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Los Angeles

Loanword accentuation in Japanese: Corpus study, modeling, and experiments

A dissertation submitted in partial satisfaction

of the requirements for the degree

Doctor of Philosophy in Linguistics

by

Hironori Katsuda

2023

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2023

ABSTRACT OF THE DISSERTATION

Loanword accentuation in Japanese: Corpus study, modeling, and experiments

by

Hironori Katsuda Doctor of Philosophy in Linguistics University of California, Los Angeles, 2023 Professor Sun-Ah Jun, Co-Chair Professor Bruce Hayes, Co-Chair

This dissertation presents a probabilistic model of loanword accentuation in Japanese, based on large-scale corpus data, and a pair of on-line adaptation experiments, in order to gain deeper understanding of the mechanism of assigning loanword accent in Japanese.

Contrary to previous work, which assigns loanword accent solely with markedness effects (i.e., language-internal principles), my corpus study (Chapter 2) reveals that faithfulness effects to English source words exist in established loanwords. Specifically, the stress pattern of English source words, as well as the epenthetic status of loanword syllables, play an important role in assigning loanword accent. These faithfulness effects are not random but systematically interact with markedness effects in a probabilistic way. My probabilistic modeling (Chapter 3), employing the Maximum Entropy Harmonic Grammar framework, shows that integrated models with both

markedness and faithfulness effects outperform markedness-only models, obtaining a description that achieves a compromise between the two.

My modeling also incorporates a novel proposal on the architecture of phonological grammar for loanword adaptation, motivated by the existence of accent patterns that cannot be accounted for by the interaction of faithfulness and markedness. I argue that Japanese speakers implicitly create a model of the English stress system, which I call the "Japanese Theory of English", and exhibit faithfulness to its outputs, even if they differ from the actual source words. Incorporating this module into the model captures the accent patterns that can be characterized as hyperforeignization, in the sense of Janda et al. (1994).

A pair of on-line loanword adaptation experiments (Chapter 4) were also conducted to test the faithfulness effects to stress and the interaction with markedness in experimental settings. The results confirmed the existence of faithfulness effects and the interaction with markedness in online adaptations, providing converging evidence that faithfulness and the interaction with markedness are part of the phonological grammar of Japanese speakers and form the basis of loanword accentuation in Japanese.

Overall, this dissertation supports the view that loanword accentuation in Japanese is determined by the competition among three factors: Japanese-internal markedness principles, faithfulness to source inputs, and faithfulness to Japanese speakers' theory of the English stress.

The dissertation of Hironori Katsuda is approved.

Claire Moore-Cantwell

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Bruce Hayes, Committee Co-Chair

University of California, Los Angeles

2023

For Mizuki

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CHAPTER 1

Introduction

1.1 Stating the problem

When native speakers of a language borrow a word from another language, they integrate the foreign word so as to conform to markedness principles that are active in the native language. For example, the English word *sky* [ska1] is integrated into Japanese as [sukai], where the loanword form employs the epenthetic vowel [ul] to resolve the initial consonant cluster, since such clusters are categorically disallowed in Japanese. Loanword phonology has long been pursued as a kind of natural laboratory because it provides opportunities to diagnose and explore effects that cannot be directly observed in native phonology (see e.g., Kenstowicz & Suchato, 2006, Kang, 2011).

Of course, within the limits of the well-formedness principles of speaker's native language, loanword adaptation tends to maximize faithfulness to the original form, as in the retention in unaltered form of all four of the original segments of [skaɪ]/[sukai]. Beyond this, borrowed forms also show some tendency actually to violate markedness principles active in the native language, introducing foreign sounds or sound sequences into the phonological structure of the borrowing language. For example, voiced geminates are not attested in native Japanese words, which is formalized as the markedness constraint called NoVOICEDGEM in Itô and Mester (1999), but possible in loanword forms when the English source word ends in a voiced obstruent after a lax vowel.

The principles of native language markedness and foreign language are often in dynamic conflict, leading to lexical variability or free variation. Thus, when native speakers of Japanese borrow a word such as *bag* [bæg] or *bad* [bæd], two variants are possible: the geminate can remain

voiced as they are in English (i.e., [baggul], [baddo]), with a cost in markedness or it can devoice to conform to the phonotactics of Japanese (i.e., [bakkul], [batto]), with a cost in faithfulness (Crawford, 2009).

As we look at a broader range of cases, we get a whole range of preferences. For example, the process of geminate devoicing is facilitated by another markedness effect, traditionally known as Lyman's Law (Lyman, 1894), which prohibits native Japanese words with more than one voiced obstruent. Consequently, loanwords with another voiced obstruent (e.g., [beddo]~[betto] 'bad') are more likely to undergo geminate devoicing, due to the cumulative effect of NoVOICEDGEM and Lyman's Law, than ones without another voiced obstruent (e.g., [heddo]~[hetto] 'head') (Nishimura, 2003; Kawahara, 2006; 2011a; 2011b).

As these examples demonstrate, the interaction of conflicting markedness and faithfulness principles often produces a probability distribution over potential output forms, which cannot be captured by categorical models, such as classical Optimality Theory (OT). Thus, loanword phonology is a potentially fertile area for the application of contemporary formal models that extend OT probabilistically, such as Maximum Entropy OT grammar (Smolensky, 1986; Goldwater & Johnson, 2003; Hayes & Wilson, 2008), as already shown by e.g., Zuraw et al. (2019) and Glewwe (2021). I will argue here that adopting such an approach can help us to engage with the data more closely and help us to detect and verify important effects that might otherwise have remained obscure.

This dissertation pursues this goal, focusing on one aspect of loanword phonology in Tokyo Japanese (henceforth "Japanese"), namely the assignment of accent (i.e., loanword accentuation). Examples are the integrations of the English words ['eidʒənt] 'agent' and [pəˈsɛnt] 'percent' as [é:ʒento] and [pa:sɛ́nto], respectively, where both assign an accent on the syllable that matches

stressed syllable in the source words. My goal is to employ a mixture of formal modeling, based on corpus data, and experimentation in order to achieve a better understanding of loanword accentuation in Japanese and that of the mechanisms of loanword phonology in general.

Earlier work on loanword accentuation in Japanese dates back to McCawley (1968), who initiated the debate by suggesting that most accented loanwords bear an accent on the syllable containing the antepenultimate mora (i.e., the "antepenultimate accent rule"), a hypothesis we will consider below. Since then, this area has been developed with the resources of traditional Generative Phonology (Poser, 1984; Haraguchi, 1991; Yoshida, 1995; Kubozono, 2002; 2006) and classical OT (Katayama, 1998; Shinohara 2000; 2004; Mutsukawa, 2005; 2006; Ito and Mester, 2016). Although loanword accentuation is arguably one of the best studied areas in Japanese phonology, I believe that there remain some unresolved issues both at the empirical and theoretical levels.

At the empirical level, researchers disagree on the way that Japanese speakers borrow certain phonological shapes, as well as the role of faithfulness to the stress pattern of the English source words; these will both be discussed extensively below. I believe that the empirical issues can be made less murky by use of a data corpus, scrutinized digitally. In this dissertation, suggestions by previous studies are checked against established loanwords in a large-scale corpus. Moreover, we can also get a clearer picture of the data by modeling it with a probabilistic framework, especially one that enables statistical testing. I here employ Maximum Entropy (MaxEnt) OT grammar (Smolensky, 1986; Goldwater & Johnson, 2003; Hayes & Wilson, 2008), which generates a probability distribution over candidates, rather than relying on a single derivational path. My MaxEnt modeling based on the corpus data reveals the multi-dimensional nature of loanword accentuation in Japanese, as well as the gradient intuition of Japanese speakers. Here is an example. In the existing literature, some researchers assign loanword accent solely with markedness constraints (i.e., language-internal principles) (Katayama, 1998; Ito and Mester, 2016), while others integrate various sorts of faithfulness effects into their models (Shinohara, 2000; 2004; Mutsukawa, 2005; 2006). It should be noted that these two types of models do not necessarily predict different outputs, because in theory what some consider to be faithfulness effects could be reanalyzed as markedness effects by others. For example, Mutsukawa (2005; 2006) argues that stress of the source word is faithfully preserved as a loanword accent when the stressed syllable corresponds to the pre-antepenultimate mora of the borrowed form (e.g., $[,p\Rightarrowse'nælti] \rightarrow [pa:sonáriti:]$ 'personality'), while Katayama (1998) attributes the same accent pattern to Japanese-internal markedness effects. With the combination of corpus study, MaxEnt OT modeling, and statistical testing, I demonstrate that loanword accents in Japanese cannot be reducible to the markedness effects alone; integrated models with both markedness and faithfulness effects significantly outperform markedness-only models.

These methods also motivate a novel proposal concerning the architecture of the phonological grammar regarding loanword adaptation. That is, I argue that Japanese speakers not only exhibit faithfulness to the stress pattern of an individual source word but also create a model of the English stress system, which represents an effort to project semi-predictable aspects of English phonology, in particular the pattern of stress on the basis of segmental form. I call this module the "Japanese Theory of English" (JTOE) and show that the existence of this module is supported by the existence of faithfulness to its outputs in loanword adaptation. These are cases that Janda et al. (1994) have characterized as "hyperforeignization". To give an example from my data, the English word *Seattle* /si'ætəl/ is integrated segmentally as [eiatoru] with either antepenultimate-mora accent (i.e., [eiátoru]). I attribute the former

to outright faithfulness to the source word, while the latter is an instance of hyperforeignization, based on faithfulness to the output of JTOE, namely ['siətəl]. The form predicted by JTOE are rational, since the majority of English words with the same phonological shape assign stress on the initial syllable (e.g., /'ænəməl/ 'animal', /'sɪləbəs/ 'syllabus').

Finally, some of the predictions made on basis of the MaxEnt OT modeling are tested with a pair of on-line adaptation experiments with English-based nonce words. Results of the experiments confirm both the existence of the faithfulness effects to stress and the interaction with markedness effects in on-line adaptations. The interaction suggests that even when source pronunciation is immediately available Japanese speakers do not *always* mimic the stress pattern of English. Rather, the faithfulness effects compete with Japanese-internal markedness effects – again, the outcome reflects a blend between conflicting factors. Overall, the results provide converging evidence that the interaction between faithfulness and markedness forms the basis of loanword accentuation in Japanese.

The remainder of this chapter provides background for the chapters that follow, summarizing the phonological and phonetic properties of pitch accent in Japanese (Section 1.2), the distinction between loanword adaptation and transmission (Section 1.3), theories of loanword adaptation (Section 1.4), and earlier research on loanword accentuation in Japanese (Section 1.5).

1.2 Pitch accent in Japanese

In Japanese, every word has at most one pitch accent (henceforth "accent"), generally realized as a prominent pitch fall. Unlike stress in stress accent languages, the accent in Japanese is not obligatory, i.e., words can be unaccented. If a word is accented, any mora in a word can bear the accent, except for the second mora of a heavy syllable. The latter types consist of a moraic nasal (e.g., [kaŋkoku] 'Korea'), the first element of a geminate consonant ([nippon] 'Japan'), and the second element of a long vowel or a diphthong ([t͡ʃuːgoku] 'China') (McCawley, 1968; Kubozono, 1993). As shown in the examples of (1), Japanese words can contrast both in the presence or absence of accent, e.g., [háʃi] vs. [haʃi] and in the location of accent, e.g., [háʃi] vs. [haʃi].

(1) A Minimal contrasting set for accent in Japanese

- [háʃi] (initial accent) 'chopsticks'
- [haſi] (final accent) 'bridge'
- [haſi] (unaccented) 'edge'

As these minimal pairs suggest, the accent of Japanese words has traditionally been considered to be unpredictable, at least for Native (Yamato) and Sino-Japanese (early loanwords from Chinese) nouns, and to be specified in the lexicon (e.g., the antepenultimate mora for [inotfi] 'life', the penultimate mora for [kokóro] 'heart', the ultimate mora for [atamá] 'head', and absent for [mijako] 'city') (McCawley, 1968; Poser, 1984). The accentual system of Japanese is sometimes referred to as a "n + 1 system", in which n + 1 contrasting patterns are possible for a word with n-syllable length (Haraguchi, 1999).

Phonetically, accent is primarily realized as a steep fall in fundamental frequency beginning near the end of the accented mora (Beckman & Pierrehumbert, 1986), or even in the following mora (Sugitō, 1982)¹. If a word is unaccented, it only carries phrasal prosody: a Low boundary tone associated with both phrase-initial and phrase-final syllables (i.e., %L and L%) plus a phrasal High tone (i.e., H-) associated with the second mora (Beckman & Pierrehumbert, 1986; Venditti,

¹ This phonetic property is reflected in accent perception of Japanese speakers, such that Japanese speakers perceive an accent on the mora if the following mora involves a fall in fundamental frequency (Sugito, 1982; Hasegawa & Hata, 1992).

1997). Unlike stress in English, which carries multiple acoustic cues, including fundamental frequency, duration, intensity, and vowel quality (e.g., Fry, 1955; 1958; Liberman, 1960; Beckman; 1986; Laver, 1994), accent in Japanese only involves fundamental frequency as the acoustic correlate (Weitzman, 1970; Sugito, 1982; Beckman, 1986).

Throughout this dissertation, I will adopt Ito and Mester's (2016) convention for marking the accentuation of a word. Thus, in addition to an acute accent mark, I will use a superscript number to indicate the location of the accented mora, with the mora being counted backward from the end of the word (e.g., ${}^{3}[inot]i]$ 'life', ${}^{2}[kokóro]$ 'heart', and ${}^{1}[atamá]$ 'head' have an accent on the antepenultimate mora, penultimate mora, and final mora, respectively). If the word is unaccented, the number "0" is assigned (e.g., ${}^{0}[miyako]$ "city"). Brackets [...] are used to indicate a prosodic word, and parentheses (...) are used to indicate a metrical foot, if necessary. To refer to phonological shapes, "L" and "H" are used to denote a light and a heavy syllable, respectively. Thus, ${}^{3}[(LL)H]$ indicates a prosodic word consisting of two light syllables forming a trochaic foot followed by an unfooted heavy syllable, with initial accent. Angle brackets <...> are used to indicate an epenthetic vowel; the examples given earlier would be notated as ${}^{2}[s<u>kái] 'sky'$, ${}^{3}[bágq<u>] 'bag', etc.$

To refer to accent patterns, I will always use the following terminology in Table 1.1. These accent patterns are based on the mora count. Following the convention in the literature, antepenultimate-mora accent is considered as the default accent pattern and thus prioritized over other accent patterns. That is, when the accent location is ambiguous between antepenultimate-mora accent accent (e.g., ³[LLHL]) or pre-antepenultimate-mora accent (e.g., ⁴[LHL]), by virtue of the fact that the second mora of a heavy syllable cannot bear an accent, it is considered as antepenultimate-mora accent. In other ambiguous cases, the accent pattern closer

to antepenultimate-mora accent is adopted. For example, the accent location ambiguous between ultimate-mora accent and penultimate-mora accent (e.g., 2 [LLLH]) is treated as penultimate-mora accent, while that ambiguous between pre-antepenultimate-mora accent and pro-pre-antepenultimate-mora accent (e.g., 5 [HLLL]) is treated as pre-antepenultimate-mora accent.

Accent pattern	LLLLL	LLLH	LLHL	LHLL	HLLL
Ultimate-mora accent	¹ [LLLLĹ]		¹ [LLHĹ]	¹ [LHLĹ]	¹ [HLLĹ]
Penultimate-mora accent	² [LLLĹL]	² [LLLĤ]		² [LHĹL]	² [HLĹL]
Antepenultimate-mora accent	³ [LLĹLL]	³ [LLĹH]	³ [LLH́L]	⁴ [LĤLL]	³ [HĹLL]
Pre-antepenultimate-mora accent	⁴ [LĹLLL]	⁴ [LĹLH]	⁴[LĹHL]		⁵ [HLLL]
Pro-pre-antepenultimate-mora accent	⁵ [ĹLLLL]	⁵ [ĹLLH]	⁵ [ĹLHL]	⁵ [ĹHLL]	

Table 1.1: Terminology concerning accent patterns.

1.3 Loanword adaptation and transmission

The literature on loanword phonology traditionally distinguishes two stages of the borrowing process: loanword adaptation and loanword transmission. The former indicates the initial adaptation of a foreign word by an individual speaker while the latter can be defined as the subsequent transmission of the adapted form to the rest of the speech community (Crawford, 2009). As these definitions suggest, loanword adaptation involves adapters' exposure to some sort of source language input (oral or written) while the inputs for loanword transmission are already adapted (i.e., nativized) forms.

While it is no doubt that a foreign word undergoes a certain degree of nativization through loanword adaptation, it is generally assumed that the transmission process makes the adapted word even more nativized (Poplack & Sankoff, 1984; Poplack et al., 1988; Davidson, 2007; Crawford, 2009). This is a rationale for distinguishing two types of loanwords, such as *nonce borrowings* vs. *widespread borrowings* in Poplack et al. (1988), *on-line loans* vs. *integrated loans* in Kenstowicz and Suchato (2006) and *on-line adaptations* vs. *established loanwords* in Kang (2010; 2011). Roughly speaking, the former of each pair indicates loanword forms that undergo loanword adaptation only, while the latter indicates ones that undergo both loanword adaptation and transmission. In this dissertation, I call them on-line adaptations and established loanwords, following Kang.

What might be the mechanism whereby established loanwords are nativized more than online adaptations? Several possibilities can be considered. First, during the transmission from speaker to speaker, one might develop a tacit sense that use of the loanword is *permissible* when speaking their native language. This change of the etymological status in the lexicon makes the word subject to weaker faithfulness effects or stronger markedness effects, facilitating nativization. Second, as Crawford (2009) suggests, nativization can occur during the transmission due to cumulative perception and production biases of native speakers. That is, the likelihood of misperception or misproduction toward more nativized forms increases as the number of speakers involved in the transmission process increases. Finally, it is also conceivable that monolinguals, who are likely to learn loanwords solely through transmission, are responsible for further nativization, as they might have a more conservative phonological system with stronger markedness effects.

While identifying the exact mechanism of the nativization during transmission is beyond the scope of this dissertation, it is crucial to note that, in any of the potential nativization mechanisms mentioned above, lexical frequency of loanwords would serve as an indicator of the degree of nativization. In fact, the correlation between the lexical frequency and the degree of nativization is observed in the context of geminate devoicing mentioned above: Kawahara (2011b) showed that lexical frequency of loanwords as Japanese words correlates with the naturalness rating of

devoiced (i.e., more native-like) outputs (e.g., [bakku] 'bag' is more natural than the less frequent [butta] 'Buddha').

Another factor that might influence the nativization of established loanwords is the accessibility of source word inputs. As Crawford (2009) suggests, adaptation of the same source word can occur multiple times, interfering with nativization through transmission. As it is reasonable to expect that source words with greater frequency are adapted more frequently than ones with lower frequency, the lexical frequency of source words in the source language can be utilized as a proxy for this anti-nativization effect.

I believe that some of the disagreements in the literature on Japanese loanword accentuation is due to the lack of explicit distinction between the adaptation and transmission processes. In this dissertation, I explicitly recognize the distinction between the two processes and acknowledge that the corpus data I analyze consist of established loanwords, which are supposed to vary in the degree of nativization. Thus, to assess the degree of (anti-)nativization, I integrate the lexical frequency of the loanwords and that of the corresponding source words into the model. While these frequency effects are not part of speakers' grammatical knowledge, controlling these extragrammatical factors by integrating them into the model allows us to obtain a deeper understanding of the grammatical knowledge regarding loanword adaptation as well as the mechanism of loanword transmission. Finally, I will compare the predictions of the model with the results of online adaptation experiments, which reflect the adaptation stage only, in order to check whether and how model's predictions are supported by the experimental results.

1.4 Theories of loanword adaptation

There has been an ongoing debate on the mechanism of loanword adaptation. There are at least three types of approaches identified in the literature.

1.4.1 Production-only approach

Some researchers argue that loanword adaptation is implemented by the production grammar of the borrowing language and thus phonological in nature (Hyman, 1970; Paradis & LaCharité, 1997; 2008; Jacobs & Gussenhoven, 2000; LaCharité & Paradis, 2005; Paradis and Tremblay, 2009). This so-called production-only approach assumes that loan adapters are usually sophisticated bilinguals, who can retrieve the underlying representation of the source word as the input of the adaptation. Crucially, this approach argues that all adaptation takes place in the production grammar of the borrowing language while perception plays little or no role.

An example of the production-only approach is Paradis and Tremblay's (2009) work on the adaptation of English words into Mandarin Chinese. Paradis and Tremblay show that aspiration, which is purely sub-phonemic in English, plays little role in determining the phonological category of adapted sounds. Specifically, English voiced (unaspirated) stops are adapted as unaspirated voiceless stops, as shown in (2a) and English voiceless stops are *always* adapted as aspirated stops, regardless of the presence or absence of aspiration, as shown in (2b) and (2c), respectively. Paradis and Tremblay attribute this insensitivity to the sub-phonemic details to the preservation of the underlying category in the English phonological system by bilingual speakers.

- (2) Adaptation of English words into Mandarin Chinese (Paradis and Tremblay, 2009)
 - a. Voiced (unaspirated): English: ['boin] 'Boeing' \rightarrow Mandarin Chinese: [pain]
 - b. Voiceless aspirated: English: [' p^h itsə] 'pizza' \rightarrow Mandarin Chinese: [p^h itsa]/[p^h isa]
 - c. Voiceless unaspirated: English: ['hɪpiz] 'hippies' \rightarrow Mandarin Chinese: [sip^hiş]

However, there is a crucial problem for this approach. That is, the patterns observed in loanword adaptation often conflict with those attested in native phonology. First, there exist loanword-specific repair strategies that are rarely adopted in the native phonology, called 'divergent repair' in Kenstowicz (2005) and 'ranking reversal' in Broselow (2009). For example, in Korean, where [s] is not allowed in coda positions, an underlying /s/ in coda position is realized as [t] in the native phonology while it is repaired by epenthesis in loanword adaptation, as shown in (3a) and (3b), respectively (Kenstowicz & Sohn, 2001).

- (3) Native alternation and loanword adaptation in Korean (Kenstowicz & Sohn, 2001)
 - a. /nas/ [nat] 'sickle-nom'

/nas + il/ [nasil] 'sickle-acc'

b. English: 'boss' \rightarrow Korean: [posi]

English: 'glass' → Korean: [kirasi]

Second, there are some cases in which loanword forms involve no marked structure in terms of the native phonology but nevertheless undergo repairs in loanword adaptation, called 'unnecessary adaptations' in Peperkamp (2005). English loanwords ending with a voiceless stop are often adapted with an epenthetic vowel in Korean, as shown in (4), although voiceless stops are allowed in coda position in Korean (Kang, 2003).

(4) Adaptation of English words into Korean (Kang, 2003)
English: 'bat' → Korean: [pæt^hi]
English: 'deck' → Korean: [tɛk^hi]
English: 'hip' → Korean: [hip^hi]

These cases throw the production-only approach into doubt, suggesting that the production grammar of the borrowing language cannot be a sole factor to account for the mechanism of loanword adaptation.

1.4.2 Perception-only approach

In response to the alleged drawbacks of the production-only approach, some researchers proposed that loanword adaptation is mostly attributable to borrowers' (mis)perception of foreign sounds (Peperkamp & Dupoux, 2002; 2003; Peperkamp, 2005; Peperkamp et al., 2008; Boersma & Hamann, 2009). That is, the adaptation of some foreign sounds is actually "heard" in the source signal during the phonetic decoding. In this so-called perception-only approach, loanword adaptation is implemented by monolinguals (as well as bilinguals), who map the acoustic signal of the source word onto the phonetically closest legal sounds of their native language during perception, the phenomenon known as "perceptual assimilation" (Best, 1994). Crucially, this

approach assumes that the production grammar of the borrowing language plays no role in loanword adaptation.

An example of the perception-only approach is found in Peperkamp et al.'s (2008) work on the adaptations of English and French words into Japanese. Peperkamp et al. focus on the asymmetry between English-derived loanwords and French-derived ones regarding the adaptation of word-final [n]: Japanese speakers adapt English word-final [n] as a moraic nasal consonant (e.g., 'pen' \rightarrow [pen]), while French word-final [n] as a nasal consonant followed by an epenthetic vowel (e.g., 'Cannes' [kan] \rightarrow [kann<u>]). Peperkamp et al. conducted a series of perception experiments and revealed that the asymmetry is due to the differences in the phonetic realization of word-final [n] in English and French. Specifically, French word-final [n] has a strong vocalic release that Japanese listeners perceive as their native vowel [u], while English word-final [n] lacks such a vocalic release.

While there is no doubt that perception plays an indispensable role in loanword adaptation, it has been generally agreed that perception alone cannot account for a wide variety of adaptation patterns observed in the data. Specifically, there are indeed some cases, where the production grammar of the native language as well as the phonological knowledge of the source language influences loanword adaptation, as the production-only approach argues.

1.4.3 Perceptual-similarity approach

Finally, yet other researchers adopt a richer approach, which assumes that both perceptual information and production grammar are responsible for loanword adaptation. This so-called perceptual-similarity approach comes in a variety of forms. Earlier work (e.g., Silverman, 1992; Yip, 1993; 2002; Kenstowicz, 2003) posits separate perception and production modules as the
architecture of loanword adaptation, while more recent work (Kang, 2003; Miao, 2005; Adler, 2006; Kenstowicz & Suchato, 2006) directly integrates the perceptual factors into the phonological grammar, characterizing the adaptation process as the maximization of perceptual similarity between the adapted form and the foreign input. The latter approach typically employs some sorts of loanword specific faithfulness constraints and interacts them with language-internal markedness constraints.

An example of the perceptual-similarity approach is Kang's (2003) work on English loanwords in Korean. Kang argues that vowel insertion after a word-final postvocalic stop in English loanwords is motivated by both perceptual factors and a morphophonemic restriction in Korean. An example of the perceptual factors is that vowel insertion occurs more frequently after a tense vowel than a lax vowel (e.g., *week* \rightarrow [wik^hi] but *quick* \rightarrow [k^hwik]). According to Kang, this is motivated by the facts that the former is more likely to be accompanied by a stop release in English and vowel insertion makes the Korean output perceptually closer to English released stops. Kang also argues that some cases of vowel insertion are motivated by the morphophonemic restriction in Korean. Specifically, Kang noted that vowel insertion is more likely after coronal stops (e.g., hit \rightarrow [hit^hi] but tip [t^hip]) and attributes it to a morphophonemic restriction against underlyingly /t/-final nouns in Korean.

Continuing in the line of the perceptual-similarity approach, Smith (2009) proposes a model which can accommodate orthographic borrowing as well as auditory borrowing. Smith (2006; 2009) pointed out that there are cases in which English words are adapted into Japanese with two distinct outputs, one with deletion repair and the other with epenthesis repair (e.g., [risurin] and [guriserin] from *glycerine*) and attributed the former to auditory borrowing, as in the perception-only approach, while the latter to the influence of orthography (notice the spelling pronunciation

of the penultimate vowel [e]). To capture these cases, Smith extends Correspondence Theory (McCarthy and Prince, 1995) to loanword-specific faithfulness relation, which Smith calls Source-to-Borrowing (SB) correspondence relation, assuming that the SB correspondence relation holds between the loanword forms and the borrower's posited representation of the source-language form.

Crucially, Smith assumes that the posited representation serves as a repository for all information the borrower has about the source form and may be shaped by multiple factors including perceptual information, orthographic information, and explicit knowledge of L2 grammar. Thus, in Smith's (2009) model, different types of repairs (e.g., deletion and epenthesis) results from different posited representations which come from different modes of borrowings. In the above-mentioned example, the posited representation for [risurin] (i.e., deletion repair) is assumed to be already faithful to the loanword form (i.e., |risurin|; the posited representation is enclosed by |...|), while that for [guriserin] (i.e., epenthesis repair) reflects the orthographic form (|griserin|). The epenthetic vowel of the latter is a result of ranking MAX-SB and *COMPONS above DEP-SB, as shown in Table 1.2.

/griserin/	MAX-SB	*COMPONS	DEP-SB	DEP-IO	MAX-IO	
griserin		1 1 1		1 1 1		
→ gu.ri.se.rin			*	*		
ri.se.rin	*!				*	
griserin		*!				

Table 1.2: Sample tableau illustrating how Smith (2009) analyzes an epenthesis repair (adapted from Smith, 2009, p. 8).

In this dissertation, I adopt the perceptual-similarity approach, as it is consistent with the central claim of this dissertation: loanword accentuation in Japanese is determined by the interaction of perceptual factors, which are formalized as loanword-specific faithfulness

constraints, and Japanese-internal markedness principles, which are formalized as markedness constraints. Furthermore, following the line of Smith's (2009) work, I introduce a novel module on the architecture of the phonological grammar regarding loanword adaptation. That is, I suggest that Japanese speakers not only exhibit faithfulness to the stress pattern of an individual source word but also create a model of the English stress system. I call this module the "Japanese Theory of English" (JTOE) and show that the existence of this module is supported by the existence of faithfulness to its outputs in loanword adaptation.

1.5 Earlier work on loanword accentuation in Japanese

Unlike the Native and Sino-Japanese nouns, whose accentuation is considered largely unpredictable, a higher degree of predictability has long been recognized for the loanword vocabulary. This section summarizes the basic accent patterns that can be predicted based on phonological shapes (i.e., markedness effects) and the role of faithfulness effects to source words discussed in the literature.

1.5.1 Accent patterns based on markedness

The literature agrees that many loanwords follow the antepenultimate-mora accent rule, which states that most accented loanwords bear an accent on the syllable containing the antepenultimate mora (e.g., ³[k<u>ris<ú>mas<u>] 'Christmas', ³[purog<ú>ram<u>] 'program') (McCawley, 1968). According to Kubozono's (2006) survey, 96% of the 722 trimoraic loanwords (i.e., words consisting of LLL, HL, or LH phonological shapes) bear antepenultimate-mora accent (e.g., ³[bánana], ³[pánda], ³[íran]). Regarding the origin of antepenultimate-mora accent, Shinohara (2000; 2004) attributed it to Universal Grammar, while Kubozono (2006) argued that it comes from the tendency that accented words in the Native and Sino-Japanese vocabulary tend to bear

antepenultimate-mora accent. In addition to this traditional accent, there are two other accent patterns discussed in the literature.

First, Katayama (1998) and Kubozono (2002; 2006) noted a deviation from antepenultimatemora accent for some phonological shapes. Specifically, the majority of the loanwords that end with a sequence of LH syllables bear an accent on the syllable containing the pre-antepenultimate mora (e.g., ⁴[dók<uu>ta:] 'doctor', ⁵[bé:kari:] 'bakery'), not on that containing the antepenultimate mora (e.g., *³[dok<uu>ta:] and *³[be:kári:]). Kubozono (2002; 2006) attributed the emergence of so-called "pre-antepenultimate-mora accent" to a diachronic shift in the phonological grammar from the antepenultimate-mora accent rule (i.e., ³[LĹH], ³[HĹH]) to a rule equivalent to the Latin stress rule (Hayes, 1995): the penultimate syllable is accented if it is heavy, while the antepenultimate syllable is accented otherwise (i.e., ⁴[ĹLH], ⁵[ĤLH]). In fact, Katayama's (1998) experiment confirmed that pre-antepenultimate-mora accent is productive for the LLH and HLH shapes. However, neither Katayama nor Kubozono explicitly discussed how this accent pattern emerged, except that Katayama stated that pre-antepenultimate-mora accent probably originates from the borrowing of English words.

Ito and Mester (2016) proposed a classical OT model, which only partially integrates preantepenultimate-mora accent discussed in the literature; the model predicts pre-antepenultimatemora accent only for loanwords ending with a sequence of LLH syllables (e.g., ⁴[ĹLH], ⁴[LĹLH]), while ones ending with a sequence of HLH syllables are predicted to bear antepenultimate-mora accent (e.g., ³[HĹH], ³[LHĹH]). This is because, in Ito & Mester's constraint hierarchy, having two consecutive unparsed syllables (i.e., violating NOLAPSE) (e.g., ⁵[(Ĥ)LH]) is more marked than having a unitary foot (i.e., violating FOOTBINARITY) (e.g., ³[(H)(Ĺ)H]) (i.e., NOLAPSE >> FOOTBINARITY).

Second, Kubozono (2006) observed that four-mora loanwords that end with a sequence of two light syllables (i.e., LLLL, HLL) tend to be unaccented (e.g., ⁰[amerika] 'America', ⁰[katarog<u>] 'catalog'). According to Kubozono's survey, 54% of LLLL words and 45% of HLL words are unaccented. Kubozono attributes the unaccented pattern to the already existing tendency that fourmora Native and Sino-Japanese words tend to be unaccented. Kubozono further noted that loanwords with the four-mora unaccented shapes (i.e., LLLL and HLL) become accented when the word-final syllable is epenthetic (e.g., ⁴[ák<u>ses<u>] 'access', ⁴[mánmos<u>] 'mammoth'). In fact, only 32% of loanwords are unaccented if only ones with a final epenthetic syllable (i.e., LLL<L>, HL<L>) are considered, while 90% of loanwords are unaccented if only ones with a final full syllable (i.e., LLLL, HLL) are considered. Kubozono attributes this to the incomplete status of a syllable containing an epenthetic vowel, arguing that a word-final epenthetic vowel constitutes a heavy syllable with the preceding light syllable (i.e., [LLL < L>] and [HL < L>] are treated as [LLH] and [HH], respectively) and that the accented status of such loanwords is due to the tendency of heavy syllables to attract an accent, though not necessarily to the syllable in question.

As we will see in Chapter 3, the key aspect of Ito and Mester's OT model is the emergence of the unaccented pattern as the least marked candidate. Roughly speaking, four-mora loanwords ending with a sequence of two light syllables become unaccented since any accented patterns for those shapes are more marked: bearing pre-antepenultimate-mora accent would violate NOLAPSE (i.e., ${}^{4}[(\acute{L}L)LL])$) or have another foot following the head foot (i.e., the one including an accented syllable), violating RIGHTMOST (i.e., ${}^{4}[(\acute{L}L)(LL)])$, bearing antepenultimate-mora accent would leave the word-initial syllable unparsed, violating INITIALFOOT (i.e., ${}^{3}[L(\acute{L}L)L])$, and assigning an accent on the penultimate syllable would parse the word-final syllable into the head foot, violating

NONFINALITY(FT') (i.e., ²[(LL)(LL)]). Ito and Mester's model produces the unaccented pattern by ranking the constraints penalizing these marked accents (i.e., NOLAPSE, RIGHTMOST, INITIALFOOT, NONFINALITY(FT')) above the one penalizing unaccented candidates (i.e., WORDACCENT).

However, Ito and Mester's model has two issues. First, it does not capture the difference that Kubozono (2006) noted between four-mora loanwords ending with a full syllable (i.e., tend to be unaccented) and ones ending with an epenthetic syllable (i.e., tend to be accented). This is simply because the model does not refer to any contrasts based on source inputs. Second, the model predicts the unaccented pattern not only for the four-mora shapes (i.e., LLLL and HLL) but also for shapes longer than four moras if they end with a sequence of HLL syllables (e.g., LHLL, HHLL). This prediction is not consistent with Kubozono's description that only four-mora words tend to be unaccented.

1.5.2 Accent patterns based on faithfulness

In addition to the predictability based on the phonological shape, researchers have discussed the possibility that some of the accent patterns can be explained by some sorts of faithfulness effects to source inputs. There are two such faithfulness effects discussed in the literature.

First, it is widely acknowledged that Japanese speakers sometimes mimic the main prominence (e.g., primary stress in English) of source words in loanword accentuation (e.g., ⁵[ák<u>sent<o>] 'áccent', ¹[fondyú] 'fondúe' (French)) (Martin, 1952; Shinohara, 2000; Mutsukawa, 2005; 2006; Kubozono, 2006; Ito & Mester, 2016). However, such faithful accents have generally been considered marginal to the phonological grammar and not been subject to serious investigation. For example, Kubozono (2006) argues that while the tendency of English loanwords to be accented (as opposed to unaccented) comes from Japanese speakers' knowledge that English words are pronounced with a pitch fall in isolation, the location of the accent is determined by the native phonological grammar. Also, some of the existing classical OT models, such as Katayama's (1998) model and Ito & Mester's (2016) model, do not integrate the faithfulness effects to stress.

One notable exception is Mutsukawa's (2005; 2006) classical OT model, which interacts faithfulness effects to stress with markedness effects. Mutsukawa assumes that prosodic words are exhaustively parsed into feet from right to left based on moras (e.g., $[...\mu(\mu\mu)(\mu\mu)]$), and argues that the English-based faithful accent is preserved when the accent falls within the penultimate foot (i.e., the pre-antepenultimate mora or antepenultimate mora) (e.g., [p3:sə'næliti] \rightarrow ⁴[pa(aso)(nári)(ti:)] 'personality') while it is shifted to the antepenultimate mora otherwise (e.g., $[d_{3}-n_{1}] \rightarrow [(jaa)(nari)(z < w > m < w >)]$ 'jóurnalism'). Crucially, Mutsukawa's model attributes pre-antepenultimate-mora accent for loanwords ending with the LLH syllables (e.g., ⁴[pa(aso)(nári)(ti:)] 'personality') to the faithfulness effects to stress. However, it should be noted that Mutsukawa's model cannot predict the same accent pattern for ones ending with the HLH syllables, because Mutsukawa assumes that a prosodic word is parsed into feet from right to left, independent of the syllable structure. As a result, the first mora of the antepenultimate heavy syllable, which is supposed to bear an accent, is outside the penultimate foot. (i.e., $[...HLH] \rightarrow$ $[\dots \mu(\mu\mu)(\mu\mu)]$). This asymmetry between loanwords ending with LLH and ones ending with HLH is inconsistent with the description in Katayama (1998) and Kubozono (2006).

Another study worth mentioning here is Shinohara's (2000) experimental work on Japanese speakers' on-line adaptation of English words. Based on on-line adaptations of 200 real English words elicited from three Japanese speakers, Shinohara argued that the primary stress of English words is generally preserved as accent in on-line adaptation (e.g., ['pik,nik] \rightarrow ⁵[pik<u>nikk<u>]

'picnic'). This finding is surprising, given that the literature typically assumes little faithfulness in established loanwords and that on-line adaptations are expected to be somehow similar to established loanwords (despite their difference in the degree of nativization).

Second, it is also known that epenthetic syllables tend to avoid bearing an accent (Kubozono, 2006; See Shinohara, 2000; 2004 for adaptation of French words). Kubozono (2006) noted that almost all loanwords with the LH shape bear final accent when the initial syllable is epenthetic (e.g., ${}^{2}[p<u>ré:]$ 'play', ${}^{2}[b<u>rú:]$ 'blue'). Kubozono argues that this phenomenon cannot be attributed solely to the general tendency that epenthetic syllables avoid bearing an accent, because an epenthetic syllable can bear an accent when it is followed by light syllables (e.g., ${}^{3}[p<\acute{u}>ras<u>]$ 'plus', ${}^{3}[g<\acute{u}>ras<u>]$ 'glass'). This led Kubozono to argue that the final accent for <L>H loanwords is caused by a cumulative effect of two factors: the tendency of an epenthetic syllable to avoid bearing an accent and that of a heavy syllable to bear an accent (i.e., Weight-to-Stress principle: all heavy syllables are accented).

1.5.3 Summary

The summary of the literature showed that researchers disagree on the dominant accent patterns of some phonological shapes and the role of faithfulness to source inputs.

There are two disagreements regarding the former. First, while Katayama's classical OT model (1998) and Kubozono's description (2006) agree that loanwords ending with a sequence of LH syllables bear pre-antepenultimate-mora accent (e.g., ⁴[ĹLH], ⁵[ĤLH]), Ito and Mester's (2016) classical OT model predicts the same accent pattern only for words ending with a sequence of LLH syllables (e.g., ⁴[ĹLH], ⁴[LĹLH]). Second, while Kubozono (2006) argues that four-mora loanwords ending with a sequence of two light syllables (i.e., [LLLL] and [HLL]) tend to be

unaccented, Ito and Mester's (2016) OT model extends the unaccented pattern to longer loanwords ending with a sequence of HLL syllables (e.g., [LHLL], [HHLL]). As we will see below, my corpus data show that loanwords ending with a sequence of LH syllables typically bear preantepenultimate mora accent, regardless of the weight of the antepenultimate syllable (i.e., ⁴[...ĹLH], ⁵[...ĤLH]), and only four-mora loanwords ending with a sequence of two light syllables tend to be unaccented (i.e., ⁰[LLLL], ⁰[HLL]).

Regarding the role of faithfulness to source inputs, some researchers adopt the markednessonly approach, considering the faithfulness effects to source inputs to be negligible, while others argue that the faithfulness effects play at least some role in the phonological grammar regarding loanword accentuation. Specifically, Katayama's (1998) model and Ito and Mester's model (2016) dispense with faithfulness effects, while Mutsukawa's model interacts faithfulness effects with markedness effects, to determine loanword accentuation. Furthermore, while the data come from on-line adaptations (not established loanwords), Shinohara (2000) argues that primary stress in English source words is generally preserved as accent in loan adaptation. As for the effects of epenthetic syllables, the only description is in Kubozono (2006), who noted that they tend to avoid bearing an accent in the <L>H loanwords.

In sum, the literature shows substantial disagreement on the following three issues: the distribution of pre-antepenultimate-mora accent, that of the unaccented pattern, and the role of faithfulness to source inputs. In the following chapter, I attempt to help resolves these and other questions with the combined methodology of corpus study, MaxEnt modeling, and statistical testing.

CHAPTER 2

Descriptive analysis of the corpus data

2.1 Introduction

In this chapter, I will present a descriptive analysis of a set of corpus data covering the accentuation of loanwords in Japanese. The purpose of this chapter is to provide the basic empirical generalizations, which I will attempt to model in Chapter 3. It should be noted that the descriptive analysis in this chapter involves no statistical evaluation; statistical analyses are conducted as I create probabilistic models in Chapter 3.

I will first provide a description of the corpus in Section 2.2. Section 2.3 provides the distribution of accent patterns for each phonological shape. Section 2.4 presents the data split by some of the contrasts based on source inputs (i.e., stress and epenthetic syllables), in order to check whether and how much they influence accent patterns. Section 2.5 summarizes the chapter.

2.2 Data

All loanwords were manually extracted from *The NHK Pronunciation and Accent Dictionary* (2016) and recorded for their phonological shapes and accent patterns. In cases where more than one accent pattern was listed for a single loanword, the accentual variants were treated as independent loanwords. Subsequently, many of the loanwords were excluded based on the following criteria. First, to focus on morphologically simple words, compound-like words, (e.g., ³[eabágg<u>] 'air bag', ³[wo:m<u>ápp<u>] 'warm-up'), truncated words (e.g., ⁰[ameфut<o>] 'American football', ⁰[iras<u>t<o>] 'illustration'), and acronyms (e.g., ²[e:ti:ém<u>] 'ATM', ²[pi:ke:ó:] 'PKO') were excluded. Second, loanwords whose source words are inflected (e.g.,

⁵[$\delta pping < w$] 'shopping', ⁴[$\delta kk < w > s < w$] 'socks') or involve a productive affix (e.g., ⁰[pi:ra:] 'peeler', ³[taipís<u>t<o>] 'typist'), based on the English Phonology Search (Haves, 2011), were excluded, as they might exhibit specific accent patterns, going beyond the scope of this inquiry. Third, to only include loanwords borrowed from English, loanwords whose source words are not listed in the Carnegie Mellon University (CMU) Pronouncing Dictionary (Weide, 1994) or in the Subtlex Corpus (Brysbaert & New, 2009) were excluded. Fourth, loanwords whose source words involve a glide which is adapted into Japanese as a high vowel (e.g., ³[iéro:] 'yellow', ⁰[azeria] 'azalea') were excluded, because the status of such adapted syllables is not clear (i.e., epenthetic or unstressed). Fifth, loanwords involving super-heavy syllables (i.e., VVN) (e.g., ³[ráin] 'line', ⁴[\$\phiaundé:[on] 'foundation') were excluded, because no consensus has been reached on how to treat such syllables in Japanese accentuation. Sixth, loanwords whose source words have two possible stress patterns (e.g., ['ım pæk<u>t<o>]~[ım'pæk<u>t<o>] 'impact' (noun vs. verb)), based on the English Phonology Search, were excluded, since it is not clear from which stress variant the corresponding loanword is derived. Finally, to maintain a simple enough grammar to be computationally checkable, loanwords longer than four syllables were excluded (such loanwords are often compound-like anyway). A total of 3,024 words was obtained for the corpus data.

Subsequently, types of English source syllables – primary stressed, unstressed, or epenthetic² (secondary stressed syllables were coded as unstressed) – were annotated for corresponding loanword syllables, based on the CMU Pronouncing Dictionary and the English Phonology Search (when they disagree, the syllable types based on the latter was coded). In addition, I make another category based on markedness effects in Japanese. It is well-known that in Japanese high vowels

² In Japanese, the default epenthetic vowel is [ui]. [i] appears after palate-alveolar affricates, $[t\hat{j}, d\hat{z}]$, in source words. [o] appears after alveolar stops [t, d] (Shoji & Shoji, 2014).

/i, u/ devoice between voiceless consonants (e.g., sika [eika] 'deer') or after a voiceless consonant word-finally (e.g., wasi [waei] 'hawk') (McCawley, 1968), and the traditional description says that syllables with a devoiced vowel tend to avoid bearing an accent (McCawley, 1977; Haraguchi, 1991; Tsuchida, 1997). Accordingly, I coded epenthetic syllables with a high vowel (i.e., <i> or <u>) as devoiced if the vowel occurs between voiceless consonants (e.g., ²[s<u>pín] 'spin'). The reason why I focus on the former environment (i.e., between voiceless consonants) and ignore the latter environment (i.e., after a voiceless consonant word-finally) is because whether the wordfinal vowel is devoiced or not has little influence on the accentuation. The reason why I focus on vowel devoicing of epenthetic vowels and ignore that of non-epenthetic (full) vowels is because the latter cases are rare in the corpus data.

2.3 Accent patterns in the corpus data

In this section I provide the distribution of accent patterns for each phonological shape, that is observed in the corpus data. Since the purpose of this section is to give readers a sense of how accent patterns are distributed based on markedness effects, contrasts based on source inputs (i.e., stress and epenthetic syllables) are not reflected on the figures that follow in this section.

Figure 1 shows the distributions of accent patterns for one- to two-syllable words. The number of loanwords included in the data is shown next to the figure title. The accent patterns observed for these shapes are antepenultimate-mora accent (Ant), penultimate-mora accent (Pen), and the unaccented pattern (Un). Remember that the accent patterns are based on moras (see Section 1.2 for details).



Figure 2.1: Distributions of accent patterns for one- to two-syllable words.

The figure shows that these words mostly bear initial accent: penultimate-mora accent for two-mora words (e.g., 2 [pén] 'pen', 2 [bós<u>] 'boss') and antepenultimate-mora accent for threeand four-mora words (e.g., 3 [náit<o>] 'night', 3 [íran] 'Iran', 4 [pé:pa:] 'paper'). A notable exception is that some of the LH words bear penultimate-mora accent. As we will see later, those words mostly begin with an epenthetic syllable (e.g., 2 [b<u>rúı:] 'blue', 2 [d<o>ró:] 'draw').



Figure 2.2: Distributions of accent patterns for three-syllable words.

Figure 2.2 shows the distributions of accent patterns for three-syllable words. In addition to the three accent patterns observed in Figure 2.1, pre-antepenultimate-mora accent (Pre) is attested for some of the phonological shapes. This figure shows that the most frequent accent pattern for LLL, HLL, LHL, LHL, and HHH is antepenultimate-mora accent (e.g., ³[ĹLL]: ³[kánada] ^{(Canada', 4}[ĤLL]: ⁴[áitem<u>] ^{(item', 3}[LĤL]: ³[repó:t<o>] ^{(report', 4}[LĤH]: ⁴[baké:fon] ^{(vacation', 4}[HĤH]: ⁴[hambá:ga:] ^(hamburger'), while that for HHL, LLH, HLH is pre-antepenultimate-mora accent (e.g., ⁵[ĤHL]: ⁵[kónsa:t<o>] ^{(concert', 4}[ĹLH]: ⁴[ámazon] ^{(Amazon', 5}[ĤLH]: ⁵[há:moni:] ^(harmony'). Aside from the dominant patterns, there are two other accent patterns worth mentioning. First, some of the LHL words bear pre-antepenultimate-mora accent (e.g., ⁴[ĹHL]: ⁴[pánikk<u>] ^(panic'). Second, while the unaccented pattern is observed for most of the shapes (e.g., ⁰[LLL]: ⁰[moder<u>] ^{(model', ⁰[LLH]: ⁰[monita:] ^(monitor'), the proportion is larger for the HLL shape (e.g., ⁰[maiami] ^{(Miami', ⁰[o:dio] ^(audio')).}}



Figure 2.3: Distributions of accent patterns for four-syllable words ending with a light syllable.

Figure 2.3 shows the distributions of accent patterns for four-syllable words ending with a light syllable. In addition to the four accent patterns observed in Figure 2.2, pro-preantepenultimate-mora accent (Pro) is attested for some of the phonological shapes. The figure shows that the most frequent accent pattern for all the shapes except for LLLL is antepenultimatemora accent (e.g., ³[HLLL]: ³[indíana] 'Indiana', ⁴[LHLL]: ⁴[edínbara] 'Edinburgh', ³[HHLL]: ³[LLHL]: ³[tfokoré:t<o>] ⁴[konsénsas<u>] 'consensus', 'chocolate'. ³[HLHL]: ³[kont<o>ró:r<u>] 'control', ³[LHHL]: ³[p<u>raibé:t<o>] 'private', ³[HHHL]: ³[pa:senté:d₃<i>] 'percentage'), while that for LLLL is the unaccented pattern (e.g., ⁰[amerika] 'America', ⁰[abokado] 'avocado'). There are two other accent patterns worth mentioning. First, some of the loanwords with the LLLL, HLLL, or LHHL shapes bear pre-antepenultimate-mora accent (e.g., ⁴[ĹLLL]: ⁵[tá:minar<u>] ⁴[círabas<u>] 'syllabus', ⁵[HLLL]: 'terminal'. ⁵[LHHL]: ⁵[pa\u00f66]:mans<u>] 'performance'). Second, some of the loanwords with the LLHL or HLHL

shapes bear pro-pre-antepenultimate-mora accent (e.g., ⁵[ĹLHL]: ⁵[ébidens<w>] 'evidence', ⁶[ĤLHL]: ⁶[ɛíːk<w>rett<o>] 'secret').



Figure 2.4: Distributions of accent patterns for four-syllable words ending with a heavy syllable.

Figure 2.4 shows the distributions of accent patterns for four-syllable words ending with a heavy syllable. The figure shows that the most frequent accent pattern for loanwords ending with a sequence of LH syllables is pre-antepenultimate-mora accent (e.g., ⁴[LĹLH]: ⁴[sekjúriti:] 'security', ⁴[HĹLH]: ⁴[kompánion] 'companion', ⁵[LĤLH]: ⁵[p<u>ráibaei:] 'privacy', ⁵[HĤLH]: ⁵[aidéntiti:] 'identity'), while that for ones ending with a sequence of two heavy syllables is antepenultimate-mora accent (e.g., ⁴[LLĤH]: ⁴[indomé:fon] 'information', ⁴[LHĤH]: ⁴[p<u>ranté:fon] 'plantation'). Other than the dominant accent patterns, the former group of loanwords also bear antepenultimate-mora accent (e.g., ³[LLĹH]: ³[maik<u>ródon] 'microphone', ³[LHĹH]: ³[ako:díon] 'accordion', ³[HHĹH]: ³[inta:déron] 'interferon'). Furthermore, some of the LLLH words also bear pro-pre-antepenultimate-mora accent (e.g., ⁵[kjárak<u>ta:] 'character').

In sum, the corpus data show the following three basic observations. First, as the literature suggest, many loanwords bear antepenultimate-mora accent. Second, loanwords ending with a sequence of LH syllables most frequently bear pre-antepenultimate-mora accent, regardless of the weight of the antepenultimate syllable (i.e., ⁴[...ĹLH], ⁵[...ĤLH]), although they also bear antepenultimate-mora accent (i.e., ³[...LĹH], ³[...HĹH]). This is consistent with the description in Katayama (1998) and Kubozono (2006) but inconsistent with Ito and Mester's (2016) classical OT model, which predicts pre-antepenultimate-mora accent for loanwords ending with a sequence of LLH syllables (i.e., ⁴[...LH]) and antepenultimate-mora accent for ones ending with a sequence of HLH syllables (³[...HĹH]). Somewhat surprisingly, pre-antepenultimate-mora accent is more prevalent than the literature suggest: it is observed for the HHL, LLLL, HLLL, and LHHL shapes as well (in fact, it is the most frequent for the HHL words). Furthermore, even pro-preantepenultimate-mora accent is observed for the LLHL, HLHL, and LLLH shapes. Finally, as Kubozono (2006) suggests, four-mora loanwords ending with a sequence of two light syllables (i.e., LLLL and HLL) exhibit a stronger tendency to be unaccented, with a caveat that the data does not distinguish words ending with a full syllable and ones ending with an epenthetic syllable (Remember that Kubozono notes that they become accented if the final syllable is epenthetic). On the other hand, longer loanwords ending with the HLL syllables (i.e., LHLL and HHLL) are overwhelmingly accented, which is inconsistent with the predictions of Ito and Mester's model.

2.4 Faithfulness effects to source words

In this section, I will present the data split by some of the contrasts based on the source inputs (i.e., stress and epenthetic syllables), in order to check whether and how much they influence the accent patterns. I will focus on three types of effects: the effect of stress pattern (Section 2.4.1), that of

epenthetic syllables to avoid bearing an accent (Section 2.4.2), and that of final epenthetic syllables to make four-mora loanwords accented (Section 2.4.3).

2.4.1 Effect of stress pattern

Figure 2.5 shows distributions of accent patterns for the shapes that end with a light syllable and exhibit variation between antepenultimate-mora accent and one of the protracted accents (i.e., preantepenultimate-mora accent and pro-pre-antepenultimate-mora accent). Four of them (i.e., LHL, HHL, LHHL, and HLLL) exhibit the variation between antepenultimate-mora accent and preantepenultimate-mora accent (left panel) while the other two (i.e., LLHL and HLHL) exhibit that between antepenultimate-mora accent and pro-pre-antepenultimate-mora accent (right panel). Crucially, the data are split by the stress pattern of source words. For convenience, the stress pattern on the horizontal axis is labeled based on which accent pattern the stress pattern in the source word corresponds to. For the sake of simplicity, loanwords are included only when they bear either one of the relevant accent patterns (i.e., antepenultimate-mora accent or preantepenultimate-mora accent for the loanwords included in the left panel while antepenultimatemora accent or pro-pre-antepenultimate-mora accent for those included in the right panel) and their source words bear stress on one of the syllables corresponding to the relevant loanword syllables. Also, to avoid confounds, loanwords with one of the relevant syllables being epenthetic are excluded. This allows us to always contrast stressed and unstressed syllables (excluding epenthetic syllables).

The figure shows clear correlations between the stress pattern and the accent pattern, such that the accent is more likely on a loanword syllable that matches the stressed syllable in the English source word. For example, loanwords whose source words bear stress on the syllable corresponding to the loanword syllable containing the pre-antepenultimate mora (i.e., Pre on the horizontal axis) tend to bear pre-antepenultimate-mora accent (e.g., ['eid3ənt] \rightarrow ⁵[é:d3ent<o>] 'agent'), while ones whose source words bear stress on the syllable corresponding to the loanword syllable containing the antepenultimate mora (i.e., Ant on the horizontal axis) tend to bear antepenultimate-mora accent (e.g., [p σ 'sent] \rightarrow ³[pa:sént<o>] 'percent').



Figure 2.5: Distributions of accent patterns for the shapes ending with the HL syllables plus the HLLL shape split by stress pattern of source words.

The figure shows two further observations. First, the effect of stress pattern is not categorical. Specifically, some loanwords bear antepenultimate-mora accent when the stress pattern favors (pro-)pre-antepenultimate-mora accent (e.g., ['saiboig] \rightarrow [saibó:g<u>] 'cyborg'), while others bear (pro-)pre-antepenultimate-mora accent when the stress pattern favors antepenultimate-mora accent (e.g., ['cyborg'), while others accent (e.g., ['arcade'). Crucially, I argue that these two types of unfaithfulness accents are caused by two difference effects. The former is simply due to the interaction between faithfulness and markedness: the faithfulness effect to stress is overridden by the markedness effects. In contrast, I attribute the latter to Japanese speakers' implicit knowledge of the English stress system. That is, Japanese speakers create a synthetic input that favors (pro-)pre-antepenultimate-mora accent (see Section 3.3.6 for details).

Second, the effect of stress pattern seems interact with the phonological shape. Among the four shapes in the left panel of the figure, the LHL shape is, in general, the most reluctant to bear pre-antepenultimate-mora accent. I attribute this to markedness effects. Specifically, pre-antepenultimate-mora accent for LHL is disfavored because it violates FOOTBINARITY (i.e., 4[(L)HL])). This suggests that the accent patterns induced by the faithfulness effects to stress are not simply memorized as exceptions. Rather, the interaction of faithfulness and markedness produces a probability distribution of accent patterns.

Figure 2.6 shows distributions of accent patterns for the shapes ending with the LH syllables, split by the stress pattern of source words. These shapes bear pre-antepenultimate-mora accent according to Katayama (1998) and Kubozono (2006). In the corpus data, five out of six shapes (i.e., LLH, HLH, HLLH, LHLH, and HHLH) exhibit variation between antepenultimate-mora accent and pre-antepenultimate-mora accent, while the other shape (i.e., LLLH) exhibits that among antepenultimate-mora accent, pre-antepenultimate-mora accent, and pro-pre-antepenultimate-mora accent. As in Figure 2.5, loanwords are included only when they bear either one of the relevant accent patterns and their source words bear stress on one of the syllables corresponding to the relevant loanword syllables. Loanwords with one of the relevant syllables being epenthetic are excluded.

Again, the figure shows clear correlations between the stress pattern and the accent pattern. This suggests that pre-antepenultimate-mora accent for loanwords ending with the LH syllables is induced by the faithfulness effects to stress.



Figure 2.6: Distributions of accent patterns for the shapes ending with the LH syllables split by stress pattern of source words.

One might wonder how the effect of stress pattern interacts with different types of heavy syllables (i.e., gradient weight): vowel plus geminate coda (G), vowel plus nasal coda (N), and long vowel or diphthong. In examining this, I focus on the penultimate syllable of the loanwords ending with the HL syllables (i.e., LHL, HHL, LHHL, LLHL, and HLHL). This is motivated by the assumption that the weight of penultimate syllable plays a crucial role in determining accent patterns in a system roughly equivalent to the Latin stress rule. Before examining the interaction between stress pattern and gradient weight, I will first focus on the sole effect of gradient weight, ignoring the effect of stress pattern. Figure 2.7 shows the distributions of accent pattern split by gradient weight of the penultimate syllable. The data are identical to those for Figure 2.5, except that the HLLL shape, whose penultimate syllable is not heavy, is removed. The figure shows a clear contrast between G and V, such that V attracts more accent than G. One exception is the LHHL shape, where there is no clear difference between the two types of heavy syllables. However,

since the number of loanwords with this phonological shape is quite small (n = 22), I ignore this exception. In contrast, the effect of N is uncertain: it generally attracts less accent than V, but whether it attracts more accent or less accent than G depends on the phonological shape.



Figure 2.7: Distributions of accent patterns for the shapes ending with the HL syllables split by gradient weight of the penultimate syllable.

Now, I check how the stress pattern interacts with the gradient weight. To observe this, Figure 2.8 presents the data for Figure 2.7 collapsed across phonological shapes and divided by the stress pattern. The figure shows two important observations. First, the effect of stress pattern is present within the same weight category, suggesting that these two effects are generally independent. Second, there is an interaction between the stress pattern and the syllable weight, such that the effect of stress is stronger in N than in G and V. Specifically, N attracts more accent than G when the syllable is stressed while N attracts less accent than G when the syllable is not stressed.



Figure 2.8: Distributions of accent patterns for the shapes ending with the HL syllables split by gradient weight of the penultimate syllable and stress pattern.

2.4.2 Effect of epenthetic syllables to avoid bearing an accent

Kubozono (2006) argues that loanwords consisting of the LH syllables almost always bear the final accent if the initial syllable is epenthetic (i.e., ${}^{2}[<L>\dot{H}]$). To check the effect of epenthetic syllables in the corpus, Figure 2.9 shows distributions of accent patterns for the LH, LLL, and LLH shapes, split by the status of the initial syllable (ST = stressed, US = unstressed, EP = epenthetic, VD = devoiced). The left panel shows variation between antepenultimate-mora accent and penultimate-mora accent for the LH and LLL shapes, while the right panel shows variation between pre-antepenultimate-mora accent and antepenultimate-mora accent for the LLH shape. Loanwords are included only when they bear either one of the relevant accent patterns and their source words bear stress on one of the syllables corresponding to the relevant loanword syllables. This means that when the initial syllable is not stress (i.e., US, EP, or VD), the second syllable is always stressed. Finally, loanwords consisting of the LLL syllables and ending with an epenthetic

syllable (i.e., [LL<L>]) are excluded because they almost always bear antepenultimate-mora accent even if the initial syllable is epenthetic (e.g., ${}^{3}[p<\dot{u}>ras<u>]$ 'plus', ${}^{3}[g<\dot{u}>ras<u>]$ 'glass').

The figure shows that the probabilities of antepenultimate-mora accent for LH and LLL (left) and that for pre-antepenultimate-mora accent for LLH (right) decrease as the initial syllable gets weaker (i.e., ST > US > EP > VD). This illustrates the following three observations: (a) the effect of stress pattern (i.e., stressed vs. unstressed) exists in these phonological shapes as well, (b) the effect of epenthetic syllables, on top of that of stress pattern, exists and is more general than Kubozono (2006) describes, and (c) the effect of vowel devoicing, on top of those of stress pattern and epenthetic syllables, exists.



Figure 2.9: Distributions of accent patterns for the LH, LLL, and LLH words, split by the status of the final syllable.

2.4.3 Effect of word-final epenthetic syllables to make four-mora loanwords accented

Kubozono (2006) argues that four-mora shapes ending with a sequence of two light syllables tend to be unaccented unless the word-final syllable is epenthetic. To check if this description is attested in the corpus data, distributions of the accent patterns for the four-mora shapes and the longer shapes that are predicted to be unaccented in Ito and Mester's (2016) model are shown in Figure 2.10. Crucially, the data are split by whether the word-final syllable is full (= Full) or epenthetic (= Epen).

The figure shows a clear correlation between word-final epenthetic syllable and the accented status of loanwords only for four-mora shapes (HLL and LLLL). In contrast, loanwords longer than four-moras (LHLL and HHLL) are generally accented, regardless of the status of word-final syllable. Overall, these observations are consistent with Kubozono's description and inconsistent with Ito and Mester's predictions.



Figure 2.10: Distributions of accent patterns for four-mora words ending with a sequence of two light syllables and longer loanwords ending with the HLL syllables, split by the status of the final syllable.

2.5 Summary

In this chapter, I provided the basic empirical generalizations of loanword accentuation in Japanese. Section 2.3 showed that loanwords typically bear antepenultimate-mora accent, except for the following two accent patterns. First, loanwords can bear pre-antepenultimate-mora accent or propre-antepenultimate-mora accent if they do not end with a sequence of two heavy syllables, which almost always bear antepenultimate-mora accent. This suggests that the protracted accents (i.e., pre-antepenultimate-mora accent and pro-pre-antepenultimate-mora accent) are more common than the literature suggests: they are observed not only for loanwords ending with the LH syllables (i.e., [...LH]) but also for other shapes ending with a light syllable (i.e., pre-antepenultimate-mora accent is observed for the LHL, HHL, LHHL, and HLLL shapes and pro-pre-antepenultimate-mora accent is observed for the LLHL and HLHL shapes). Second, as Kubozono (2006) argues, four-mora words ending with a sequence of two syllables (i.e., LLLL and HLL) tend to be more unaccented than other shapes. In contrast, longer loanwords ending with the HLL syllables (i.e., LHLL and HHLL) are overwhelmingly accented.

Section 2.4 shows that the variation between antepenultimate-mora accent and (pro-)preantepenultimate-mora accent is mostly induced by the stress pattern. In addition, the effect of gradient weight was also observed, in particular, between heavy syllables closed by a geminate coda (G) and ones consisting of a long vowel or a diphthong (V). The effect of heavy syllables closed by a nasal coda (N) was not as certain as those of the other two types: it seems to attract more accent than G when it is stressed while less accent than G when it is unstressed. The effect of epenthetic syllables to avoid bearing an accent is more general than Kubozono (2006) describes: it is observed not only in the LH shape but also in the LLL and LLH shapes. Furthermore, the effect of vowel devoicing was also observed for the same shapes. Finally, as Kubozono (2006) notes, four-mora loanwords ending with a sequence of two light syllables tend to be accented when they end with an epenthetic syllable.

In Chapter 3, I will create probabilistic models to capture these basic empirical generalizations.

CHAPTER 3

Modeling Japanese loanword accentuation

3.1 Introduction

In this chapter, I will describe probabilistic models intended to capture the basic empirical generalizations put forth in Chapter 2. In doing so, I will try to answer the following five research questions shown in (5).

- (5) Research questions
 - a. To check how Ito and Mester's (2016) classical OT model, the most comprehensive of the existing models, works against my corpus data
 - b. To check the effects of markedness principles that are described in the literature or observed in my corpus data, but not integrated into Ito and Mester's model
 - c. To test whether and how faithfulness effects to English source words influence loanword accentuation
 - d. To test whether and how lexical frequency of English source words and that of loanwords as Japanese words influence loanword accentuation
 - e. To test whether and how Japanese speakers' implicit knowledge of the English stress system (see Section 1.1), beyond outright faithfulness to individual source words, influences loanword accentuation

To answer these research questions, I create a series of probabilistic models based on my corpus data, employing Maximum Entropy Optimality Theory (MaxEnt OT) (Smolensky, 1986;

Goldwater & Johnson, 2003; Hayes & Wilson, 2008) as the grammatical framework. Specifically, I adopt Ito and Mester's model as a baseline model and update the model four times to reach the final model, gradually integrating in the factors listed in (1b-e). The validity of each update is statistically assessed by means of a likelihood ratio test (e.g., Wasserman, 2004).

The rest of Section 3.1 gives a brief introduction of MaxEnt OT, followed by a brief explanation of the way I compare probabilistic models. Section 3.2 provides a description of the basic structure of my MaxEnt modeling. In Section 3.3, I create a series of probabilistic models by gradually adding more factors to a baseline model, with each addition being assessed by a likelihood ratio test.

3.1.1 Maximum Entropy Optimality Theory

MaxEnt OT is a variety of Harmonic Grammar (Legendre et al., 1990; Legendre et al., 2006), which shares the basic architecture with classical OT: GEN creates candidates for each input and EVAL selects outputs from the candidates. Harmonic Grammar assigns numerical weights to constraints, which represent their relative strength, rather than ranking them as in classical OT. As a probabilistic framework, MaxEnt OT uses these weights to generate a probability distribution over candidates.

The first step to obtain the probability of candidate x is to calculate a penalty score called the "harmony" for the candidate (h(x)), as shown in (6). First, the number of violations of the candidate against the constraint is multiplied by the weight of the constraint (w_i) to yield the violation score for the candidate ($w_iC_i(x)$). Then, the violation scores for all constraints are summed up to yield the harmony for the candidate. As it is a penalty score, higher harmony leads to lower probability of the candidate.

(6)
$$h(x) = \sum_{i}^{N} w_i C_i(x)$$

The second step is to calculate the normalization term Z, as shown in (7). The harmony of each candidate is negated and exponentiated to calculate a value sometimes called "eHarmony" (e^{-H}) (Hayes, 2020). Then, the eHarmonies of all candidates for the input are summed up to produce Z.

(7)
$$Z = \sum_{j}^{N} (e^{-H})_{j}$$

Finally, the probability of a candidate (p(x)) is computed by dividing the eHarmony of the candidate by Z, as shown in (8).

(8)
$$p(x) = \frac{e \text{Harmony}(x)}{Z}$$

3.1.2 Fitting weights to data

MaxEnt OT is usually employed in conjunction with a learning algorithm. Given the observed data and a set of constraints, a MaxEnt OT model finds the constraint weights that maximize the likelihood of the model (L), which has the effect of minimizing the difference between the observed and predicted probabilities. As shown in (9), the likelihood of the model is calculated by taking the product of the predicted probabilities of each output based on the model (y) given its input (x).

(9)
$$L = \prod_{j=1}^{n} p(y_j | x_j)$$

Because multiplying probabilities results in a vanishingly small likelihood value that is hard to interpret, the likelihood is log-transformed, which turns a multiplication into an addition, as in (10).

(10)
$$\log L = \sum_{j=1}^{n} \log p(y_j | x_j)$$

To fit constraint weights to my corpus data, I use the Excel Solver (Fylstra et al., 1998), which uses Conjugate Gradient Descent to find weights in a way as to maximize the likelihood of the model, employing the conditions that weights must be positive.

3.1.3 The likelihood ratio test

A fundamental issue of comparing models is to mediate between simplicity and accuracy. While adding more parameters (i.e., constraints) to a baseline model would naturally bring more accuracy, it is not always clear whether this improvement justifies the increased complexity of the model. As a criterion to deal with this issue, I only include constraints whose contribution to the model's accuracy passes a statistical test. The test chosen here is the likelihood ratio test (e.g., Wasserman, 2004), which compares the log likelihood functions of two nested models (i.e., models in a subset relation), with one model (i.e., full model) including more constraints than the simpler model.

The test statistic of the likelihood ratio test is shown in (11).

(11) Test statistic of the likelihood ratio test

$$-2 \times \left(\frac{\log \text{ likelihood of simpler model}}{\log \text{ likelihood of full model}} \right)$$

The chi-square test is conducted on the test statistic, with the difference in the number of constraints for the two models as degrees of freedom. The null hypothesis is that there is no significant difference between the two models in terms of the models' performance, which thus suggests that the simpler model is the best model. Rejection of the null hypothesis, on the other hand, means that the full model significantly outperforms the simpler model, justifying the addition of constraints. The significance level is set to be 0.05. The difference in log likelihood between the full and simpler models is shown as Δ log likelihood.

3.2 Baseline model: Ito and Mester (2016)

I adopt Ito and Mester's (2016) classical OT model as the starting point of my probabilistic modeling³.

In this section I will provide a brief overview of their model and explain how I adapt their structure in a way as to be appropriate for MaxEnt modeling.

3.2.1 Inputs and outputs

The inputs of Ito and Mester's (2016) model consist of all possible phonological shapes up to five syllables in length ([L]~[HHHHH]), while the outputs (i.e., candidates) of each input consist of all logically possible foot structures for the input, under the three requirements shown in (12). These requirements exclude candidates with an accent not coinciding with the head syllable of its head foot (12a), without a foot (12b), and with a foot containing more than two syllables (12c). Note

³ The basic structure of the grammar was generated in Ito and Mester (2016) using OTWorkplace (the open-source program downloadable from https://sites.google.com/site/otworkplace/). Many thanks to Junko Ito and Armin Mester for kindly providing me with their spreadsheet.

that capital letters indicate head syllables while small capital letters indicate non-head syllables in (12).

- (12) Three requirements on the output structure
 - a. If the prosodic word contains an accent, it must coincide with the head syllable of its head foot (e.g., ²[L(LL)], ²[(LL)] instead of (*³[L(LL)], *¹[(LL)]).
 - b. Headless forms are not qualified as candidates, i.e., a prosodic word contains at least one foot (e.g., ³[(ĹL)L], ³[(Ĥ)L] instead of *³[ĹLL], *³[ĤL]).
 - c. Feet must be maximally binary in the level of the syllable (e.g., *³[(ĹLL)], *⁰[(HLL)]).

These requirements are consequences of three undominated constraints: WORD PROMINENCE TO WORD HEAD for (12a), HEADEDNESS for (12b), and the maximal version of FTBIN for (12c). Undominated constraints are never violated by winners, and in a best-fit MaxEnt OT model they receive an infinite weight, giving a probability infinitely close to zero to the candidates which violate them. Thus, excluding the candidates violating any undominated constraints is a reasonable way to limit the number of candidates considered.

This includes a total of 15,863 outputs for 62 inputs. In my modeling, however, the shapes that are not included or unattested in my corpus data (e.g., five-syllable shapes) are excluded. To further streamline the structure, I also exclude all outputs that violate Ito and Mester's MORAICTROCHEE constraint, which penalizes feet that contain more than two moras or are iambic (i.e., (HL), (HL), (LH), (LH), (LL)), from the models. MORAICTROCHEE is undominated in Ito and Mester's analysis, and I follow this assumption in my modeling as well. Accordingly, I will not employ Ito and Mester's convention of using capital and small capital letters to indicate head and

non-head syllables, respectively. Readers should note that all feet are trochaic. For example, (LL) always indicates (LL), instead of (LL), in Ito and Mester's notation.

3.2.2 Constraints

Ito and Mester's (2016) model employs 10 constraints (excluding MORAICTROCHEE), which are ranked with each other to capture what they call the "default" loanword accentuation in Japanese. The constraints and their rankings are shown in (13). The constraints ranked in Stratum 1 (a-d) are undominated and never violated by winners, while the other constraints are ranked in one of the lower strata (Stratum 2-5) based on their dominance relationship.

(13) Ito and Mester's (2016) constraint system (excluding MORAICTROCHEE)

Stratum 1

- a. NONFINALITY(σ) (NONFIN(σ)): Word-final syllables are not footheads.
- b. NOLAPSE: Syllables are parsed into feet.
- c. MINIMALWORDACCENT (MINWDACC): A minimal word contains a prominence peak.
- d. RIGHTMOST: The head (accented) foot is the right most foot within the prosodic word.

Stratum 2

- e. WEIGHT-TO-STRESS PRINCIPLE (WSP): Heavy syllables are footheads.
- f. FOOTBINARITY (FTBIN): Feet are minimally binary at some level of analysis (μ, σ) .

Stratum 3

- g. INITIALFOOT (INITFT): A prosodic word begins with a foot.
- h. NONFINALITY (FT') (NONFIN(FT')): The head (accented) foot does not contain the final syllable in the prosodic word.

Stratum 4

i. WORDACCENT (WDACC): A prosodic word contains a prominence peak.

Stratum 5

j. PARSE- σ : All syllables are parsed into feet.

In this classical OT model, the constraint system assigns antepenultimate-mora accent to most accented loanwords, as shown in Table 3.1. The table shows that loanwords consisting of three light syllables (represented by [banana] 'banana') and five light syllables (represented by [baruserona] 'Barcelona') are assigned antepenultimate-mora accent, as the constraints require

syllables to be maximally parsed into feet with a final syllable being unparsed (i.e., a. ³[(bána)na]), d. ³[(baruı)(séro)na]).

	NoLapse	RIGHTMOST	InitEt	Nonfin(Ft')	WDACC	PARSE-0
/banana/ 'banana'						
\rightarrow a. ³ [(bána)na]		1 1 1		1 1 1		*
b. ⁰ [(bana)na]					*!	*
c. ² [ba(nána)]			*!	*		*
/baruserona/ 'Barcelona'						
\rightarrow d. ³ [(baru)(séro)na]						*
e. ⁰ [(baru)(sero)na]		1		1	*!	*
f. ⁵ [(báru)(sero)na)		*!				*
g. ² [(baru)se(róna)]		1		*!		*
h. ⁵ [(báru)serona]						***
i. ⁴ [ba(rúise)(rona)]		*!	*			*

Table 3.1: Sample tableau showing how Ito and Mester's (2016) model predicts antepenultimatemora accent for loanwords consisting of three light syllables and five light syllables (adapted from Ito and Mester, 2016, p. 487).

Crucially, the same constraint system produces the unaccented pattern for loanwords consisting of four light syllables (i.e., LLLL) and ones ending with the HLL shape (i.e., [...HLL]), as shown in Table 3.2. For these shapes, the optimal foot structure is the one with the final four syllables being exhaustively parsed into bimoraic feet (a. ⁰[(ame)(rika)], b. ⁴[(áme)(rika)], and ²[(ame)(rika)]), due to the undominated status of NOLAPSE (Stratum 1) and the relatively high ranking of INITFT (Stratum 3). Furthermore, assigning any accents critically violates either RIGHTMOST (b. ⁴[(áme)(rika)]) or NONFIN(FT') (c. ²[(ame)(rika)]), making the unaccented candidate (a. ⁰[(ame)(rika)]) optimal. In other words, being unaccented is relatively less marked than assigning any accent.
/amerika/ 'America'	NoLapse	RIGHTMOST	INITFT	Nonfin(Ft')	WDACC	PARSE-0
\rightarrow a. ⁰ [(ame)(rika)]					*	
b. ⁴ [(áme)(rika)]		*!				
c. $^{2}[(ame)(rika)]$				*!		
d. ⁴ [(áme)rika]	*!					**
e. ³ [a(méri)ka]			*!			*

Table 3.2: Sample tableau showing how Ito and Mester's (2016) model predicts the unaccented pattern for loanwords consisting of four light syllables (adapted from Ito and Mester, 2016, p. 486).

Finally, the constraint system assigns pre-antepenultimate-mora accent for loanwords ending with the LLH shape (i.e., ⁴[...ĹLH]), as shown in Table 3.3. For these shapes, the candidate with antepenultimate-mora accent (e. ³[do(rá)gon]) is excluded by violating FTBIN. Furthermore, these shapes do not become unaccented because the ones with the final heavy syllable being parsed (e.g., 0 [(dora)(gon)]) are excluded by NONFIN(σ), which is undominated.

	$NONFIN(\sigma)$	RIGHTMOST	WSP	FTBIN	INITFT	NONFIN(FT'	WDACC	PARSE-0
/doragon/ 'dragon'		1 1 1		1 1 1		$\overline{}$		
\rightarrow a. ⁴ [(dóra)gon]		1 1 1	*	1 1 1				*
b. ⁰ [(dora)(gon)]	*!						*	
c. ² [(dora)(gón)]	*!					*		
d. ⁴ [(dóra)(gon)]	*!	*						
e. ³ [do(rá)gon]		1	*	*!	*			**

Table 3.3: Sample tableau showing how Ito and Mester's (2016) model predicts the preantepenultimate mora accent for loanwords with the LLH shape (adapted from Ito and Mester 2016, p. 505).

In sum, Ito and Mester's model successfully predicts some of the well-documented accent patterns, including antepenultimate-mora accent for most accented loanwords, preantepenultimate-mora accent for loanwords ending with the LLH shape, and the unaccented pattern for loanwords with the LLLL shape and ones ending with the HLL shape. While some of its predictions are inconsistent with the results of my corpus analysis, the fact that their model is the most comprehensive and accurate among the existing models makes it a good starting point for my MaxEnt modeling.

3.2.3 Dealing with the hidden structure problem

From the learnability perspective, it is reasonable to assume that the leaning data that learners are exposed to are merely surface accent patterns of words (e.g., ${}^{2}[LLL])$, instead of foot structures of words (e.g., ${}^{2}[L(LL)]$, ${}^{2}[(LL)]$). In other words, what researchers assume to be the optimal foot structure of each accent pattern is not provided to learners in advance, rather, it is something that learners must be able to infer as they accumulate the learning data that only consists of surface accent patterns over segmental strings.

This is an instance of the "hidden structure" problem (discussed in e.g., Tesar and Smolensky, 1998; Jarosz, 2015). To deal with hidden structure here in MaxEnt, I summed up the predicted probabilities of all foot structures for the same surface accent pattern of each input, following the method put forth by Moore-Cantwell (2020) in an analysis of English stress assignment. This is illustrated using a sample tableau in Table 3.4, which fits weights of Ito and Mester's constraints (only FTBIN and NONFIN(FT') are shown in the tableau) to the LL words in the corpus data.

	probability			FTBIN	NONFIN(FT')	h
/LL/	observed	pred	licted	6.86	0.90	> >
a. ² [(ĹL)]			0.97		1	0.90
b. ${}^{2}[(L)(L)]$	0.97	0.97	0.00	1		17.35
c. ${}^{2}[(L)L]$			0.00	1		6.86
d. ${}^{1}[L(L)]$	0.00	0.00	0.00	1	1	11.39
e. ${}^{1}[(L)(L)]$	0.00	0.00	0.00	1	1	18.25
f. ${}^{0}[(LL)]$			0.00			4.51
g. ${}^{0}[(L)L]$	0.02	0.02	0.03	1		11.38
h. ${}^{0}[L(L)]$	0.03	0.03	0.00	1		15.00
i. ${}^{0}[(L)(L)]$			0.00			\$ 21.87

Table 3.4: Sample tableau illustrating how the predicted probability for each surface accent is calculated. Constraints other than FTBIN and NONFIN are omitted for the sake of simplicity.

As Table 3.4 shows, the input phonological shape of LL has three foot structures for penultimate accent (a-b), two for ultimate accent (d and e), and four for the unaccented pattern (f-i); the predicted probability of each surface accent is obtained by summing up those of all the foot structures for the accent (e.g., ${}^{2}[(LL)]: 0.97 + {}^{2}[(L)(L)]: 0.00 + {}^{2}[(LL)]: 0.00 = {}^{2}[LL]: 0.97$). In this way, constraint weights are fitted based solely on surface accents in the observed data (i.e., with information actually available to the learner), but allocate probability to the various foot structures in a way determined by the model.

This suggests that whether learners can learn the foot structures that the researcher assumes to be optimal depends on whether such foot structures are learnable given the observed data and the constraints. In this simple example, a unique foot structure is learned for each accent: ${}^{2}[(\acute{L}L)]$ for penultimate accent and ${}^{0}[(L)L]$ for ultimate accent. However, this is not necessarily the case especially when the model includes more complex data: it is possible that the predicted probability of a surface accent is shared by more than one foot structure (e.g., ${}^{2}[(\acute{L}L)]$: $0.70 + {}^{2}[(\acute{L})(L)]$: $0.00 + {}^{2}[(\acute{L})L]$: $0.27 = {}^{2}[\acute{L}L]$: 0.97) (see Moore-Cantwell 2020 for concrete examples).

3.3 Comparing a series of models of Japanese loanword accentuation

In this section, I create a series of probabilistic models of Japanese loanword accentuation by gradually integrating more factors into the baseline model (i.e., Ito and Mester's 2016 model). More specifically, the baseline model will be updated four times to integrate (1) additional markedness effects, (2) faithfulness effects, (3) frequency effects, and (4) a version of the Japanese Theory of English. This creates a series of four models, and each update is justified by the improvement in model accuracy it brings, as assessed by likelihood ratio tests. While the updated models will be named after the ingredient just added to the model for the update, readers should keep in mind that the process is incremental: ingredients already added to the model in previous update(s) remain as long as their contribution to the model is significant. For visual inspection, the scattergram that plots the observed and predicted probabilities will be presented for each model. Each dot represents an accent pattern for an input which includes at least five individual loanwords; dots for inputs with less than five loanwords are removed to avoid having them misrepresent the results.

An issue regarding the comparison of these models is that later (richer) models are sensitive to more distinctions in the inputs. For example, to integrate the faithfulness effects to English stress, the inputs of the model must reflect the distinctions between different stress patterns (e.g., /'LLL/ vs. /L'LL/). Thus, this type of update multiplies the inputs (and their outputs) with the number of newly required distinctions. While some distinctions are only relevant for later (richer) models, the structure of the grammar with the fullest distinctions, which will be established in Section 3.3.4, will be maintained throughout the updating process, to enable direct comparisons among the models (this applies to the scattergrams as well: they are all based on the structure with the fullest distinctions).

3.3.1 Assessment of Ito and Mester's (2016) original model

As a starting point I adopt Ito and Mester's (2016) constraint system as a baseline model. Before making their model probabilistic, however, it is instructive to see how their original (i.e., categorical) model works against the corpus data. To this end, Figure 3.1 plots the observed probabilities of the accent patterns in the corpus data against the winners predicted by their model. Since the model is expressed in classical OT, the predicted probabilities are either one (default) or zero (non-default), and each dot represents an accent pattern for an input (e.g., [ĹLL] for /LLL/). The histograms in the margins are added to clearly indicate how many datapoints are overlapping in the scattergram.



Figure 3.1: Observed probabilities based on the corpus data vs. predicted probabilities based on Ito and Mester's (2016) classical OT model.

If the data exhibit the exact accent patterns the model predicts, all the dots would be found in the upper right corner (i.e., attested) or lower left corner (i.e., unattested). In reality, however, there are some dots spreading over the horizontal axis, which suggests that there are some accent patterns that are not accounted for by the model. For example, while shapes like LHL, HHL, HLH, HLLL are all predicted to bear antepenultimate-mora accent, many of the loanwords in the corpus data with these shapes bear pre-antepenultimate-mora accent (e.g., LHL: ⁴[pánikk<u>] 'panic', HHL: ⁵[kónsa:t<o>] 'concert', HLH: ⁵[há:moni:] 'harmony', HLLL: ⁵[tá:minar<u>] 'terminal'). Also, many of the loanwords that are predicted to be unaccented in Ito and Mester's model (i.e., ⁰[(LL)(LL)] and ⁰[...(H)(LL)]) are actually accented, often when they end with an epenthetic syllable (e.g., LHLL: ⁴[edínbara] 'Edinburgh'). Furthermore, as it is indicated by the non-binarity of the observed probabilities, there are quite a few accent patterns that are probabilistic (i.e., not categorically attested or unattested) in the corpus data.

3.3.2 A MaxEnt version of Ito and Mester's (2016) model

The next step is to make Ito and Mester's model probabilistic, employing the MaxEnt approach. In this model and the models that follow, the constraints are weighted based on their relative importance to account for the accent patterns in the corpus data, with the learning algorithm. Table 3.5 shows the best-fit weights of the Ito-Mester constraints. The log likelihood of the model was -2233.53.

Strata	Constraint	Weight
Stratum 1	Nonfin(σ)	3.24
	NOLAPSE	0.10
	MINWDACC	4.44
	RIGHTMOST	0.94
Stratum 2	WSP	1.39
	FtBin	1.81
Stratum 3	InitFt	0.00
	NONFIN(FT')	3.27
Stratum 4	WDACC	2.04
Stratum 5	Parse-s	0.95

Table 3.5: Best-fit constraint weights in the MaxEnt version of Ito and Mester's model.

While many of the constraints gained reasonably high weights (showing that they are meaningful), the constraint system in Ito and Mester's original model is not fully reflected in the weights. In particular, the weights of NOLAPSE (0.10), RIGHTMOST (0.94), and INITFT (0.00) are smaller than what we would expect based on their constraint system (NOLAPSE and RIGHTMOST are in Stratum 1 while INITFT is in Stratum 3). I argue that there are two reasons for these.

The first reason is due to a property of Harmonic Grammar. Unlike the ranked constraint hierarchy of OT, the weighted constraint system of Harmonic Grammar allows constraints with smaller weights to add up, or gang up, to exceed a constraint with a greater weight. A consequence of this is that constraints with an overlapping violation profile share a weight. This happens with NOLAPSE, INITFT, and PARSE- σ , which are all violated by some sorts of unparsed syllables. As PARSE- σ is more general than NOLAPSE and INITFT (i.e., the candidates violating either NOLAPSE or INITFT always violate PARSE- σ , but not vice versa), the weights of NOLAPSE and INITFT are taken up by that of PARSE- σ .

The second reason is because the fairly abundant cases of pre-antepenultimate-mora accent and pro-pre-antepenultimate-mora accent, which Ito and Mester's model does not predict, often violate either NOLAPSE or RIGHTMOST (e.g., LHL: ⁴[(pá)nikk<u>] or ⁴[(pá)(nik)k<u>] 'panic', HHL: 5[(kon)sa:t<o>] or 5[(kon)(sa:)t<o>] 'concert', HLH: 5[(ha:)moni:] or 5[(ha:)(mo)ni:]'harmony', HLLL: ⁵[(tá:)minar<u>] or ⁵[(tá:)(mina)r<u>] 'terminal', LLLL: ⁴[(áni)mar<u>] or 4[(ani)(mar < u >)]'animal', LHLL: ⁴[e(dín)bara] or ⁴[e(dín)(bara)] 'Edinburgh', LLHL: ⁵[(ébi)dens<u>] ⁵[(ébi)(den)s<u>] 'evidence', HLHL: 6[(ci:k < u) + ci:k < u)]or or ⁶[(ci:k<u>)(ret)t<o>] 'secret'). To allocate some probability to such accent patterns, the best-fit weights of those constraints in this model turn out to be small, even though they were ranked high in the original analysis.

The left panel of Figure 3.2 plots the observed probabilities in the corpus data against probabilities predicted by the MaxEnt version of Ito and Mester's model, while the right panel of the figure shows the same data split by the accent patterns to enable a more detailed inspection. The broad scatter of dots in the figure shows that the model does not account for the corpus data well. Unsurprisingly, the accent patterns that are not predicted by Ito and Mester's classical model, i.e., pre-antepenultimate-mora accent (Pre) (e.g., ⁵[há:moni:] 'harmony') and pro-pre-antepenultimate-mora accent (Pro) (e.g., ⁵[ébidens<u>] 'evidence') are generally underpredicted. This suggests that simply making Ito and Mester's model probabilistic does not capture the accent pattern (Un) (e.g., ⁰[amerika] 'America') is also underpredicted. This is because producing the unaccented pattern requires many conditions to be met and some of them are inconsistent with the abundance of pre-antepenultimate-mora accent and pro-pre-antepenultimate-mora accent. Specifically, while producing the unaccented pattern requires the weights of NOLAPSE and

RIGHTMOST to be reasonably high (e.g., in order to exclude ${}^{4}[(ame)rika]$ and ${}^{4}[(ame)(rika)]$ 'America', respectively), they are kept small in the current model to account for preantepenultimate-mora accent and pro-pre-antepenultimate-mora accent, which necessarily violate either NOLAPSE or RIGHTMOST (e.g., ${}^{5}[(ha:)moni:], {}^{5}[(ha:)(mo)ni:]$ 'harmony'; ${}^{5}[(ebi)dens<u>],$ ${}^{5}[(ebi)(den)s<u>]$ 'evidence').



Figure 3.2: Observed probabilities based on the corpus data vs. predicted probabilities based on the MaxEnt version of Ito and Mester's model.

3.3.3 Augmented Ito-Mester model

The second probabilistic model to be examined here includes markedness constraints I have added, in order to capture further markedness effects that seem to play a non-negligible role according to the descriptions in the literature and/or my corpus analysis. The additional markedness constraints are shown in (14).

- (14) Additional markedness constraints
 - a. WSP(G): Heavy syllables consisting of a vowel plus an obstruent coda (i.e., the first element of a geminate) are foot heads.
 - b. WSP(N): Heavy syllables consisting of a vowel plus a nasal coda are foot heads.
 - c. WSP(V): Heavy syllables consisting of a long vowel or a diphthong are foot heads.
 - d. *DEVOICEDACCENT (*DEVACCENT): Syllables with a devoiced vowel must not be accented.

Splitting WSP into three more specific constraints (14a-c) is based on my observation that heavy syllables consisting of a long vowel (e.g., 3 [ikó:r<u>] 'equal') or a diphthong (e.g., 3 [mobâir<u>] 'mobile') are more likely to bear an accent (i.e., to be parsed into a foot in Ito and Mester's analysis) than ones consisting of a vowel plus an obstruent coda (e.g., 4 [ród3ikk<u>] 'logic') or a vowel plus a nasal coda (e.g., 4 [sékand<o>] 'second') (see Section 2.4.1). Thus, it is expected that WSP(V) (14c) gains a greater weight than WSP(G) (14a) and WSP(N) (14b). Introducing *DEVACCENT (14d) is intended to test the earlier claims that devoiced vowels tend to avoid bearing an accent (McCawley, 1977; Haraguchi, 1991; Tsuchida, 1997).

Including the additional markedness constraints requires finer distinctions in the inputs of the grammar. That is, including the more specific versions of WSP (14a-c) requires the gradient syllable weight distinction of heavy syllables, and including *DEVACCENT (14d) requires the distinction between consonant clusters resulting in the C<V>C sequence (with a *voiced* epenthetic vowel) and ones resulting in the C<V>C sequence (with a *devoiced* epenthetic vowel) (remember that the voiced/devoiced distinction is only made for epenthetic vowels because non-epenthetic (full) syllables with a devoiced vowel (i.e., CVC) are rare in my corpus data). To avoid making

the structure unnecessarily complex, each of the distinctions was made only for syllables in which the distinction is maximally meaningful. Specifically, the gradient syllable weight distinction was made only for heavy syllables followed by a word-final light syllable and preceded by at least one syllable (e.g., [LHL], [HHL], [LLHL]), while the distinction between voiced and devoiced vowels was made only for light syllables which potentially bear an accent based on the Latin stress rule (e.g., [LLL], [LLH], [LLLL]).

Table 3.6 shows the best-fit constraint weights in the augmented Ito-Mester model along with those in the MaxEnt version of Ito and Mester's model. Crucially, the additional markedness constraints gained reasonable weights. First, the gradient versions of WSP gained weights expected based on the descriptive analysis of my corpus data: WSP(V) gained a high weight (2.96) while WSP(G) and WSP(N) did not gain weights. It should also be noted that adding these constraints made the weight of WSP a zero. This indicates that the entire effect of WSP comes from WSP(V) in the specific environments where the gradient syllable weight distinction was made. Second, *DEVACCENT gained a high weight (3.30), exhibiting the tendencies that syllables with a devoiced vowel tend to avoid bearing an accent.

Likelihood ratio tests confirmed that adding the gradient versions of WSP at once and adding *DEVACCENT significantly improve the model's fit to the data (WSP(G), WSP(N), WSP(V): Δ log likelihood = 17.79, p > 0.001; *DEVACCENT: Δ log likelihood = 26.03, p > 0.001). The log likelihood of the model improves to -2191.45, from -2233.53 (Δ log likelihood = 42.08) in the MaxEnt version of Ito and Mester's model.

Turna	Constraint	We	ight
Туре	Constraint	Ito & Mester	Augmented I-M
Ito & Mester	Nonfin(σ)	3.24	1.92
	NOLAPSE	0.10	0.00
	MINWDACC	4.44	4.59
	RIGHTMOST	0.94	1.21
	WSP	1.39	0.00
	FtBin	1.81	2.00
	INITFT	0.00	0.00
	NONFIN(FT')	3.27	3.45
	WDACC	2.04	2.16
	PARSE-0	0.95	0.73
Additional	WSP(G)		0.00
markedness	WSP(N)		0.00
	WSP(V)		2.96
	*DEVACCENT		3.30

Table 3.6: Best-fit constraint weights in the augmented Ito-Mester model (right) and in the MaxEnt version of Ito and Mester's model (left).

Figure 3.3 shows the predicted vs. observed plot based on the augmented Ito-Mester model. While the correlation became slightly stronger, the underprediction of the accent patterns that are deviant from Ito and Mester's predictions, especially pre-antepenultimate-mora accent (Pre) and pro-pre-antepenultimate-mora accent (Pro), and that of the unaccented pattern (Un) still persist.



Figure 3.3: Observed probabilities based on the corpus data vs. predicted probabilities based on the augmented Ito-Mester model.

3.3.4 Faithfulness model

I assume that English-based loanwords in my corpus data are mostly adapted by bilinguals, who can either retrieve the underlying representation or faithfully perceive the surface representation of the English source words. This means that the input of loanword adaptation reflects the non-native phonological properties including English stress, consonant clusters, and word-final (non-nasal) consonants, the latter two of which result in epenthetic syllables in loanword forms (e.g., $/plet/ \rightarrow 2[p < u > r\acute{ei}]$ 'play', $/fap/ \rightarrow 3[f\acute{o}pp < u >]$ 'shop').

Based on these assumptions, I treat different stress patterns for the same phonological shape (e.g., /'LLL/ and /L'LL/) as different inputs. For example, /'kænədə/ ³[kánada] 'Canada' counts towards the /'LLL/ input (with a faithful accent ³[kánada]) while /bə'nænə/ ³[bánana] 'banana' towards the /L'LL/ input (with an unfaithful accent ³[bánana]). In addition, the presence of consonant clusters and word-final consonants in the source words is also reflected in the inputs. For example, /'LLL/ (e.g., /'kænədə/ ³[kánada] 'Canada'), /'LLc/ (e.g., /'dæləs/ ³[dáras<u>] 'Dallas'), and /'Lcc/ (e.g., /'gɪft/ ³[gíф<u>t<o>] 'gift') are all treated as different inputs although

they all result in the same adapted shape (i.e., [LLL]). To reflect these assumptions, each input (and its outputs) is multiplied by the number of combinations of its stress patterns and syllable structures observed in the corpus data.

In formalizing the faithfulness effects, I introduce four loanword faithfulness constraints that govern the relationship between English source words and the corresponding loanwords, as shown in (15).

- (15) Faithfulness constraints
 - a. DEP[ACCENT]: Do not assign accent on loanword syllables that correspond to unstressed syllables in English source words (e.g., violated by /bəˈnænə/ → ³[bánana] 'banana').
 - b. MAX[ACCENT]: Do not make loanwords unaccented (e.g., violated by /ə'mɛrɪkə/ \rightarrow ⁰[amerika] 'America').
 - c. DEP[ACCENTEDVOWEL] (DEP[\acute{V}]): Do not assign accent on epenthetic syllables (e.g., violated by /plAs/ \rightarrow ³[p<ú>ras<u>] 'plus').

DEP[ACCENT] (15a) is violated by loanword forms with an accent on syllables that come from unstressed syllables in English. This constraint is included to test whether and how the stress pattern in source words influences the accent pattern of the corresponding loanwords. MAX[ACCENT] (15b) is violated by loanword forms that are unaccented. It should be noted that MAX[ACCENT] is equivalent to Ito and Mester's WDACC in terms of the violation profile; the former is simply a faithfulness version of the latter, representing the faithfulness effect to the presence of a pitch fall associated with a stress in English source words. Thus, I simply rename WDACC as MAX[ACCENT]. For this reason, the weight of MAX[ACCENT] is not discussed in the current model. Finally, DEP[V] (15c) is violated by inserting any accented vowels (i.e., assigning an accent on epenthetic syllables).

Table 3.7 shows the best-fit constraint weights in the faithfulness model along with those for the augmented Ito-Mester model. As the table shows, both DEP[ACCENT] and DEP[\acute{V}] gained reasonable weights: DEP[ACCENT]: 0.92 and DEP[\acute{V}]: 1.51. Likelihood ratio tests indicate that including each of them significantly improves the model's fit to the corpus data (DEP[ACCENT]: Δ log likelihood = 88.88, p > 0.001; DEP[\acute{V}]: Δ log likelihood = 86.53, p > 0.001). The log likelihood of the model increases to -2038.08, from -2191.45 in the augmented Ito-Mester model (Δ log likelihood = 153.37), indicating a significant improvement of the model's fit to the observed data.

	Constraint	Wei	ight
Туре	Constraint	Augmented I-M	Faithfulness
Ito & Mester	Nonfin(σ)	1.92	1.80
	NOLAPSE	0.00	0.00
	MINWDACC	4.59	4.50
	RIGHTMOST	1.21	1.48
	WSP	0.00	0.00
	FTBIN	2.00	1.57
	INITFT	0.00	0.00
	NONFIN(FT')	3.45	3.46
	WDACC	2.16	
	PARSE-0	0.73	1.25
Additional	WSP(G)	0.00	0.00
markedness	WSP(N)	0.00	0.00
	WSP(V)	2.96	3.07
	*DEVACCENT	3.30	2.55
Faithfulness	DEP[ACCENT]		0.92
	MAX[ACCENT]		2.63
	DEP[V]		1.51

Table 3.7: Best-fit constraint weights in the faithfulness model (right) and in the augmented Ito-Mester model (left).



Figure 3.4: Observed probabilities based on the corpus data vs. predicted probabilities based on the faithfulness model.

Figure 3.4 shows the predicted vs. observed plot based on the faithfulness model. The figure shows that the correlation became much stronger while there is still room for improvement, especially for the unaccented pattern (Un).

3.3.5 Frequency model

Let us consider how the frequency of English source words might influence how Japanese speakers assign loanword accents. High English frequency potentially leads to more exposure to the source pronunciation. Thus, we have a priori reason to expect that the faithfulness effects to the source word become *stronger* as the frequency of the source word goes up. To my knowledge, this frequency effect has not been tested before in the loanword phonology literature.

Consider next how the frequency of loanwords as Japanese might influence loanword accentuation. High Japanese frequency possibly induces more nativization of the loanword, as a frequent use in Japanese makes the loanword seem less foreign, reducing the salience of its source word pronunciation. Thus, the faithfulness effects are likely to become *weaker* as the loanword frequency goes up. This type of frequency effect has been commonly observed in the literature (e.g., Kawahara 2011 for loanword geminate devoicing in Japanese), and seems to be consistent with Itô and Mester's (1999) core-periphery model, where more nativized words are subject to weaker faithfulness effects than less nativized words (e.g., assimilated vs. unassimilated loans).

It should be noted that these frequency effects are not intended as part of speakers' phonological knowledge. The effect of English frequency simply reflects accessibility of source word pronunciation (i.e., higher frequency \rightarrow greater exposure), which is extra-grammatical, while that of loanword frequency reflects the etymological status of loanwords in the lexicon (higher frequency \rightarrow more nativization), and thus is an issue of lexical specification. Nevertheless, I integrate these two types of lexical frequencies in my MaxEnt OT model, in order to test the potential effects of them based on the natural assumptions on the borrowing process, as well as to gain a more accurate picture of the phonological knowledge by explicitly controlling the extra-grammatical effects involved in established loanwords.

To test the potential effects of lexical frequencies, I divide the loanwords into two frequency bins, once by the English frequency (the cutoff point is 268 occurrences in the Subtlex Corpus) and once by the loanword frequency (the cutoff point is 92 occurrences in the Balanced Corpus of Contemporary Written Japanese (Maekawa et al., 2014)). This creates the following four frequency categories: (i) English-High/Japanese-High, (ii) English-High/Japanese-Low, (iii) English-Low/Japanese-High, and (iv) English-Low/Japanese-Low. Accordingly, I multiply the entire faithfulness system that was established in Section 3.3.4 by four and add four frequency-sensitive sub-constraints for each faithfulness constraint, each of which is responsible for words falling into each frequency bin of each lexical frequency type (e.g., DEP[ACCENT](JP-HIGH), DEP[ACCENT](ENG-HIGH), and DEP[ACCENT](ENG-LOW)). The weights

of the frequency-sensitive constraints are expected to *positively* correlate with the lexical frequency of the English source words (e.g., DEP[ACCENT](ENG-HIGH) > DEP[ACCENT](ENG-LOW)) while *negatively* correlate with the lexical frequency of the loanwords as Japanese words (e.g., DEP[ACCENT](JP-LOW) > DEP[ACCENT](JP-HIGH)).

Table 3.8 shows the best-fit weights of the frequency-sensitive constraints along with those of the general faithfulness constraints in the frequency model (the weights of the markedness constraints are not shown as they do not change appreciably). As the table shows, the weights of the frequency-sensitive constraints *positively* correlate with the frequency of the English source words while *negatively* correlate with the frequency of loanwords as Japanese words.

				Weight			
Constraint	Japanese			English			Ganaral
	Low		High	Low		High	General
DEP[ACCENT]	0.24	>	0.15	0.09	<	0.94	0.33
MAX[ACCENT]	0.91	>	0.43	0.48	<	0.81	1.33
Dep[Ý]	0.64	>	0.00	0.09	<	0.68	0.85

Table 3.8: Best-fit weights of the faithfulness constraints in the frequency model (all distinctions are made).

Likelihood ratio tests reveal that five out of six distinctions significantly improve the model's fit to the data. Specifically, splitting MAX[ACCENT] and DEP[\acute{V}] based on Japanese frequency and DEP[ACCENT], MAX[ACCENT], and DEP[\acute{V}] based on English frequency significantly improves model's fit to the data (MAX[ACCENT](JP-LOW) vs. (JP-HIGH): Δ log likelihood = 6.27, p > 0.001; DEP[\acute{V}](JP-LOW) vs. (JP-HIGH): Δ log likelihood = 2.22, p > 0.05; DEP[ACCENT](ENG-LOW) vs. (ENG-HIGH): Δ log likelihood = 16.93, p > 0.001; MAX[ACCENT](ENG-LOW) vs. (ENG-HIGH): Δ log likelihood = 2.20, p > 0.05; DEP[\acute{V}](ENG-LOW) vs. (ENG-HIGH): Δ log likelihood = 2.20, p > 0.05). These suggest that loanwords that are frequent in Japanese tend to be unaccented and less

sensitive to epenthetic syllables (due to due to weaker effects of MAX[ACCENT] and DEP[\dot{V}], respectively), while ones whose source words are frequent in English tend to bear a faithful accent, be accented, and more sensitive to epenthetic syllables (due to stronger effects of DEP[ACCENT], MAX[ACCENT], and DEP[\dot{V}], respectively). In contrast, splitting DEP[ACCENT] based on Japanese frequency does not significantly improve the model's performance. The best-fit weights of the faithfulness constraints in the revised frequency model are shown in Table 3.9. The log likelihood of the model increases to -2012.02, from -2038.08 in the faithfulness model (Δ log likelihood = 26.06).

				Weight			
Constraint	Japanese			English			Conoral
	Low		High	Low		High	General
DEP[ACCENT]				0.03	<	0.85	0.59
MAX[ACCENT]	1.29	>	0.84	0.51	<	0.82	0.93
Dep[Ý]	0.63	>	0.03	0.10	<	0.68	0.81

Table 3.9: Best-fit weights of the faithfulness constraints in the frequency model (only significant distinctions are made).

Figure 3.5 shows the predicted vs. observed plot based on the frequency model. Although the figure does not look very different from that for the faithfulness model, the increase in log likelihood suggests that the frequency model significantly outperforms the faithfulness model. The underprediction of the unaccented pattern persists.



Figure 3.5: Observed probabilities based on the corpus data vs. predicted probabilities based on the frequency model.

3.3.6 JTOE model

An existing study shows that modest exposure to a foreign language enables speakers to develop sophisticated phonotactic knowledge of that language. Oh et al. (2020) shows that adult New Zealanders who do not speak Māori but are extensively exposed to it are able to evaluate the well-formedness of Māori-like nonwords just as well as fluent Māori speakers. Given that Japanese speakers' exposure to English is undoubtedly much greater than New Zealanders' exposure to Māori, it is reasonable to expect that Japanese speakers develop phonotactic knowledge of English stress by being exposed to English source pronunciation. I call this knowledge the "Japanese Theory of English" (JTOE).

Let us consider how JTOE might influence how Japanese speakers assign loanword accents. A potential consequence is a phenomenon that Janda et al. (1992) have characterized as "hyperforeignization", where speakers overapply patterns induced by existing non-native forms to novel non-native forms. To give an English example, when Japanese words ending with a light syllable are borrowed into English, English speakers often assign stress on the penultimate syllable, regardless of the way the original words are pronounced in Japanese. An example of this is English speakers' adaptation of the Japanese place name *Nagasaki*: English speakers pronounce [,nɑgə'sɑki], although the original Japanese word bears antepenultimate-mora accent (i.e., ³[nagásaki]). In this example, English speakers overapply the penultimate stress rule, which likely is induced based on their exposure to Spanish (and Italian) words ending with a light syllable, to Japanese-based loanwords.

My corpus data include some apparent instances of hyperforeignization. For example, the English word *Seattle* /si'ætəl/ is integrated into Japanese with either antepenultimate accent (i.e., ³[eiátor<u>]) or pre-antepenultimate accent (i.e., ⁴[eíator<u>]). I attribute the former to outright faithfulness to the source word while the latter is an instance of hyperforeignism, based on faithfulness to the output of JTOE, namely /'siætəl/. The form predicted by JTOE is rational, since the majority of English words with the same phonological shape assign stress on the initial syllable (e.g., /'ænəməl/ 'animal', /'sɪləbəs/ 'syllabus').

To approximate JTOE, I employ the English stress grammar in Hayes (in unpublished work). The English stress grammar is a MaxEnt OT model which predicts primary stress locations of around 18,000 English words based on their syllable and segmental structures. The model employs 28 constraints, mostly extracted from the literature. A crucial difference between my MaxEnt OT model and the English stress grammar is that the former employs phonological shapes as inputs, aggregating across individual words, while the latter treats individual words as inputs. To calculate probabilities of stress patterns for phonological shapes (not individual words), I collapse the English source words of the loanwords in my corpus data into phonological shapes based on the standard convention in the literature: syllables with a long vowel, a diphthong, or a short vowel followed by a coda consonant are heavy (i.e., H), ones with a short vowel are light (i.e., L), and

ones with both a long vowel or a diphthong followed by a coda consonant and ones with a short vowel followed by two coda consonants are superheavy (i.e., S) (e.g., Gordon, 2007). I then feed the phonological shapes into the best-fit English stress grammar and have the model return probabilities of stress patterns based on their violation profiles. The probabilities calculated for English phonological shapes are shown in Table 3.10 for two-syllable words, Table 3.11 for three-syllable words, and Table 3.12 for four-syllables. In addition to the three types of syllables (i.e., L, H, and S), the letter "c" is used to indicate an initial consonant cluster, which is marked only when the existence of it influences the stress pattern of a phonological shape.

Probability		English shares	Evenuela
΄σσ	σ΄σ	English shape	Example
0.99	0.01	L/H+L	/'deɪtə/ 'data'
0.93	0.07	L/H+H	/'sizən/ 'season'
1.00	0.00	cL/cH+L	/'skubə/ 'scuba'
0.36	0.64	L+S	/dɪˈfɔlt/ 'default'
0.88	0.12	H+S	/'sɛntəns/ 'sentence'
0.96	0.04	cL/cH+H	/'steifən/ 'station'
0.52	0.48	cL+S	/ˈskɛd͡ʒul/ 'schedule'

Table 3.10: Probabilities of stress patterns for two-syllable English shapes based on JTOE. Slashes indicate the syllables separated by them are interchangeable.

Probability			English Shana	Example
່σσσ	σ΄σσ	σσ΄σ	English Shape	Example
0.66	0.34	0.00	L/H+L+L	/ˈkænədə/ 'canada'
0.45	0.55	0.00	L/H+H/S+L	/əˈmibə/ 'amoeba'
0.44	0.54	0.02	L/H+H+H	/əˈluʃən/ 'Aleutian'
0.65	0.34	0.01	L/H+L+H	/ˈænəməl/ 'animal'
0.93	0.04	0.03	L/H+L+S	/'epi_soud/ 'episode'
0.43	0.53	0.04	L/H+H+S	/kou'ɛnzaɪm/ 'coenzyme'

Table 3.11: Probabilities of stress patterns for three-syllable English shapes based on JTOE. Slashes indicate the syllables separated by them are interchangeable.

Probabi	lity			English shana	Example
' თთთ	σ΄σσσ	σσ'σσ	σσσ'σ	English shape	Example
0.06	0.67	0.28	0.00	H/L+L+L+L	/ə'mɛrəkə/ 'America'
0.02	0.69	0.28	0.00	H/L+H+L+L	/kəˈlʌmbiə/ 'columbia'
0.04	0.48	0.47	0.00	H/L+H/L+H+L	/pɛɹəˈnoɪə/ 'paranoia'
0.06	0.66	0.27	0.01	H/L+H/L+H/L+H	/əˈkædəmi/ 'academy'

Table 3.12: Probabilities of stress patterns for four-syllable English shapes based on JTOE. Slashes indicate the syllables separated by them are interchangeable.

In applying the probabilities predicted by JTOE to loanword syllables, I follow general assumptions on how English phonological shapes are adapted into Japanese, as shown in Table 3.13. Specifically, English light syllables (i.e., L) are adapted as Japanese light syllables (a). English heavy syllables (i.e., H) are adapted as Japanese heavy syllables (b), sequences of a heavy syllable consisting of a vowel plus an obstruent coda followed by an epenthetic syllable (i.e., G<L>) (c), or ones of a light syllable followed by an epenthetic syllable (i.e., L<L>) (d). English super-heavy syllables (i.e., S) are adapted as Japanese super-heavy syllables (note that loanwords involving a super-heavy syllable are excluded from the corpus data) (e), sequences of a heavy syllable consisting of a long vowel or a diphthong followed by one or two epenthetic syllables (i.e., V<L>(L>) (f), ones of a heavy syllable consisting of a vowel plus a nasal followed by one or two epenthetic syllables (i.e., N<L> or N<L><L>) (g), or ones of a light syllable followed by two or three epenthetic syllables (i.e., L<L>C> or L<L><L>) (h). However, the actual

adaptations do not always follow these assumptions (e.g., some adaptations are based on orthographic information).

English \rightarrow Japanese	Example
a. $L \rightarrow L$	[ˈkænədə] → [kanada] 'Canada'
b. $H \rightarrow H$	$[tai] \rightarrow [tai]$ 'tie'
c. $H \rightarrow G \leq L >$	$[gæp] \rightarrow [gjapp < u >] 'gap'$
d. $H \rightarrow L < L >$	$[dæm] \rightarrow [dam < u >] 'dam'$
e. $S \rightarrow S$	$[lain] \rightarrow [rain]$ 'line'
f. $S \rightarrow V < L >, V < L > < L >$	$[ais] \rightarrow [ais < w >]$ 'ice'
g. $S \rightarrow N < L >, N < L > < L >$	$[geim] \rightarrow [geim < u >]$ 'game'
h. $S \rightarrow L < L > < L > , L < L > < L >$	$[galf] \rightarrow [gor < w > \phi < w >] 'golf'$

Table 3.13: General assumptions on how English phonological shapes are adapted into Japanese.

To implement the potential faithfulness effects to the outputs of JTOE, I employ FAITH-JTOE[ACCENT], which is defined in (16).

(16) FAITH-JTOE[ACCENT]: Do not deviate from JTOE (i.e., assign 1 minus probability based on JTOE for each accent)

FAITH-JTOE[ACCENT] works as a bias towards accent patterns that are derived from frequent stress patterns in English. Table 3.14 illustrates how violations of FAITH-JTOE[ACCENT] are assigned to the candidates of the input /L'LH/, along with violations of the faithfulness constraints. In this sample tableau, candidates that share the same surface accent are collapsed for the sake of simplicity.

/L'LH/	FAITH-JTOE	Dep	MAX	DEP
(e.g., /si'ætəl/)	[ACCENT]	[ACCENT]	[ACCENT]	[Ý]
Pre: ⁴ [ĹLL <l>] (⁴[ɕíator<ɯ>])</l>	*0.35 (1-0.65)	1		
Ant: ³ [LĹL <l>] (³[ciátor<u>])</u></l>	*0.66 (1-0.34)			
Pen: ² [LLĹ <l>] (²[ɕíator<ɯ>])</l>	*0.99 (1-0.01)	1		
Ult: ¹ [LLL<Ĺ>] (¹ [ɕiatór<ɯ>])				1
Un: $^{0}[LLL < L >]$ ($^{0}[eiator < u >])$			1	

Table 3.14: Sample tableau illustrating how violations of FAITH-JTOE[ACCENT] and the faithfulness constraints are assigned to the candidates of the input /L'LH/.

According to JTOE, the predicted probabilities of antepenultimate stress (/'LLH/), penultimate stress (/L'LH/), and ultimate stress (/LL'H/) are 0.65, 0.34, and 0.01, respectively. This means that antepenultimate stress is the most frequent stress pattern for this phonological shape (e.g., /'ænəməl/ 'animal', /'sıləbəs/ 'syllabus'), suggesting the exceptional status of penultimate stress (e.g., /si'ætəl/ 'Seattle') and ultimate stress (no such words exist in my corpus data). The violation of FAITH-JTOE[ACCENT] is simply calculated by subtracting the probability based on JTOE from 1 for each corresponding accent pattern. Thus, the violations are 0.35, 0.66, and 0.99, for the candidates with pre-antepenultimate-mora accent (represented by 4[LLL<L>]), those with antepenultimate-mora accent (represented by ${}^{3}[LLL < L>]$), and those with penultimate-mora accent (represented by $^{2}[LL\dot{L} < L>]$). Notice that DEP[ACCENT] and FAITH-JTOE[ACCENT] are in conflict, with DEP[ACCENT] favoring antepenultimate-mora accent while FAITH-JTOE[ACCENT] favoring pre-antepenultimate-mora accent. Please also note that the candidates with ultimate-mora accent (represented by ${}^{1}[LLL < \dot{L} >]$) and those with the unaccented pattern (represented by ⁰[LLL<L>]) do not incur any violation of FAITH-JTOE[ACCENT] but their probabilities would be reduced as necessary by DEP[V] and MAX[ACCENT], respectively.

Results of the JTOE model show that FAITH-JTOE[ACCENT] gained a weight of 0.79 and a likelihood-ratio test confirmed that including this constraint significantly improves the model's fit

to the data (p < 0.001). The log likelihood of the model increases to -1993.04, from -2012.02 in the frequency model (Δ log likelihood = 18.98).

Figure 3.6 shows the predicted vs. observed plot based on the JTOE model. Again, the figure does not look very different from that for the frequency model, with the underprediction of the unaccented pattern being still an issue, but the likelihood ratio test confirmed that the JTOE model significantly outperforms the frequency model.



Figure 3.6: Observed probabilities based on the corpus data vs. predicted probabilities based on the JTOE model.

Let us identify the loanwords on which JTOE exerts positive effects. The first step is to identify loanwords which bear an unfaithful accent. As the inputs of the model are not individual loanwords but phonological shapes, I extracted the input shapes for which the number of loanwords with an unfaithful accent is equal to or greater than ones with a faithful accent. Note that unfaithful accents are due either to markedness principles or to faithfulness to the outputs of JTOE. Thus, the next step is to exclude the cases in which unfaithful accents are induced by markedness principles. To do this, I excluded the cases in which the predominance of an unfaithful accent is already accounted for by markedness principles in the frequency model (i.e., the unfaithful accent is already assigned a higher probability than the faithful accent due to the effects of markedness constraints). Finally, I further excluded the cases in which the increase in probability of the unfaithful accent is small, specifically less than 0.3, under the JTOE model. This left 36 potential cases of hyperforeignisms. These loanwords are divided into two groups: loanwords whose accent patterns cannot be explained by the antepenultimate-mora accent rule or a rule equivalent to the Latin stress rule are shown in Table 3.15, while ones whose accent patterns of the former group can be simply attributed to the effect of JTOE, as they are unlikely to be supported by the markedness effects. On the other hand, the accent patterns of the latter group might be attributed to a cumulative effect of JTOE and markedness, as they are likely to be motivated by the markedness effects as well.

Input	Output	English	Loanword
/H'Gc/	⁵ [HG <l>]</l>	Georgette	⁵ [d͡ʒóːzett <o>]</o>
		roulette	⁵ [rúu:rett <o>]</o>
/L'GL/	⁴ [ĹGL]	regatta	⁴ [régatta]
/H'Vc/	⁵[H́V <l>]</l>	arcade	⁵ [á:ke:d <o>]</o>
/L'LLc/	4[ĹLL <l>]</l>	Caracas	⁴ [káraka<ɯ>]
		oasis	⁴ [óacis <w>]</w>
		delicious	⁴ [déri∫as<ɯ>]
		official	4[óфi∫ar <u>]</u>
		initial	⁴ [íni∫ar<ɯ>]
		Seattle	⁴ [síator <w>]</w>
/Lc'Lc/	4[Ĺ <l>L<l>]</l></l>	success	⁴ [sák <w>ses<w>]</w></w>
/H'LLc/	5[HLL <l>]</l>	Antares	⁵ [ántares <u>]</u>
		Honduras	⁵[hónd͡ʒɯɾas<ɯ>]
/LL'Gc/	⁵ [ĹLG <l>]</l>	minuet	⁵ [ménuett <o>]</o>
		cigarette	⁵ [ʃigarett <o>]</o>
/LL'Nc/	⁵ [ĹLN <l>]</l>	suspense	⁵ [sás <w>pens<w>]</w></w>
/H'LNc/	6[HLN <l>]</l>	Wyoming	⁶ [wáiomiŋg<ɯ>]
/H'LGc/	⁶ [HLG <l>]</l>	organic	⁶ [ó:ganikk <u>]</u>
/Lc'Gc/	5[Ĺ <l>G<l>]</l></l>	technique	⁵ [ték <w>nikk<w>]</w></w>

Table 3.15: Potential cases of hyperforeignisms whose accent patterns cannot be explained by the antepenultimate-mora accent rule or a rule equivalent to the Latin stress rule.

Input	Output	English	Loanword
/'LNc/	³ [LŃ <l>]</l>	legend	³ [reʒénd <o>]</o>
/'LHH/	⁴[LĤH]	Washington	⁴ [wacinton]
/'HHH/	⁴[HĤH]	hamburger	⁴ [hambáːgaː]
		messenger	⁴ [messénd͡ʒaː]
/'LLcc/	3[LĹ <l><l>]</l></l>	cobalt	³ [kobár <u>t<o>]</o></u>
		synapse	³ [sináp <w>s<w>]</w></w>
/LL'LL/	³ [LĹLL]	Hallelujah	³ [harérɯja]
/LH'LL/	⁴ [LĤLL]	volunteer	⁴ [borántia]
/cH'LL/	⁴ [<l>ĤLL]</l>	frontier	⁴ [øɯɾóntia]
/'LLLH/	4[LĹLH]	literacy	⁴ [ritéraci:]
		dormitory	⁴ [domítoriː]
/'LLLH/	³ [LLĹH]	television	³ [terebíd͡ʒon]
/'LHLH/	⁵ [LĤLH]	melancholy	⁵ [meránkori:]
/'LLcH/	4[LĹ <l>H]</l>	register	⁴ [reʒís<ɯ>taː]
		penalty	⁴ [penár <u>tiː]</u>
		character	⁴ [kjarák<ɯ>taː]
/'LLHH/	⁴[LLĤH]	elevator	⁴ [erebéːtaː]

Table 3.16: Potential cases of hyperforeignisms whose accent patterns can be explained by the antepenultimate-mora accent rule or a rule equivalent to the Latin stress rule.

3.3.7 Final model

In this section, I finalize the MaxEnt OT model by removing unnecessary constraints from the model created in Section 3.3.6. Specifically, I conduct a likelihood ratio test for each constraint until the model includes only constraints that statistically improve the model's fit to the data.

Likelihood ratio tests reveal that the effects the following constraints are not significant: NoLAPSE, WSP, INITFT, WSP(G), and WSP(N). Furthermore, including a frequency-sensitive sub-constraint which is weaker than the corresponding sub-constraint in each frequency pair (i.e., MAX[ACCENT](JP-HIGH), DEP[\acute{V}](JP-HIGH), DEP[ACCENT](ENG-LOW), MAX[ACCENT](ENG-LOW), and DEP[\acute{V}](ENG-LOW)) turns out to be redundant. This is because these sub-constraints with a weaker effect can be disposed of by simply adjusting the weights of the corresponding general faithfulness constraints (i.e., DEP[ACCENT], MAX[ACCENT], and DEP[\acute{V}]). Furthermore, the effects of DEP[\acute{V}](JP-LOW), MAX[ACCENT](ENG-HIGH), and DEP[\acute{V}](ENG-HIGH), which were significant in the frequency model, became non-significant in the final model, leaving only two frequency effects: loanwords which are frequently used as Japanese words tend to be unaccented while loanwords whose source words are frequent tend to bear a faithful accent. The best-fit weights of the constraints in the final model are shown in Tables 3.17. The log likelihood of the final model was -1997.37.

Туре	Constraint	Weight
Ito & Mester	Nonfinality(σ)	1.67
	NOLAPSE	
	MINIMALWORDACCENT	4.21
	RIGHTMOST	1.81
	WSP	
	FOOTBINARITY	1.46
	INITIALFOOT	
	NONFINALITY(Ft')	3.47
	WORDACCENT	
	PARSE-0	1.43
Additional	WSP-G	
markedness	WSP-N	
	WSP-V	3.11
	*DEVOICEDACCENT	2.53
Faithfulness	DEP[ACCENT]	0.45
	MAX[ACCENT]	2.75
	DEP[ACCENTEDV]	1.64
Frequency-sensitive:	DEP[ACCENT](JP-LOW)	
Japanese	MAX[ACCENT](JP-LOW)	0.36
	DEP[ACCENTEDV](JP-LOW)	
	DEP[ACCENT](JP-HIGH)	
	MAX[ACCENT](JP-HIGH)	
	DEP[ACCENTEDV](JP-HIGH)	
Frequency-sensitive:	DEP[ACCENT](ENG-LOW)	
English	MAX[ACCENT](ENG-LOW)	
	DEP[ACCENTEDV](ENG-LOW)	
	DEP[ACCENT](ENG-HIGH)	0.70
	MAX[ACCENT](ENG-HIGH)	
	DEP[ACCENTEDV](ENG-HIGH)	
JTOE	FAITH-JTOE[ACCENT]	0.81

Table 3.17: Best-fit weights of the constraints in the final model.

Finally, to show how each of the main components contributes to the model, I compare the final model with the models without the relevant component(s) by likelihood ratio tests. Results of the comparisons are summarized in Table 3.18. Ito and Mester's markedness constraints and additional markedness constraints are included in the markedness component, while faithfulness constraints and frequency-sensitive sub-constraints are included in the faithfulness component.

The model with the JTOE component only is not included in the table, as such a model is unreasonable given that JTOE is constructed based on faithfulness.

Include	Exclude	Log likelihood	Δ log likelihood
Faithfulness + JTOE	Markedness	-2592.98	595.61
Markedness + JTOE	Faithfulness	-2145.83	148.46
Markedness + Faithfulness	JTOE	-2018.14	20.77
Faithfulness	Markedness + JTOE	-2724.82	727.45
Markedness	Faithfulness + JTOE	-2190.64	193.27

Table 3.18: Comparisons of the components in the final model.

The table shows that the contribution of the markedness constraints to the final model is the greatest (Δ log likelihood = 595.61), followed by that of the faithfulness constraints (Δ log likelihood = 148.46) and that of JTOE (Δ log likelihood = 20.77). As it is already shown, however, none of these components are redundant for accounting for loanword accentuation in Japanese. Interestingly, the cumulative effect of two components is greater than simply summing up the individual effects of the two components. That is, the cumulative effect of faithfulness and JTOE (Δ log likelihood = 193.27) is greater than the addition of their individual effects (i.e., 148.46 + 20.77 = 169.23). Likewise, the cumulative effect of markedness and JTOE (Δ log likelihood = 727.45) is greater than the addition of their individual effects (i.e., 595.61 + 20.77 = 616.38). This suggests that the effect of each component is not independent. Rather, they work in tandem with each other.

3.3.8 Should the model be augmented further?

While the JTOE model (and the final model) captures the accent patterns more accurately than any existing models, it still makes some systematic errors in specific areas. While this section describes an effort to fix the errors, readers should be aware that the analysis put forth here is tentative. This

is because the constraints to be introduced in this section are more specific than those already included in the model and thus the status of them in terms of productivity and plausibility needs to be checked before integrating them into the final model.

The first systematic error is the underprediction of the unaccented pattern. That is, while the corpus data show that four-mora loanwords ending with a sequence of two light syllables tend to be unaccented, those loanwords generally receive a lower predicted probability of the unaccented pattern than the observed probability. I argue that there are two issues to be addressed here.

First, the MaxEnt OT model does not capture two of the observations that Kubozono (2006) makes on the unaccented pattern and confirmed by my corpus analysis. The first observation is that only four-mora loanwords (i.e., [LLLL] and [HLL]) tend to be unaccented while longer loanwords (i.e., [...HLL]) are overwhelmingly accented. The second observation is that four-mora loanwords with the unaccented shape tend to become accented when the final syllable is epenthetic (e.g., ⁴[ánimar<u>] 'animal'). To capture these two observations, I introduce two constraints shown in (17).

- (17) Additional constraints to capture the unaccented pattern
 - a. LONGACCENT: Loanwords longer than four moras must be accented.
 - b. DEP[FINALFOOTEDVOWEL] (DEP[FIN(V)]): Do not parse a final epenthetic vowel into a foot. (e.g., violated by /ˈænəməl/ → ⁰[(ani)(mar<u>)] 'animal').

LONGACCENT (17a) is a markedness constraint subject to a specific size requirement and intended to capture the first observation. I consider this as an analogy with the fact that native and Sino-Japanese words longer than four moras are typically compounds and thus bear the compound accent (Ito & Mester, 2018). DEP[FIN(V)] (17b), on the other hand, is a faithfulness constraint specific to a certain position and intended to capture the second observation. This penalizes the exhaustive footing for four-mora loanwords ending with an epenthetic syllable ($^{0}[(LL)(L < L)]$ violates the constraint), making the relevant loanwords accented: $^{4}[(LL)L < L]$ and $^{3}[L(LL) < L]$ are relatively better than $^{0}[(LL)(L < L)]$.

Second, Ito and Mester's (2016) mechanism to produce the unaccented pattern is inconsistent with the abundance of pre-antepenultimate-mora accent and pro-pre-antepenultimate-mora accent. Specifically, the former requires the four-mora unaccented shapes to be maximally parsed into feet (i.e., exhaustive footing: ⁰[(LL)(LL)], ⁰[(H)(LL)]), while the latter requires the relevant shapes to be minimally parsed (e.g., ⁵[(H)LH], ⁵[(LL)HL]). In the MaxEnt OT model I described, this conflict was resolved by prioritizing the latter, simply because they outnumber the former. I argue that the tendency for such four-mora loanwords to be unaccented comes from the tendency that four-mora compounds which consist of two bimoraic native words or Sino-Japanese morphemes are unaccented (e.g., ${}^{2}[kúro]$ 'black' + ${}^{2}[néko]$ 'cat' $\rightarrow {}^{0}[kuro+neko]$ 'black cat') (Kubozono & Fujiura, 2004; Oda, 2005; 2006). Ito and Mester (2016) attribute the unaccented pattern for such compounds to a strong tendency that each lexical item projects its own foot (LEXICALFOOT) (i.e., ${}^{0}[(LL)+(LL)], {}^{0}[(H)+(LL)], {}^{0}[(LL)+(H)], and {}^{0}[(H)+(H)])$. In line with their analysis, I argue that Japanese speakers tend to exhaustively parse four-mora loanwords into two bimoraic feet, being influenced by the existence of four-mora compounds. To capture the tendency, I introduce a constraint specific to four-mora loanwords, called PARSEFOURMORA (18), which requires fourmora loanwords which can be exhaustively parsed into two bimoraic feet to be parsed so.

(18) PARSEFOURMORA: Four-mora loanwords which can be exhaustively parsed into two bimoraic feet must be footed so (i.e., [(LL)(LL)], [(H)(LL)], [(LL)(H)], [(H)(H)]).

The second systematic error is that penultimate-mora accent for the LH loanwords with the initial syllable being epenthetic (i.e., ${}^{2}[<L>\dot{H}]$) is also underpredicted. In fact, this error is closely related to the first error (i.e., the underprediction of the unaccented pattern), such that penultimate-mora accent for the LH loanwords is at odds with the unaccented pattern for the four-mora loanwords. Specifically, the former accent pattern requires the weight of NONFIN(FT') to be low, as it necessarily violates the constraint (i.e., ${}^{2}[<L>(\dot{H})]$), while the latter requires it to be high, in order to exclude penultimate-mora accent (i.e., ${}^{2}[(LL)(\dot{L}L)]$, ${}^{2}[(H)(\dot{L}L)]$). To solve this conflict, I argue that violation of NONFIN(FT') is more allowable for monosyllabic and disyllabic loanwords than longer loanwords and introduce a version of NONFIN(FT') specific to loanwords consisting of more than two syllables, namely NONFIN(POLY), shown in (19).

(19) NONFINALITY(POLYSYLLABIC) (NONFIN(POLY)): The head (accented) foot does not contain the final syllable in loanwords consisting of more than two syllables.

Crucially, this constraint is not violated by penultimate-mora accent for loanwords with the LH shape (e.g., $^{2}[<L>\dot{H}]$) but violated by the same accent pattern for the four-mora loanwords ending with a sequence of two light syllables (i.e., $^{2}[(LL)(\dot{L}L)]$, $^{2}[(H)(\dot{L}L)]$).

Table 3.19 shows the best-fit weights of the four constraints included in the final model. Likelihood ratio tests confirm that including each of them significantly improves the model's fit to the data (LONGACCENT: Δ log likelihood = 42.57, p > 0.001; DEP[FIN(V)]: Δ log likelihood =

13.86, p > 0.001; PARSEFOURMORA: Δ log likelihood = 26.44, p > 0.001; NONFIN(POLY): Δ log likelihood = 59.82, p > 0.001). The log likelihood of the model increases to -1863.22, from - 1997.37 in the final model (Δ log likelihood = 134.15).

Constraint	Weight
LONGACCENT	1.66
Dep[Fin(V)]	2.69
PARSEFOURMORA	2.47
NONFIN(POLY)	5.89

Table 3.19: Best-fit weights of the four specific constraints included in the final model.

Figure 3.7 shows the predicted vs. observed plot based on the final model plus the four constraints introduced in this section. The correlation became much stronger and the underprediction of the unaccented pattern significantly improved.



Figure 3.7: Observed probabilities based on the corpus data vs. predicted probabilities based on the final model plus the four specific constraints.

3.4 Conclusion

In this chapter, I created a series of probabilistic models of Japanese loanword accentuation, in order to answer the five research questions in (5), repeated here as (20).

(20) Research questions of this chapter

- a. To check how Ito and Mester's (2016) classical OT model, the most comprehensive of the existing models, works against my corpus data
- b. To check the effects of markedness principles that are described in the literature or observed in my corpus data, but not integrated into Ito and Mester's model
- c. To test whether and how faithfulness effects to English source words influence loanword accentuation
- d. To test whether and how lexical frequency of English source words and that of loanwords as Japanese words influence loanword accentuation
- e. To test whether and how Japanese speakers' implicit knowledge of the English stress system (see Section 1.1), beyond outright faithfulness to individual source words, influences loanword accentuation

The baseline model, the MaxEnt version of Ito and Mester's (2016) model, revealed that simply making Ito and Mester's model probabilistic does not account for the corpus data well, suggesting that there are some components missing in the model. In particular, the accent patterns that are not predicted by Ito and Mester's classical model, i.e., pre-antepenultimate-mora accent for some shapes (e.g., ⁵[há:moni:] 'harmony') and pro-pre-antepenultimate-mora accent (e.g.,
⁵[ébidens<u>] 'evidence'), as well as the unaccented pattern (e.g., ⁰[amerika] 'America'), were generally underpredicted.

The first update, the augmented Ito-Mester model, confirmed the existence of two additional markedness effects in my corpus data. First, there was an effect of gradient syllable weight: heavy syllables consisting of a long vowel or a diphthong (i.e., V) are more likely to be parsed into feet (and thus more likely to be accented) than ones consisting of a vowel plus an obstruent coda (i.e., G) or a vowel plus a nasal coda (i.e., N). Second, as has been traditionally described in the literature (McCawley, 1977; Haraguchi, 1991; Tsuchida, 1997), devoiced vowels tend to avoid bearing an accent.

The second update, the faithfulness model, confirmed the existence of two types of faithfulness effects (excluding MAX[ACCENT], which is equivalent to Ito and Mester's markedness constraint, WDACC). First, loanword syllables that come from stressed syllables (as opposed to unstressed syllables) in English source words tend to be accented. Second, epenthetic syllables, which are derived from consonant clusters or word-final (non-nasal) consonants in English, tend to avoid bearing an accent. The fact that the integration of these faithfulness effects dramatically improved the model's fit to the corpus data (Δ log likelihood = 153.37), suggests that, contrary to the mainstream literature, loanwords with a faithful accent are not merely idiosyncratic exceptions, but the systematic, probabilistic competition between markedness and faithfulness shapes the basic structure of Japanese loanword accentuation.

The third update, the frequency model, confirmed the existence of two types of frequency effects (excluding the ones that turned out to be non-significant in the final model) as factors modulating the faithfulness effects: loanwords that are used more in Japanese tend to be unaccented, while ones whose source words are frequent in English tend to bear a faithful accent.

The former effect reflects the etymological status of loanwords in the lexicon, while the latter reflects the amount of exposure to source pronunciation. While these effects are not part of speakers' phonological grammar, the existence of such frequency effects in the established loanwords better our understanding of the borrowing process.

The fourth update, the JTOE model, revealed that Japanese speakers' implicit knowledge of the English stress system plays a crucial role in assigning loanword accents. Specifically, I argue that Japanese speakers create a model of the English stress system (i.e., JTOE) by being exposed to English source inputs and try to be faithful to the outputs of JTOE, even if they disagree with actual inputs. The faithfulness to JTOE occasionally overrides that to the actual inputs, leading to hyperforeignization. To my knowledge, this is the first evidence found in support of a module that represents native speakers' theory of a non-native language.

Finally, there were two accent patterns that were underpredicted in the JTOE model: the unaccented pattern for loanwords ending with a sequence of two light syllables (i.e., 0 [LLLL] and 0 [HLL]) and penultimate-mora accent for loanwords with the LH shape and the initial syllable being epenthetic (i.e., 2 [<L>H́]). I argued that these accent patterns require four constraints that are either subject to a certain size requirement or specific to a certain position. While including the constraints dramatically improved the model's fit to the data, improving the underpredictions of the two accent patterns, more work is needed to confirm the status of such constraints in terms of productivity and plausibility.

CHAPTER 4

Loanword adaptation experiments

4.1 Introduction

In Chapter 3 I showed that loanword accentuation in Japanese can be best explained by the combination of three factors: Japanese-internal markedness principles, faithfulness to source word inputs, and faithfulness to Japanese speakers' theory of the English stress system (JTOE). In this chapter, I conduct on-line adaptation experiments to seek converging evidence, going beyond the corpus data. This could be done in various ways, but two of the claims particularly accessible to experimental testing are faithfulness to source word inputs and the interaction with markedness. These are assessed in two ways: a choice task in Experiment 1 and a rating task in Experiment 2. Results of Experiment 1 are further discussed in comparison with the predictions of the MaxEnt OT model I created in Chapter 3. The results of Experiment 2 should be considered as supplementary.

The rest of Section 4.1 gives a brief background on the experiments, focusing on the difference between on-line adaptations and established loanwords (Section 4.1.1). Section 4.2 presents Experiment 1. Following this, Section 4.3 compares the experimental results and the predictions of the MaxEnt OT model. Section 4.4 presents Experiment 2. Section 4.5 concludes the chapter.

4.1.1 On-line adaptations vs. established loanwords

It is generally assumed that on-line adaptations exhibit stronger faithfulness than established loanwords (e.g., Glewwe, 2021). This assumption makes sense given that the latter are supposed to undergo loanword transmission in addition to loanword adaptation (Crawford, 2009). Given the

existence of the faithfulness effects in the corpus data (i.e., established loanwords), we naturally expect on-line adaptations to exhibit the faithfulness effects as well. Another question worth asking is whether the interaction between markedness and faithfulness observed in the corpus data is a consequence of loanword adaptation or loanword transmission. In fact, Shinohara (2000) argues that English words that are on-line adapted by Japanese speakers (presumably with a good command of English) generally preserve the primary stress as accent, indicating the absence of markedness in loanword adaptation at least as far as accent goes. This implies that the interaction between markedness and faithfulness observed in the corpus data mostly emerges as a result of increase in markedness through loanword transmission. However, since Shinohara does not provide details of the experimental design and results, it is not clear whether and how much Shinohara's finding is generalizable to other contexts. For example, we do not know whether the stress is *always* preserved regardless of the severity of markedness violation, nor how the knowledge of source words influences their adaptations (Shinohara's stimuli were real English words). Thus, it is worth conducting a more systematic experimental study on Japanese speakers' on-line adaptation of English words, in order to refine our understanding of this issue by comparing on-line adaptations with established loanwords.

4.2 Experiment 1: Choice task

In Experiment 1, I conducted an on-line loanword adaptation experiment, implementing a choice task. The choice task was chosen so that the results can be straightforwardly compared with the predictions of the MaxEnt OT model.

4.2.1 Methods

Participants listened to the English pronunciation of an English-based nonce word (e.g., ['sʌmɪp]), followed by its adapted Japanese forms with logically possible accent patterns (i.e., 4 [sámipp<u>], 3 [samípp<u>], 1 [samipp<ú/>ip<], and 0 [samipp<u>]). To distinguish finally-accented forms and unaccented forms, Japanese forms were embedded into a frame sentence *x*-*da* '(It) is x'. This prevents the application of the well-known neutralization process of Japanese (Poser, 1984; Sugiyama, 2006) whereby word-final accents are deleted. The participants' task was to make the most appropriate choice from the Japanese forms as a loanword version of the corresponding English source word. The crucial manipulation was that each English stimulus was given two pronunciations that vary in stress location, i.e., trochaic: ['sʌmɪp] vs. iambic: [sə'mɪp]. Participants were told that the English words they heard were place names in English.

4.2.2 Materials

A total of 24 English-based nonce words (counting stress variants separately) were prepared, such that their adapted shapes were either LH<L> or HH<L>. These two shapes were chosen because they exhibited a clear faithfulness effect and an interaction with two types of markedness effects, i.e., categorical weight for the antepenultimate syllable (L vs. H) and gradient weight for the penultimate syllable (geminate coda vs. nasal coda vs. long vowel). As we saw in Chapters 2 and 3, heavy syllables tend to be more accented than light syllables (H > L), and heavy syllables with a long vowel (i.e., V) tend to be more accented than ones with a nasal coda (i.e., N) and ones with a geminate coda (i.e., G) (V > N = G). In the MaxEnt OT model, the effect of categorical weight

was captured by FTBIN, while that of gradient weight was captured by the gradient versions of WSP (i.e., WSP(V), WSP(N), WSP(G)).

English nonce words were created by combining two consonant templates, i.e., [s-m-p] and $[p-\int k]$, with vowel templates, which were $[-\Lambda-I/i-]$ or [-3-I/i-] for trochaic words and [-3-I/i-] or \mathfrak{P} -I/i-] for iambic words. The word-initial vowels were adapted as [a] or [a:], with the non-rhotic vowels being adapted as short [a] (i.e., $[\Lambda, \Im] \rightarrow [a]$) and the rhotic vowels being adapted as long [a:] (i.e., $[\mathfrak{F}, \mathfrak{F}] \rightarrow [a:]$). The word-final vowels were adapted as [i] or [i:], with [I] being adapted as short [i] (i.e., $[I] \rightarrow [i]$) and [i] was adapted as long [i:] (i.e., $[i] \rightarrow [i:]$). These segmental adaptations are consistent with the basic correspondences between English and Japanese vowels (Crawford, 2009; Kubozono, 2015). Furthermore, the final syllable of the English-based nonce words was manipulated so as to be adapted as different types of heavy syllable. Specifically, there were three types: [I] + C, [I] + NC, and [i] + C. The first was adapted as [i] followed by a geminate coda (G), as in /'sAMIP/ \rightarrow [samipp<u>], the second was adapted as [i] followed by a nasal coda (N), as in /'s nmmp/ \rightarrow [samimp<u>], and the third was adapted as a long vowel (V), as in $/s_{\text{Amip}} \rightarrow [sa_{\text{mip}} < w]$. These three adaptation patterns are all well-established (See Kubozono et al., 2008 for the contrast between the first and third adaptations). The English nonce words and their adapted Japanese forms are shown in Table 4.1.

Consonant	English trochaic	English iambic	Adapted form	Adapted shape
[s-m-p]	'sлmīp	səˈmɪp	samipp <u></u>	LG <l></l>
	'sлттр	səˈmɪmp	samimp <u></u>	LN <l></l>
	'sлтip	sə'mip	samiːp<ɯ>	LV <l></l>
	's3•mīp	səˈmɪp	sa:mipp <u></u>	HG <l></l>
	's3•mImp	səˈmɪmp	sa:mimp <u></u>	HN <l></l>
	's3-mip	sə'mip	sa:mi:p <u></u>	HV <l></l>
[p-∫-k]	'p∧∫ık	pəˈ∫ık	pacikk <w></w>	LG <l></l>
	ˈpʌʃɪŋk	pəˈ∫ɪŋk	paciŋk <w></w>	LN <l></l>
	'pʌʃik	pəˈ∫ĩk	paci:k <w></w>	LV <l></l>
	'p3-∫ik	pəˈ∫ik	pa:cikk <u></u>	HG <l></l>
	ˈpɜ₋ʃɪŋk	pəˈ∫ıŋk	pa:ciŋk <w></w>	HN <l></l>
	ˈp₃∫ik	pə'∫ik	pa:ci:k <w></w>	HV <l></l>

Table 4.1: Stimuli for Experiment 1.

In addition to these 24 nonce words, three real place names, *Canada, Iraq*, and *Guam*, were included to guarantee the quality of the data. That is, participants who chose an unattested form for these real place names were excluded, as they are unlikely to be a native speaker of Tokyo Japanese, or may have not been paying enough attention to the task. The attested forms in the corpus data were ³[kánada] for *Canada*, ³[írak<u>] for *Iraq*, and ²[guám<u>] and ³[gúam<u>] for *Guam*. In addition, I accepted ²[irák<u>] for *Iraq* as it is acceptable as a loan adaptation, based on my near-native speaker's intuition of Tokyo Japanese. That is, participants were excluded if they chose either penultimate accent, ultimate accent, or no accent for *Canada* (i.e., ²[kanáda], ¹[kanadá], or ⁰[kanada]), or ultimate accent or no accent for *Iraq* and *Guam* (i.e., ¹[irak<ú>], ⁰[irak<u>], ¹[guam<ú], or ⁰[guam<u>]), as the best form.

English stimuli were recorded by a native speaker of Mainstream American English, who grew up in Ohio and represents a plausible model for the variety most often encountered by Japanese speakers. Japanese stimuli were recorded by the author, a near-native speaker of Tokyo Japanese. Both speakers were phonetically trained. The English speaker produced the phonetic transcription shown in Table 4.1 and the Japanese speaker produced each of the Japanese forms shown in Table 4.1 with four possible accent patterns (with a frame sentence *x-da* '(It) is x'). Both recordings were done in a sound-attenuated booth, using an SM10A ShureTM microphone and headset. The mean intensity of each stimulus was normalized to 70 dB.

4.2.3 Procedure

Participants performed the task remotely. They were instructed to use their own headphones in a quiet room. In each trial, participants first listened to an English-based nonce word (e.g., ['sʌmɪp]) repeated twice. They were then presented its adapted form in katakana orthography (e.g., $\psi \in \mathcal{Y}$ \mathcal{T}), the purpose of which is to show them how the word is normally segmentally adapted into Japanese. Following this, participants listened to the adapted Japanese forms with logically possible accent patterns, followed by the particle da (i.e., ⁴[sámipp<u>]-da, ³[samípp<u>]-da, ¹[samipp<ú>]-da, and ⁰[samipp<u>]-da), in a pseudorandomized order, with each adapted form being associated with a number (e.g., Sound 1 (音声 1): ⁴[sámipp<u>]-da, Sound 2 (音声 2): ³[samípp<u>]-da, Sound 3 (音声 3): ¹[samipp<ú>]-da, and Sound 4 (音声 4): ⁰[samipp<u>]da). Participants then moved to a different page, where they were able to listen to each of the adapted forms as many times as they liked and chose the best one as a loanword version of the corresponding English-based nonce word. The purpose of this design was to constrain the order in which participants heard the adapted forms while ensuring enough opportunities for them to listen to each adapted form. Participants repeated this process for 24 English-based nonce words and three real place names (27 trials in total).

Following a within-subjects design, each adapted Japanese form was presented to each participant twice: once after the trochaic English word (e.g., ['sAm1p] \rightarrow [samipp<u>]) and once after the iambic English word ([sə'm1p] \rightarrow [samipp<u>]). To reduce the priming effect, trials

were blocked into two, with the stress variants, which are adapted as the same segmental form, falling into different blocks. Participants were able to take a break between the two blocks.

Prior to the test trials, participants completed two nonce word practice trials. After the test trials, they filled out a language background questionnaire, which included questions to ensure their eligibility for the experiment and to assess their English proficiency level. In the questionnaire, participants were also asked whether they guessed the purpose of the experiment; nobody correctly guessed the purpose (i.e., influence of English stress on loanword accentuation). Participants provided informed consent to participate and were paid for their time. The experiment took approximately 20 minutes to complete.

4.2.4 Participants

Participants were recruited through Crowdworks (https://crowdworks.jp), a crowdsourcing website based in Japan. A total of 70 participants completed the experiment, but three of them were excluded because they provided wrong responses to real words. In total, results from 67 speakers (18 males and 49 females; mean age: 39; age range: 20-57) were analyzed.

To check if participants' English proficiency influences their responses, the participants were classified into three English proficiency levels which are determined based on their self-evaluations on a five-point scale of their comprehension, production, and pronunciation. Their English proficiency levels were determined based on the average of the three scores: participants who had average scores below 2.5 were classified as speakers with low English proficiency (21 speakers), ones who had average scores between 2.5 and 3.5 were classified as speakers with intermediate English proficiency (24 speakers), and ones who had average scores above 3.5 were classified as speakers with high English proficiency (22 speakers).

4.2.5 Statistical analysis

As it is shown later, loanword forms with ultimate accent (e.g., ¹[samipp $\langle \mathfrak{u} \rangle$]) or no accent (i.e., ⁰[samipp $\langle \mathfrak{u} \rangle$]) were rarely chosen as the best form (only 1.21% of the entire set of responses). Thus, those forms were excluded from the data for the statistical analysis. I analyzed the data using a mixed-effects Bayesian logistic regression model, as implemented in *brms* (Bürkner, 2017) in R. The accent pattern (pre-antepenultimate-mora vs. antepenultimate-mora), which was modeled with a logistic link function, specified as *family* = *bernoulli* in *brms*, was predicted by the stress pattern (trochaic vs. iambic), English proficiency (low vs. intermediate vs. high), categorical weight of the antepenultimate syllable (L vs. H), gradient weight of the penultimate syllable (G vs. N vs. V), and the interactions between English proficiency and each of the other predictors. I additionally included random intercepts for speaker and item.

The model was fit with weakly informative priors for the intercept and coefficient parameters, specified as normal($\mu = 0$, $\sigma = 1.5$), which is interpreted as no prior expectation of participants' baseline responses and an effect of each predictor. The model was fit to draw 4000 samples in each of four Markov chains, discarding the first 1000 samples from each chain and keeping the remaining 75% of samples for inference. I report the median estimate, 95% credible interval (Crl) for an effect, and the probability of directionality (pd) value, the last of which is obtained using the p_direction function in *bayestestR* (Makowski et al., 2019). The credible interval indicates the range of estimates for the effect in the posterior distribution. Thus, when 95% Crl excludes the value of zero (i.e., no effect), we have reliable evidence that the predictor in question has an effect. The pd value indicates the percentage that the posterior distribution for an estimate exhibits a given directionality, which corresponds very roughly to a p-value in the frequentist approach. A high pd value is taken as reliable evidence for the presence of an effect; I consider the effect of an estimate

is "credible" when the pd value is higher than 95%. When there is a credible interaction, post hoc comparison of contrasts was conducted using *emmeans* (Lenth et al., 2018).

4.2.6 Results

Before reporting the results of the statistical analysis, I will first provide a brief overview of the results based on visual inspection of the experimental data. Figure 4.1 shows proportion of accent patterns chosen by the participants. For convenience, the stress pattern on the horizontal axis is labeled with which accent pattern the stress pattern in the source word corresponds to (i.e., Troch: Pre, Iambic: Ant). The figure clearly shows that the faithfulness effect to stress exists in the experimental results, as there is a clear correlation between stress pattern and accent pattern across phonological shapes, such that the trochaic stress pattern (e.g., ['sʌmɪp]) induces more responses for pre-antepenultimate-mora accent (i.e., Pre, e.g., ⁴[sámipp<u>]), while the iambic stress pattern (e.g., [sə'mɪp]) induces more responses for antepenultimate-mora accent (i.e., Ant, e.g., ³[samípp<u>]).



Figure 4.1: Proportion of accent patterns from Experiment 1, split by stress pattern (horizontal axis) and phonological shape (facets).

Figure 4.2 shows the results split only by the phonological shape (i.e., collapsing the stress patterns). First, it is generally the case that antepenultimate heavy syllables attract more accent than antepenultimate light syllables (e.g., HG<L> vs. LG<L>). One exception is that light syllables in LV<L> attract more accent than heavy syllables in HV<L>, which is due to participants' unexpectedly strong preference for pre-antepenultimate-mora accent for LV<L> (i.e., 4 [sámi:p<u>], 4 [páci:k<u>]) when the accent pattern matches the stress pattern in the source word (i.e., ['sʌmip], ['pʌʃik]), as shown in Figure 4.1. Second, there is a tendency, such that heavy syllables with a long vowel (i.e., V) attract more accent than ones with a nasal coda (i.e., N) and the latter attract more accent than ones with a geminate coda (i.e., G). However, the general pattern is again reduced by the strong preference for pre-antepenultimate-mora accent for LV<L> when the source word bears an initial stress.



Figure 4.2: Proportion of accent patterns from Experiment 1, split only by phonological shape.

I now report the results of the statistical analysis. In performing a mixed-effects Bayesian logistic regression model, the two-level variables were contrast-coded (i.e., stress pattern: iambic = -0.5 and trochaic = 0.5, categorical weight: H = -0.5 and L = 0.5) and the three-level variables, gradient weight and English proficiency, were coded with heavy syllables with a nasal coda (i.e., N) and high English proficiency being the reference levels. These categories (i.e., heavy syllables with a nasal coda and high English proficiency) exhibit intermediate values and thus making them the reference levels allows us to compare the categories efficiently.

Results of the model show that there is a credible effect of the stress pattern, such that the trochaic stress pattern induces more responses for pre-antepenultimate-mora accent (β =1.48, 95% Crl [1.09,1.89], pd = 100). This is clearly shown in the left panel of Figure 4.3, where the results are split only by the stress pattern, collapsing the phonological shapes. The right panel of Figure 4.3 shows the proportion of adapted forms with the faithful accent chosen as the best by individual participants, who are grouped into three English proficiency categories (dots in each English proficiency category are randomly scattered over the horizontal axis in order to avoid them overplotting). The figure shows that most of the speakers chose the adapted forms with the faithful accent adove chance level (i.e., 0.5, excluding few cases of ultimate accent and unaccented pattern). The effect of English proficiency will be discussed later.



Figure 4.3: Proportion of accent patterns from Experiment 1, split only by stress pattern (left) and proportion of faithful accents chosen by individual speakers grouped by English proficiency (right).

Furthermore, there is also a credible effect of gradient weight in the penultimate syllable, such that heavy syllables with a geminate consonant induce more responses for pre-antepenultimatemora accent than ones with a nasal coda (β =1.44, 95% Crl [0.59,2.24], pd = 100). This means that the former attract less accent than the latter on the syllable in question. However, there is no credible effect of heavy syllables with a long vowel when it is compared with ones with a nasal coda (β =-0.31, 95% Crl [-1.15,0.50], pd = 79), although the former induces slightly more responses for antepenultimate-mora accent (attract more accent on the syllable in question) than the latter, as shown in the right panel of Figure 4.4. There is no credible effect of the categorical weight of the antepenultimate syllable (β =-0.40, 95% Crl [-1.07,0.28], pd = 89), although heavy syllables induce slightly more responses for pre-antepenultimate-mora accent (attract more accent) than light syllables, as shown in the left panel of Figure 4.4.



Figure 4.4: Proportion of accent patterns from Experiment 1, split only by categorical weight of the antepenultimate syllable (left) and split only by gradient weight of the penultimate syllable (right).

I now turn to the effects of speakers' English proficiency. Figure 4.5 shows the basic results broken down by the English proficiency. Results of the model revealed some unexpected but intriguing effects regarding speakers' English proficiency. First, there is a credible effect of English proficiency, such that speakers with intermediate or low English proficiency generally prefer more pre-antepenultimate-mora accent than ones with high English proficiency (High vs. Intermediate: β =0.87, 95% Crl [0.05,1.69], pd = 98; High vs. Low: β =0.82, 95% Crl [-0.02,1.67], pd = 97). Second, there is a credible interaction between the stress pattern and English proficiency, such that speakers with low English proficiency are less sensitive to the stress pattern than ones with high proficiency (β =-0.54, 95% Crl [-1.13,0.05], pd = 96), and speakers with intermediate English proficiency are more sensitive to the stress pattern than ones with high English proficiency in (β =0.50, 95% Crl [-0.11,1.10], pd = 95). Both the main effect and interactions are easily observed in Figure 4.6, where the results split by the stress pattern are further broken down by the English

proficiency. Post-hoc comparison for contrasts, however, shows that the effect of stress pattern is credible for speakers with any of the English proficiency categories, meaning that every speaker's choice is more or less influenced by the stress pattern regardless of their English proficiency (Low: β =-0.94, 95% Crl [-1.37,-0.49], pd = 100; Intermediate: β =-1.99, 95% Crl [-2.42,-1.52], pd = 100; High: β =-1.48, 95% Crl [-1.88,-1.08], pd = 100).



Figure 4.5: Proportion of accent patterns from Experiment 1, split by stress pattern (horizontal axis), phonological shape (horizontal facets), and English proficiency (vertical facets).



Figure 4.6: Proportion of accent patterns from Experiment 1, split by stress pattern (horizontal axis) and English proficiency (facets).

Finally, there are no credible interactions between the English proficiency and each of the two types of syllable weights (i.e., categorical and gradient syllable weight), suggesting that sensitivity to the syllable weight does not vary depending on participants' English proficiency.

4.2.7 Summary

This experiment confirmed the existence of faithfulness to stress and the interaction with markedness in on-line adaptations. First, the results of the statistical analysis confirmed the existence of the faithfulness effect to the stress pattern: participants tended to prefer the adapted form with the accent pattern, which matches the stress pattern of the source input. Second, the faithfulness effect was modulated by some of the markedness effects: heavy syllables with a geminate coda (G) attract less accent than ones with a nasal coda (N) and ones with a long vowel

(V). An interesting difference between the corpus data and the experimental results is that the former group G and N together (i.e., G = N < V) while the latter group N and V together (i.e., G < N = V). A potential explanation for this is that G involves a shorter sonorant duration (i.e., one mora) than N and V do (i.e., two moras) and the role of this phonetic factor is greater in on-line adaptations than in established loanwords. While there were no credible effects of categorical syllable weight (L vs. H) and the gradient weight between heavy syllables with a nasal coda and ones with a long vowel (N vs. V), it is worth pointing out that they are both probably due to participants' unexpectedly strong preference for pre-antepenultimate-mora accent for LV<L> (i.e., ⁴[sámi:p<u>], ⁴[páci:k<u>]) when the accent pattern matches the stress pattern in the source word (i.e., ['sʌmip], ['pʌʃik]).

The experiment also revealed some surprising effects of English proficiency. First, there was a tendency that speakers with high English proficiency generally prefer antepenultimate-mora accent more than ones with intermediate and low English proficiency. Second, while participants are generally sensitive to the stress pattern, their sensitivity varies depending on their English proficiency: speakers with low English proficiency exhibited the weakest effect of the stress pattern while the ones with intermediate English proficiency exhibited the strongest effect of the stress pattern.

4.3 Comparing experimental results and model's predictions

In this section, I compare the results obtained in Experiment 1 with the predictions of the MaxEnt OT model created in Chapter 3, in order to check whether the accent patterns predicted by the MaxEnt OT model are supported by the experimental data. In doing so, I compare the aggregated experimental data, disregarding any influence of English proficiency, with the predictions of the

MaxEnt OT model (i.e., the final model established in Section 3.3.7) for two groups of loanwords: loanwords that are low frequent in Japanese and whose source words are low frequent in English and ones that are low frequent in Japanese and whose source words are high frequent in English. Loanwords that are low frequent in Japanese are chosen because on-line adaptations have never been used in Japanese (i.e., zero frequency) while ones with both low and high frequent source words are chosen because the accessibility of source inputs probably depends on several different factors, such as the amount of exposure to source inputs, and it is not certain which frequency category is more comparable to on-line adaptations.

Figure 4.7 shows the experimental results aggregating across individual speakers (top), the probabilities of accent patterns predicted for loanwords that are low frequent in Japanese and whose source words are low frequent in English (Model-LL; middle), and those of accent patterns predicted for loanwords that are low frequent in Japanese and whose source words are high frequent in English (Model-LH; bottom). The comparison between the experimental data and model's predictions shows that the faithfulness effects to stress and the interactions with the categorical and gradient weights, predicted by the MaxEnt OT model, are generally confirmed by the experimental data. To see the effects of individual factors more easily, Figure 4.8 shows the data split by the stress pattern, while Figure 4.9 shows the data split by the categorical weight (left) and split by the gradient weight (right). A caveat regarding the latter is that the model predicts a three-way contrast among the gradient weight categories (i.e., G > N > V), as shown in the right panel of Figure 4.9, while the corpus data group G and N together excluding V (i.e., G = N > V) (remember that only WSP(V) gained a weight in the modeling). This difference is a consequence of incorporating Japanese Theory of English (JTOE) into the model (Section 3.3.6). Specifically, JTOE is modelled based on the assumption that V and N are derived from English super-heavy

syllables (e.g., $[as] \rightarrow [ais < u>]$ 'ice', $[geim] \rightarrow [geim < u>]$ 'game') while G is derived from English heavy syllables (e.g., $[gæp] \rightarrow [gjapp < u>]$ 'gap'), and the interaction of the gradient versions of WSP and FAITH-JTOE[ACCENT] results in the three-way contrast. The validity of this interaction is uncertain and needs to be checked in future research.



Figure 4.7: Proportion of accent patterns from Experiment 1 (top), probabilities of accent patterns predicted by Model-LL (middle), and probabilities of accent patterns predicted by Model-LH (bottom).



Figure 4.8: Proportion of accent patterns from Experiment 1 and model's predictions, split by stress pattern.



Figure 4.9: Proportion of accent patterns from Experiment 1 and model's predictions, split by categorical syllable weight (left) and gradient syllable weight (right).

There are two major differences between the experimental data and model's predictions. First, while the unaccented pattern was extremely rare in the experimental data, the MaxEnt OT model predicts some probability for it. Second, the experimental data generally exhibit a larger proportion of pre-antepenultimate-mora accent than the predictions of the MaxEnt OT model. I argue that these differences can naturally be explained by nativization in established loanwords. Specifically, the first difference can be explained by the decrease in faithfulness in established loanwords. While it is reasonable that participants chose an "accented" pattern of the adapted form as the best when the source pronunciation was immediately available to them, as it clearly contains a pitch fall, the faithfulness effect decreases during loanword transmission. The second difference can be explained by the increase in markedness in established loanwords. It is generally the case that preantepenultimate-mora accent is more marked than antepenultimate-mora accent. Remember that pre-antepenultimate-mora accent necessarily violates either NOLAPSE or RIGHTMOST (e.g., 5[(sa)mipp < w] or 5[(sa)(mip)p < w], while antepenultimate-mora accent does not (e.g., 3[(sa)(mip)p < u >] or 3[sa(mip)p < u >]). Thus, increase in these markedness effects naturally leads to a larger proportion of antepenultimate-mora accent.

To see the validity of these explanations, I modeled experimental data based on the MaxEnt OT model. In doing so, I created mini models which only include the relevant phonological shapes (i.e., LG<L>, LN<L>, LV<L>, HG<L>, HN<L>, HV<L>) and predict probabilities for loanwords with the two relevant frequency categories (i.e., Model-LL and Model-LH). I then fed the experimental data to each model as inputs, added two faithfulness constraints, DEP[ACCENT] and MAX[ACCENT], and one markedness constraint, RIGHTMOST, to capture the experimental data, and fitted the weights of them, allowing the weights to be negative and the weights of the existing constraints to be fixed. MAX[ACCENT] and RIGHTMOST are chosen to be responsible for changing

the ratio of accented and unaccented patterns and that of pre-antepenultimate-mora accent and antepenultimate-mora accent, respectively, while DEP[ACCENT] is added to check if there is any difference between the experimental data and model's predictions in terms of the faithfulness to the stress pattern.

Table 4.2 shows the best-fit weights of the additional constraints based on Model-LL and Model-LH. The table shows that the weight of MAX[ACCENT] increases while that of RIGHTMOST decreases to capture the experimental data in both models, confirming that the experimental data exhibit a stronger faithfulness and a weaker markedness than established loanwords. The weight of DEP[ACCENT] depends on the base model: it increases if the base model is Model-LL while decreases based on Model-LH. This suggests that the effect of DEP[ACCENT] for the experimental data is intermediate between the effect for loanwords whose source words are low frequent (Model-LL) and that for ones whose source words are high frequent (Model-LH).

	DEP[ACCENT]	MAX[ACCENT]	RIGHTMOST
Model-LL	0.12	1.74	-2.12
Model-LH	-0.54	1.74	-2.12

Table 4.2: Best-fitted weights of the constraints introduced to capture the experimental data.

Figure 4.10 shows the accent patterns observed in the experimental data and the predictions of the models with the additional constraints. As the figure shows, they exhibit a reasonable match, confirming that the difference between on-line adaptations and established loanwords can be generally attributed to nativization in established loanwords.



Figure 4.10: Proportion of accent patterns from Experiment 1 (top), probabilities of accent patterns predicted by Model-LL with additional constraints (middle), and probabilities of accent patterns predicted by Model-LH with additional constraints (bottom).

A remaining question is why the effect of the stress pattern in on-line adaptations is weaker than that in loanwords whose source words are high frequent in English. I argue that there are two potential reasons for this. First, it is possible that the design of the experiment made the effect of the stress pattern weaker than it could be. Specifically, the number of repetitions for each source input (i.e., twice) might not be enough given that participants were given no further opportunities to listen to it while listening to the adapted forms and choosing the best one. Second, the participants of this experiment might not represent the loan adaptors for real English words. While the participants of this experiment (intentionally) include speakers with varying English proficiency, it is reasonable to assume that loan adaptors in real language situations have at least some knowledge of the borrowing language.

In sum, the predictions of the MaxEnt OT model were generally replicated by the experimental data. While there are some differences, they have natural explanations in terms of the difference

in the nature of the data. That is, the experimental data, which consist of on-line adaptations, exhibit stronger faithfulness and weaker markedness effects than the predictions of the MaxEnt OT model, which are based on established loanwords.

4.4 Experiment 2: Rating task

In Experiment 2, I implemented a rating task, to seek further converging evidence that faithfulness and the interaction with markedness form the basis of loanword accentuation in Japanese.

4.4.1 Methods

Participants listened to the English pronunciation of an English-based nonce word (e.g., ['sʌmɪp]), followed by its adapted Japanese form with one of the accent patterns (e.g., ⁴[sámipp<u>]). Their task was to rate the Japanese forms on a five-point scale (1 = not acceptable at all, 5 = very acceptable) as a loanword version of the corresponding English source word. Note that, unlike Experiment 1, each trial involves listening to one English-based nonce word followed by one adapted Japanese form (instead of four). To keep the duration of the experiment short enough, the adapted forms with no accent (e.g., ⁰[samipp<u>]) were excluded from the stimuli. As in Experiment 1, the crucial manipulation was that each English stimulus was given two pronunciations that vary in stress location (e.g., trochaic: ['sʌmɪp] vs. iambic: [sə'mɪp]). Participants were told that the English words they heard were place names in English.

4.4.2 Materials

The materials for Experiment 2 were identical to those for Experiment 1, except that the unaccented pattern for adapted Japanese forms (e.g., ⁰[samipp<u>]) was removed. The same real

place names as in Experiment 1 (i.e., *Canada*, *Iraq*, and *Guam*) were included to ensure the quality of the data. In this experiment, participants who failed to give the maximum score (5 = very acceptable) to any of the attested form(s) (e.g., give 4 to ³[kánada] *Canada*) or ones who gave a score higher than 3 to any of the unattested form(s) (e.g., give 4 to ²[kanáda] *Canada*) were excluded.

4.4.3 **Procedure**

The procedure of Experiment 2 was identical to that of Experiment 1, except that participants performed a rating task instead of a choice task. In each trial, participants first listened to an English-based nonce word (e.g., ['sʌmɪp]) repeated twice. They were then presented its adapted form in katakana orthography (e.g., $\# \notin \mathscr{Y} \mathscr{T}$). Following this, participants listened to the adapted Japanese form with one of the three accent patterns (i.e., ⁴[sámipp<u>], ³[samípp<u>], or ¹[samipp<ú>]). Participants then rated the adapted Japanese form as a loanword version of the corresponding English-based nonce word. Note that participants heard the adapted Japanese form with only one accent pattern in each trial. Participants repeated this process for all the three accent patterns (presented in a pseudorandomized order) for 24 English-based nonce words and three real place names. Each participant completed a total of 81 trials (i.e., (24 nonce words + 3 real words) × 3 accent patterns).

As in Experiment 1, trials were blocked into two, with the stress variants of each Englishbased nonce word (e.g., ['sʌmɪp] and [sə'mɪp]) falling into different blocks, to avoid them influencing with each other. Participants were able to take a break between the two blocks. Prior to the test trials, participants completed two nonce word practice trials. After the test trials, they filled out the language background questionnaire used for Experiment 1. As in Experiment 1, nobody correctly guessed the purpose (i.e., influence of English stress on loanword accentuation). Participants provided informed consent to participate and were paid for their time. The experiment took approximately 20 minutes to complete.

4.4.4 Participants

Participants were recruited through Crowdworks. A total of 79 participants completed the experiment, but 20 of them were excluded because they either failed to give the maximum score (5 = very acceptable) to any of the attested accent pattern(s) for a real word or gave a score higher than 3 to an unattested form for a real word. In total, results from 59 speakers (20 males and 39 females; mean age: 37; age range: 20-58) were analyzed.

The participants were classified into three English proficiency levels based on the average of their self-evaluations of their comprehension, production, and pronunciation. The thresholds were identical to those for Experiment 1.

4.4.5 Statistical analysis

As it is shown later, adapted forms with ultimate accent (e.g., ¹[samipp<ú>]) were constantly rated low (the mean rating for ultimate accent across the shapes was 1.54), indicating their inadequacy as an accent pattern for adapted forms in general. Thus, the adapted forms with ultimate accent were excluded from the data for the statistical analysis. I analyzed the data using a mixed-effects Bayesian ordinal logistic regression model, as implemented in *brms* in R. To reduce the complexity of the model, the difference between the ratings for the two accent patterns, i.e., preantepenultimate-mora accent and antepenultimate-mora accent, for the same source input (e.g., ['sʌmɪp] \rightarrow ⁴[sámipp<u>] and ['sʌmɪp] \rightarrow ³[samípp<u>]) was modeled with a logistic link function, specified as *family* = *cumulative* in *brms* as the dependent variable. The predictors were the same as the Experiment 1: the stress pattern (trochaic vs. iambic), English proficiency (low vs. intermediate vs. high), categorical weight of the antepenultimate syllable (L vs. H), gradient weight of the penultimate syllable (G vs. N vs. V), and the interactions between English proficiency and each of the other predictors. As in Experiment 1, I included random intercepts for speaker and item.

The model was fit to draw 2000 samples in each of four Markov chains. I report the median estimate, 95% credible interval (Crl) for an affect, and the probability of directionality (pd) value. To further explore interactions, post hoc comparison of contrasts was conducted using *emmeans*.

4.4.6 Results

Figure 4.11 shows mean ratings for the accent patterns (horizontal axis), split by the phonological shape (horizontal facets) and the stress pattern (vertical facets). Let us first compare the facets vertically (Troch: Pre vs. Iamb: Ant), in order to check the effect of the stress pattern for each phonological shape. Based on visual inspection, it is clear that the trochaic stress pattern induces a higher mean rating for adapted forms with pre-antepenultimate-mora accent (red bars), while the iambic stress pattern induces a higher mean rating for ones with antepenultimate-mora accent (blue bars). The stress pattern does not seem to influence the mean ratings for ultimate accent (purple

bars). To see the effect of stress pattern more generally, Figure 4.12 presents the results split only by the stress pattern, collapsing the phonological shapes.



Figure 4.11: Mean ratings from Experiment 2, split by accent pattern (horizontal axis), phonological shape (horizontal facets) and stress pattern (vertical facets).



Figure 4.12: Mean ratings from Experiment 2, split by accent pattern (horizontal axis) and stress pattern (facets).

Figure 4.13 shows the results split by the phonological shape, collapsing the stress patterns, to visually check the effects of the phonological shape. The figure shows that the mean ratings systematically vary depending on the phonological shape.



Figure 4.13: Mean ratings from Experiment 2, split by accent pattern (horizontal axis) and phonological shape (facets).

First, there are general patterns based on the gradient weight of the penultimate syllable: heavy syllables with a geminate coda (G) induces a higher mean rating for pre-antepenultimate-mora accent (red bars) (attract less accent on the syllable in question), ones with a long vowel (V) induces a higher mean rating for antepenultimate-mora accent (blue bars) (attract more accent on the syllable in question), and ones with a nasal coda (N) exhibit an intermediate pattern (i.e., which accent pattern is preferred more depends on the categorical weight of the antepenultimate syllable). Second, the effect of categorical weight in the antepenultimate syllable is generally observed: light syllables induce a higher mean rating for antepenultimate-mora accent (attract less accent on the syllable in question), except for the contrast between HL<L> and LV<L>, where the latter induces

generally higher ratings for both pre-antepenultimate-mora accent (red bars) and antepenultimatemora accent (blue bars) and the preference relation between them does not look different (i.e., antepenultimate-mora accent is generally preferred). As in Experiment 1, this is caused by an unexpectedly higher rating for pre-antepenultimate-mora accent for LV<L> (i.e., 4[sámi:p<u>], 4[páci:k<u>]) when the accent pattern matches the stress pattern in the source word (i.e., ['sʌmip], ['pʌʃik]).

In performing a mixed-effects Bayesian ordinal logistic regression model, the difference between the ratings for pre-antepenultimate-mora accent and antepenultimate-mora accent (a higher value means more preference for pre-antepenultimate-mora accent) was coded as an ordered factor. As in Experiment 1, two-level variables were contrast-coded (i.e., stress pattern: iambic = -0.5 and trochaic = 0.5, categorical weight: H = -0.5 and L = 0.5) and the three-level variables, the gradient weight and English proficiency, were coded with heavy syllables with a nasal coda (i.e., N) and high English proficiency being the reference levels.

Results of the model show that there is a credible effect of the stress pattern, such that the trochaic stress pattern leads to more preference for pre-antepenultimate-mora accent (β =0.77, 95% Crl [0.46,1.08], pd = 100). This effect is clearly shown in Figure 4.14, where the difference between the ratings for pre-antepenultimate-mora accent and antepenultimate-mora accent is split only by the stress pattern.



Figure 4.14: Difference between the ratings for pre-antepenultimate-mora accent and antepenultimate-mora accent from Experiment 2, split only by stress pattern.

Furthermore, there are some credible effects related to the phonological shape. First, light syllables induce more preference for antepenultimate-mora accent (attract less accent on the syllable in question) than heavy syllables (β =0.68, 95% Crl [0.07,1.29], pd = 98), as shown in the left panel of Figure 4.15. Second, heavy syllables with a geminate coda in the penultimate syllable induce more preference for pre-antepenultimate-mora accent (attract less accent on the syllable in question) than ones with a nasal coda (β =1.08, 95% Crl [0.33,1.85], pd = 99), as shown in the right panel of Figure 4.16. However, there is no credible effect of heavy syllables with a long vowel as compared to ones with a nasal coda (β =-0.28, 95% Crl [-1.06,0.46], pd = 78).



Figure 4.15: Difference between the ratings for pre-antepenultimate-mora accent and antepenultimate-mora accent from Experiment 2, split only by categorical weight (left) and split only by gradient weight (right).

There are some credible interactions regarding the effect of the English proficiency. First, there is a credible interaction between the stress pattern and the English proficiency, such that speakers with intermediate proficiency tends to be more sensitive to the stress pattern than ones with high English proficiency (β =0.61, 95% Crl [0.16,1.07], pd = 99). There is no credible difference between speakers with low English proficiency and ones with high English proficiency in terms of their sensitivity to the stress pattern (β =-0.01, 95% Crl [-0.48,0.46], pd = 51). Post-hoc comparison for contrasts, however, shows that the effect of the stress pattern is credible for every group of speakers (Low: β =-0.76, 95% Crl [-1.13,-0.43], pd = 100; Intermediate: β =-1.38, 95% Crl [-1.73,-1.06], pd = 100; High: β =-0.77, 95% Crl [-1.09,-0.46], pd = 100). These results can be easily observed in Figure 4.16.



Figure 4.16: Difference between the ratings for pre-antepenultimate-mora accent and antepenultimate-mora accent from Experiment 2, split by stress pattern (horizontal axis) and English proficiency (facets).

Second, there is a credible interaction between the categorical weight and the English proficiency, such that the effect of categorical weight is weaker for speakers with low English proficiency compared to ones with high English proficiency (β =-0.74, 95% Crl [-1.20,-0.28], pd = 100), as shown in Figure 4.17. There is no credible interaction when speakers with intermediate English proficiency and ones with high English proficiency are compared (β =-0.17, 95% Crl [-0.63,0.29], pd = 76). Post-hoc comparison for contrasts show that the effect of the categorical weight is only credible for speakers with intermediate and high English proficiency (Low: β =-0.06, 95% Crl [-0.71,0.54], pd = 59; Intermediate: β =0.51, 95% Crl [-0.09,1.15], pd = 95; High: β =0.68, 95% Crl [0.07,1.29], pd = 98).



Figure 4.17: Difference between the ratings for pre-antepenultimate-mora accent and antepenultimate-mora accent from Experiment 2, split by categorical weight (horizontal axis) and English proficiency (facets).

Finally, there is a credible interaction between the gradient weight and the English proficiency, such that heavy syllables with a long vowel, compared to ones with a nasal coda, induce a lesser preference for pre-antepenultimate-mora accent (attract more accent on the syllable in question) for speakers with low English proficiency than for speakers with high English proficiency (β =-0.73, 95% Crl [-1.28,-0.16], pd = 99), as shown in Figure 4.18. There is no credible interaction when speakers with intermediate English proficiency and ones with high English proficiency are compared (β =-0.26, 95% Crl [-0.82,0.30], pd = 82). Post-hoc comparison for contrasts show that the effect of the gradient weight is only credible for speakers with low English proficiency (Low: β =1.01, 95% Crl [0.30,1.82], pd = 99; Intermediate: β =0.53, 95% Crl [-0.25,1.35], pd = 92; High: β =0.28, 95% Crl [-0.46,1.06], pd = 78).



Figure 4.18: Difference between the ratings for pre-antepenultimate-mora accent and antepenultimate-mora accent from Experiment 2, split by gradient weight (horizontal axis) and English proficiency (facets).

4.4.7 Summary

Results of Experiment 2 confirmed three main effects: the faithfulness effect to the stress pattern, the effect of categorical weight (heavy syllables attract more accent than light syllables), and the effect of gradient weight in terms of the contrast between heavy syllables with a geminate coda and ones with a nasal coda and a long vowel (heavy syllables with a geminate coda attract less accent than ones with a nasal coda and a long vowel).

The results also revealed some interactions regarding the English proficiency. First, the effect of the stress pattern is stronger for speakers with intermediate English proficiency than ones with low and high English proficiency, suggesting that the former group of speakers exhibit a stronger faithfulness effect to stress than the latter groups of speakers. Second, the effect of categorical weight is present only for speakers with intermediate and high English proficiency. Finally, the effect of gradient weight in terms of the contrast between heavy syllables with a nasal
coda and ones with a long vowel (N vs. V) is present only for speakers with low English proficiency.

4.5 General discussion and conclusion

A pair of the experiments generally confirmed the faithfulness effect to stress and the interaction with markedness. Specifically, the effect of the stress pattern and that of gradient weight in terms of the contrast between heavy syllables with a geminate coda and ones with a nasal coda and a long vowel (G vs. N, V) were consistently observed in both experiments, and thus seem to be robust. On the other hand, the effect of categorical weight (L vs. H) was only credible in Experiment 2, and that of gradient weight in terms of the contrast between heavy syllables with a nasal coda and ones with a long vowel (N vs. V) was not credible in either experiment. The absence of these effects is likely due to the unexpectedly strong preference for the pre-antepenultimatemora accent for LV<L> (i.e., ⁴[sámi:p<u>], ⁴[páci:k<u>]) when the accent pattern matches the stress pattern in the source word (i.e., ['sʌmip], ['pʌʃik]). Why is the effect of stress stronger than expected in these cases? A potential reason is that the phonetic similarity between the source words and their adapted forms might have caused the source words sound more Japanese-like than other source words, making perception of the source words in terms of the stress location easier. Specifically, the English [i] and Japanese [i:] for ['sAmip] and 4[sámi:p<u>] are closer to each other than the English [1] and Japanese [i] for ['sʌmɪp] and ⁴[sámipp<u>] or ['sʌmɪmp] and 4[sámimp<u>] are. Furthermore, the English [Λ] and Japanese [a] for ['sAmip] and 4[sámi:p<u>] are closer to each other than the English [3-] and Japanese [a] for ['s3-mip] and 5 [sá:mi:p<u>] are. Because of the higher degree of overall similarity between the source words and their adapted forms, participants might have been able to pay more attention to the stress pattern of the source words. To check if the validity of this explanation, another experiment without listening to source inputs would be needed.

There were also some intriguing effects of the English proficiency on the sensitivity to stress. First, speakers with intermediate English proficiency exhibited the strongest sensitivity to stress in both experiments. Second, speakers with low English proficiency exhibited a degraded sensitivity to stress in Experiment 1. I argue that the latter is due to the design of the experiment. That is, since the design of Experiment 1 constrains participants' exposure to source inputs more than that of Experiment 2, speakers with low English proficiency might have had trouble memorizing or even just hearing the source inputs. While the former is more puzzling, I offer a potential reason why speakers with intermediate English proficiency are more sensitive to stress than ones with high English proficiency (disregarding speakers with low English proficiency). The stronger faithfulness exhibited by speakers with intermediate English proficiency might have been caused by the same mechanism as hypercorrection (Labov, 1966). That is, speakers with intermediate English proficiency know that ones with high English proficiency, who are often responsible for loan adaptation, often preserve English stress as accent in loan adaptation, which leads them to overapply the patterns in experimental settings.

There were three credible effects only observed in one of the experiments. First, speakers with high English proficiency exhibited a general preference for antepenultimate-mora accent in Experiment 1. Second, the effect of categorical weight was only observed for speakers with intermediate and high English proficiency in Experiment 2. Third, the effect of gradient weight in terms of the contrast between heavy syllables with a nasal coda and ones with a long vowel (N vs. V) was present only for speakers with low English proficiency in Experiment 2. A potential reason for the first effect is that speakers with high English proficiency frequency-matched the accent patterns in the lexicon more than ones with lower English proficiency. While a similar explanation can be given to the second effect as well, there seem to be no obvious reasons why the third effect is present only for speakers with low English proficiency for the second and third effects. More experiment work is needed to confirm the status of these effects.

Finally, results of the experiments generally confirmed the predictions of the MaxEnt OT model. The comparison between them exhibited a reasonable match between the two in terms of the markedness-modulated faithfulness effects, with some intriguing differences. Specifically, the experimental results exhibited stronger faithfulness and weaker markedness than the predictions of the MaxEnt OT model. The former is mostly shown by the abundance of accented forms, while the latter is shown by a larger proportion of pre-antepenultimate-mora accent, in the experimental results. Contrary to the mainstream literature, which regards faithfulness as marginal enough to be negligible, results of the experiments provided converging evidence that faithfulness and the interaction with markedness form the basis of loanword accentuation in Japanese.

CHAPTER 5

Discussion and implications

5.1 Summary of findings

This dissertation presented a probabilistic model of loanword accentuation in Japanese (Chapter 3), based on large-scale corpus data (Chapter 2), and a pair of on-line adaptation experiments (Chapter 4), in order to gain deeper understanding of the mechanism of assigning loanword accent in Japanese.

My MaxEnt modeling supports the view that faithfulness effects exist in established loanwords. Furthermore, the effects are not random but systematic and probabilistic. That is, the competition between faithfulness and markedness probabilistically determines accent patterns of English-based loanwords. This means that the probability of assigning a loanword accent that is faithful to the stress pattern of the corresponding source word shifts depending on the severity of markedness violation.

My modeling also incorporates a novel proposal on the architecture of the phonological grammar for loanword adaptation, motivated by the existence of accent patterns that cannot be accounted for by the interaction of faithfulness and markedness. I argued that Japanese speakers implicitly create a model of the English stress system, Japanese Theory of English (JTOE), and exhibit faithfulness to its outputs, even if they disagree with the actual source words. Incorporating this module into the model captures what Janda et al. (1994) have characterized as hyperforeignization. The improved fit of models incorporating JTOE provides further evidence for Japanese speakers' sensitivity to source inputs and multi-dimensional nature of loanword phonology.

Results of the on-line adaptation experiments confirmed the existence of faithfulness effects to stress in experimental settings. Contrary to Shinohara's (2000) finding that the primary stress of English words is generally preserved as accent in on-line adaptation, the results also exhibit the interaction of faithfulness and markedness in on-line adaptations, suggesting that the interaction is not simply a product of nativization during loanword transmission, but part of the phonological grammar of Japanese speakers. Overall, the experiments provided converging evidence that the competition of faithfulness and markedness form the basis of loanword accentuation in Japanese.

5.2 Where does loanword accentuation come from?

Given that the literature disagrees on the empirical generalizations, it is not surprising that it also disagrees on the origin of loanword accentuation in Japanese. On the one hand, Shinohara (2000; 2004) argues that the general tendency to assign antepenultimate-mora accent comes from Universal Grammar. On the other hand, Kubozono (2006) attributes the same accent pattern to the most frequent accented pattern in the native phonology (i.e., antepenultimate-mora accent) and the abundance of accented loanwords (as opposed to unaccented) to Japanese speakers' knowledge that the primary stress of an English word is realized as a pitch fall when the word is produced in isolation. Outside Japanese, C. Ito (2014) proposes a mechanism of loanword adaptation in terms of loanword accentuation in Yanbian Korean. Ito argues that at the initial stage of the borrowing all loanwords are adapted as faithfully as possible to the source inputs, introducing only faithfulness constraints. After a certain number of loanwords are borrowed, speakers start to analyze the accentuation in loanwords phonologically and assign weights to markedness constraints, reducing the weights of faithfulness constraints. In the context of loanword

accentuation in Japanese, Ito's theory would predict an accentuation system almost equivalent to the English stress system.

Crucially, none of the previous accounts are consistent with the results of my MaxEnt OT modeling and on-line adaptation experiments. I argue that loanword accentuation in Japanese comes from the competition among three factors: Japanese-internal markedness principles, faithfulness to source inputs, and faithfulness to Japanese speakers' theory of the English stress system. This proposal highlights the probabilistic and multi-dimensional nature of loanword adaptation.

A remaining question is where the markedness principles come from. In this dissertation, I adopt Ito and Mester's (2016) markedness system as a baseline, assuming that they come from the accentuation of native and Sino-Japanese words, following Kubozono (2006). However, this hypothesis must be tested in future work, by explicitly comparing the accent patterns across the lexical strata.

5.3 Implications

In this section I discuss two implications of this dissertation.

5.3.1 Gradience in loanword phonology

While gradience is one of the current themes in theoretical phonology (e.g., Hayes & Londe, 2006; Anttila, 2007; Hayes et al., 2009; Zuraw & Hayes, 2017), it is relatively understudied in loanword phonology. As a series of studies in this dissertation show, gradience is abundant in loanword accentuation in Japanese. For example, both the MaxEnt OT modeling and on-line adaptation experiments revealed that neither pre-antepenultimate-mora accent nor antepenultimate-mora accent is categorically chosen for the LHL and HHL loanwords; their probabilities gradually shift due to the influence of at least three factors: markedness principles, faithfulness to source inputs, and faithfulness to JTOE. The use of the MaxEnt OT grammar enabled us to identify the effect of each component as well as that of each constraint in this highly complex system.

I assume that many phenomena in loanword phonology are inherently gradient, given the competition between markedness and faithfulness is often gradient. Without gradient formal methods, there would be a risk of oversimplifying the phenomena, failing to gain deeper insights from them on the mechanism of loanword phonology.

5.3.2 Native speakers' theory of a non-native language

The JTOE model successfully accounted for the role that Japanese speakers' implicit knowledge of the English stress system plays in determining loanword accents. To my knowledge, this dissertation represents the first attempt to model the interaction between native speakers' theory of a non-native language with the phonological grammar of the native language.

Furthermore, I argue that the mechanism whereby hyperforeignization occurs is even more general; speakers might overapply their theory of a non-native dialect (either social or geographical) to their speech in certain situations. A well-known classical example is hypercorrection in sociolinguistics, whereby speakers from a less prestigious dialect use the prestigious value of a linguistic variable more frequently than ones from a more prestigious dialect in formal speech styles (e.g., Labov, 1966).

This phenomenon can be understood as overapplication of less-prestigious speakers' theory of the more prestigious dialect. I hope this dissertation invites further attempts to model overcorrection phenomena, which I believe leads to a better understanding of crosslanguage/dialect phonology in general.

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