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An evolutionary account of loanword-induced sound change in Japanese

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Abstract

Generative accounts of loanword phonology typically focus on the role of an individual speaker's grammar and/or perceptual biases in generating the phonological adaptations seen in loanwords. While these types of generative models can be successfully used to explain static synchronic patterns in loanword adaptations in terms of the set of existing constraints in the native phonology, it is more difficult to use these models to explain changes in such patterns over time. In this paper I will propose a so-called "evolutionary" model of loanword borrowing which extends generative accounts by considering how the transmission of a loanword among the members of a speech community affects the establishment of adaptation patterns over time, allowing integration into the model of both the perceptual and social factors influencing adaptation patterns. I then use an agent-based implementation of the evolutionary model to model diachronic data on the adaptation of coronal obstruents before /i/ in Japanese loanwords from English, showing that the greater acceptability of [ti] and [di] sequences over time can be tied to the increase in contact with English speakers that took place during the late 19th and early 20th centuries.

An Evolutionary Account of Loanword–Induced Sound Change in Japanese

Clifford Crawford*

1 Introduction

Loanword phonology has traditionally posed a problem for rule-based theories of phonology, since they typically require loanword-specific rules, which are otherwise unmotivated in the native phonology, to account for the adaptation patterns seen in borrowings. However, since the publication of Yip (1993), there have been many analyses of loanword phenomena using the mechanisms of Optimality Theory (Ito and Mester 1995, 1999, Davidson and Noyer 1996, Broselow 2004:inter alia) as well as other constraint-based approaches (Paradis and LaCharité 1997, LaCharité and Paradis 2005). These analyses generally argue that loanword adaptation patterns occur during the production of a loanword token, and are driven by the interaction between faithfulness to the source language form and markedness constraints of the borrowing language. An alternative approach, also couched within the OT framework, focuses instead on the role of perception, specifically on the parsing of non-native phonetic patterns in terms of the native phonology (Kang 2003, Iverson et al. 2003, Peperkamp 2004). However, while both of these types of models have been successfully used to explain static synchronic patterns in loanword adaptations in terms of the set of existing constraints in the native phonology of the borrowing language, it turns out to be more difficult to use these models to explain changes in such patterns over time.

The particular adaptation pattern that I will be focusing on in this paper is the adaptation of coronal obstruents before [i] in Japanese loanwords from English. In the native phonology of Japanese, the coronal obstruents [t], [d], [s], and [z] cannot occur before the high front vowel [i]. This constraint not only holds as a static generalization over possible word forms, but also governs morphophonemic alternations in verb conjugation patterns. For example, the final /t/ in the root /mat-/ ‘wait’ surfaces as [t] in a form like /mat+anai/ → [matanai] ‘wait (neg.)’, but as [tʃ] in /mat+i+masu/ → [matʃimasu] ‘wait (polite)’.

A similar process of palatalization seems to take place in loanwords which are derived from source words containing a coronal obstruent before a high

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front vowel /i/ or /ɪ/ (the latter of which is borrowed into Japanese as [i]). For example, the English word ‘team’ has been borrowed into Japanese as [tʃi:mɯ], with the /ti/ sequence in English being adapted as [tʃi] instead of [ti]. However, in more recent loanwords, coronal stops (but not fricatives) tend to be preserved in this environment. For example, the word ‘director’ is only attested as [direkɯta:], not *[dʒirekɯta:], while ‘CD’ has been borrowed as [ʃi:di:] instead of *[ʃi:dʒi:]. Also note that in [ʃi:di:], the fricative is still palatalized even though the coronal stop is preserved. Thus there has been a change over time in the adaptation of coronals before /i,ɪ/ into Japanese; originally all coronals were palatalized in this environment, but now coronal stops are preserved while fricatives are still palatalized. This has created a new contrast before coronal and palatal stops before /i/ in recent loanwords which does not exist in the native phonology.

The goal of this paper, then, is to come up with a synchronic account of Japanese speakers’ behavior during the period of contact with English which can also be used to explain the facts of the historical change in the acceptability of [ti] and [di] sequences. I will now turn to a more detailed discussion of data collected from Arakawa (1977) showing the likelihood of palatalization of coronals during different time periods. After considering possible production-based and perception-based accounts of this data, I will then propose a so-called “evolutionary” model of loanword borrowing which extends the production and perception accounts by considering how the transmission of a loanword among the members of a speech community affects the establishment of adaptation patterns over time, allowing integration of both the perceptual and social factors influencing adaptation patterns into the model. I will conclude with a discussion of an agent-based implementation of the evolutionary model, showing how the acceptability of [ti] and [di] can be tied to the increase in contact with English speakers that took place during the late 19th and early 20th centuries.

2 Historical Data

In Crawford (2007) I discuss data gathered from Arakawa (1977), a Japanese loanword dictionary which gives for each entry several citations from newspapers, literary works, and other texts dating from the time the loanword was first attested, as well as more recent attestations from the mid-20th century if the word was still in use. From this dictionary I collected a set of 339 loanwords derived from source words containing a coronal stop followed by /i/ or /ɪ/. I used the orthography used in the citations to judge the likely pronunciation

of the loanword at that time, and then compared the most common outcome among all of the citations in each entry with the earliest listed date of attestation (which I assumed to be close to the date that the word was originally borrowed). The results are shown in Figure 1.

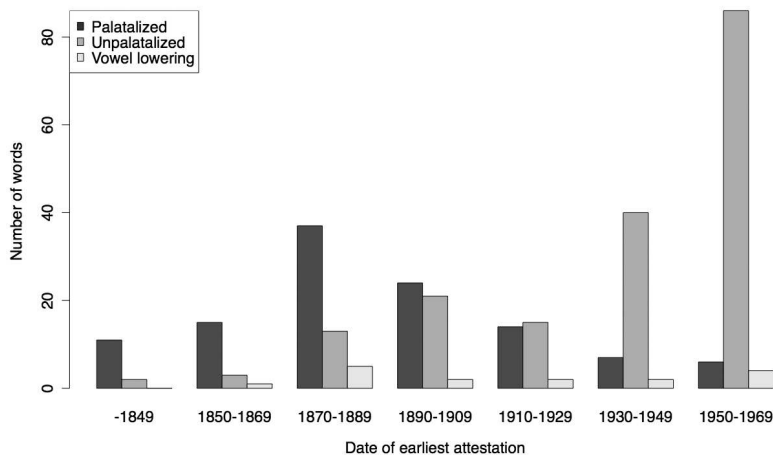


Figure 1: Adaptation patterns over time of TI-containing loanwords

One thing that is immediately striking is that the total number of new loanwords coming into the language has generally increased over time, with two discernible peaks occurring in the periods 1870-1889 and 1950-1969. These two peaks correspond with two significant events in Japanese history which increased Japanese contact with the outside world: the beginning of the modernization of Japan during the Meiji era, and the post-WWII occupation of Japan by the United States, respectively. As far as the individual adaptation patterns themselves, words first attested before about 1890 usually show the TI → ČI adaptation pattern,¹ while words first attested after about 1930 usually show the TI → TI adaptation pattern instead, with a gradual shift from TI → ČI to TI → TI taking place from 1870-1930. A third adaptation pattern, TI → TE, where the coronal stop is preserved but the vowel is lowered

¹In discussing adaptations, I will use the notation TI to refer to either the set of four possible source sequences /ti/, /tɨ/, /di/, and /dɨ/ or the set of unpalatalized outcomes [ti] and [di], ČI to refer to the set of palatalized outcomes [tʃi] and [dʒi], and TE to refer to the vowel-lowered outcomes [te] and [de]. SI, ŠI, and SE will be used for the corresponding sequences with /s/ and /z/.

to [e], turns out to never be very common relative to the other two adaptation patterns, except for a slight peak during the period 1870-1889.

During the period of variation from 1870-1930, adaptation patterns also depend on the phonological neighborhood that TI occurs in. For example, words with final /-ti/ ('city', 'humanity', ...), and words with TI occurring before a final /ŋ/ ('wedding', 'batting', ...), are commonly adapted as TI in the late 19th century, well before the general change to the TI → TI pattern (Figure 2), while words with /-tk(s)/ ('statistics', 'mystic', ...) and /#di-/ ('dimension', 'diploma') are variably adapted as TI or ĆI in the early 20th century (Figure 3). The likelihood of the TI → TI pattern turns out to correspond to the type frequency of the phonological environment that the TI sequence occurs in, in that it tends to be attested earlier in more frequent environments. Word-final /-ti/ is the most common environment for TI among loanwords first attested from 1870-1910, and /-tk(s)/ and /#d-/ are relatively common during this time period as well (Table 1).

1870–1889		1890–1909		1910–1929		1930–1949		1950–1969	
-ti#	14	-ti#	8	-tk(s)	8	-tk(s)	9	-tŋ#	16
-tk(s)	6	#d-	8	-ti#	5	#d-	7	#d-	14
#d-	6	-tk(s)	6			-diV	6	-diV	11
-diV	5	-diV	6					-ti#	9
-di#	5							-di#	6
								#dis-	6
								-dŋ#	5
all /ti/	40	all /ti/	28	all /ti/	23	all /ti/	30	all /ti/	50
all /di/	25	all /di/	23	all /di/	12	all /di/	24	all /di/	48

Table 1: Type frequencies of phonological environments for TI-containing loanwords. (Only environments with 5 or more examples for each time period are listed here.)

3 Previous Explanations

I will now examine how both production and perception models of loanword borrowing would account for the data above. As we will see, while both models are able to capture some aspects of the synchronic generalizations governing loanwords borrowed during a specific time period, neither can easily be used to explain the change in adaptation patterns over time.

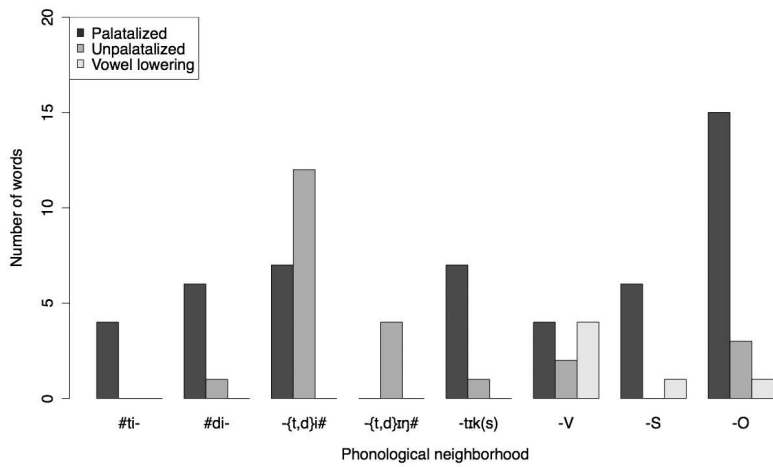


Figure 2: Adaptation patterns by phonological neighborhood, 1870-1899. (V=vowel; S=sonorant; O=obstruent)

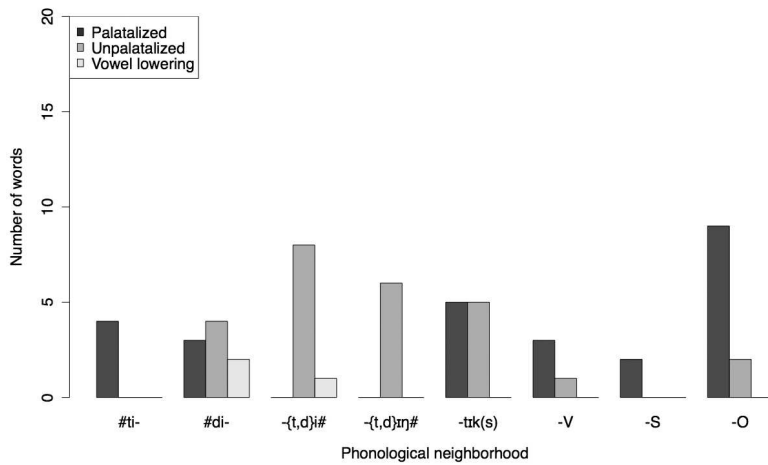


Figure 3: Adaptation patterns by phonological neighborhood, 1900-1929

3.1 A Production Account

One way of accounting for the palatalization of coronals in loanwords is to argue that there is a constraint against coronals occurring before /i/ in the phonological grammar of Japanese. (This constraint would also be active in the native phonology, causing the palatalization of root-final coronals in the verb conjugations discussed in section 1 above.) Japanese speakers, when borrowing a word containing TI, would then have to repair the illegal TI sequence to avoid violating this constraint (Table 2). This is exactly the approach taken in recent OT analyses of Japanese loanword phonology, such as Katayama (1998) and Ito and Mester (1999).


'team'	*TI	IDENT[CONT]
ti:muu	*!	
 tʃi:muu		*

Table 2: Adaptation of 'team' as [tʃi:muu] (based on Katayama 1998:170)

While this account unifies palatalization processes occurring in loanword and native phonology, by postulating a common constraint causing both, it cannot easily be used to explain why palatalization does not affect more recent loans, and why only stops, but not fricatives, can remain unpalatalized in recent loans. Ito and Mester (1999), in addressing these two questions, propose two different markedness constraints forbidding coronals before /i/, *SI (affecting fricatives only) and *TI (affecting stops only), as well as two sets of faithfulness constraints, one of which (FAITH₁) governs recent loans and the other (FAITH₂) which governs both older loans and native words, with the ranking *SI >> FAITH₁ >> *TI >> FAITH₂. While this does account for the data, it ends up being a rather stipulative account, and does not really explain, for example, why *SI is necessarily ranked above *TI, resulting in stops but not fricatives being preserved in recent loans.

3.2 A (Possible) Perceptual Account

Another possibility is to look at the role of perception in determining loanword adaptations, along the lines of Iverson et al. (2003) and Peperkamp (2004). Under this kind of approach, palatalization of TI would not result from a phonological constraint against TI sequences, but rather would result from Japanese listeners tending to confuse spoken tokens of TI with ČI (presumably because TI sequences do not exist in native Japanese words, and ČI

is the most perceptually similar sequence available in Japanese phonology). This leads into a possible explanation for the different behavior of coronal stops and fricatives in loanwords. The perceptual cues distinguishing [ti] from [tʃi] would be more salient than the cues distinguishing [si] from [ʃi], since [s] and [ʃ] are both fricatives, but [t] and [tʃ] differ in their manner of articulation (in particular, there is a burst of frication noise in the production of [tʃi] which would not be present in [ti]). Thus a Japanese listener may not have as much difficulty in distinguishing [ti] from [tʃi] in English as they would have in distinguishing [si] from [ʃi], and would presumably be more likely to preserve [ti] in loanwords.

However, a perception-based account does not turn out to be any better than a markedness-based account in explaining the change over time in acceptability of TI sequences. If the differences in the perceived input among different speakers were the only factor determining whether a TI sequence would be adapted as either ČI or TI, then we would expect the relative proportions of ČI vs. TI adaptations in new loanwords to remain constant over time. But in fact TI sequences in words first attested before 1890 are usually adapted as ČI, while TI sequences in words first attested after 1930 are usually adapted as TI, and it is hard to see how there could be a perceptual reason for this difference, since there is no reason to believe that mid 19th-century English speakers produced coronal stops before /i/ and /ɪ/ substantially differently from mid 20th-century English speakers.

4 Loanword Borrowing as an Evolutionary Process

The failing of both the markedness and perception-based approaches in explaining loanword adaptation is that neither approach can explain how the preferred adaptation strategy in a speech community can change over time. This is because both approaches focus solely on the role of the individual speaker in generating a particular adaptation, and do not consider how the conventions for adapting loanwords are eventually established among the members of a speech community. While knowledge of these conventions depends on knowledge of how individual loans are adapted, and thus would also depend on knowledge of the loans themselves outside of the bilingual speakers who originally borrowed them, most generative work on loanword phonology does not consider what role, if any, the transmission of loanwords from the initial borrowers to other members of the speech community may have in determining the final established form of the loanword. Instead, these researchers, if they consider this issue at all, seem to be assuming that the established loan-

word will remain unchanged after its initial adaptation. Paradis and LaCharité (1997) is an exception, but even they seem to put more emphasis on the role of individual (bilingual) borrowers' adaptations than on the subsequent diffusion of loans in explaining loanword adaptations: "Sociolinguistic studies show that the role of monolinguals in loanword phonology is *limited* to using and transmitting established loans, and, phrased in our terms, adapting the peripheral segments, which may sometimes have been left unadapted by bilinguals." (p. 394, my emphasis)

However, the main sociolinguistic study that Paradis and LaCharité cite, Poplack et al. (1988)'s investigation of borrowing in Francophone neighborhoods in the Ottawa-Hull area, can be interpreted as providing evidence for the importance of the diffusion process as well. While bilingual speakers produced many more loanword tokens than monolinguals in their study, the tokens produced by bilinguals tend to show less nativization than those produced by monolinguals. Also, there is a correlation between the number of speakers attested using a loanword and the degree of nativization, with those words being used by an intermediate number of speakers (less than about 20 speakers, based on their data) showing a degree of nativization falling in between nonce borrowings used only by a single speaker and established borrowings widely used throughout the speech community. The degree of nativization of a loanword also correlates to the length of time it has been attested, with tokens of words that have been attested since the 19th century showing more nativization than those words that have only been attested recently. These two correlations suggest that, as a loanword becomes more widespread through a speech community over time and is being transmitted among more and more monolingual speakers, these speakers are performing additional phonological changes to the original form of the loanword as it was introduced by bilingual speakers, creating new variants which become more and more nativized over time.

This leads into thinking about loanword borrowing as a kind of "evolutionary" process, in the sense that there is a population of loanword variants that are competing with each other as they spread through the speech community (Crawford 2007). This is compatible with recent work applying models from evolutionary biology to the general problem of language change (Croft 2000, Niyogi 2006, Nowak 2006). Let us consider what would happen as a loanword containing TI spreads through a community of speakers who are biased towards perceiving TI as ĆI. Some of these speakers will end up incorrectly learning the loanword as containing ĆI instead of TI, and will use only the ĆI variant in their own speech; yet there is no corresponding perceptual bias which would "correct" the ĆI variants back to TI. Depending on the like-

likelihood of $TI \rightarrow \check{C}I$ misperception, then, we would expect the $\check{C}I$ variants to eventually outnumber the TI variants, resulting in the established form of the loanword having $\check{C}I$ instead of TI . However, if the bias towards perceiving TI as $\check{C}I$ depends on a lack of exposure to tokens of words containing TI , then a large influx of TI loanwords over a short time period can potentially reduce the likelihood of $TI \rightarrow \check{C}I$ misperception among individual speakers, which would make it more likely for the TI variants of a new loanword to end up outnumbering any $\check{C}I$ variants created as it spreads through the speech community. This can potentially result in a change in the adaptation strategy for the entire speech community, such that $TI \rightarrow TI$ would be preferred over $TI \rightarrow \check{C}I$ for new loanwords.

In Crawford (2007) I derive three specific predictions that the evolutionary model of borrowing makes with regards to how nativization takes place:

1. The likelihood of nativization should vary with the average distance to bilingual speakers in the social network, such that if this distance becomes shorter, either through increased bilingualism over time, or through more exposure to bilingual speakers through e.g. mandatory second-language education, then nativization should become less likely (because there are fewer opportunities for misperception).
2. Nativization should be less likely during times of increased borrowing, because speakers are exposed to more examples of non-native phonological patterns.
3. Nativization should be less likely when a particular pattern occurs in a phonological environment with a high type frequency, again because speakers are exposed to more examples of the pattern in this context.

All of these predictions fit the historical data on TI adaptations in Japanese. Palatalization of TI was nearly obligatory until the 1870's, during which time there was both increased contact with English speakers and increased borrowing from English. Also, during the period of variation from 1870-1930, TI sequences first became acceptable in high type-frequency environments like word-final $/-ti/$, and then spread to lower-frequency environments over time, as was shown in section 2.

5 An Agent-Based Model of Loanword Borrowing

In order to further test the predictions of the evolutionary model above, I have developed an agent-based implementation of the model using NetLogo

(Wilensky 1999). A Java applet of this model is available at the following website: <http://www.people.cornell.edu/pages/cjc26/lw-model.html>.

5.1 Methods

The model consists of a population of N agents which are embedded in a social network, such that they can communicate only with the other agents they are directly connected to in the network. The network is generated using the algorithm in Davidsen et al. (2002). I chose this particular algorithm over more well-known social network models, such as Watts and Strogatz (1998)'s small-world model, and Albert and Barabási (1999)'s preferential-attachment model, because it has only a single tunable parameter (the probability of replacing a node in the network), making it simpler to understand its behavior over a range of values, and because it generates networks that are highly clustered, a property of real-world acquaintance networks (Kossinets and Watts 2006) which Albert and Barabási (1999)'s model fails to replicate.

The spread of a single loanword is modeled in the simulations described here. Each agent in the network represents its knowledge of the loanword using a parameter p which is the probability that the loanword contains a TI sequence. If $p = 1$, then the agent will always produce the loanword with TI, whereas if $p = 0$, then the agent will always use ČI instead. A certain fraction f_{biling} of the agents are designated as “bilinguals”, meaning that they start out with $p = 1$; all other agents start out with $p = 0$, reflecting the perceptual and articulatory biases against TI that Japanese speakers would have had before the late 19th century.

On each time step of the simulation, each agent which knows the loanword (only the “bilingual” agents, at the beginning) picks one of its neighbors in the network, and then produces a token of the loanword containing TI with probability p (and ČI with probability $1 - p$). The neighbor then updates its internal value of p so that p increases if it heard TI, and decreases if it heard ČI (specifically, $p_{new} = (1 - \lambda)p_{old} + \lambda\phi$, where $\phi = 0$ for ČI, $\phi = 1$ for TI, and λ is a tunable parameter controlling the rate of learning). Then, with probability p_{learn} , the neighbor “learns” the loanword and will begin producing it on the next timestep. Table 3 summarizes the parameters of the model, and the values tested in the simulations I ran.

5.2 Results and Discussion

For each possible permutation of parameter values, 10 models were generated and tested. Each model was run for an initial $4N$ time steps without loanword

Parameter		Values
N	Number of agents	5000
$p_{replace}$	Probability of agent replacement	0.04
f_{biling}	Fraction of bilingual agents	{0.01, 0.1, 0.25}
p_{learn}	Probability of learning loanword	{0.05, 0.1, 0.2}
λ	Learning rate	{0.05, 0.1, 0.2}

Table 3: Parameters and values used in loanword model

spreading to generate the social network, then run for an additional 250 time steps with loanword spreading. Then the mean value of p among all of the agents was recorded, and compared with the value of f_{biling} , the fraction of agents who are bilingual. The results show that the likelihood of the loanword being TI or ČI depends on the value of f_{biling} as the loanword spreads through the speech community (Figure 4).² In the case of low bilingualism ($f_{biling} = 0.01$), the ČI variants win out in the process of loanword spread. However, as bilingualism increases, the TI variants are more likely to survive. In these cases, a randomly chosen agent is on average closer to one of the bilingual agents in the network than they would be in the low bilingualism case (in terms of there being fewer links from the agent to the bilingual), reducing the likelihood of misperception of TI as ČI. With $f_{biling} = 0.1$, the final result is variation between TI and ČI forms of the loanword (with a slight bias towards TI variants), while with $f_{biling} = 0.25$, the TI variants end up winning out over the ČI variants.

In future simulations (Crawford In progress), I plan on having the agents use more realistic lexical representations, in order to capture the phonological neighborhood effects discussed in section 2. Also, increasing the fraction of bilinguals is not an accurate representation of what has actually occurred in the Japanese speech community during the period of contact with English. While English education has increased such that nearly all Japanese students nowadays study English in school, actual bilingualism in English remains relatively rare. One way to simulate this would be to have the few bilingual nodes in the network connected to many more nodes than they would be on average, to represent the effect of English teachers in the network.

²The other two parameters that were tested (p_{learn} and λ) do not directly effect the likelihood that TI or ČI will win out, but instead control the variance of the distribution of values of p in the population.

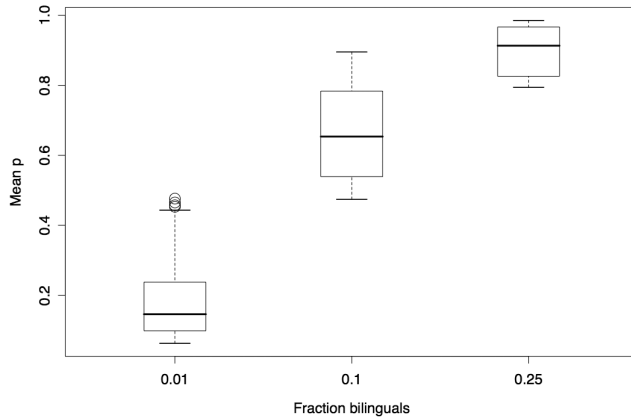


Figure 4: Box-and-whiskers plot of mean value of p for various values of f_{biling}

6 Conclusion

I have shown that, while models of loanword borrowing based on production or perception constraints can be used to explain synchronic patterns in loanword adaptations, using evolutionary models of sound change can help us to understand as well the interaction of individual-level (e.g. grammatical, perceptual) and social-level (degree of bilingualism) effects in changing adaptation patterns over time. In particular, this work suggests that the markedness effects seen in loanword adaptations are the result of an emergent process that takes place during loanword transmission (in the sense that less marked variants will tend to outnumber more marked variants), in addition to the grammatical constraints imposed by individual speakers. Thus it will be important in future research on loanword borrowing to separate out the effects of on-line adaptations done by individual speakers from the effects of transmission of new loanwords to other members of the speech community. While this can be inferred to some degree based on the length of time that a particular loanword is attested, as I have done with the data on TI palatalization in Japanese, more sociolinguistic research like Poplack et al. (1988) looking at how loanwords spread through a speech community over time will further our understanding of how this process can result in a change in adaptation strategies, and ultimately in the borrowing of non-native phonological patterns.

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