Variable Adaptation of English loanwords in German – a perceptual study

Emily Zelda Hillison

Master of Arts by Research

University of York

Language & Linguistic Science

May 2015

Abstract

A big question in the field of loan phonology, is that of the extent to which the perception of the speakers of the borrowing language affects the adaptation itself. Past researchers have had varying thoughts about this, ranging from the idea that perception is of utmost importance (Peperkamp, 2003), to the thought that is of very little significance (Uffmann, 2006). One phenomenon in this field that offers us useful insight into such issues is that of variable adaptation, namely when one word or sound is adapted in multiple ways into one language, and this is what I am interested in.

I investigate variable adaptation of the English FACE diphthong into German, which does not contain this "phoneme". The diphthong is adapted sometimes to /ɛ:/ and sometimes to /e:/, and the source of the variability is not lexical, as German dictionaries list both pronunciations as possible options for German speakers. Jax (2011) suggested that the variation may be due to the internal timing of the diphthong's formant trajectories, and the way this is perceived by German listeners.

Another important aspect within this field that I address is that of the methodology used in studying loan phonology. Generally, in past studies, the methods used have differed a lot based on whether researchers have been approaching the issue from a phonological of a phonetic viewpoint. For instance, the level of bilingualism that the subjects who are tested possess varies greatly. By taking methods generally used to measure the perception of an L2, such as those used by Boersma & Escudero (2002, 2004) and Iverson & Evans (2007), I am able to control for more variables, enabling me to argue that loan word adaptation can neither be treated as an entirely phonetic nor an entirely phonological process.

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Acknowledgements

Special thanks go to Dr Sam Hellmuth, without whom I almost certainly would not have been able to complete this project; the staff of the Department of Language & Linguistic Science at the University of York for helping with my endless queries; and the Philological Society, who provided me with the funding to complete this project.

Author's Declaration

I, Emily Hillison, declare that this thesis is a presentation of original work and I am the sole author. This work has not previously been presented for an award at this, or any other, University. All sources are acknowledged as References.

1. INTRODUCTION

In a world of global interaction and constant language contact, it is not surprising that linguistic borrowings are so commonplace an occurrence. Phonologically speaking, this gives rise to some interesting issues, since speakers of one language will have to find ways to overcome the fact that the words they are borrowing might not necessarily "fit" into their phonological system.

A range of phonological differences can arise: sometimes the two languages do not have the same contrasts for a certain feature (e.g. Dolhus 2005). Sometimes a language will not be able to cope with the syllable structure of a new lexical item (e.g. Peperkamp et al. 2008). In some circumstances, a loanword will be adapted variably, which presents an issue in phonological theory, as it makes the adaptation process a lot more complicated to explain. For instance, Japanese does not permit consonant clusters, and so they need to be either epenthesised or deleted when borrowed from other languages that permit them, such as English:

(1) Possibilities for English loanwords in Japanese

	English form	*Deletion*	*Epenthesis*
Cement	/səmɛnt /	[se.men_]	[se.men.to]

(From Smith 2006, page 68)

Languages choose to adapt loanwords in differing ways, and sometimes one language will treat borrowings from separate languages differently, although they may seem to be similar in phonological form. This is one reason that a lot of research and theories have been presented in attempts to explain such phenomena. A key point that arises over and over is that of perception, which is viewed as having various levels of importance in adaptation,

from being of highest importance, to being of very little significance.

Those theorists that view perception as being important usually tend to take a phonetic approach to loan phonology (Peperkamp, 2003), saying that the alterations made are due to misperception on a phonetic level. Researchers who do not estimate perception as being important often give phonologically-based reasoning for the adaptations that occur, saying that borrowings and loan words are accurately perceived but need to be mapped onto existing phonological categories in the target language in order to be phonologically grammatical (Uffmann, 2006).

Studying L2 phonology can also provide us with insight into what is going on with cases of loan phonology, as this field also looks at how people deal with and perceive foreign sounds. The rich perceptual methodology of L2 phonology may be very useful when applied to the field of loan phonology, and findings from this field can tell us a lot about how loan phonology might work, especially in a population that is already to some extent familiar with the source language.

In this paper, an experiment to test for a range of variables was carried out, with the intention of exploring the idea that loan word adaptation is neither wholly phonetic nor wholly phonological, but a combination of the two. The paper looks at the case of the adaptation of the English FACE vowel into German, which maps onto the two German categories /e:/ and /ɛ:/ but has no native diphthongal equivalent, and is adapted variably, sometimes even by the same speaker in the same phonological context. In order to investigate what might be causing the variation methods used in studies of L2 phonological perception were combined with the theoretical issues of loan phonology, the perception of synthesised target vowels on a continuum was tested, and the factors that affect the way

sounds are perceived were explored. By using methods from L2 phonology to address long standing issues within the field of loanword phonology, the aim was to show that a more thorough methodology could be a solution to better investigating some of the more complex cases of variable adaptation.

The remainder of this paper will summarise the relevant literature, before describing an experiment designed to test theories about variable adaptation in German loan phonology. Section 2 will be a literature review, Section 3 outlines the design of my study. Results are presented in Section 4, discussed in Section 5 and summarised in Section 6.

2. LITERATURE REVIEW

2.1. English and German phonology

2.1.1. Premise

One reported case of variable adaptation came from Jax (2011), in which the question was: “Do phonological features influence the borrowing of a foreign word?” She made some very interesting findings, including the fact that words containing highly salient foreign consonants, such as the English /θ/ and /ð/ seem to be simply avoided when borrowings are being made: in her corpus of 433 loanwords from English into German, only one of them contained a dental fricative (*meth*, as in *crystal meth*). Another point which she mentioned, but only in passing, was that the English diphthong /eɪ/, which does not exist in German, is adapted variably, as either /ɛ:/ or /e:/.

Another study, by Julia Abresch (2007), looked at German speakers' preferences when adapting English phonemes into German, to see whether there were patterns in whether a sound remained true to its English form or was generally adapted into a more German sounding phone. German listeners heard all versions of each phoneme when embedded into filler sentences, and had to choose which one they preferred. For some of the cases of variability, the preferences and production differences could be explained by the phonological context of the sound in question, such as whether it was in an open or closed syllable, or its surrounding phones, but for the FACE vowel this was not the case. The largest factor for this vowel seemed to be how much English each participant spoke - subjects who spoke less English tended towards a very "German" sounding adaptation of this vowel, and the more English a subject spoke, the more likely they were to show a preference for the British English form when hearing loanwords embedded in German sentences, and the closer their pronunciation came to an English diphthong.

Of the English xenophones that were looked at, the following were rated better in their original form than in any German sounding adapted form: [θ, ð, dʒ, ɹ, w, əʊ, eɪ, ɒ], [z] in the syllable coda and [s, sp, st] in syllable onsets. Most of the vowels, velarised [ɬ] and [b, d, dʒ, g, v] in syllable codas are not accepted by German listeners for English words in German contexts. The results were stable regardless of listeners' knowledge of whether the forms used were "correct" or not. In addition to this, she found that for the FACE vowel in particular, there were a lot of discrepancies over how it was and ought to be pronounced - the production test she carried out, which looked at both common and proper nouns, showed the following usages: [e:], [ei] and [ɛ:]. Interestingly, Abresch used natural speech samples to test perception, but suggested that the experiment would have been better carried out using synthesised speech, as it would give more control over the phonetic details being presented to participants.

Hillison (2012) carried out a small scale study of the adaptation of the English FACE vowel by German speakers. According to Duden, an esteemed German dictionary, a large amount of loan words that contain the FACE vowel suggest multiple pronunciations of the same word.
For instance:

Steak - [steːk] , [ʃteːk] , [stɛːk] , [ʃtɛːk] auch: [steɪk]

Date – [deːt] , [dɛːt] , [deɪt]

- from Duden dictionary of loan words.

This suggested that it isn't the word-internal phonological context that might be causing this vowel to be adapted in different ways. Based on this, Hillison (2012) made recordings of German speakers to see what sort of pronunciations they actually made, and

in which contexts each of these variations occurred. Evidence suggested that the variation was entirely random: Individual speakers would produce the same word differently at different points in conversation, sometimes even within the same sentence, showing that the variation isn't, like with lots of other types of phonological variation, related to the word-internal phonological environment. The place within the sentence or syntactic location of the word didn't seem to have any effect either - different types of variation showed up in different word classes (though mostly just in nouns and verbs, as the majority of borrowed words fall into these two categories), and for nouns the variation didn't depend upon whether the word was subject, (in)direct object, etc.

Looking at the production of these vowels by German speakers, and analysing them, showed that there was indeed internal variation across different utterances of the same words, even by the same speakers, as can be seen in the following cases (Figure 1 & Figure 2). In example 1 there is diphthongisation of the first formant, but not of the second formant, meaning that there was raising of the tongue but no centring, whereas in the second utterance of this word, the second formant shows significantly more movement, whilst the first formant moves a little bit, but not as much as in the first utterance, translating to a vowel that raises only slightly but becomes clearly more central.

German Make Up 1

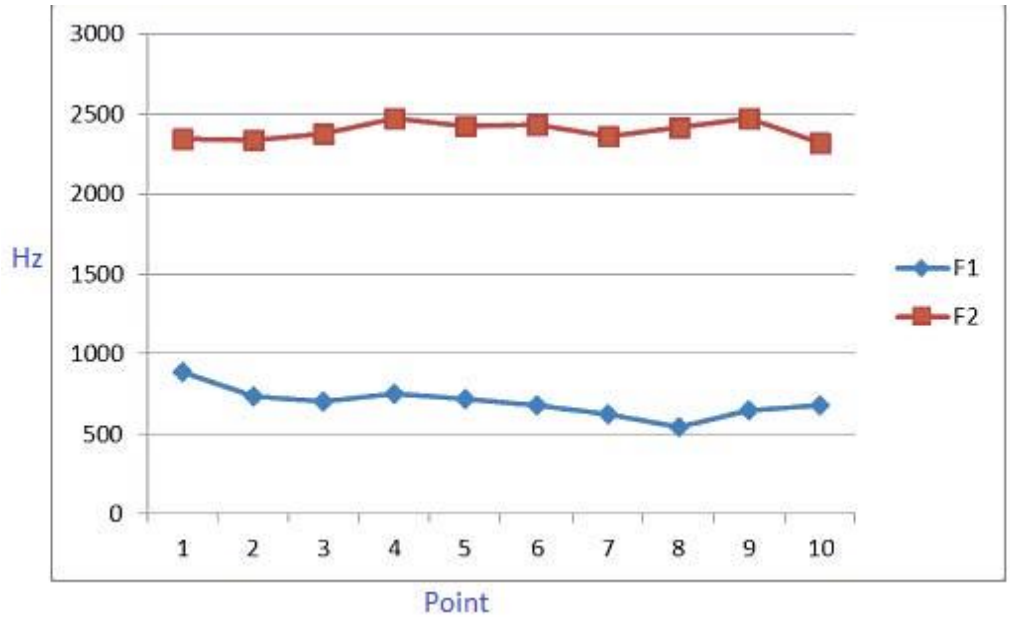


Figure 1: German Make Up 1

German Make Up 2

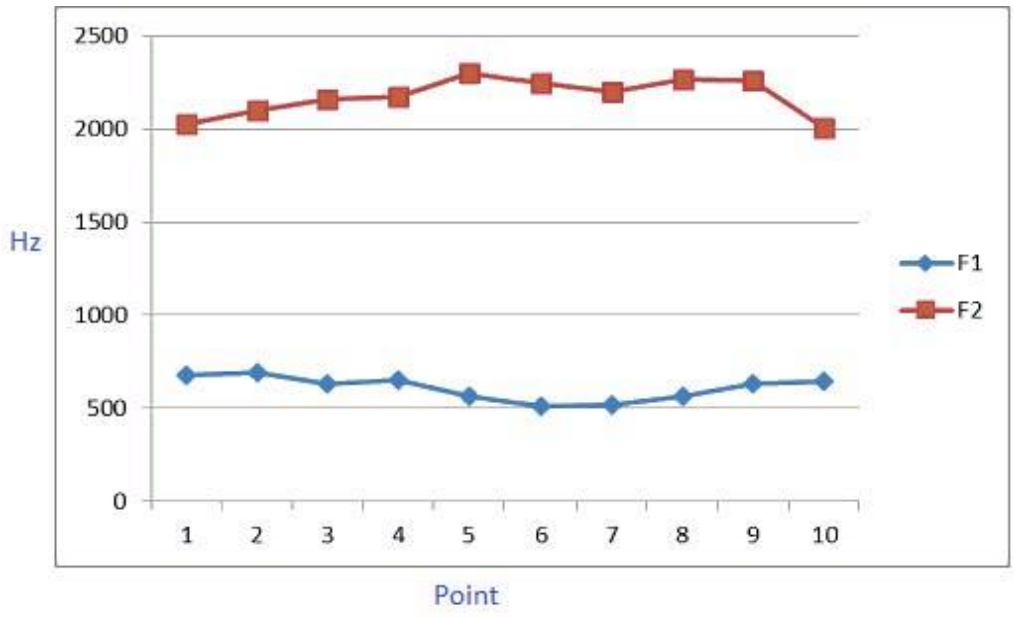


Figure 2: German Make Up 2

The same can be seen for the following example, this time a German speaker uttering the

word "date" in a German language context. In the first example both the F1 and the F2 move in a way that is similar to the internal movement of this diphthong in an SSBE accent, but the formant trajectories are significantly flatter, with less internal acoustic change. This would suggest an attempt at diphthongisation that is definitely not "German" sounding, but hasn't reached the level of movement required for an English FACE vowel. Compared with this, Example 2 of the same word seems far less "English" - the formants are almost flat, with movement appearing to be random acoustic fluctuations, instead of a defined trajectory, and the formant values, at ~500Hz and 2200Hz, are far more similar to German vowels than to anything found in English.

German Date 1

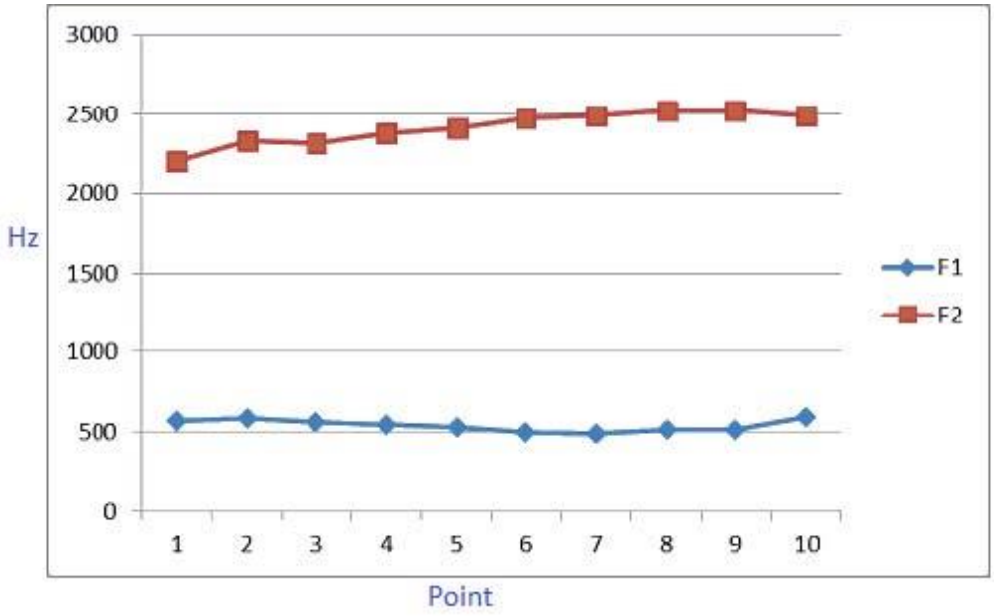


Figure 3: German Date 1

German Date 2

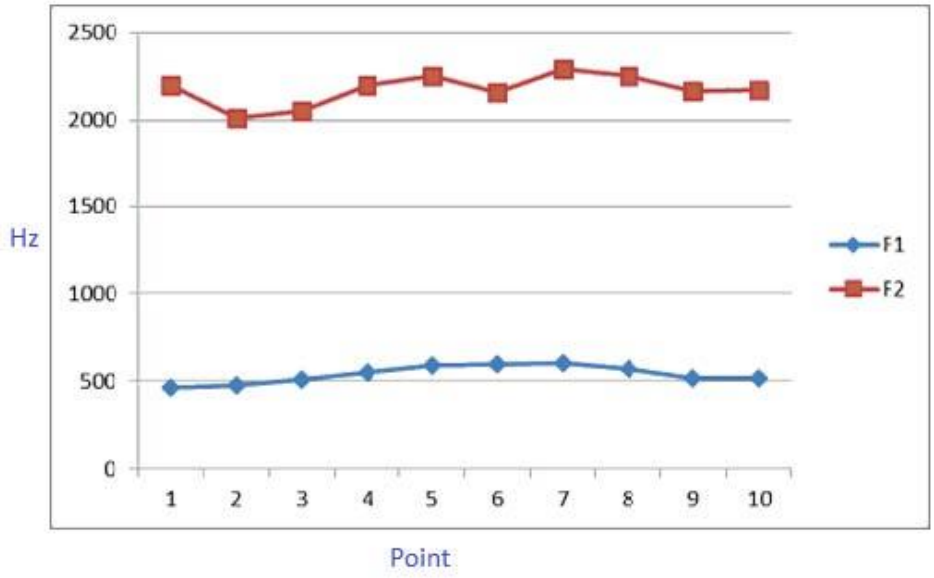


Figure 4: German Date 2

2.1.2. German

2.1.2.1. Cultural Overview

English as a global language is influencing many cultures and providing languages all over the world with new words and phrases, and this is the case for German as for many other languages. An example of this is that in 2010 a competition was set up called Anglizismus des Jahres (Anglicism of the Year), which in 2011 was won (to much protest) by the word "shitstorm", meaning an unforeseen problem that seemingly comes from nowhere and is almost impossible to correct. Anatol Stefanowitsch, who headed the jury, said that shitstorm "fills a gap in the German vocabulary that has become apparent through changes in the culture of public debate".

Galinsky (1967) did a study to see why German borrowed so many words from English,

the following being the main reasons he found:

1. Conveying the American atmosphere or setting.
2. Precision.
3. Creating or facilitating intentional disguise/euphemism.
4. Brevity.
5. Metaphorical translations to produce vividness in language.
6. Variation of expression.

As this study was done before the introduction of computer technology into everyday life and when there were fewer English and American influences on German media, it is likely that this list has since changed. A possibility is that the main reasons for borrowing will be reflected in the types of words that are commonly borrowed. Predictably, since English is the lingua franca for business, there are many technical, professional and scientific words in German that have been borrowed from English, examples include “das Briefing” and “das Downgrading”. However, the most common sources of borrowing that are used by a large amount of the population in everyday life are either related to technology or have entered German through the media. Examples of these are “das E-mail”, “der Hip Hop”, “das Wellness” and “der Fitness”. For many of the words borrowed, German has its own version, such as “Arbeiten” (to work), which is now being replaced by the loanword “Jobben”. This shows that German isn’t borrowing words due to necessity. Instead, the driving force behind the borrowing seems to be one of lifestyle, which is being fed down to the public from the media. Magazines and television shows use Anglicisms very frequently, and these are passed on to the people who are watching and reading. This results in the idea that peppering one’s conversation with English is “cool”.

2.1.2.2. Linguistic Overview

German has a consonantal inventory which is largely similar to English, apart from the absence of /θ, π, w, ɹ/ and the presence of /χ, ʁ, ʔ/. Details of this can be found in Table 1.

	Bilabial	Labiodental	Dental	Alveolar	Post-Alveolar	Palatal	Velar	Uvular	Glottal
Plosive	p b			t d			k g		**ʔ**
Affricate	**pf**			**ts**	tʃ dʒ				
Nasal	m			n			ŋ		
Fricative		f v	*ϴ* *ð*	s z		**ç**		**χ** **ʁ**	h
Approximant				*ɹ*	j		w		
Lateral Approximant				l					

Table 1: English and German consonant inventory. Phonemes common to both languages are represented in black, phonemes that only exist in German are bold, and phonemes that only exist in English are represented in italics. (Taken and adapted from: The International Phonetic Association, 1999, p.41 & p. 86.)

The German vowel inventory is also largely similar to English (both American and British) apart from the fact that it only has one open vowel which is central. It also has front rounded vowels which are absent from English. German, unlike English, only has three linguistic diphthongs: /aɪ/, /ɔɪ/ and /aʊ/. English has all of these, as well as /eɪ/ and /əʊ/, as well as three centering diphthongs (see Table 2 for details).

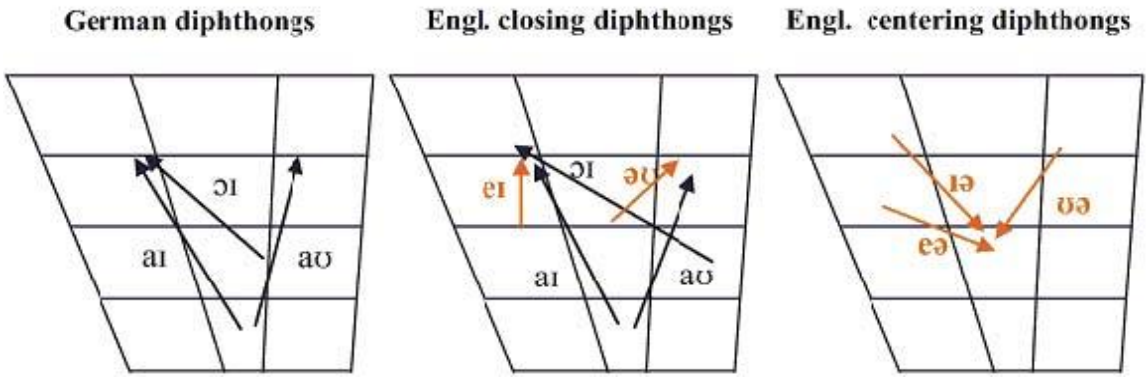


Table 2: English and German diphthongs. Taken and adapted from: The International Phonetic Association, 1999, p.41 & p. 86.)

Looking at the German vowel system in comparison to the English vowel system, it is clear that German contains a lot more front vowels than English. Unlike English German has front rounded vowels, and four vowel heights. As such, the German vowel space is used somewhat differently to the English vowel space. It should be observed that German has two front monophthongs in an area where English only has one, namely /ɛ:/. However if one looks at the English /eɪ/ diphthong, one can see that its start and end points are almost alike in quality to two German vowels /e:/ and / ɛ:/. This is because the use of the vowel space in the two languages is different, so the German /e:/ is in a similar location to what English speakers would perceive as something approaching /ɪ/, whilst the German /ɪ/ is itself further to the front and top of the vowel space.

The adaptation of English diphthongs into German in cases where there is no German version of the same diphthong is an interesting one. Since diphthongs, unlike most consonants and other vowels, are characterised by their internal movement, it may mean that there is scope for variation within the adaptation.

2.2. Loan phonology

2.2.1. Origins

It was Silverman (1992) who first suggested that there may be a separate loanword phonology that was different from both L1 and L2 phonology, the basic assumption being that loan words do not come equipped with their own phonology. In his 1992 paper "Multiple Scansions in Loan Phonology: Evidence from Cantonese" he outlined a model for loan word phonology in which there were two distinct levels of adaptation: the Perceptual Level and the Operative Level. The Perceptual Level was said to take the acoustic input and apply native segment and tonal inventory constraints, meaning that unfamiliar sounds or tones would be mapped onto a corresponding L1 phone or tone (though how to decide the corresponding phone or tone is not mentioned in Silverman's work). At the Operative Level, native phonotactic constraints and preferences are applied, leading to an output that is in keeping with the speaker's L1 phonology. There are a few issues with this idea, which can be explored by looking at other examples of loanword phonology. The first, which came about largely because Silverman only studied existing adapted words rather than studying the perception of incoming words by native Cantonese speakers, is that it is not clear from Silverman's model whether speakers of Cantonese are able to perceive the subtle differences between the sounds they are hearing and the adaptation of the sounds that Silverman claims they commit to memory. Perhaps it is because this study came before Best's 1994 work and Flege's 1995 work on the perception of second language sounds (see section, 2.3. for more details on L2 perceptual studies), which make predictions on how easily a listener will identify sounds that are not a part of their native phonemic inventory. This lack of prediction about newly incoming sounds means that Silverman's work, whilst ground breaking in its own right, lacks the ability to deal with some of the subtleties of loan word adaptation that have been explored since. Most studies of loan phonology since Silverman (1992) have followed the

idea that there is a separate loan word phonology, which is used for adapting unfamiliar sounds. However, there are those, such as Boersma & Hamann (2008) who argue that such a distinction doesn't exist, and loanword adaptation happens as part of a speaker's L1 phonology. Which, if either of these, is the case, is a very important factor to consider when studying cases of loan phonology, so these ideas will have to be explored in more depth.

2.2.2. Models

2.2.2.1. Silverman (1992)

As already seen, Silverman (1992) used already established loanwords from English in Cantonese to propose a model of loanword phonology in which there are two scansions. The idea was that the input was raw sound, which was then adapted to match the phonetic inventory of the borrowing language, after which the word was adapted such that it fitted with the phonological rules of the language, in regards to suprasegmental elements, such as stress and syllable structure. Presented below is the model he posits (Figure 5), in which the perceptual level and the operative level are shown as having different constraints.

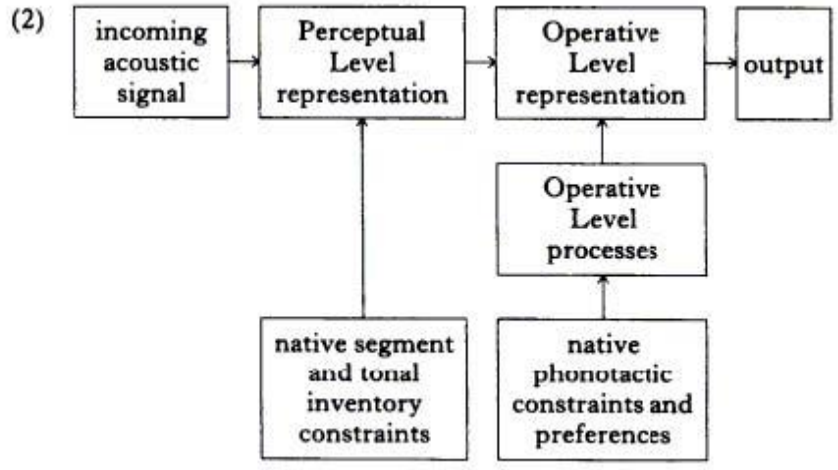


Figure 5: Silverman's model of Loan Phonology. Silverman, 1992, p. 293

2.2.2.2. Boersma et al. (2002, 2004, 2008)

Boersma & Escudero's (2002) model of the L2 acquisition of new sounds, suggested that listeners use a Gradual Learning Algorithm in order to over time adapt their native categories to include new phonological categories. This differs from Silverman in that it states that the original input will not always be falsely mapped onto an existing category, instead learners of a second language will, over time, begin to create new, distinct, categories for the new sounds. The extent to which this occurs has been shown to differ depending on the extent to which the learner in question is familiar with their L2. In Boersma & Escudero's 2004 study, it was found that Dutch learners of Spanish were able to create new categories relative to how well they spoke Spanish.

Boersma and Hamann (2008) present an Optimality Theory-based model of loan word adaptation. Their main claim in this is that, unlike what many other researchers have stated, whether loan word adaptation is driven by perception or phonology is a moot point, as phonology so influences native perception that they are one and the same thing. This, they state, allows for a single model of perception and production of both native and borrowed words.

2.2.2.3. Herd (2005)

Herd (2005) Loanword adaptation and the evaluation of similarity based on Clements (2001), which sought to create a phonological model that eliminated superfluous specifications, similar to underspecification theory. Herd uses an adaptation of Clements' model to study the differing adaptations of non-native consonants in Polynesian languages. In doing so he sets out to find a way of dealing with what Steriade (2001) has termed the "Too Many Solutions" problem of optimality theoretic analyses of loan phonology, namely that Optimality Theory generally allows for a far larger range of possible repairs than are actually attested; and the so called "Persistence of the Subjective" problem, that questions

why it might be that the same segments are adapted differently across languages. Clements' Theory of Constraints and Repair Strategies (TCRS) states that repairs must apply to the lowest phonological level possible, and that repairs must contain as few phonological steps as possible. Herd uses a model of feature underspecification to ascribe similarity between languages and explain why it is that different Polynesian languages deal with unfamiliar segments differently. However, Herd admits that this model doesn't explain language-internal variation in adaptation. Cook Islands Maori adapts the English phone [f] as both [p] and [v]. [v] is only found word initially, but [p] can be found word initially as well as in other positions, so there is some variation that is not positional. Herd admits that this problem is not dealt with by looking at cross-linguistic differences in phonological hierarchies, and suggests a number of possible ideas for where the answer to this problem might be found. One suggestion is that the variation is diachronic, and reflects differences over time in the language's phonological hierarchy; another is that it might be due to dialectal differences in those responsible for the original borrowings. The idea that speakers of the same dialect might vary their adaptations is one that is troubling to this model of loanword phonology, as it suggests one of the following things: either that feature hierarchy is not as rigid as Clement's theory suggests, and that speakers of the same dialect may have differing phonological hierarchies; or that the model that has been put forward is more deterministic than the actual process of nativisation in some languages.

This sort of variation is what I hope to investigate, and find some sort of explanation for. Whilst Herd's model of loanword adaptation is sufficient to explain differences in cross-language variation, I do not think it takes into account things like fine-grained phonetic details, and speakers' abilities to gradually change their phonologies over time, which is something that Boerma and Escudero's Gradual Learning Algorithm does take into account. As such, I will not be using Herd's model as, despite being interesting, it is

too rigid and abstract for my purposes.

2.2.3. Phonetic/acoustic views

In terms of phonetically-based theories, the strongest opinions in this field are held by Peperkamp (Peperkamp & Dupoux, 2003; Peperkamp, Inga & Kimihiro, 2008). Peperkamp and Dupoux (2003) challenged the idea that the phonetic forms of source words are faithfully copied onto an abstract underlying form: "The native language distorts the way in which we produce, but also memorize, and even perceive foreign sounds" (Peperkamp & Dupoux 2003, page 367). They claim that it is no accident that there is general similarity between loanword adaptations and so called phonological "deafness". This phonological "deafness" is said to be present in almost all speakers, since native phonological boundaries and categorical perception begin to form between 6 months and 1 year of age, therefore the only people who would be able to accurately hear words in their non-native language would be highly proficient, simultaneous bilinguals (that is, bilinguals who have learned both languages from birth as two L1s, as opposed to acquiring first one language, then the other as an L2): anyone else who introduced loanwords into their L1 would misperceive the word and unknowingly adapt it even before mentally storing its form. Phonological decoding is disregarded; Peperkamp and Dupoux claim that the only decoding process that is needed will happen when a word that is phonologically ungrammatical gets mapped onto the phonetic possibilities that exist for a speaker. In their 2003 paper, Peperkamp and Dupoux outline a suggested method for testing their theories about loanword adaptation, which would need to involve the following things: (1) An assessment of the precise phonetic characteristics of productions in both source and borrowing languages.

(2) Finding out whether the perception of the non-native sound patterns are as expected on the basis of the phonetic distance between the source and target categories, and whether

this is the same in isolated lab conditions and normal speech.

(3) The perception data should be checked against loanword data. Because of the issues with words that have already been borrowed, a good method here would be to do this with nonsense words.

Following the guidelines set out by Peperkamp & Dupoux (2003), Peperkamp, Inga & Kimihiro (2008) provide empirical data that supports claims that loanword adaptation takes place on a purely phonetic and perceptual level. This is from the case of the differing adaptation of French and English words with a word-final [n] into Japanese. The only consonants that are allowed to occupy coda position in Japanese are moraic nasal consonants or the first half of a geminate, so adaptation is necessary. English words are always adapted with a final moraic nasal consonant, whereas French words always end with a word-final epenthetic vowel.

(2) a. *Loanwords from English*

wōkuman < walkman

monsūn < monsoon

b. *Loanwords from French*

kannu < Cannes [kan]

terinu < terrine [tɛʁin] 'pâté, terrine'

(From Peperkamp, Inga & Kimihiro 2008, page 130)

They suggest various possible reasons for this including orthography; adaptations calculated based on the underlying form not the surface form; global differences in English and French phonology; and that adaptations are calculated on the basis of fine-grained phonetic representation rather than the phonological surface representation of the source

language. Of these, the only suggestion tested was the final one, as it supported their hypothesis and it lacked the flaws that the other theories had (namely that they would require words to enter the language either orthographically or via highly proficient bilinguals). Their tests showed that the French word-final nasals were produced with a release that was both longer and of a greater acoustic intensity than the English word-final nasals. Japanese speakers were then tested for ability to perceive differences in nonsense words, and were found to perceive the words spoken by speakers of French as having a word-final vowel significantly more than the same words spoken by English speakers. Based on this, they concluded that perception of phonetic details was definitely what was causing the different adaptations of word-final nasals from French and English into Japanese. However, the failure to test for phonological or orthographic possibilities may mean that the relative importance of these factors has possibly been overlooked.

Whilst not taken from actual cases of loanword adaptation, the work of Hay, Pierrehumbert & Beckman (1999) is still very relevant as an argument for phonetic adaptation in loan phonology. They experimented using cross-spliced clusters as part of nonsense words, and asked participants to do judgements of well-formedness and orthographic transcriptions of the words. The findings were that both the judgements of well-formedness and the orthographic adaptation given to the words reflected the frequency of the phones they were made up of within the participants' L1, and it was not simply the case that all legal clusters were perfectly understood whilst all illegal clusters were misinterpreted. The results showed that speakers perceive what they hear frequently better than what they hear infrequently and that this is less to do with phonological rules and more with the fact that knowledge of phonological grammar is said to abstract over the lexicon.

2.2.4. Phonological views

At odds with phonetically-based theories are those which support the idea that adaptation is phonologically driven, such as LaCharité and Paradis (2005), which provides arguments and evidence for phonological adaptation over phonetic adaptation. The main piece of evidence is that, in loanword adaptation, category preservation is preferred to phonetic proximity. The claim is that typical L2 perception and interpretation errors are not reflected in the adaptations of loanwords, and that borrowers accurately identify L2 sound categories, operating on the mental representation of an L2 sound, not directly on its surface phonetic form. This is in direct opposition to Peperkamp and Dupoux (2003). LaCharité and Paradis (2005) assume that those who originally borrow and adapt words in a language are proficient bilinguals, and that words are adapted by them to best match the phonologies of the two languages before going into wider use by monolinguals of the borrowing language.

LaCharité and Paradis (2005: page 226) propose the Category Preservation Principle: "If a given L2 phonological category (i.e. feature combination) exists in L1, this L2 category will be preserved in L1 despite phonetic differences". An example is that of the voicing contrast in English and Spanish: both languages have a voiced/voiceless contrast in plosives in word-initial position. English differentiates /p, t, k/ and /b, d, g/ based on voice onset time not actual voicing, so both series of stops are actually phonetically voiceless (in that voicing begins after the release of the stop closure instead of during the stop, as is the case in Spanish), it's just that /p, t, k/ have a longer voice onset time (by about 20ms) than /b, d, g/. Spanish, on the other hand, differentiates the two based on voicing, with /b, d, g/ being prevoiced and /p, t, k/ being phonetically more like the English /b, d, g/ than /p, t, k/. Despite this, when adapting English words borrowed into Spanish, bilingual speakers maintain the phonological voicing distinction rather than being true to the phonetic reality

of the loanwords.

Smith (2006) similarly argues that the perception-only model of loanword adaptation is too restrictive and suggests that whilst perception does play a role in adaptation, phonological grammar is important too. Smith points out that in several languages loanwords are treated one way, whilst native words of similar phonetic categories are treated in a different way. An example is Japanese, which doesn't contain consonant clusters, and generally breaks them up in native words with deletion, should they arise due to affixing and in loanwords with epenthesis, apart from in the phenomenon of loan doublets.

(3) a. Deletion repairs in non-loan phonology

Non-past /-ɾɯ/ *causative /-sase/*

'read' /jom-ɾɯ/ [jo.m ɯ] /jom-sase/ [jo.m a.se]

'fly' /tob-ɾɯ/ [to.b_ɯ] /tob-sase/ [to.b_a.se]

(From Smith 2006, page 66)

b. Epenthesis repairs in loanwords

cream > kɯ.ɾiː.mɯ

(From Smith 2006, page 64)

Since Japanese only allows moraic nasals in coda position, word-final consonants generally have to be adapted when being borrowed into Japanese. When this happens, there are sometimes "doublets": words that have one form in the source language but two forms when borrowed into Japanese, one of which epenthesises and one of which deletes part of the cluster.

(4) Deletion/epenthesis loanword doublets (19th-20th century loans)

	Deletion	*Epenthesis*
Cement	[se.men_]	[se.men.to]
Pocket	[pok.ke_]	[po.ket.to]

(From Smith 2006, page 68)

Although epenthesis is the most common adaptation, deletion repairs do exist, especially if the medium of borrowing is auditory rather than orthographic. This suggests that orthography can play a part in the perception (and resultant adaptation) of loanwords. Essentially, Smith suggests that whether or not a complete consonant cluster enters the phonological grammar of the borrower may depend on whether an orthographic representation of the word is provided. She analyses this in terms of Optimality Theory using a Faithfulness constraint to the original underlying form, which is very much a phonological way of viewing this. She nonetheless claims that perception is of vital importance in the adaptation because it is the perceptual process (which may or may not be aided by orthography) that provides the input form on which the phonological grammar can operate using Optimality Theory.

First conceived by Prince and Smolensky (1993), Optimality Theory (or OT) is based on the idea that for any given input of a word form, a (potentially infinite) number of candidate representations are generated. Since usually only one output can be chosen, there is then a set of constraints, which is ranked differently in different languages. The optimal candidate is the one which least violates the highest ranked constraints, and this becomes the output form. There are said to be two types of constraints at play: faithfulness constraints and markedness constraints. In general, faithfulness constraints dictate that an output form should be as similar as possible to its corresponding input form, whilst the markedness constraints ensure that the output will be well-formed in the phonological

grammar of a given language.

Steriade (2001) introduced the P-Map to Optimality Theory, the primary purpose of which was to include perception as a factor in the ranking of constraints, thus diminishing what she described as the "too-many-solutions" problem. The solution orders constraints by "confusability", which is said to be a good measure of phonetic salience.

In relation to loan phonology, a faithfulness constraint has been suggested called MATCH (Kang, 2010). This constraint means that the loanword should be as similar to the original form as possible. Kang's study of the Korean treatment of the English post-alveolars /ʃ/ & /ʒ/ is unusual for a loan phonology study in that it was done diachronically. When these sounds were first adapted into Korean, they became either a [w] or a [j]. The [w] reflected the lip-rounding that accompanies /ʃ/ & /ʒ/ in English, which is only a surface enhancement. However the [j] adaptation better reflects the bunched tongue position of post-alveolars. This, Kang suggests, is due to the fact that when a word is first adapted there are no norms, so every speaker is left to his own devices, creating variability. In OT terms this is described as MATCH dominating the adaptation. But, languages also favour UNIFORMITY, and so will tend to adapt toward the more frequent form, which is why in contemporary Korean [j] is the far more common form. MATCH and UNIFORMITY are said to be in conflict with one another in this case of adaptation.

Shinohara et al. (2011) suggested a loanword grammar that is separate from the native phonological grammar. In the adaptation of Japanese oral stops into Korean, perception is only partially reflected leading the researchers to believe that some other explanation is also needed.

2.2.5. Other ideas

2.2.5.1. Orthography

Whilst orthography has never been reported to be the primary influence in perception and resultant loanword adaptation, it has been shown by some researchers to have an influence in the adaptation process (Dohlus, 2005; Smith, 2006). Researchers will often posit orthography as a possible motivation or driving force for a certain loanword adaptation; for instance Peperkamp, Inga & Kimihiro (2008) suggested that orthography might be an influence in the differing ways in which word-final /n/ is adapted from English and French, since French orthography often includes an unpronounced word-final vowel which could account for the epenthesis in Japanese. However, they quickly dismissed this, saying that for orthography to have an effect on adaptation, loanwords would have to have specifically entered the adaptation through written text. This dismissal was based not on any empirical findings, but purely on untested theoretical ideas, something which is important to consider.

Despite the fact that orthography tends not to be viewed as the main factor in loanword adaptations, some researchers have explored the issue more fully. Dohlus (2005) studied the adaptation of French and German mid-rounded vowels in Japanese. Since Japanese only has five vowels: /i/, /e/, /a/, /o/ and /u/, the relatively more marked front-rounded vowels of French and German need to be adapted to fit into the phonology of Japanese. The German vowels /ø/ and /œ/ are mapped onto the Japanese vowel /e/, whilst the French versions of these vowels are adapted as the Japanese /u/. Phonologically speaking, the features being preserved from the French vowels were interesting, since it was only [+ROUND] that was being preserved, which seems unusual since this isn't a contrastive feature in the phonology of Japanese vowels. Based on faithfulness to features, the adaptation of German vowels seems far more appropriate, as it keeps [+FRONT] and

[+MID]. To attempt to explain this, Dohlus did tests of perception, and found that monolingual speakers of Japanese actually perceive the vowels from both languages as /u/. This implied that cases from the two languages would have to be treated separately, since one was seemingly behaving according to phonological rules, and one according to phonetic rules. Dohlus then came up with an explanation for this: orthography. She suggested that Japanese borrow French and German words in different social contexts, with French generally entering orally through the fields of fashion and culture and German entering mainly through written media, usually in academic areas. This, combined with the fact that German has a more phonetic orthography than French, led her to the following conclusions: loanword adaptation is mostly phonetic, but with some cases having phonological grounding; the lack of oral input and a large influence of written media may trigger phonological grounding. The borrowing process is too complicated to be accounted for by phonetic approximation alone; there are frequently secondary factors, such as knowledge of the source language and orthography.

As detailed above, Smith (2006) showed that Japanese loan doublets stem from orthographic versus aural introduction of a word into the language, since Japanese speakers tend not to perceive any consonant clusters, unless they are presented orthographically, as this makes them far more salient.

2.2.5.2. Articulatory Theories

Best (1994) proposed a Perceptual Assimilation Model (PAM) of loanword adaptation that claims complete misperception of non-native sounds is not likely, but rather non-native sounds will be perceived as native-like if they are articulated in similar ways. In contrast, sounds which are produced in ways completely differently to native sounds will be more easily recognised as different. Because this theory is based on articulatory similarity, not

phonology, it can accommodate cases where one sound from a source language gets adapted to two or more sounds in the borrowing language. It also explains very well cases where two different sounds from one language are mapped onto a single sound in the borrowing language. For example, both the Thompson Salish ejective velar /k'/ and uvular /q'/ are likely to assimilate to English /k/, although English speakers will recognise them as being discrepant from the English velar plosive.

2.2.5.3. Cultural Context

Lev-Ari and Peperkamp (2014) looked at social factors that might affect whether a foreign sound is adapted into the L1 or retained as the L2 sound. Specifically they investigated whether the prestige of the donor language in the context of borrowing, and how individuals can influence adaptation within their speech community, and attempted to show how this adaptation can lead to a "norm". In doing so, they attempted to create a small-scale model for how a community might borrow a sound from another language (though I would question the extent to which such a tiny model can actually mirror the way sound change works in a non-experimental setting – experimental sociolinguistics done in a lab setting tend to have the disadvantage that the very thing they are trying to observe is removed if you take the phenomena out of its social setting).

They designed a game using the word Genna, /ʤɛnːa/, as a brand name for a made up product. The people taking part in the study were L1 French speakers, and the word was an Italian word. In some cases the word referred to an ice cream product (which is a highly rated Italian export), and in others it was beer (rated far lower in comparison to other countries'). They played a game based on Go Fish, in which they had to ask if the other players had this product. It was found that the Italian pronunciation was more likely to be retained if they were referring to the ice cream than when they were referring to beer. This,

the authors suggest, indicated that words from prestigious semantic fields are more likely to be retained in the original pronunciation, as it has positive connotations. This reflects general patterns of cross-linguistic borrowing, in which generally languages that are more prestigious will be the ones that are borrowed, such as the way English is borrowed into most other languages.

Another thing that was observed was that the dynamics of the interactions in which the loan word is used will affect whether or not the sound in question is adapted or retained. All it takes is for one speaker within a group to change the sound, and others will begin to converge. However, the limitations of a small group of participants were that they were not able to differentiate between a merging of all the speakers and the convergence towards the speech of one influential speaker.

Another similar test is that of Hay and Drager (2010), in which the perception of synthesised Australian and New Zealand-like vowels by speakers of the respective countries was tested, and the only cue given to alter the listeners' perceptions was the addition of a set of cuddly toys to the room, which the experimenter pretended to find in a cupboard and then place on the table in order to ensure that participants noticed them. For one set of tests the toys were a kangaroo and a koala bear, representing Australia, and for the other condition the toys were kiwi birds, representing New Zealand. The results showed a clear interaction between the presence of the different toys and the perception of vowels as being either “Australian” or “Kiwi”. This study also showed an interaction between gender and stuffed toy, which was attributed to the fact that the Kiwis were sports toys, and therefore more likely to attract male attention. This helped them to explain that a variety of social and cultural factors can affect perception, not just acoustics. It will be interesting to see the extent to which this is the case when participants are faced with

vowels that are not necessarily from their L1.

2.2.6. Issues

Despite the large amounts of previous research done in loan phonology, there are still many unresolved issues and much disagreement. One reason for this is likely to stem from the fact that the methods used by researchers differ so much in their applications. Listed below are some of the major discrepancies, any one of which could very easily affect the findings of an investigation.

Generally, articles which have looked at perceptually and phonetically grounded adaptation have studied monolingual speakers, whereas articles presenting phonologically-based arguments have studied bilingual speakers. In the case of LaCharité and Paradis (2005), it is clearly stated that a phonological theory of loanword adaptation assumes by necessity that the people doing the original borrowing are bilingual speakers. Even within the set of "bilingual speakers" there is a lot of scope for differing linguistic ability (Grosjean, 2008), which may affect the phonological knowledge that speakers bring to the process. Some studies of bilingual speakers, such as Adler (2006), have looked at speakers with varying proficiencies in the source and borrowing language. This raises the question of how proficient a speaker needs to be before they can be considered to have sufficient phonological knowledge in both languages for the theories of LaCharité and Paradis to be applicable to their adaptation process.

Similarly, few, if any, studies have directly compared the adaptation strategies, or processes, of bilinguals and monolinguals and the results that they produce. One reason for this may be that researchers who are working from one theory will only be looking for evidence to back that up, and do not invest time finding data which may well go against

their hypotheses. However, if a fair test is to be executed, it should combine the types of method and participants that have previously been studied by people with opposing views.

Another variable factor in loanword experimentation is the method by which data is presented to the participants of studies. Since orthography has been found to be at least partially influential in the way that certain loanwords are perceived and therefore adapted, it should be strictly controlled wherever possible. If it is to be tested, it should be tested against a control group who only receive aural information, as this will determine to what level it has influence.

Whether or not to use words that have already been adapted and entered into a language is an issue. Some researchers do this, whilst other researchers use words that have not been adapted into a language, which may be either real words or nonsense words that are acoustically similar to words from the source language. If one is to control other factors in testing, such as who the borrowers are, or what the linguistic context of borrowing is, then logically one should avoid using words that have already been adapted into a language at all costs. After all, since factors such as orthography and levels of bilingualism have been proven to have an effect on these matters, controlling them is important in ensuring a fair test. Whether or not one should use nonsense words or real words that have simply not been adapted is a lesser issue, but an important one nevertheless if one is to use bilingual speakers. On the one hand, in order to test the perceptual differences between mono- and bilingual speakers, it would be important to use existing words. However, given that bilingual speakers (provided they are proficient enough) know the phonological system of the source language anyway, perhaps nonsense words would be more suitable in ensuring that other contextual or grammatical knowledge of the words doesn’t affect the adaptation process of the bilingual speakers. For cases that discuss the perception of small phonetic

details as a factor in adaptation, such as Peperkamp, Inga & Kimihiro (2008) and Abresch (2007), perceptual tests that focus solely on the sound in question may also be a good idea.

An ideal study of loan phonology would take such things into account, and test and control for the effects of both bilingualism and orthographical stimulus within the specific case it concerned itself with, if not testing them as dependent variables then controlling them to ensure they don't have a confounding effect. In this paper, a methodology has been posited that begins to address these issues in a more structured way.

2.2.7. Cases of Variable Adaptation

The cases of loanword adaptation that have the potential to be the most telling about the driving force behind adaptation are those of variable adaptation. Studies such as that done by Dohlus (2005) show cases of variable adaptations of one sound from two different languages, but the arguably more interesting cases are those which concern a sound from one language being variably adapted into the borrowing language.

A case of variable adaptation based on phonetic details in the source language was identified by Kang (2003). When an English word with a post-vocalic stop is adapted to Korean, a vowel is variably inserted after the final stop.

(5) a. *Vowel insertion after postvocalic word-final stops*

Bat > pæ.t^{h}ɨ

Pad > p^{h}æ.tɨ

Gag > kæ.kɨ

b. *No vowel insertion after postvocalic word-final stops*

Bag > pæk

Cap > kʰæp

Club > kʰɨl.lʌp

c. *Variable vowel insertion after postvocalic word-final stops*

Cut > kʰʌ.tʰɨ ~ kʰʌt

Cake > kʰɛ.i.kʰɨ ~ kʰɛ.ik

(From Kang 2003, page 223)

This is puzzling due to its variability and the fact that it doesn't seem to be motivated by the native phonology. Kang suggested that this variability is due to phonetic, phonemic and morphophonemic factors, with the strongest piece of evidence being the important role of tenseness in the pre-final vowel; vowel insertion is more frequent when the pre-final vowel is tense than when it is lax. The fact that this did not depend on the phonological system (since it did not reflect the phonemic boundaries of the source language), and that it was variable and based only on the surface realisations of words, meant that it can be used as evidence for phonetic perception being the main driving force in this case of loan word adaptation.

Smith's (2006) report of Japanese loan doublets is another case of variable adaptation. Unlike Kang (2003), Smith concludes that the form of the adaptation depends on the medium of the borrowing: orthography is an important factor that may cause variability. Essentially, Smith suggests that whether or not a complete consonant cluster enters the phonological grammar of the borrower may depend on whether an orthographic representation of the word is provided.

2.3. L2 phonology

2.3.1. Relation to loan phonology

Loan phonology can be an interesting way of finding out how it is that speakers perceive sounds from a language other than their own, and bears many similarities to L2 phonology, which looks at how speakers acquire a second phonology when learning a language with a different inventory from their own.

Since the extent to which a borrower of a given word is familiar with the source language is not always clear, it is possible that some theories relating to how learners of a second language perceive and alter their phonemic categories will also be particularly relevant when looking at certain cases of loan phonology.

Insight into how this works is not only theoretically interesting, but can be used to create new theories of L2 education and can help us foresee potential barriers and boundaries for language learners.

2.3.2. Best (1994)

Best's 1994 work looks at the development of a phonological perception that is language specific in infants. The phonetic details of the L1 phonology are strongly ingrained in the production patterns of mature speakers. A result of this is that adults usually maintain an L1 accent when they learn to speak an L2, and typically find it quite difficult to pronounce the sounds of the L2 with fully correct phonetic details. However, young children learning an L2 rarely have this problem and are generally able to acquire a native-like accent.

Best assumes that the idea that adults are completely unable to perceive any phonological discrepancies between an L1 and an L2 can be dismissed. Instead, she claims that

phonologically mature speakers (those who have mastered their L1 and passed the critical age for language acquisition) perceive in nonnative phones information about the gestural similarities to native phonemes. A listener will fail to detect discrepancies between native and nonnative phonemes if (s)he perceives the phonemes to be very similar in their articulatory-gestural properties to a native phoneme category. In this case, the nonnative phonemes will be assimilated to the native phoneme category that the listener perceives to be the most similar. However, even if a speaker assimilates a nonnative phone to the most similar native sound, the speaker often recognises the discrepancy between them. According to this model, not all nonnative sounds should be equally easy to recognise and adapt.

2.3.3. Flege (1995)

Flege, however, maintains that just by listening to sounds enough adults are able to produce them, so little articulatory practice is needed. In fact, adults are better than children at imitating unfamiliar sounds.

The main issue, Flege says, is that category recognition entails being able to group a wide range of sounds as the same, even though they are phonetically different, and to *know which phonetic cues are relevant* and which ones aren't, and the ability to distinguish these exemplars from other categories. It is this, he states, that causes L2 learners difficulties.

The main difference between Best and Flege is that Best claims that L2 perception and the issues they discuss are based on articulatory distance, whilst Flege claims it is related to perception and acoustic differences.

2.4. Perception testing

2.4.1. Iverson

Iverson & Evans (2007) carried out a study on L2 assimilation and learning in which they looked at speakers of various European languages and their perception of English vowels. Their aim was to examine people attending to L2 sounds would pay attention only to phonologically salient information from their L1, such as vowel length for Spanish speakers, or whether they were able to attend to all of the acoustic cues of a given sound, regardless of whether or not these are informative in their L1. Contrary to previous second language learning models (Best, 1994 & Flege, 1995), they found that speakers appeared to be attending to all of the phonetic details of the vowels they were hearing, rather than just listening to whether or not a given vowel was "similar" to something they already knew. As such, Iverson & Evans proposed a more holistic pattern of L2 learning, in which phonetic details such as vowel length and tenseness are taken into account. Therefore, when creating stimuli, it will be important to consider things like length as well as just focusing on formant transitions.

Iverson & Kuhl's 1996 also carried out a study of Japanese speaker's perceptions of English /l/ and /r/ sounds, which were synthesised on a continuum and presented in a random order, with participants having to decide whether the sound in question was closer to /l/ or /r/. Their results demonstrated that 'category goodness', as well as a listener's phonological knowledge is an important factor in the identification of sounds on a continuum.

2.4.2. Boersma and Escudero

Studies of the German vowel system have shown that some vowels in German reliably differ from their tense/lax counterpart only due to vowel length. In their 2004 perceptual

study, Boersma and Escudero found that Dutch listeners listened first to vowel length, then to vowel quality when mapping Spanish front vowels to their native Dutch front vowels. When experimenting, they tested first in Dutch, then twice in Spanish – the first time participants were asked to listen "with Dutch ears" and the second time "with Spanish ears". When vowels were presented as Spanish, Dutch listeners were unable to listen "with Dutch ears", which was shown by the fact that the categories in which they placed the vowels the second time round differed from the categories they chose when the vowels were presented as Dutch. Stimuli in the current study were presented first as German, then as English (with a break between the two tests), with a view to see how this affects the treatment of the vowel. This could be seen as looking at words that are undergoing on-line adaptation versus words that have already been established as anglicisms within the German language. Since listeners whose L1 is a Germanic language such as Dutch or German place such phonological weight on vowel length, sometimes above quality, a researcher would have to decide whether vowel length is something I vary or control. Having vowels which resemble both long and short German vowels as well as English vowels would mean that it would be possible to see whether this is the case when adapting the FACE diphthong. Alternatively, controlling the vowels so that they are all of a roughly "English" length will better reflect the fact that cross-dialectal variation of vowel length in English is generally far less significant than phonemic vowel length variation in German (Fox & Jacewicz, 2002), and might therefore be considered the better option.

2.4.3 Strange

Strange (2004) studied the acoustic and perceptual similarity of North German and American English vowels. By looking at acoustic similarities before carrying out a perceptual study, she was able to map the two vowel spaces and see that corresponding phonemes from each language do not necessarily correspond acoustically, which allowed

her to better understand the way that North German vowels were perceived by American listeners. After this, Strange asked American listeners to map North German sounds to native categories, first looking at isolated utterances, then looking at the vowels within sentences, and for each choice, to give their decision a goodness rating on a scale of one to seven, where one was “completely foreign” and seven was “totally native”. Based on this, as well as the variety of options listeners chose, Strange was able to assess how easily assimilated each sound was. In isolation, listeners had trouble with German /e:/, more often matching it to /ɪ/ or /i:/ than to /eɪ/. This was partly due to the fact that the North German vowel space places front unrounded vowels higher than that of American English, and possibly also due to the fact that American listeners are less likely to focus on durational cues than German listeners. Based on this, as well as Iverson's work (2004, 2007), I intend to ask listeners to assign English vowels first to a native category, and then to an English category, and for each exemplar I intend to ask them for a goodness rating. A lot of variation and/or low goodness ratings in either language will go some way to explaining why there might be variation in the way the English FACE vowel is adapted.

2.5. The Classification and Identification of Diphthongs

One important question is also: what is the exact boundary between a diphthong and a monophthong? Feng (2008) looked at phonetic boundaries between monophthongs and diphthongs in Suzhou Chinese, some of which had been under dispute for many years. Using an objective method to calculate the degree of vowel quality change (DQC) she quantitatively measured the vowels of Suzhou Chinese but was still left facing issues. Namely, she found herself coming to the conclusions that, due to high inter- and intraspeaker variability and the similarity of some monophthongs and diphthongs even when measured using DQC, the terms “monophthong” and “diphthong” are at best phonological terms, not phonetic ones. She claimed these results to be strong evidence that

there is no universal boundary between monophthongs and diphthongs fitting to all world languages.

How to define and identify a diphthong is a matter of theoretic importance, as though diphthongs are a single phonological entity, the movement that categorises the production of them means that they cannot be described in the same way as monophthongal vowels. There has been little study into the perception of diphthongs and which acoustic details we attend to when we identify them, but a few theories of vowel inherent spectral change (VISC) do exist.

There are three contemporary models for modelling VISC. These are: The slope hypothesis, the direction hypothesis and the offset hypothesis. All three theories state that the onset is important, but they disagree when it comes to what else matters. Slope hypothesis - Listeners attend to the rate of change in each format's frequency. (See: Gottfried, Miller & Meyer, 1993; Morrison & Neary, 2007) Direction hypothesis - The only relevant factor is the direction of movement (raising, lowering, or centering) in F1*F2 space. Offset hypothesis - Listeners additionally (to the onset) and minimally need a certain amount of change by the vowel offset. (See: Miller, 1989).

Morrison (2007) argues that the field of forensic speech scientist should not just use an onset and offset model of speaker recognition, but instead should use information about the whole formant trajectory, particularly information extracted using parametric curves. He believes that by improving our understanding of VISC, forensic speech scientists might be able to better identify speakers based on their diphthongs.

Fox & Jacewicz (2009) showed that different US accents have differing formant

trajectories, which is an important part of what makes particular accents. This proves that even across different accents in the US (also the UK) diphthongs don't all follow the same formant trajectories, which is why I want to look into having different internal formant dynamics. In doing so, I will be able to assess the extent to which variable adaptation of the FACE diphthong in German is due to the vowel's variations across different English accents. Indeed, given the differing theories about what a diphthong is or isn't, and which parts of a diphthong are the phonetically/phonemically relevant parts, looking at the effect of the internal formant dynamics on the perception of the FACE diphthong will be entirely necessary, as assumptions cannot be made as to what German listeners attend to when they hear it.

2.6. Summary

By combining theories about loanword phonology with studies of L2 perception, I have been able to design a study that better investigates how it might be that one phonemic category in a source language might have variable manifestations when borrowed. Since numerous researchers studying loan phonology have discussed the importance of perception in the process of on-line adaptation, and have speculated as to what the role of perception might be designing a perceptual experiment to look into the role of perception in loanword adaptation is a logical step. For instance, Peperkamp, Inga & Kimihiro (2008) reached the conclusion that Japanese speakers adapt English and French word final nasals differently due to fine grained phonetic details and the perception thereof, but despite claims that perception was the driving force behind this variation, a perceptual test was not carried out. Peperkamp and Dupoux (2003) suggested that in order to back up claims made in this field, perceptual tests that are carefully designed to address issues relating to loanword adaptation would be necessary. Both Peperkamp and Dupoux (2003) and Abresch (2007), amongst others, have stated that when testing the perception of sounds

within the context of loan phonology, testing real words is undesirable, as it introduces too many confounding factors, since knowledge of a given word will likely confound the answers given by participants in an experimental setting. Peperkamp and Dupoux suggested, therefore, that nonsense words be used, whilst Abresch, who was looking at cases of adaptation from English into German, suggested that synthesised speech segments would be better for controlling phonetic details, especially of vowels.

Meanwhile, L2 phonology is a field with a rich tradition of perceptual testing, and it is important to consider the findings of this field when looking at loan words in a context where the source language is in fact the most common L2 of the population of the borrowing language, such as German speakers borrowing English words. The level of fluency within the source language is a factor of loanword adaptation that needs to be considered carefully when researching specific cases, due to its being a contentious point within the field. Because of this, the methodology of L2 phonology, especially as used by Boersma and Escudero (2004), in which listeners were grouped by their level of fluency within the L2: some had no knowledge of the L2 or were beginners, whilst some had intermediate knowledge, and another group were proficient bilinguals. Taking this idea and applying it to a study of loan word phonology allows better control of the linguistic abilities of participants, making it possible to better ascertain whether the driving force behind adaptation might be phonetically, phonologically or otherwise based.

The work of Hay and Drager (2010) shows us that when running perceptual tests, it is possible to elicit different results from the same data simply by subtly altering the testing conditions. Boersma and Escudero (2004) showed that the same is possible just by telling the listener that the language has changed, so presenting one set of stimuli and simply subtly changing the linguistic environment is an effective way of testing crosslinguistic

perception of stimuli.

Based on this, a study was designed in order to attempt to answer the following research questions:

1. Does the amount of English a German speaker knows affect how they perceive the FACE diphthong?
2. How does the timing of the FACE diphthong's formant trajectory affect perception of the diphthong?
3. Is there an interaction between these two factors?

3. METHODOLOGY

3.1. Participants

The participants were organised into the following three groups:

- Group 1 - 9 native German speakers who had not lived in the UK and did not use English more than one or two times a month (at most). (Tested in Marburg, Germany.)
- Group 2 - 7 native German speakers who had lived in the UK for 2 or more years, and who use English at least weekly. (Tested in York, UK.)
- Group 3 - 6 native English speakers who had no formal education in or knowledge of German. (Tested in York, UK.)

All German participants, bar one, had been taught English at school, for 5-11 years. All participants had been raised in monolingual homes, and had not been taught another language prior to starting school. None of the English participants had lived abroad, and all had lived in York for at least 5 years.

The participants for my first test were native speakers of German with a reasonable grasp of the English language. The reason for this was that they best reflect the part of the population that are instigating language change and borrowings, and it was therefore intuitively the best plan to start with these people. They were participants who are in their late teens and twenties, and are all from the same region of Germany. This was designed to make it possible to tell if within this particular group of speakers it is the case that the adaptation is phonetically driven or not, and to see whether knowledge of English phonology plays a part in the phonological categorisation of incoming foreign sounds.

However, there are some difficulties and possible issues that could arise through this. For instance: in an ideal world the test would also be run on a group of German speakers with

no knowledge of English phonology. Unfortunately it is standard in Germany that everyone be taught English throughout their time at school and although ability levels vary they are almost all fairly proficient, so the best way to find a group of non-English speaking Germans would be to enrol older participants who had grown up in East Germany, without the influence of the English language. But in doing this two problems would arise. The first would be that this would mean that the two groups, if the first group of participants were kept the same, would be mismatched in more than just their levels of English, in terms of age, social background, etc., which would throw in more variables unnecessarily. The way to solve this would be to have the English speaking group matched to the non-English speaking group, but this leads to the second problem, namely that older people who don't speak any English aren't the people leading the addition of so many anglicisms to the German language; as with a lot of language change in process, this is being led by young people, who also happen to have some understanding of the English language through their education.

3.2. Stimuli

The stimuli were a set of synthesised vowels that range from a German monophthongal /e:/ sound to diphthongs with varying formant dynamics, and differing glide times. Although synthesised vowels sound less natural than human speech, this allowed a far greater degree of control over the formant trajectories within the stimuli and to better test my hypothesis. Bond (1982) used synthesised vowels in a study of diphthong perception and found that despite the vowels used being synthetic, listeners were still perfectly able to distinguish between them.

The stimuli were 10 /I/ - /ei/ - /E/ tokens that were synthesized to model natural speech. The formant values for the vowels were based on the suggested formants given in Klatt &

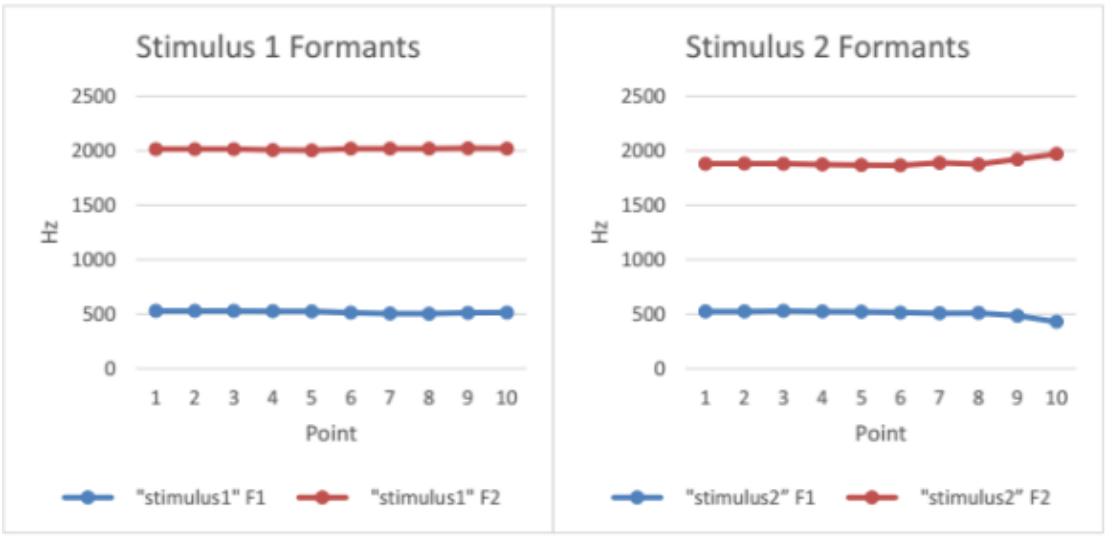
Klatt (1990), and then cross-referenced against Southern British speech samples from the IviE corpus, in order to ensure the formant values given were actually accurate representations of SSBE speech. Filler vowels were included, based on the SSBE vowels /u:/ and /au/, both of which are present in German.

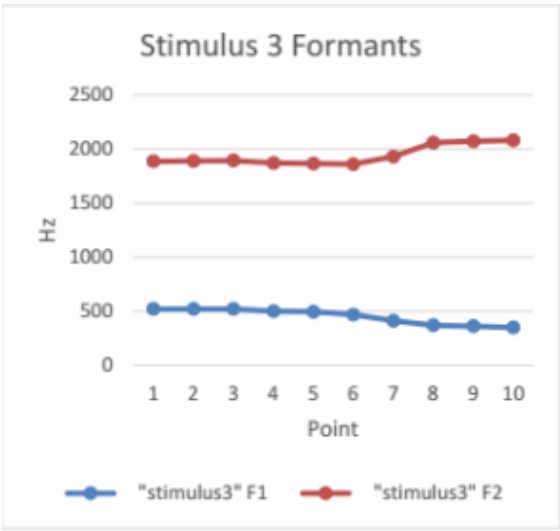
The stimuli varied in the frequencies of the first and second formants, which were edited to create a continuum of vowels, ranging from an /ɪ/ like vowel to an /ɛ/ like vowel. The stimuli were identical in all other respects; their length was 150ms and F3 upwards remained identical across the stimuli. The bandwidths were 70Hz, falling to 55Hz for F1, and for F2 and F3 were 100Hz and 200Hz respectively, matching the formant amplitudes of natural recordings. The F3 started at 2520Hz, rising to 2600Hz throughout the sounds, and the F4 was constant at 3600Hz throughout the stimuli. The fundamental frequency of the synthesised vowels was 128Hz falling across the vowel to 108Hz. They were created using a KlattGrid, which enabled me to manipulate individual aspects of both the source and the filter, thereby modelling synthetic vowels by modelling the acoustics of a vocal tract. When creating a KlattGrid one can first choose the timing of the synthesised segment, and specify the number of formants that are to be created (in this case four), before editing first the phonation type to specify the pitch. After this the oral formants can be edited on a grid, in which it is possible to choose the exact frequency of a given formant at any point along the sound, making manipulation of trajectories a simple task.

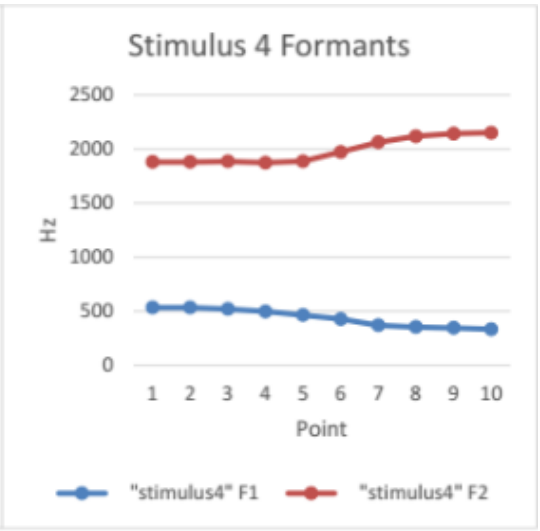
Below are visual representations of the first two formants for each of the ten target stimuli that were used in the experiment, and the formant frequencies of each stimulus are listed in Appendix 3. Stimuli 1 and 10 are both completely monophthongal, with formant values that match the BET vowel and the BIT vowel of English (as based on my findings from recorded speech and the IViE Corpus, mentioned above), and the BAEREN (Gloss: *Bears*)

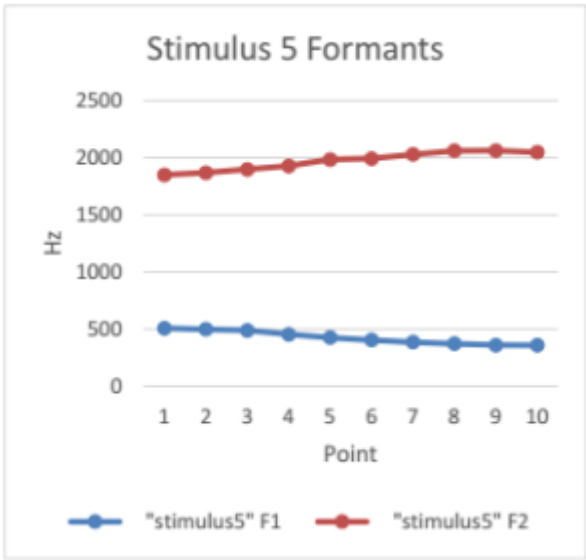
vowel and the BETEN (Gloss: *To pray*) vowel of German, respectively. The start and end points for all of the diphthongal vowels are the same, the only thing that differs between them is the point at which the formant values shift, creating a trajectory from one vowel to another, which mirrors the formant movement of diphthongs. As little research has been done into speakers' perceptions of the internal acoustics of diphthongs, it was not clear to me how the differing stimuli would be perceived by native speakers of English, much less non-native speakers. The graphs shown below (stimulus 1-10) were created using the exact formant values of the simulated vowels in the experiment, the exact values at each point of the vowel can be found in Appendix 2. Each stimulus was split into nine equal segments, from the start of the vowel until the end of the vowel, creating ten measureable points at equal intervals along each vowel. Because the vowels were all the same length, the measurable points were the same temporal length apart across vowels, as well as being proportionally equivalent. In order to measure the formant values I first of all extracted the values from Praat's formant listing for each point I was measuring, before checking visually by looking at both the vowel in question and the Klattgrid used to create the stimulus, to ensure accuracy of measurement. Points one to ten were measured for the first two formants for each vowel, and the extracted values were plotted from a chart created using Microsoft Excel in order to visualise them.

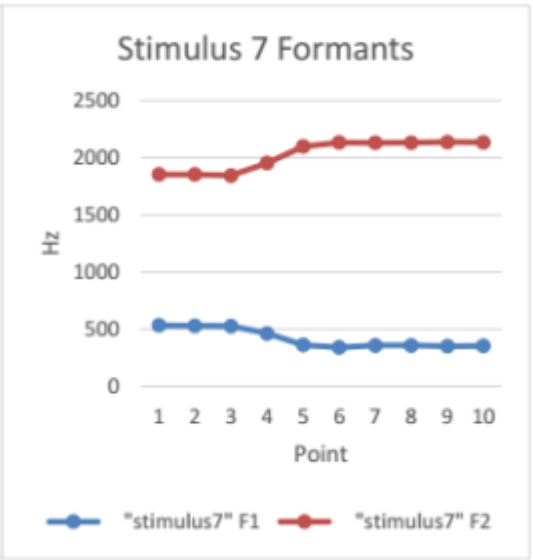
Figures 6-15: Visualisations of the first two formants of the stimuli.

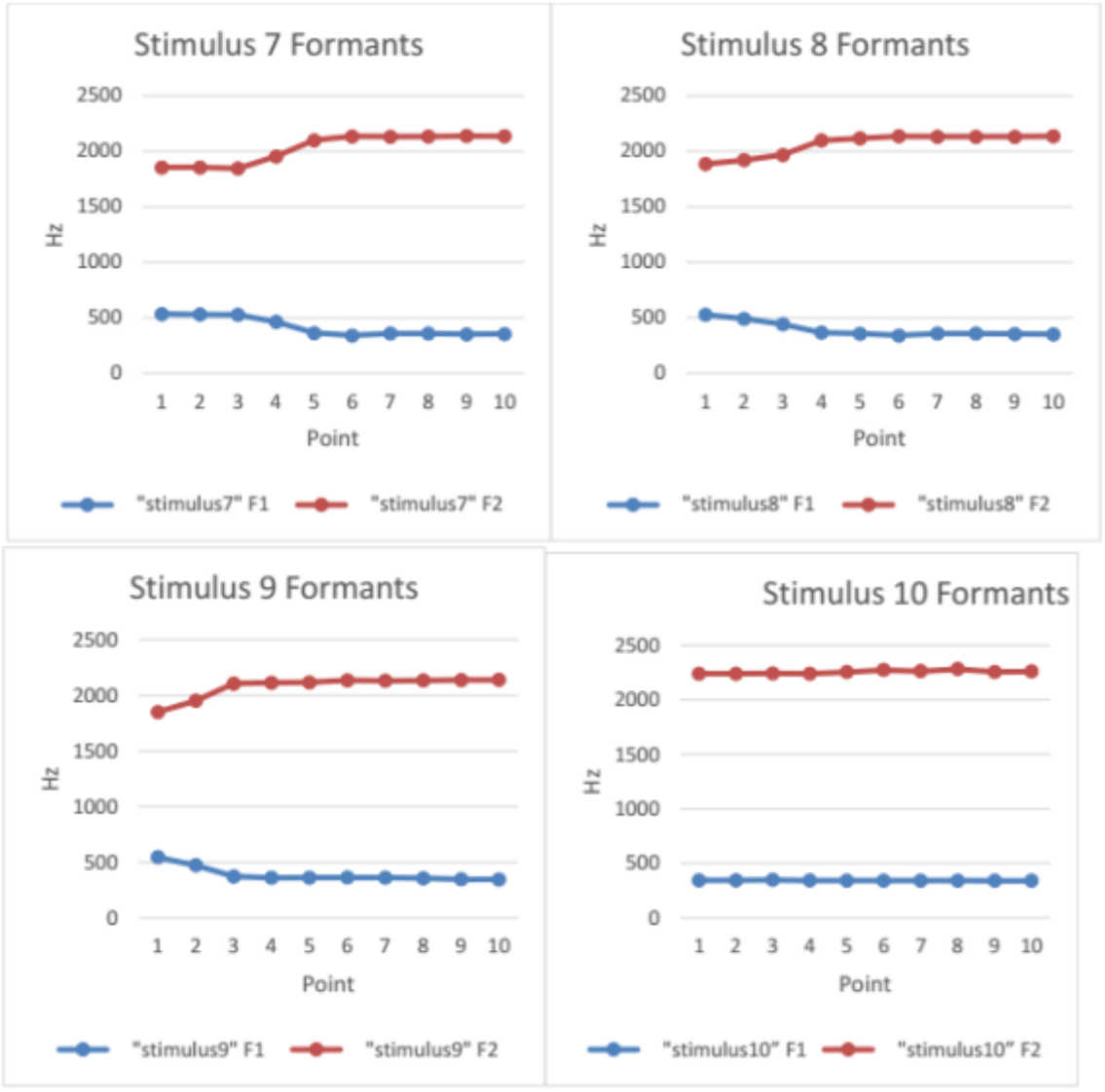












3.3. Procedure

Identification task - A closed-set identification task was used to see which categories listeners assign the differing sounds to, similar to Iverson & Kuhl's 1996 study of Japanese speaker's perceptions of English /l/ and /r/ sounds. Participants were presented with the stimuli first in their native language, then in the other language. For the German participants the experiment was conducted in two halves: the first half was conducted entirely in German, and included an introduction to the experiment, a practice block of 8 trials and the first half of the experiment which included 5 repetitions of 20 stimuli (10 were the target vowels, 10 were fillers), presented in a random order. Participants were

asked to sort each stimulus into one of their native categories and rate their goodness of fit within this category on a scale of 1 (a poor fit) to 5 (a good fit). After the German half of the experiment, a small break was taken in which a questionnaire was completed and the language was casually switched to English for the second half of the experiment, in which the same set of 20 vowels were repeated 5 times each, again in a random order, and participants were asked to sort the stimuli into English phonological categories. This method of switching target language throughout the experiment was based on Boersma and Escudero (2002, 2004), and their findings that the language in which stimuli are presented as being effects the responses participants give, even when the stimuli are identical in each case. For the English group, the same was done but with English first, and the entire experiment was conducted in English, as this group were all monolingual. Running the experiment in German for the English speakers helped me to ascertain that the stimuli were subtle enough that it wasn't possible for participants to identify the stimuli with ease if they were unfamiliar with the presented categories. The experiment was presented using Praat, in an interface that looked like this:

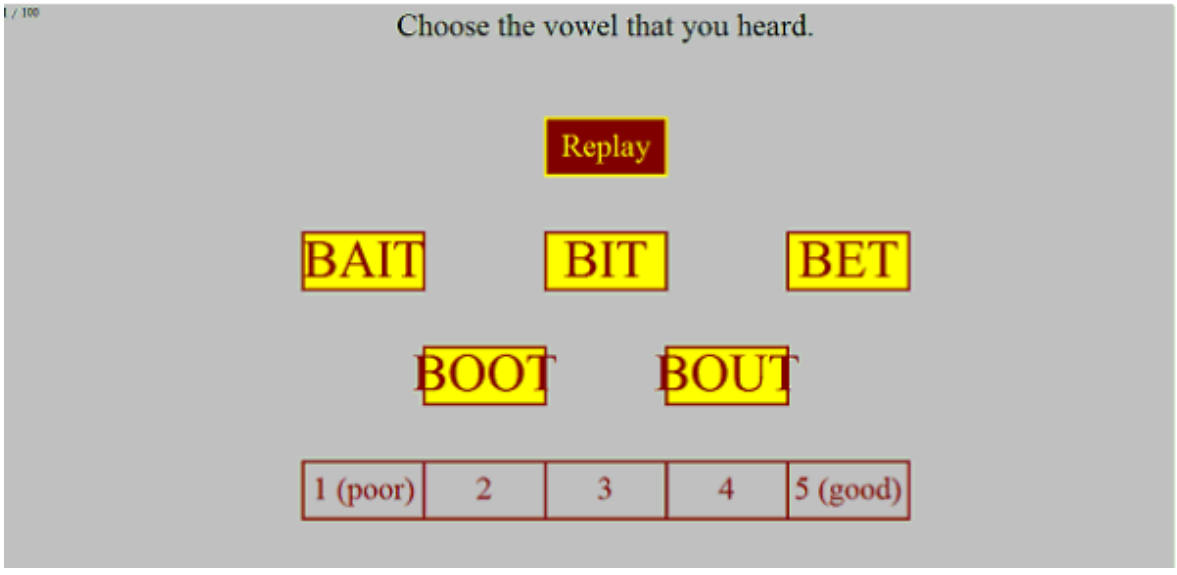


Figure 16: English experiment screen

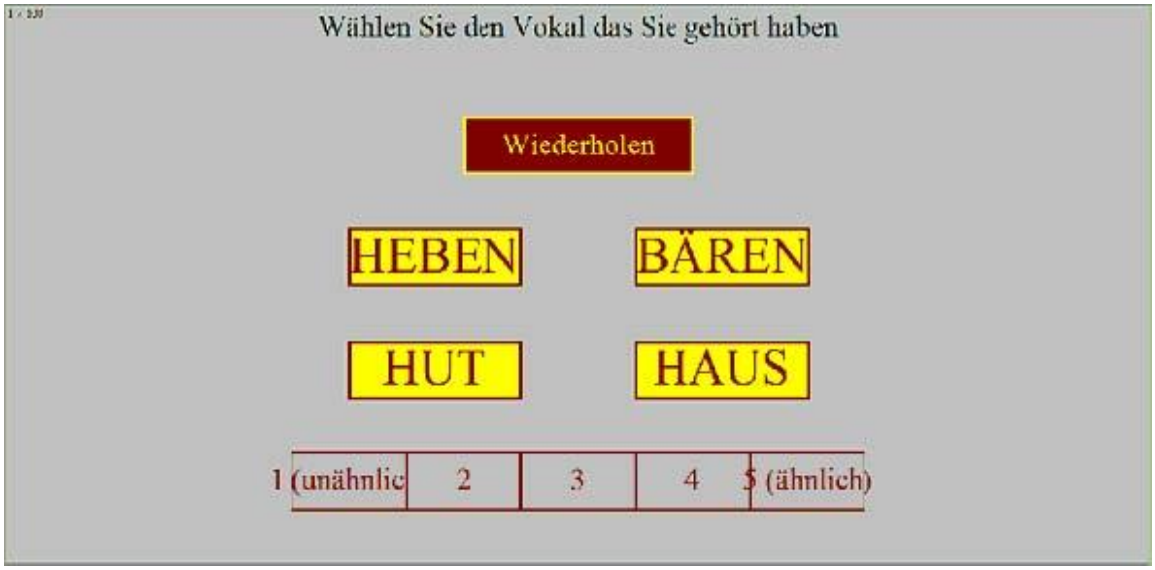


Figure 17: German experiment screen

The vowel would play automatically when each new screen loaded, and could then be replayed up to five times.

The experiment took place in places that were quiet but accessible to the public - both in Marburg and York this meant using empty university rooms.

The headphones used had the following specifications: Philips CitiScape Headband Headphones, SHL5605FB/10, which have a dynamic frequency range of 18-22,000Hz, an impedance of 30 Ohm, and a sensitivity of 104dB. Participants were allowed to set the volume as they pleased, so that they could hear the stimuli clearly.

The computer used for the experiment was an Intel(R) Core(TM) i3-3110M CPU @ 2.40GHz. The stimuli were presented using Praat, version 5.4.01.

4. RESULTS

English Participants English Results

Plotting a table of the mean responses for the English speakers when presented with the data in "English" shows that there is clear categorical perception between what is considered a monophthong and a diphthong for native English speakers. The completely 'flat' stimuli, in which there is no formant movement throughout the vowel, are both perceived as being monophthongs all of the time. Formant movement only in the first or last ~30ms of the vowel are more unclear, with the majority of these vowels being perceived as monophthongs but a significant amount being recognised as diphthongs. This suggests to me that these stimuli (2 & 9) were able to be perceived as having formant movements, but the overall body of the vowel being flat means that the overall vowel will be generally classified as a monophthong.

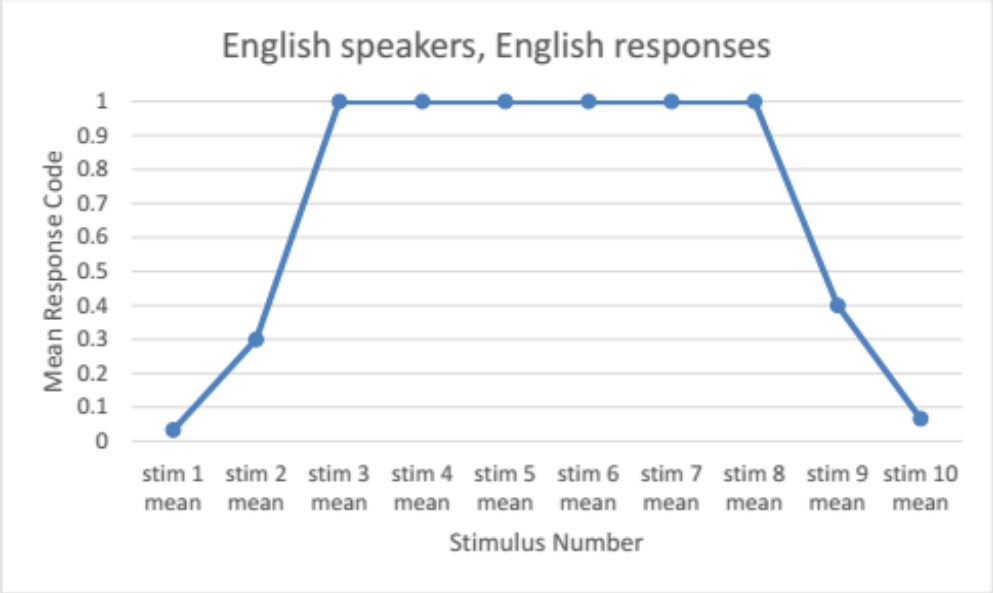


Figure 18: English speakers, English responses

Note for the interpretation of this chart: The responses were converted to the binary digits 0 and 1 for the purpose of plotting results. 1 refers to something being classified as a

diphthong, and 0 refers to something being classified as a monophthong. Although there were two possible monophthongs to choose from, in 100% of cases stimuli 1 & 2 were identified as BET and stimuli 9 & 10 were identified as BIT (as can be seen in Appendix 1), so the three options from the test were able to be converted into a binary. This is also true of the chart showing the German participants' responses to English stimuli.

A linear regression was run to see which of the independent variables had the greatest effect on whether a vowel was perceived as a diphthong or a monophthong. The variables in question were age of participant, which stimulus was being presented, which repetition of a given stimulus was presented, the participant in question, how often the participant used English, how many years of English education a participant has had, and gender. The details of the outcome of this regression can be found in Appendix 2. For English participants being tested in English, the most significant factor by far was the stimulus itself, with a p-value of <2e-16. None of the other factors looked at seem to be even slightly statistically relevant for
these results.

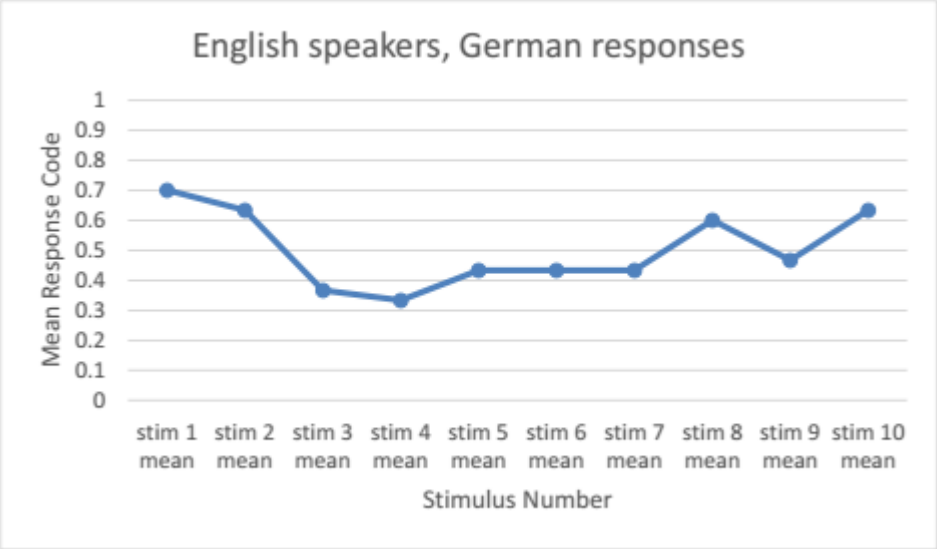
English Participants, German Results

Somewhat unsurprisingly, as the English control group had no knowledge of German, the responses reveal that the English participants were unable to distinguish between the two German front vowels /e/ and /ɛ/.

In this case, stimulus was not the most significant variable (0.843035), which makes sense given these participants had no knowledge of the language that they were being asked to assess. The factors that are the most significant here are age (5.04e-05) and gender (0.000113), but we have to consider that in the English participant group there was only

one female participant, who was also significantly older than the other participants, so it is to be expected that in this data set, if age is significant, gender will be too. Unfortunately, due to the size of this data set, it is not clear whether either age or gender were actually significant in this dataset, or if this is just a random anomaly based on that specific participant. A larger data set would be needed to explore this, but intuitively it seems that age and gender would not turn out to be significant, given the main factor in this set is the fact that the people were being tested on completely unknown phonological factors, so anything other than random results would be highly surprising.

Figure 19: English speakers, German responses



German Participants German Results

Stimulus was the most significant factor in predicting the response code (< 2e-16). This is

to be expected, especially when participants are being tested in their L1, because what it shows is that native phonological knowledge is the greatest factor in predicting how a person will complete a phonological task. Also significant (but not to nearly so great an extent) was Attainment of English (0.0165), which was interesting. Obviously, there are a number of speculations one can make here as to why this might be the case: perhaps people who are better at their L2 have a slightly different way of listening to their L1, or perhaps this is a reflection of the populations that were tested – the German speakers who had a better knowledge of English were all tested in the UK, and had been living in England for more than 2 years; perhaps this would be a relevant factor to consider.

Figure 20: German speakers, German responses

English Results

The German participants' perception of the stimuli when presented in English is

interesting, as it follows the trend of the responses given by the English participants, but the results are not quite so clear cut, which suggests that the perception of the unfamiliar FACE diphthong is one that is in the process of being learned, as opposed to with the English speakers, who will have acquired this distinction when first learning their L1.

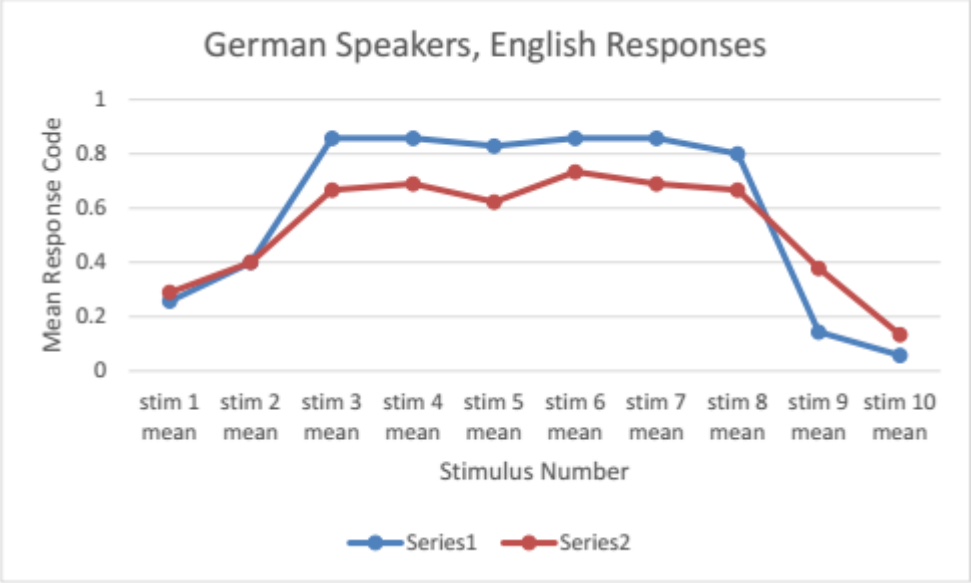
Figure 21: German speakers, English responses

The most significant factor in predicting the outcome of the dependent variable was Years of English Education (1.34e-07). Stimulus was still a relevant factor (0.009137), but less so than with other sets. Perhaps a reason for this could be that whilst the participants who had a good grasp of English were able to perform quite well on this task, looking at the graphs of the German results separated into High and low attainment of English, we see that stimulus was a high factor in the choices of the German speakers who were better at English, but not so much for those whose English was intermediate or basic. This suggests that for the German speakers as a group, the reason for the fact that stimulus number is less significant is likely to do with the discrepancies across the two smaller German speaking

groups.

When we split the German speakers into two groups - those who are completely fluent in English and use it regularly and those who are not and use it less frequently (based on frequency of usage and time spent in UK, as reported in the methodology), we can see that across the two groups there is a difference in how English sounds are perceived. The intermediate speakers are still able to categorise the vowels following the pattern of native English speakers, but the numbers suggest that they are not as sure about their choices or their ability to perceive the English vowels correctly (here correctly is used to mean in the same way that a native English speaker would perceive them), as can be seen from the fact that, unlike the English responses, none of the stimuli are clearly defined as being either 0 (wholly monophthongal) or 1 (entirely diphthongal). Also of interest is the gradient of the slope between the formants that are more likely to be perceived as monophthongs and those that are more likely to be perceived as diphthongs. This suggests that although these participants have some awareness of the English vowel system, they do not yet have categorical perception.

Figure 22: German speakers, English responses. (Series 1 = fluent speakers, Series 2 = Intermediate speakers)



In comparison, the fluent group of German speakers behave much more like the English participants, but their responses are not as uniform as those of English speakers. This indicates that there is still some level of uncertainty in the responses given even by those German speakers who are fluent in English.

This suggests that the level of English someone speaks will affect how they perceive English vowels, which shows that misperception of diphthongs is one possible reason for variable adaptation of the English FACE diphthong.

5. DISCUSSION

5.1. General Discussion

The findings show that when listening in their L1, all participants were able to focus on the stimuli, and no other factors were really all that significant. What this means is that all of them displayed categorical perception of their L1 based on the acoustic details of the stimuli.

However, in the L2, the amount of English a listener speaks does affect how they will interpret the sound they hear. This shows that it is not simply a case of one thing or the other being relevant, but in fact there is an interaction between these two variables that suggests that when studying variability in this particular case, the differing levels of English that are spoken by the varying people who use loanwords is going to go at least some way to explaining why it might be that this variation exists. What this shows, is that by grouping participants based on their L2 abilities, like Boersma and Escudero (2002), and checking for the differences across the groups, we can see that it is indeed important to control carefully for level of bilingualism when studying loanword adaptation. Had previous researchers within the field of loan phonology (eg. Dohlus (2005), Smith (2006), Peperkamp, Inga & Kimihiro (2008)) controlled more for the borrowers' proficiencies in the source language, their findings may well have been very different.

Another vital reason for variation in the case of German becomes clear when comparing the categorical perception of the German and English speakers in their first languages. For English speakers, Stimuli 1 and 10 were clearly perceived as monophthongal, whilst Stimuli 3-8 were always perceived as being diphthongs. Meanwhile, German speakers categorised Stimuli 1-3 as clearly being like BAEREN, and Stimuli 8-10 as clearly being

like BETEN. It was the middle stimuli where they had more difficulty. What this shows is that for the German speakers, the phoneme boundary between /e:/ and /ɛ:/ falls at a point at which, for English speakers is the middle of another category. That is, the point at which English speakers are most sure they are hearing a diphthong is the point at which German speakers, if listening to German, have the most confusion in identifying which L1 category the incoming signal belongs to.

This may be key in explaining why there is variability in the adaptation of this vowel. The fact that the amount of English someone speaks appears to affect their ability to reflects earlier findings (Iverson (2007) & Boersma (2004)) that suggest that category formation in an L2 is a gradual process, and that it is for this reason that speakers may sometimes produce something approaching a diphthong and other times adapt a sound to one of their native categories. It would be interesting to find out if fluent speakers of English exhibit less intraspeaker variation than intermediate speakers of English, as this could be explained by the fact that they are less sure (unconsciously, of course) about the unfamiliar category, and whether to use it or to use more familiar L1 categories.

In relation to the research questions set out on Page 41 of this document, this experiment seems to have been successful in providing answers. As discussed, the amount of English a German speaker knows does appear to affect how they perceive the FACE diphthong, as does the timing of the diphthong's formant trajectory. The fact that the way the formant trajectory is perceived is related to the listener's L2 knowledge is in fitting with previous literature, and was to be expected but was still important to test.

It is also possible that this case of variation might be the beginning of a language shift towards the formation of a new L1 category for German speakers. If it is the case that

English continues to have such a large influence in the German language, it is certainly possible that over time younger German speakers may integrate English words into their language to the extent that over time a new category may begin to form not just as part of their L2, but also within their L1. This would obviously depend on the frequency of exposure to such sounds, as category formation depends on having a large enough exposure to examples from a given set.

Based on these results, it is possible to conclude that the experimental design used here was an effective step towards addressing some of the issues within the field of loan phonology. For instance, by using a scale of synthesised stimuli it was possible to test whether listeners attend to fine phonetic details when hearing sounds in a language other than their L1, and this has made it possible to look into the so called "phonological deafness" that has been reported by other loan phonology researchers (such as Peperkamp and Dupoux (2003)) but not tested. The results show that there is definitely something to be learned from using perceptual tests based on L2 studies when looking at loan words. It is also very much clear that it is important when studying loan phonology, especially in cases where the source language is taught in schools, not to make assumptions about the levels of bilingualism of those doing the borrowing. A speakers' phonological knowledge of the source language is a big factor in how they will perceive a given sound, so researchers studying cases of loan phonology cannot afford to make assumptions or generalisations across a population without first investigating how this might affect the borrowing.

Although it was not possible to acquire an entire group of participants who spoke no English whatsoever, it was possible to find and include one participant who fell within this category. The listener in question was an older participant from Thuringen, who had grown

up and spent all of her life in the former East Germany and therefore never learned English. Her results in particular are interesting, because it is clear from this what the effect of having no familiarity with the English FACE diphthong seems to be. It was not possible to quantify her results, but her performance was little better than guess work on the English test, which matched how the English speakers responded to the German test. She overwhelmingly chose monophthongal answers, and only twice reported hearing a diphthong.

5.2. Possible Improvements and Limitations

Only having a limited amount of time to carry out this study meant it was only possible to test the perception of German speakers from one area (namely Hesse). Because German, like English, has such large regional and social variation of accents, looking at groups of speakers with potentially differing ways of categorising their vowel space would further help. Although the existence of intraspeaker variation suggests that accent cannot be the only factor in this case, seeing how much effect it might have would be of interest. By ensuring all of the German speakers in Germany were from the same region, and that all of the participants that were tested in the UK were from the same region, it was possible to control for this variable, without having to worry about it confounding current results.

In a sense, the lack of German speakers who do not speak any English may be seen as a limitation of this study, but this is not one I consider to be a realistic problem.-- People living in Germany learn English from a young age, and it is very rare for people not to speak any English. Furthermore, to have gone out of my way to have found such a group wouldn't reflect the majority of the people who speak German, and therefore the results wouldn't actually be a good reflection of why variation is or isn't happening.

If I were to carry expand upon this study, I would, for each of my participants, record and measure performance of the target vowel in different speech styles (ie. Casual conversation, interview, reading from a passage, reading from a list). This would show me if speakers' perception matches their production of front vowels in both their L1 and their L2, as well as telling me the extent to which being less certain of a vowel's identity when completing listening and identification tasks correlates with variation in producing the vowel(s) in question.

6. CONCLUSION

Studying other people's theories and looking at my own results has allowed me to conclude that both the incoming acoustic signal and our own linguistic abilities have an effect on how we perceive and categorise both new and familiar sounds. Perception doesn't seem to simply be based on the information we are provided with but also how we are able to filter that, which is based, amongst other things, on how familiar we are with exemplars of a given category.

I also conclude that methodology within this field really does need to focus on controlling for a greater amount of variables, especially as so many of them have been shown over and over to have a significant effect on linguistic/phonological perception. For instance: controlling for the amount of English a participant spoke showed that this does have a significant effect, and ought to be addressed when looking at other cases of loan phonology.

Loanword adaptation and perception of foreign phones is not always categorical, sometimes it can be gradient. We can see this by looking at the German speakers' responses to the English sounds, and this is in fitting with work done by people who have studied L2 perception.

I also believe that it is not the case that loan phonology can be reduced to a simple argument of perception/L1 phonology. Like Boersma and Hamann (2009, p. 36), I must conclude that:

"(p)erception simply *is* phonological."

APPENDICES

Appendix 1

English Participants, English Results

Residuals:

```
      Min          1Q     Median          3Q         Max
-0.78085 -0.30223    0.00451    0.30282    0.63437
```

Coefficients: (1 not defined because of singularities)

```
                   Estimate Std. Error t value Pr(>|t|)
(Intercept)        0.832201   0.355861   2.339   0.0200 *
Age               -0.025318   0.014464  -1.750   0.0811 .
stimulus           0.157111   0.006843  22.959   <2e-16 ***
goodness.rating   -0.021621   0.018173  -1.190   0.2351
repetition         0.009288   0.013746   0.676   0.4998
Participant       -0.020397   0.011847  -1.722   0.0862 .
Attainment               NA         NA      NA       NA
Gender             0.742759   0.439467   1.690   0.0921 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Residual standard error: 0.3331 on 293 degrees of freedom

Multiple R-squared: 0.6611, Adjusted R-squared: 0.6542

F-statistic: 95.26 on 6 and 293 DF, p-value: < 2.2e-16

English Participants, German Results Residuals:

```
    Min       1Q   Median       3Q      Max
```

-0.6293 -0.5329 0.3730 0.4105 0.7441

Coefficients: (1 not defined because of singularities)

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	2.494341	0.495863	5.030	8.55e-07	***
Age	-0.085809	0.020854	-4.115	5.04e-05	***
stimulus	-0.001984	0.010012	-0.198	0.843035	
repetition	-0.001808	0.020064	-0.090	0.928276	
Participant	0.006837	0.017709	0.386	0.699706	
Attainment	NA	NA	NA	NA	
Gender	2.478827	0.633335	3.914	0.000113	***

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.49 on 293 degrees of freedom

Multiple R-squared: 0.06181, Adjusted R-squared: 0.0426

F-statistic: 3.217 on 6 and 293 DF, p-value: 0.004476

German participants, German results

Residuals:

Min	1Q	Median	3Q	Max
-1.20238	-0.18912	-0.02455	0.16830	0.80364

Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)

(Intercept) -0.3559513 0.0577076 -6.168 1.1e-09 ***

Age -0.0013273 0.0008828 -1.504 0.1331

stimulus 0.1443756 0.0036630 39.414 < 2e-16 ***

repetition 0.0025219 0.0071152 0.354 0.7231

Participant -0.0041649 0.0048590 -0.857 0.3916

Attainment 0.1203574 0.0500966 2.403 0.0165 *

Years.of.Enlish.Education -0.0026223 0.0020247 -1.295 0.1957

Gender 0.0170194 0.0256939 0.662 0.5079

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.2834 on 791 degrees of freedom

Multiple R-squared: 0.6796, Adjusted R-squared: 0.6763

F-statistic: 209.7 on 8 and 791 DF, p-value: < 2.2e-16

F-statistic: 10.27 on 8 and 791 DF, p-value: 1.002e-13

German participants, English Results

Residuals:

Min 1Q Median 3Q Max

-0.8372 -0.5235 0.2637 0.4186 0.8445

Coefficients:

Estimate Std. Error t value Pr(>|t|)

(Intercept) 0.576676 0.101539 5.679 1.90e-08 ***

Age -0.005117 0.001395 -3.667 0.000261 ***

stimulus	-0.015301	0.005855	-2.613	0.009137 **
repetition	-0.013037	0.011886	-1.097	0.273048
Participant	-0.001818	0.008133	-0.224	0.823160
Attainment	-0.011194	0.083815	-0.134	0.893784
Years.of.Enlish.Education	0.018610	0.003497	5.321	1.34e-07 ***
Gender	-0.100013	0.043121	-2.319	0.020629 *

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.4754 on 791 degrees of freedom

Multiple R-squared: 0.09408, Adjusted R-squared: 0.08492

Appendix 2

Column1	Column2	Column3	Column4	Column5	Column6	Column7	Column8	Column9	Column10	Column11	
Vowel name	0	0.17	0.34	0.5	0.66	0.81	0.96	1.12	1.32	1.5	
"stimulus1" F1	530	530	530.0682	527.20733	525.48754	514.08365	505	504	512	515	
"stimulus1" F2	2015	2015	2014.4686	2007	2004	2018.7013	2019	2018	2022	2020	
"stimulus2" F1	525	525	529.89622	524.22177	521.59964	515.60134	508.24467	511.35445	485	430	
"stimulus2" F2	1880	1882	1880	1873.4816	1868.4181	1865	1888.8961	1875.4315	1920	1970	
"stimulus3" F1	520	520	519.74708	500.49776	494.54098	467.76725	411.91388	369.56924	361.968369	350	
"stimulus3" F2	1885	1890	1893.3745	1870.6949	1865.138	1860	1930.4151	2058.4898	2072.11067	2080	
"stimulus4" F1	534	534	520.04415	497.12027	464.36775	427.63822	369.6935	354.09268	345.396543	334	
"stimulus4" F2	1880	1880	1885	1873.0743	1886.9549	1972.2477	2062.8324	2117.7809	2141.76994	2150	
"stimulus5" F1	510	500	490.43887	455.30063	427.8546	405.91574	386.70147	373.57264	361.403585	360	
"stimulus5" F2	1850	1870	1898.6566	1928.5869	1984.9434	1993.2406	2029.1567	2061.9941	2062.85483	2048	
"stimulus6" F1	530	530	529.89164	517.6392	463.69505	354.42624	359.67772	358.40388	352.615356	350	
"stimulus6" F2	1890	1890	1885	1878.6633	1942.45	2085.0621	2130.8867	2132.4242	2134	2138	
"stimulus7" F1	535	531	527.70978	463.3596	362.86964	341.62252	359.53792	358.39288	352.648475	355	
"stimulus7" F2	1855	1854	1844.9229	1954.4551	2099.7089	2134.5088	2131.659	2132.8798	2138.1523	2135	
"stimulus8" F1	528	492	442.84633	367.10319	357.87879	341.16043	359.62672	358.39161	355	352	
"stimulus8" F2	1885	1920	1966.808	2097.5761	2116.6862	2134.7397	2131	2132	2132	2135	
"stimulus9" F1	546	473	372.67253	360.97447	361.56288	363.10753	362.15544	356.64343	346.520708	345	
"stimulus9" F2	1850	1951	2105.6569	2114.0829	2116.5438	2135.979	2131.5476	2133.4241	2137.61376	2140	
"stimulus10" F1	345	345	347.85829	342.49524	341.13419	342.21929	341.56485	342.32683	340	340	
"stimulus10" F2	2240	2240	2242.1152	2239.9601	2255.3369	2273.4791	2263.3501	2281.7014	2256	2260	

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