Mitsuhiko Ota to the CHILDES and PhonBank databases, we completed the transcription work on this corpus, in both languages, which we are now returning to the database as an augmented version of the original contribution. In addition to this empirical contribution, our data descriptions offer a starting point not only for the hypotheses we formulated based on these descriptions, in particular about prosodic licensing, but also about the origins of some idiosyncrasies noted in the data,

for example about lexical exceptions to the main patterns observed. However, much work remains to be done in the development of our initial hypotheses, some of which would require further explorations of the corpus data. For example, while we observed a transfer effect from Japanese to English and delayed acquisition of English obstruents in coda position, we could not find clear evidence of acceleration, fusion, and/or different order of acquisition. An investigation into the presence or absence of these interaction patterns is left for future work. Furthermore, it would have been more useful to compare Naoki to monolingual learners of Japanese and of English. This unfortunately transcends the scope of this thesis, but the interested readers could look at the studies of Ota & Ueda (2007) and Ota (2015) for Japanese monolingual development, and McLeod, Doorn & Reed (2001) and Howard (2007) for English monolingual development. Finally, this is a case study, where only one participant was observed. Therefore, we cannot generalize all aspects of our analysis to other bilingual or child second-language learners. Nonetheless, this thesis offers a demonstration of how multilingual corpora can be analyzed within the context of PhonBank, through only minimal annotations of the corpus data. It is our hope that these contributions will serve as a useful stepping stone for further empirical and theoretical research in Japanese-English language acquisition studies, as well as more general research in phonology, language acquisition, and multilingualism.

References

Almeida, Letícia & Maria João Freitas. 2010. Target Phonologies in Bilingual and Monolingual Development of Branching Onsets. Paper presented at the *Phon & PhonBank: Future Directions*, Memorial University of Newfoundland.

Almeida, Letícia, Yvan Rose & Maria João Freitas. 2012. Prosodic Influence in Bilingual Phonological Development: Evidence from a Portuguese-French First Language Learner. In Alia K. Biller, Esther Y. Chung & Amelia E. Kimball (eds.), *Proceedings of the 36th Annual Boston University Conference on Language Development*, 42–52. Somerville, MA: Cascadilla Press.

Barlow, Jessica A. 1997. *A Constraint-Based Account of Syllable Onsets: Evidence from Developing Systems*. Ph.D. Dissertation. Indiana University.

Bernhardt, Barbara Handford & Joseph Paul Stemberger. 1998. *Handbook of phonological development. From the perspective of constraint-based nonlinear phonology*. San Diego: Academic Press.

Bernhardt, Barbara May & Joseph Paul Stemberger. 2018. Tap and Trill Clusters in Typical and Protracted Phonological Development: Conclusion. *Clinical Linguistics & Phonetics* 32(5–6). 563–575. https://doi.org/10.1080/02699206.2017.1370496.

Chomsky, Noam. 1957. *Syntactic Structures*. Mouton: The Hague.

Clyne, Michael. 1987. “Don’t You Get Bored Speaking Only English?” Expressions of Metalinguistic Awareness in a Bilingual Child. In Ross Steele & Terry Threadgold (eds.), *Language Topics: Essays in Honour of Michael Halliday*, 85–103. Amsterdam: John Benjamins.

Correia, Susana. 2004. *A Aquisição Da Rima Em Português Europeu - Ditongos E Consoantes Em Final De Sílaba*. Master’s Thesis. Universidade de Lisboa.

Cruttenden, Alan. 2014. *Gimson’s Pronunciation of English*. 8th edn. Oxford: Routledge.

De Houwer, Annick. 1990. *The Acquisition of two Languages from Birth: A Case Study*. Cambridge: Cambridge University Press.

De Houwer, Annick. 1995. Bilingual Language Acquisition. In Paul Fletcher & Brian MacWhinney (eds.), *The Handbook of Child Language*, 219–250. Oxford: Blackwell Publishers.

De Houwer, Annick. 1987a. Gender Making in a Young Dutch-English Bilingual Child. In Anne E Mills, John Local & Patrick Griffiths (eds.), *Preceedings of the 1987 Child Language Seminar*, 53–65. York: University of York.

Dell, François. 1995. Consonant Clusters and Phonological Syllables in French. *Lingua* 95(1). 5–26. https://doi.org/10.1016/0024-3841(95)90099-3.

Fabiano-Smith, Leah & Jessica A. Barlow. 2010. Interaction in Bilingual Phonological Acquisition: Evidence from Phonetic Inventories. *International Journal of Bilingual Education and Bilingualism* 13(1). 81–97.

Freitas, Maria João. 1997. *Aquisição Da Estrutura Silábica Do Português Europeu*. Ph.D. Dissertation. Universidade de Lisboa.

Freitas, Maria João. 2003. The Acquisition of Onset Clusters in European Portuguese. *Probus* 15(1). 27–46. https://doi.org/10.1515/prbs.2003.004.

Genesee, Fred. 1989. Early Bilingual Development: One Language or Two? *Journal of Child Language* 16(1). 161–179. https://doi.org/10.1017/S0305000900013490.

Goad, Heather & Yvan Rose. 2004. Input Elaboration, Head Faithfulness and Evidence for Representation in the Acquisition of Left-Edge Clusters in West Germanic. In René Kager, Joe Pater & Wim Zonneveld (eds.), *Fixing Priorities: Constraints in Phonological Acquisition*, 109–157. Cambridge: Cambridge University Press.

Goodz, Naomi, Lynda Bilodeau & Marie C. Légaré. 1988. Variables Influencing Parental Language Mixing to Children in Bilingual Families. Paper presented at the *International Conference on Infant Studies*, Washington.

Goodz, Naomi, Marie C. Légaré & Lynda Bilodeau. 1987. The Influence of Bilingualism in Linguistic Awareness in Pre-School Children. Paper presented at the *Annual Meeting of the Canadian Psychological Association*, Vancouver.

Hakuta, Kenji & Rafael M. Diaz. 1985. The Relationship between Degree of Bilingualism and Cognitive Ability. In Keith E. Nelson (ed.), *Children's Language*, vol. 5, 319–344. Hillsdale, NJ: Lawrence Erlbaum Associates.

Howard, Sara. 2007. English Speech Acquisition. In Sharynne McLeod (ed.), *The International Guide to Speech Acquisition*, 188–203. Clifton Park, NY: Thomson Delmar Learning.

Hulk, Aafke & Natascha Müller. 2000. Bilingual First Language Acquisition at the Interface between Syntax and Pragmatics. *Bilingualism: Language and Cognition* 3(3). 227–244. https://doi.org/10.1017/S1366728900000353.

Idiazábal, Itziar. 1984. Conciencia Bilingüe Del Niño Bilingüe [Bilingual Awareness of the Bilingual Child]. In Miguel Siguán (ed.), *Adquisición Precoz de Una Segunda Lengua [Early Acquisition of a Second Language]*, 55–63. Barcelona: Universitat de Barcelona.

Itô, Junko. 1986. *Syllable Theory in Prosodic Phonology*. Ph.D. Dissertation. University of Massachusetts.

Itô, Junko & Armin Mester. 1993. Licensed Segments and Safe Paths. *Canadian Journal of Linguistics/Revue Canadienne de Linguistique* 38(2). 197–213.

Jakobson, Roman. 1941. *Kindersprache, Aphasie, Und Allgemeine Lautgesetze*. Uppsala: Almqvist & Wiksell.

Jekat, Susanne J. 1985. *Die Entwicklung Des Wortschatzes Bei Bilingualen Kindern (Französisch-Deutsch) in Den Ersten Vier Lebensjahren*. Master's Thesis. University of Hamburg.

Jensen, John T. 1993. *English Phonology*. Amsterdam: John Benjamins.

Kaiser, Georg A. 1994. More about INFL-Ection and Agreement: The Acquisition of Clitic Pronouns in French. In Jürgen M. Meisel (ed.), *Bilingual First Language Acquisition : French and German Grammatical Development*, 131–159. Philadelphia: John Benjamins.

Kazama, Masae. 2000. The Relationship between the Development of the Ability to Produce Speech Sounds and That of Phonological Awareness in Preschool Children. *The Japanese Journal of Communication Disorders* 17(2). 72–78.

Kehoe, Margaret. 2002. Developing Vowel Systems as a Window to Bilingual Phonology. *International Journal of Bilingualism* 6(3). 315–334. https://doi.org/10.1177/13670069020060030601.

Kehoe, Margaret. 2018. The Development of Rhotics: A Comparison of Monolingual and Bilingual Children. *Bilingualism: Language and Cognition* 21(4). 710–731. https://doi.org/10.1017/S1366728916001279.

Kehoe, Margaret, Geraldine Hilaire-Debove, Katherine Demuth & Conxita Lleó. 2008. The Structure of Branching Onsets and Rising Diphthongs: Evidence from the Acquisition of French and Spanish. *Language Acquisition* 15(1). 5–57. https://doi.org/10.1080/10489220701774229.

Kehoe, Margaret & Carol Stoel-Gammon. 2001. Development of Syllable Structure in English-Speaking Children with Particular Reference to Rhymes. *Journal of Child Language* 28(2). 393–432.

Keshavarz, Mohammad H. & David Ingram. 2002. The Early Phonological Development of a Farsi-English Bilingual Child. *International Journal of Bilingualism* 6(3). 255–269. https://doi.org/10.1177/13670069020060030301.

Köppe, Regina. 1996. Language Differentiation in Bilingual Children: The Development of Grammatical and Pragmatic Competence. *Linguistics* 34(5). 927–954. https://doi.org/10.1515/ling.1996.34.5.927.

Labrune, Laurence. 2012. *The Phonology of Japanese*. Oxford: Oxford University Press.

Lawrence, Wayne P. 2004. High Vowels, Glides, and Japanese Phonology. *Gengo Kenkyu* 2004(125). 1–30. https://doi.org/10.11435/gengo1939.2004.125_1.

Levy, Yonata. 1985. Theoretical Gains from the Study of Bilingualism: A Case Report. *Language Learning* 35(4). 541–554. https://doi.org/10.1111/j.1467-1770.1985.tb00360.x.

Lin, Candise Y., Chenxi Cheng & Min Wang. 2018. The Contribution of Phonological and Morphological Awareness in Chinese-English Bilingual Reading Acquisition. *Reading and Writing: An Interdisciplinary Journal* 31(1). 99–132. https://doi.org/10.1007/s11145-017-9775-8.

Liu, Liquan & René Kager. 2016. Perception of a Native Vowel Contrast by Dutch Monolingual and Bilingual Infants: A Bilingual Perceptual Lead. *International Journal of Bilingualism* 20(3). 335–345.

Lleó, Conxita. 2006. The Acquisition of Prosodic Word Structures in Spanish by Monolingual and Spanish-German Bilingual Children. *Language and Speech* 49(2). 205–229. https://doi.org/10.1177/00238309060490020401.

Lleó, Conxita. 2016. Bilingualism and Child Phonology. In *Oxford Handbooks Online* (Scholarly Research Reviews). Oxford: Oxford University Press. https://www.oxfordhandbooks.com/view/10.1093/oxfordhb/9780199935345.001.0001/oxfordhb-9780199935345-e-53.

Lleó, Conxita, Imme Kuchenbrandt, Margaret Kehoe & Cristina Trujillo. 2003. Syllable Final Consonants in Spanish and German Monolingual and Bilingual Acquisition. In Müller Natascha (ed.), *(In) Vulnerable Domains in Multilingualism*, 191–220. Philadelphia: John Benjamins.

Lleó, Conxita & Martin Rakow. 2003. Markedness Effects in Voiced Stop Spirantization in Bilingual German-Spanish Children. In James Cohen, Kara T. McAlister, Kellie Rolstad & Jeff MacSwan (eds.), *Proceedings of the 4th International Symposium on Bilingualism (ISB4)*, 1353–1371. Somerville, MA: Cascadilla Press.

Lleó, Conxita & Martin Rakow. 2006. Nasalassimilation Und Prosodische Hierarchie Im Monolingualen Und Bilingualen Erwerb Des Spanischen Und Des Deutschen. In Christliebe El Mogharbel & Himstedt Katja (eds.), *Phonetik Und Nordistik. Festschrift Für Magnús Pétursson Zum 65. Geburtstag*, 95–117. Frankfurt am Main: Theo Hector.

Logan, John S., Scott E. Lively & David B. Pisoni. 1991. Training Japanese Listeners to Identify English /r/ and /l/: A First Report. *The Journal of the Acoustical Society of America* 89(2). 874–886. https://doi.org/10.1121/1.1894649.

Major, Roy C. 1992. Losing English as a First Language. *The Modern Language Journal* 76(2). 190–208.

Mateus, Maria Helena Mira & Ernesto d'Andrade. 2000. *The Phonology of Portuguese*. Oxford: Oxford University Press.

McLeod, Sharynne, Jan van Doorn & Vicki A. Reed. 2001. Normal Acquisition of Consonant Clusters. *American Journal of Speech-Language Pathology* 10(2). 99–110. https://doi.org/10.1044/1058-0360(2001/011).

Meisel, Jürgen M. 1986. Word Order and Case Marking in Early Child Language. Evidence from Simultaneous Acquisition of Two First Languages: French and German. *Linguistics* 24(1). 123–184. https://doi.org/10.1515/ling.1986.24.1.123.

Meisel, Jürgen M. 1989. Early Differentiation of Languages in Bilingual Children. In Kenneth Hyltenstam & Loraine K. Obler (eds.), *Bilingualism across the Lifespan: Aspects of Acquisition, Maturity, and Loss*, 13–40. Cambridge: Cambridge University Press.

Meisel, Jürgen M. 1990. INFL-Ection: Subjects and Subject-Verb Agreement. In Jürgen M. Meisel (ed.), *Two First Languages: Early Grammatical Development in Bilingual Children*, 237–300. Dordrecht: Foris.

Meisel, Jürgen M. 2007. On Autonomous Syntactic Development in Multiple First Language Acquisition. In Heather Caunt-Nulton, Samantha Kulatilake & I-hao Woo (eds.), *Proceedings of the 31st Annual Boston University Conference on Language Development*, vol. 1, 26–45. Somerville, MA: Cascadilla Press.

Meisel, Jürgen M. 1990b. Grammatical Development in the Simultaneous Acquisition of Two First Languages. In Jürgen M. Meisel (ed.), *Two First Languages: Early Grammatical Development in Bilingual Children*, 5–22. Dordrecht: Foris.

Meisel, Jürgen M. & Axel Mahlau. 1988. La Adquisición Simultánea De Dos Primeras Lenguas. Discusión General E Implicaciones Para El Estudio Del Bilingüismo En Euzkadi [the Simultaneous Acquisition of Two First Languages. General Discussion and Implications for the Study of Bilingualism in the Basque Country]. In *Actas Del II Congreso Mundial Vasco: Confreso Sobre La Lengua Vasca, Tomo III [Proceedings of the Second Basque World Congress: Congress on the Basque Language]*. Victoria: Servicio de publicaciones del Gobierno Vasco.

Mishina-Mori, Satomi. 2002. Language Differentiation of the Two Languages in Early Bilingual Development: A Case Study of Japanese/English Bilingual Children1.

IRAL, International Review of Applied Linguistics in Language Teaching 40(3). 211–233.

Müller, Natascha & Aafke Hulk. 2001. Crosslinguistic Influence in Bilingual Language Acquisition: Italian and French as Recipient Languages. *Bilingualism: Language and Cognition* 4(1). 1–21. https://doi.org/10.1017/S1366728901000116.

Nasukawa, Kuniya. 1998. Prosodic Integrity and Melodic Representation in Nasals. *Interdisciplinary Information Sciences* 4(1). 1–8. https://doi.org/10.4036/iis.1998.1.

Ota, Mitsuhiko. 1998. Minimality Constraints and the Prosodic Structure of Child Japanese. In David J. Silva (ed.), *Japanese/Korean Linguistics*, vol. 8, 331–344. Stanford: CSLI Publications.

Ota, Mitsuhiko. 2003. *The Development of Prosodic Structure in Early Words: Continuity, Divergence, and Change* (Language Acquisition & Language Disorders v. 34). Amsterdam: John Benjamins.

Ota, Mitsuhiko. 2015. L1 Phonology: Phonological Development. In Haruo Kubozono (ed.), *Handbook of Japanese Phonetics and Phonology*, 681–717. Berlin: Mouton de Gruyter.

Ota, Mitsuhiko & Isao Ueda. 2007. Speech Acquisition of Japanese. In Sharynne McLeod (ed.), *The International Guide to Speech Acquisition*, 457–471. Clifton Park, NY: Thomson Delmar Learning.

Otake, Takashi, Giyoo Hatano, Anne Cutler & Jacques Mehler. 1993. Mora or Syllable? Speech Segmentation in Japanese. *Journal of Memory and Language* 32. 258–278.

Otake, Takashi & Keiko Yamamoto. 2001. Nichi-Ei-Go Monoringaru Washa to Nichi-Ei-Go Bairingaru Washa Ni Yoru Meta Gengo Toshite No On'in Tan'i No Ninshiki (日英語モノリンガル話者と日英語バイリンガル話者によるメタ言語としての音韻単位の認識) [Phonological Awareness by Monolingual and Bilingual Speakers of Japanese and English]. *Onsei Kenkyu (音声研究) [Journal of the Phonetic Society of Japan]* 5(1). 107–116. https://doi.org/10.24467/onseikenkyu.5.1_107.

Paradis, Johanne. 2001. Do Bilingual Two-Year-Olds Have Separate Phonological Systems? *International Journal of Bilingualism* 5(1). 19–38. https://doi.org/10.1177/13670069010050010201.

Paradis, Johanne & Fred Genesee. 1996. Syntactic Acquisition in Bilingual Children: Autonomous or Interdependent? *Studies in Second Language Acquisition* 18(1). 1–25. https://doi.org/10.1017/S0272263100014662.

Parodi, Teresa. 1990. The Acquisition of Word Order Regularities and Case Morphology. In Jürgen M. Meisel (ed.), *Two First Languages: Early Grammatical Development in Bilingual Children*, 157–190. Dordrecht: Foris.

Piaget, Jean. 1955. *The Language and Thought of the Child*. New York: Meridian Books.

Piaget, Jean. 1971. *Biology and Knowledge: An Essay on the Relations Between Organic Regulations and Cognitive Processes*. Chicago: University of Chicago Press.

Pléh, Csaba, Alexandr Jarovinskij & Alexandr Balajan. 1987. Sentence Comprehension in Hungarian-Russian Bilingual and Monolingual Preschool Children. *Journal of Child Language* 14(3). 587–603. https://doi.org/10.1017/S0305000900010308.

Quay, Suzanne. 1995. The Bilingual Lexicon: Implications for Studies of Language Choice. *Journal of Child Language* 22(2). 369–387. https://doi.org/10.1017/S0305000900009831.

Queen, Robin M. 2001. Bilingual Intonation Patterns: Evidence of Language Change from Turkish-German Bilingual Children. *Language in Society* 30(1). 55–80. https://doi.org/10.1017/S0047404501001038.

Rose, Yvan. 2000. *Headness and Prosodic Licensing in the L1 Acquisition of Phonology*. Ph.D. Dissertation. McGill University.

Rose, Yvan. 2014. The Emergence of First Language Phonology: Perception, Articulation and Representation. In João Costa, Alexandra Fiéis, Maria João Freitas, Maria Lobo & Ana Lúcia Santos (eds.), *New Directions in the Acquisition of Romance Languages: Selected Proceedings of the Romance Turn V*, 35–61. Newcastle upon Tyne: Cambridge Scholars Publishing.

Rose, Yvan & Brian MacWhinney. 2014. The PhonBank Project: Data and Software-Assisted Methods for the Study of Phonology and Phonological Development. In Jacques Durand, Ulrike Gut & Gjert Kristoffersen (eds.), *The Oxford Handbook of Corpus Phonology*, 308-401. Oxford: Oxford University Press.

Rose, Yvan, Brian MacWhinney, Rodrigue Byrne, Gregory Hedlind, Keith Maddocks, Philip O'Brien & Todd Wareham. 2006. Introducing Phon: A Software Solution for the Study of Phonological Acquisition. In David Bamman, Tatiana Magnitskaia & Colleen Zaller (eds.), *Proceedings of the 30th Annual Boston University Conference on Language Development*, 489–500. Somerville, MA: Cascadilla Press.

Rose, Yvan & Natalie Penney. 2021. Language and Learner Specific Influences on the Emergence of Consonantal Place and Manner Features. *Frontiers in Psychology*.

Saito, Yoshio. 2018. *Nihongo Onseigaku Nyumon (*日本語音声学入門*) [Introduction to Japanese Phonetics]*. 14th edn. Tokyo: Sanseido.

Sakakibara, Maki. 2016. *Phonological Awareness Development in Bilingual Children*. Master's Thesis. Stockholms Universitet.

Santos, Christophe dos. 2007. *Développement Phonologique En Français Langue Maternelle*. Ph.D. Dissertation. Université Lumière Lyon 2.

Tsujimura, Natsuko. 1996. *An Introduction to Japanese Linguistics*. Cambridge: Blackwell Publishers.

Volterra, Virginia & Traute Taeschner. 1978. The Acquisition and Development of Language by Bilingual Children. *Journal of Child Language* 55. 311–26.

Yip, Virginia & Stephen Matthews. 2000. Syntactic Transfer in a Cantonese–English Bilingual Child. *Bilingualism: Language and Cognition* 3(3). 193–208. https://doi.org//10.1017/S136672890000033X.