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THE ROLE OF SIMILARITY IN PHONOLOGY: EVIDENCE FROM LOANWORD ADAPTATION IN HEBREW

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Abstract

This study investigates the notion of phonological similarity, while focussing on the relevance of similarity to the process of loanword adaptation, the categorisation of sounds, and the distinction among different sounds in a language.

The study presents a formal model for the quantification of similarity, and suggests a grammatical system which predicts the outcome of processes of adaptation and perception. In order to construct this model, I appeal to loanwords, as their adaptation has long been recognised as being similarity-based.

One may wonder why the study of loanwords is at all relevant in the study of phonological systems. Since the source of loanwords is, by definition, non-native, is there any point in investigating loanwords when studying *native* phonological systems?

Despite their foreign source, loanwords are integrated into the native mental lexicon. Therefore, the study of loanwords could reveal the structural constraints on phonological well-formedness, constraints which are relevant to all lexical items. Since all living languages continue to adopt and adapt loanwords, and these, in turn, continue to undergo adaptation, the system of adaptation, whatever it may be, has to be an active system.

I will only briefly address the question of whether the system of adaptation is the same as the native system (§2.2.2). What is important is that there is a system, and this system is similarity-based.

The adaptation of loanwords is systematic, and the system is similarity-based. We adapt X as Y rather than as Z, because X is more similar to Y than to Z. The question, of course, is what makes X more similar to Y than to Z. Can this elusive property be identified and quantified within a formal framework?

The notion of phonological similarity is appealed to in the literature in order to describe and explain various phenomena. The adaptation of loanwords relies on segmental and prosodic similarity (Hyman 1970, Kenstowicz 2001, Steriade 2001a,b,

Shinohara 2006 inter alia), rhyming patterns in poetry depend on the similarity between segments (for example, Zwicky 1976, Kawahara 2007). Furthermore, our ability to distinguish categories from one another depends on how similar they are to one another (Best et al. 2001, Escudero et al. 2007, Cohen et al. in progress). And the list of similarity-dependent phonological phenomena goes on. It appears that the notion of similarity is most relevant to phonological theory. I deal with the various approaches to similarity in §5.

This study is broken down into several sections. I start with a discussion of loanwords (§2) and the difference between them and the other lexical items in a language. First, I deal with compliant loanwords, those which follow the grammatical constraints of the language (§2.1.1), and then I discuss non-compliant loanwords, those which do not follow the language's restrictions (§2.1.2). I continue by presenting a formal definition of loanwords (§2.1.3 and §2.1.4) and the various sources of loanwords (§2.1.5).

Following the introductory sections, I discuss adaptation (§2.2), starting with non-phonological influences on the adaptation process (§2.2.1), followed by the phonological aspects of adaptation (§2.2.2).

After defining loanwords, I move on to investigate loanwords in contemporary Hebrew (henceforth: Hebrew). I start with an overview of the language's phonology (§3), focussing on a featural and acoustic analysis of the vowel system (§3.2.1 and §3.2.2), concluding with a rundown of the prosodic constraints on syllable structure and stress.

The subsequent section §4 deals primarily with the theoretical frameworks which I adopt in my analyses, starting with Optimality Theory (§4.1) and Stochastic Optimality Theory (§4.2), continuing with a discussion of *just noticeable differences*, *jnd*s (§4.3) and concluding with a similarity-based model, Steriade's (2001a) P-map (§4.4).

Section §5 deals with the notion of similarity. First, I present a general view of the notion, focussing on phonological similarity (§5.1, §5.2 and §5.3). Then I present my formal model of similarity (§5.4).

This study relies heavily on empirical data from various sources. These are presented in §6. I start with a discussion of my loanword corpus (§6.1), and follow with two experiments I conducted in order to evaluate the predictive powers of my model presented in §5.

The following §7 is the heart of this study. Here, I integrate the various notions discussed in the previous sections and present the role of similarity in phonology as reflected in loanword adaptation. First, I discuss the notion of segmental similarity (§7.1) and prosodic similarity (§7.2). Later, I present a few apparent deviations from the norm (§7.3). The final §7.4 presents a similarity-based model for the adaptation of loanwords.

The following §8 presents concluding remarks.

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It finally dawned upon me that I was wasting my time studying law, when all I could appreciate in the criminal law lectures was the professor's impressive knowledge of Latin syntax and morphology. That was the point at which I decided to cross the campus and continue my studies in the linguistics department.

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Chapter 1. Introduction

1.1. Loanwords and similarity

In this study, I investigate the notion of phonological similarity, focusing on the relevance of similarity to the adaptation of loanwords, the categorisation of sounds and the distinction among differing sounds.

In order to formulate a model for similarity, I appeal to loanwords (§1.1.1), as their adaptation has long been recognized as a process involving similarity (§1.1.2).

1.1.1. Why study loanwords?

One may ask why the study of loanwords is at all relevant in the study of phonological systems. Since the source of loanwords is, by definition, non-native, is there any point in studying loanwords when investigating *native* phonological systems?

Despite their non-native origins, loanwords are incorporated into the native lexicon. Therefore, their investigation reflects on the well-formedness constraints on phonological forms relevant to all words in the lexicon. Since all living languages continue to adopt and adapt loanwords, whatever the system of their adaptation may be, it has to be an active system.

I only briefly concern myself with the question as to whether the system governing adaptation is the same as the native phonological system (§2.2.2). What is important is that there is a system, and that this system is similarity based.

1.1.2. Similarity

When reading any study of loanword adaptation, it is clear that sound adaptation can be patterned systematically, and is in no way random. Systematic adaptation relies on similarity. We adapt X to Y rather than to Z, because X is more similar to Y than to Z. The question is what makes X more similar to Y. And can this elusive property be captured within a formal model?

The notion of phonological similarity has been appealed to in a large variety of linguistic (and non-linguistic) phenomena. Loanword adaptation relies on segmental and prosodic similarity (e.g. Hyman 1970, Steriade 2001a, Kenstowicz 2001, Shinohara 2006, and many more), and poetic rhyming patterns (e.g. Zwicky 1976, Kawahara 2007) depend on syllable similarity. Furthermore, our ability to distinguish different categories from one another depends on how similar they are to one another (Best et al. 2001, Escudero et al. 2007, Cohen et al. in progress). And so continues the list of phonological phenomena to which similarity is relevant.

It appears, therefore, that the notion of similarity is most pertinent in phonological theory. I discuss the various approaches to similarity in §5.

1.2. Outline of dissertation

In §2, I discuss the nature of loanwords and loanword phonology, starting with distinctions between compliant and non-compliant words (§2.1.1 and §2.1.2). Then I move on to formal definitions of what loanwords are (§2.1.3 and §2.1.4) and various sources of loanwords (§2.1.5). Following the introductory section on loanwords, I discuss the nature of adaptation (§2.2), first treating non-phonological influences in the process of loanword adaptation (§2.2.1), and then continuing to the phonological aspects of loanword adaptation (§2.2.2).

After having clarified what loanwords are, I proceed to investigate loanword adaptation in Modern Hebrew (henceforth: Hebrew). I start with a background of the language (§3), presenting both phonological (§3.2.1) and acoustic (§3.2.2) analyses of the segmental system, followed by a rundown of Hebrew's prosody (§3.3).

The next section §4 is all about the theoretical frameworks which I adopt in my analysis, starting with Optimality Theory (§4.1) and Stochastic Optimality Theory (§4.2), following with the notion of *just noticeable differences*, *jnd*s (§4.3), and concluding with a similarity-based model, Steriade's (2001a) P-map (§4.4).

§5 deals with the notion of similarity. I start with a discussion regarding the nature of similarity in general, and phonological similarity in particular (§5.1, §5.2, §5.3), and follow with a presentation of my formal model of similarity (§5.4).

This study relies heavily on data from various sources. These are discussed in §6, starting with a loanword corpus I constructed (§6.1), and two experiments I conducted (§6.2) to evaluate my similarity model's predictive powers.

The following §7 connects the dots, as I present the role of similarity in adaptation. I start with an extensive discussion of segmental similarity (§7.1) and prosodic similarity (§7.2), followed by a few noteworthy deviations from the norm (§7.3). The similarity-based grammar of loanword adaptation is next (§7.4).

The final section (§8) consists of concluding remarks.

Chapter 2. Loanwords

2.1. What are loanwords?

Any investigation of loanword phonology first requires the identification of loanwords. The fact that a word used in conversation in a language L1 is originally from a foreign language L2 does not necessarily qualify the word in question as a loanword. There are several such words used in L1 conversation which I exclude from my definition of loanwords: (a) words which are part of bilingual conversation; (b) words which are merely speaker-specific idiosyncratic productions; (c) words which are unique one-time productions mimicking some L2 phonetic form. These three types of word are not loanwords.

So, what *are* loanwords? Indeed, much of the loanword literature endeavours to answer this question and to determine various aspects of the coining of loanwords. I follow Paradis (1996) and Kenstowicz (2001) inter alia, adopting the view that loanwords are first and foremost lexical items originating in L2 and used in L1 conversation in order to fill some semantic void (semantics is an issue I largely ignore throughout this study. They are used extensively in exclusively L1 conversation, even by speakers who are monolingual L1 speakers who are not necessarily aware of the word's source.

In many cases, the first L1 community using a loanword has knowledge of L2 (see, however, §2.1.5 on adapting speakers), and can be considered bilingual for our purposes. I do not use "bilingual" in the strictest sense of the word, whatever that may be, but rather only to refer to L1 speakers with a broad, possibly near native, knowledge of L2. However, the word becomes a loanword when there are monolinguals (i.e. speakers unfamiliar with L2's lexicon or grammar) who utter them without reference to or knowledge of L2. During the borrowing process itself, bilinguals borrowing the loanword may not have fully deactivated L2. Only when L2 has been fully deactivated does a lexical item become a loanword (Paradis and

LaCharité 1997). Established loans are only those used throughout the L1 community and fully incorporated into L1 discourse.

Note, the mere fact that speakers know the word's origins does not diminish the word's status as a loanword, provided it is used within an exclusively L1 context. Many speakers, even those aware of the word's L2 source, have nevertheless never heard the word used in L2 conversation.

In order to ensure mutual understanding among bilingual speakers, the loanword has to be as *similar* as possible to its source in L2. Since L1 and L2 phonetics and phonology are not identical, the L2 inputs may not fully comply with the L1 system (whether the required compliance is the same as those in the native vocabulary or specific to loanwords is an issue discussed in §2.2.2.2). If loanwords do not comply fully with the L1 system, they may have to be modified to some extent. If they do comply, no modification is necessary.

2.1.1. Compliant loanwords

In a perfect world, an L2 word fully complies with the L1 system. Such L2 words do not require any changes during the borrowing process. Before providing the first set of data, a note regarding my transcription throughout this study is necessary. First of all, primary stress has only been marked in polysyllabic words and secondary stress has not been marked. Secondly, Hebrew and English vowels are transcribed differently. The reason for the different phonetic transcriptions is technical and historical. I have used the same symbols commonly used in linguistic literature regarding English and Hebrew. While the English transcription aspires towards some degree of phonetic accuracy, which is necessary in such a rich vowel inventory, the Hebrew transcription does not, and the symbols chosen for its transcription are historically those chosen for most 5-vowel languages, <a e i o u> (see §3.2 for phonetic details of Hebrew vowels), as these are simply easier to type. In addition, the quality of the vowels in different English dialects may vary even though the symbol used to transcribe the vowels is the same (see §6.1.1 for the transcription of English vowels).

The following table (1) presents compliant loanwords not undergoing any changes. The apparent mismatches are only orthographic:

(1) *L1-compliant loanwords not requiring modification*

	English (L2)	Hebrew (L1)	
a.	[klʌt͡ʃ]	[klat͡ʃ]	'clutch'
b.	[dʌŋk]	[daŋk][1]	'dunk'
c.	[nɛt]	[net]	'net'
d.	[sɛt]	[set]	'set'
e.	[tɛst]	[test]	'test'
f.	[wɛb]	[web][2]	'web'
g.	[spid]	[spid][3]	'speed (drug)'
h.	[hip]	[hip]	'heap (computer term)'
i.	[aɪ di]	[ai di]	'ID'
j.	[faɪn kʌt]	[fain kat]	'fine cut (cinematic term)'
k.	[haʊs]	[haus]	'house (music genre)'

Hebrew and English consonantal categories are largely the same (see extensive discussion in §3.1). The main exceptions are the following:

[1] /ŋ/ is not considered a Hebrew phoneme. It appears only as an allophone of /n/ before velar stops. Loans with /ŋ/ before velar stops do not require modification. Loans with /ŋ/ in other positions do require modification. See also §3.1 for discussion of velar nasals in Hebrew.

[2] Although /w/ is not usually considered a native Hebrew phoneme, it does not ordinarily undergo modification in loanwords. Older speakers, however, may adapt /w/ as /v/. See also §3.1 for discussion of /w/ in Hebrew.

[3] The Hebrew vowel is shorter than its English counterpart. I have largely ignored the issue of non-contrastive vowel length in this study. For details on the Hebrew vowels, see §3.2.

a. The English interdental fricatives /θ, ð/, which Hebrew does not have;
b. The English velar nasal /ŋ/, which only exists in Hebrew allophonically before velar stops /k, ɡ/;
c. The rhotics, which are /ɹ, ɹ̧/ in various dialects of English, but /ʁ/ in Hebrew;
d. The Hebrew voiceless velar fricative /x/, which most dialects of English do not have.

There may be other small variations in the phonetic properties of the consonantal inventories, however, in this study, I focus mainly on vowels, while referring to consonants only when relevant to the vowels.

Regarding the vowels, although I have used different vowel symbols in the two columns, the vowels are almost identical:

a. Hebrew /a/ in (1a-b) is acoustically almost identical to English /ʌ/ with respect to quality and length.
b. Hebrew /ɛ/ in (1c-f) is acoustically almost identical to English /e/ with respect to quality and length.
c. Hebrew /i/ in (1g-h) is almost identical in quality to English /i/, though considerably shorter.
d. The Hebrew diphthongs /ai/ in (1i-j) and /au/ in (1k) are almost identical to the English diphthongs /aɪ/ and /aʊ/ respectively, with a slight difference in the quality of the glide. Essentially, the kinds of vowels that occur in diphthongs are no different from those occurring as single vowels (Ladefoged and Maddieson 1996:322). A complete discussion of Hebrew and English vowels appears in §3.2 and §7.1 respectively.

However, there are cases in which an L2 word up for adoption does not fully comply with the L1 system. Such cases are discussed in the following §2.1.2.

2.1.2. Non-compliant loanwords

How does L1 deal with potential L2 loanwords if they do not comply with the L1 system? The candidate can follow any of three possible routes: blocking, incorporation and adaptation.

Blocking refers to cases in which the borrowing is blocked. The word is not adopted by L1 and the semantic void is otherwise filled. Evidence for blocking cannot exist (logically) as no process has occurred, but it is possible that blocking does occur for phonological reasons. Note, all sounds deemed by speakers to be linguistically relevant can be adapted in the borrowing process. Even the most extreme cases, in which a sound is perceived to be quite alien by a speaker, can still undergo adaptation. For example, Zulu clicks in isolation, which are often not recognised by English speakers as linguistically relevant, are borrowed as English oral stops when they appear in context (Best et al. 2001). Furthermore, even sounds perceived by speakers to be non-linguistic can undergo a form of linguistic approximation, such as is the case with onomatopoeia. For example, a high pitched violin note may be produced by a speaker as [iii], whereas a low pitched drum roll might be produced as [bumbumbum]. The two utterances may be considered by speakers to be linguistic approximations of the non-linguistic musical sounds.

Incorporation is when the word is incorporated as is, despite the fact that it does not comply with the well-formedness restrictions of the L1 system. In effect, the result is a word in L1 which does not conform to the L1 system *prior to* the incorporation of the word. However, note that once the incorporation has occurred, the result is a *de facto* expansion of the L1 system. The question why some segments are borrowed as is while others are modified is addressed in Ussishkin and Wedel (2003), who suggest an articulatory basis for segmental borrowing and the subsequent inventory expansion. The basic proposition is that novel segments can be incorporated into a language's phonemic system if their production is a combination of already existing motor gestures in the language's pre-existing inventory. For example, English speakers might adopt word-initial post-alveolar voiced fricatives /ʒ/ more readily than a pharyngeal consonant. The reason for this is that native English speakers already possess the molecule for the medial-onset [ʒ] (e.g. [ˈvɪ.ʒən] 'vision') and the word initial /ʃ/ (e.g. [ʃɪn] 'shin'), which differs only in voicing from /ʒ/, and voiced-voiceless pairs are common in English. In this case, speakers are essentially filling an accidental gap here by introducing word-initial /ʒ/. All they lack, in fact, is the new *context* for the segment, i.e. word-initial position. On the other hand, as opposed to /ʒ/, pharyngeals cannot be produced through a recombination of existing gestures in English, as English has no pharyngeal consonants.[4] Otherwise put, novel sounds which can be articulated without the introduction of some new feature or combination of features (especially those resulting from accidental gaps in the phonological inventories) are borrowed and can achieve phonemic status more readily than sounds which require novel articulatory gestures. A question remains as to why consonants are sometimes (albeit, rarely) incorporated, but vowels are never incorporated.

Incorporation is very rare, and there is no evidence for blocking.

Adaptation, on the other hand, is the option speakers usually go for. Adaptation refers to cases in which the L2 candidate is altered in order to conform to *some* phonology of L1 (§2.2.2.2), something which would result in segmental and/or prosodic alteration of the L2 source word. The following table (2) includes a few examples of segmental and prosodic adaptation, focussing on the highlighted elements. In some cases, there are several possible L1 outputs (§6.1.2.3), but I have only given one in the following table:

[4] Some dialectal forms of English rhotics may be pharyngealised (Ladefoged and Maddieson 1996:234). I do not consider this secondary articulation to be of significance with respect to the incorporation of pharyngeal segments.

(2) *Segmental and prosodic adaptation*

	English (L2)	Hebrew (L1)	
a.	[**θɹ**ɛd]	[**tʁ**ed]	'thread'
b.	[ˈk**ɜ**ɹ.səɹ]	[ˈk**e**ʁ.seʁ]	'cursor'
c.	[ˈb**æ**.ləns]	[ˈb**e**.lens]	'balance'
d.	[ˈb**æ**.nəɹ]	[ˈb**a**.neʁ]	'banner'
e.	[g**ɪə**ɹ]	[g**i**ʁ]	'gear'
f.	[ˈd͡ʒɔɹ.**dn̩**]	[ˈd͡ʒoʁ.**don**]	'(Michael) Jordan'
g.	[ˈd͡ʒɜɹ.**nl̩**]	[ˈd͡ʒuʁ.**nal**]	'journal'
h.	[fɪ**ɫm**]	[ˈfi.**lim**]	'film'

The English segments [θ], [ɜ], [æ] and [ɪə] in (2a-e), which are not part of the Hebrew phonemic inventory, are replaced by [t], [e], [e/a] and [i] respectively in Hebrew.[5] Hebrew disallows syllabic consonants as in (2f-g), epenthesising a vowel before them in order to get a vocalic nucleus (Graf and Ussishkin 2002, Schwarzwald 2002). Hebrew avoids clusters of sonorants (Schwarzwald 2002, Ussishkin and Wedel 2003), epenthesising a vowel to break up such sequences, as in (2h). Note the variable adaptation of [æ] in (2c-d) and the different epenthetic vowels in (2f-h). This is discussed in §5.4.5.1, §7.1 and §7.2. An extensive discussion of the Hebrew segmental inventory and prosodic structures is given in §3.

[5] The interdentals have variable adaptations in Hebrew: They may be adapted as Hebrew alveolar fricatives with the same voicing (θ→s; ð→z) or as Hebrew alveolar stops with the same voicing (θ→t; ð→d). The difference seems to be age-related (the younger speakers are more likely to adapt them as stops) or culturally related (speakers with Eastern European backgrounds are more likely to adapt them as fricatives). See also Hyman (1970) for discussion on the variable adaptation of English interdentals in French and Serbo-Croat. This discussion in particular, and consonant adaption in general, is beyond the scope of this study.

2.1.3. How to identify a loanword

While it is widely accepted that loanwords are essentially L2 forms adapted and then subsequently used in L1 conversation by monolinguals, it is not clear that the process itself is initiated by bilinguals (§2.1.5). For example, lexical items may be borrowed by individuals who do not necessarily have any knowledge of L2. I am not referring to cases in which a monolingual L1 speaker merely uses an adapted form, but rather to cases in which the monolingual L1 speaker actually coins the loanword. Instances in which L2 nouns are incorporated into L1 or in which speakers adapt forms picked up from films or television are such cases. This may start as the mere mimicry of a foreign phonetic form, and I would be hesitant to call such productions loanwords. However, once incorporated into L1 syntax and morphology, these forms must have an L1 phonological representation, i.e. must have undergone adaptation.

Determining whether a word is a loanword is complex. On the one hand, we have the historical analyses which can almost invariably determine the origins and time of inception of non-native lexical items. On the other hand, the historical analyses by no means reflect the synchronically *active* phonological processes in loanword adaptation or even explain what native L1 speakers may or may not know about their language.

Speakers appear to have some notion or feeling of what does or does not constitute an acceptable borrowing (Holden 1976). Such a subjective classification of loanwords seems to have some validity. Simply put, if monolingual speakers of L1 consciously identify a word as being native, why claim it is otherwise (except, of course, for the sake of historical accuracy)? Granted, there may be more complicated cases in which judgements may differ, but by and large, foreign words are often identified by speakers as being such. The question is whether there are objective criteria for identifying a word as non-native which speakers may refer to in their decisions.

Such linguistic criteria have been suggested for loanwords in Hebrew by Schwarzwald (2002). The phonological criteria suggested by Schwarzwald, however, are all (with the sole exception of CCCVC syllables, as in [ʃpʁi͡ts] 'squirt') synchronically applicable to what Schwarzwald calls *native* Hebrew words and it is doubtful whether they can, individually, separate non-native forms from the native lexicon. Note, it is possible that the simultaneous occurrence of several of the criteria in a single word are what classify the word in speakers' minds as foreign, though this is not addressed in Schwarzwald (2002):

a. *Segmental composition* (pp. 48-50): Words including non-native segments, especially /ʒ/, /t͡ʃ/, /d͡ʒ/ are often identified as foreign by speakers; e.g. [kla**t͡ʃ**] 'clutch', [ˈpan.**t͡ʃ**eʁ] 'puncture', [ˈ**d͡ʒ**uʁ.nal] 'journal', [ga.ˈʁa**ʒ**] 'garage'. It could be claimed that monolinguals identify this foreignness on the basis of these segments' relative rarity in the language.

   The problem, however, is that these borrowed segments can only be identified as such historically as they appear in derived environments as allophones in native Hebrew words; e.g. [**ʃ**a.ˈmaʁ] 'guarded' vs. [**t͡ʃ**moʁ] 'guard!' (Bolozky 1979, Bat El 2002), [xi.ˈ**ʃ**ev] 'calculated' vs. [xe**ʒ**.ˈbon] 'calculation' (Schwarzwald 2002).

b. *Atypical allophonic distribution* (pp. 124, 127-128): Loanwords may deviate from native allophonic variation, such as is the case with spirantisation, which applies post-vocalically in Hebrew; e.g. [**b**a] 'he came' vs. [la.ˈ**v**o] 'to come', [**p**a.ˈtax] 'he opened' vs. [li**f**.ˈto.ax] 'to open'. In loanwords, post-vocalic stops do not ordinarily undergo spirantisation, as is the case, for example, in [d͡ʒi**p**] 'jeep' and [bo**b**] 'Bob'. The criterion, however, is also problematic. First of all, the systematic spirantisation process in *native* Hebrew paradigms is in disarray (Adam 2002). Post-vocalic stops in native vocabulary do occur, e.g. [ak.ˈʁa**b**] 'scorpion', [xa.ˈʁa**p**] 'medical corps (acronym of [**x**el **ʁ**e.**f**u.ˈa])'.[6] In many verb paradigms,

[6] The normative form [ak.ˈʁav] 'scorpion' follows the Hebrew principles of allophonic distribution. The sub-standard form [ak.ˈʁab] is a backformation from the normative plural form [ak.ʁa.ˈbim] 'scorpions'.

allophonic spirantisation has been eliminated throughout. For example, some speakers produce [**v**i.ˈkeʃ] - [le.**v**a.ˈkeʃ] 'asked - to ask', [**x**iˈ.bes] - [le.**x**a.ˈbes] 'washed clothes - to wash clothes', [**f**i.ˈʁek] - [le.**f**a.ˈʁek] 'dismantled - to dismantle', instead of the respective normative forms [**b**i.ˈkeʃ] - [le.**v**a.ˈkeʃ], [**k**i.ˈbes] - [le.**x**a.ˈbes], [**p**e.ˈʁek] - [le.**f**a.ˈʁek]. Furthermore, Hebrew speakers are often not even aware that words which violate this principle are historically loanwords (e.g. [**f**e.ˈja] 'fairy').

c. *Non-native stress* (pp. 50-53): Stress position in Hebrew stems is historically final and mobile (i.e. during suffixation, the stress moves to the end of the word) in inflectional paradigms (e.g. [xaj.ˈ**zaʁ**] / [xaj.za.ˈ**ʁim**] 'alien/s', [ˈ**xug**] / [xu.ˈ**gim**] 'circle/s').[7] In loanwords, stress is often non-final and almost always fixed (e.g. [ˈ**lej**.zeʁ] / [ˈ**lej**.ze.ʁim] 'laser/s', [ˈ**d͡ʒuk**] / [ˈ**d͡ʒu**.kim] 'cockroach/es' (see also §3.3.2).

While this distinction is certainly correct historically, it is no longer the case, as is evident in native words such as [ˈ**gli**.da] / [ˈ**gli**.dot] 'ice-cream/s', [ˈ**klaf**]→[ˈ**kla**.fim] 'playing cards'. Lexical and fixed stress are commonplace in modern Hebrew (Bat El 1993/2005, Graf and Ussishkin 2002, Becker 2003).

d. *Non-native syllable structure* (pp. 50-53): Consonant clusters in onsets and codas in native Hebrew vocabulary, are very limited in distribution due to historical reasons. Native complex codas appear only in 2nd person feminine past (e.g. [ka.ˈtaf/ka.ˈta**ft**] 'he/she picked). In nouns, clusters may appear only word initially and are limited to two consonants (e.g. [**tʃ**u.ˈva] 'an answer', [**ʃt**u.ˈfa] 'washed fem.', [**kt**u.ˈa] 'be severed fem.', [**tk**u.ˈa] 'be stuck fem.'). In loanwords, clusters appear all over the place and may consist of two to three consonants (e.g. [**stʁ**uk.ˈtu.ʁa] 'structure', [ab.ˈ**stʁ**ak.ti] 'abstract' [te**kst**] 'text').

Clusters formed in derived environments are broken up via epenthesis. For

[7] There is a class of native Hebrew nouns, the segholates, in which the stress in the uninflected form is penultimate. During inflection, however, stress in the segholates is final (Bolozky 1995, Bat-El 1993 and more).

example, although the cluster [tv] exists in native Hebrew words in underived environments (e.g. [**tv**u.ˈa] 'produce, crop'), the same cluster is broken up when formed in a derived environment. Note the following case. The stem final vowel is deleted in past tense paradigms when adding vowel-initial suffixes. If this deletion creates a cluster, epenthesis follows (e.g. the stem final [nix.ˈtav] 'it was written' → *[nix**tv**u] / [nix.**te**.ˈ**v**u] 'they were written').

Therefore, it is likely that the reason clusters have not begun to form in native Hebrew words, despite their being acceptable in loans, is simply because there are no native Hebrew morphological processes which would initiate such cluster formation without the interference of restrictions upon derived clusters.

These criteria are certainly useful in determining the etymology of words, however, they are somewhat problematic insofar as the synchronic analysis of loanword adaptation in Hebrew is concerned. Since the goal of my study is, inter alia, to determine the *active* grammar in loanword adaptation, my study concentrates only on words which actively undergo adaptation processes rather than words which were historically deemed to have done so. Through the analysis of loanword data, we see the active components in the system, something which may not necessarily be evident in all native data (Danesi 1985 in LaCharité and Paradis 2005). For this reason, I will only investigate those very processes which can be shown to be active by recent adaptations (§6.1) or in experimental data (§6.2). In the following sections, I will differentiate between dormant phonological phenomena, which may be of interest to historical linguists, and the active phonological component in the grammar, which is relevant insofar as any new introductions to L1 are concerned.

2.1.4. Institutionalised vs. ad hoc creations

A language's lexicon, Hebrew in our case, may include morphological items from many sources (Zuckerman 2003, 2004, 2005). However, the forms of these words do not necessarily reflect the speakers' grammar at a certain point in time. I suspect that the speakers' grammar is reflected in the initial coining of words, but once adopted (and adapted), this production grammar is irrelevant.

Following this, loanwords can be grouped into two major types:

a. *Institutionalised loanwords*: Words which have been around for a while and whose adaptation does not reflect the current speakers' active and productive phonology. Often, they are not even perceived as loanwords by current speakers and/or their origins are unknown to speakers, who may never have been exposed to the L2 original. Many of these words exist in L1 dictionaries and all of them have orthographic representations in L1 (e.g. [tuf] 'tuff (volcanic rock)').

b. *Ad hoc creations*: Words which have to maintain a certain degree of transparency, at least until they have become institutionalised. These words have ordinarily not been incorporated into L1 monolingual dictionaries, yet are necessary in order to fill semantic voids. In many cases, they exist alongside the L2 originals via exposure to L2 in the media, on the web, etc. Terminology in certain fields, proper nouns and Hebrew-like pronunciations of foreign phrases are such examples.

Ad hoc creations are the only type of loanword which I consider in my study, as only they reflect an active phonology.

2.1.5. Adapting speakers

Who coins loanwords? A possible approach (e.g. Paradis 1996, Paradis and LaCharité 1997, LaCharité and Paradis 2005) is that loanwords are introduced into L1 by bilinguals who have access to the phonology of the source language (L2). The initial introduction is via idiosyncratic productions. Only people who are proficient to some extent in L2 can borrow a word into L1. The word becomes a loanword only when the L2 grammar is fully deactivated. The grammar (§2.2.1.2) and orthography (§2.2.1.1) of L2 might interfere during these initial stages of adaptation.

However, this is not the only possible option. I claim that alongside the adaptors who are proficient in L2, there may be monolingual L1 speakers who initiate adaptation. The current exposure to foreign words in the media, the internet, due to extensive travel and emigration etc. allows for widespread adaptation, even by speakers of L1 who are not familiar with L2 at all, but have merely been exposed to L2 phonetic structure (even partially). Furthermore, speakers with no knowledge of L2 might adapt solely on the basis of an orthographic representation, without ever having heard the L2 original being pronounced (imagine reading a menu in a foreign restaurant).

Therefore, it is possible to distinguish among different types of adapting speakers. Some may be proficient to a certain extent in L2 (often referred to in loanword literature as "bilinguals"). Others may only have some knowledge of L2. A third group may be monolingual speakers of L1, having no knowledge whatsoever of L2. Bilinguals have linguistic knowledge of L2's phonology and morphology, speakers with some knowledge of L2 may have access to orthography and some meta-linguistic knowledge of the language's morphology, phonology etc., while the third group only has access to L2 phonetic representations (which may not even have been perceived accurately) or orthographic forms. Of course, the kind of speaker carrying out the adaptation and the sources to which s/he is exposed may affect the nature of the adaptation itself (§7.1).

2.2. Adaptation

In this section, I outline the main points relevant to adaptation in order to lay the foundations for the following chapters of this study. An extensive discussion of all aspects of adaptation appears in §7.

Given that a word is eligible for borrowing (§2.1), it becomes necessary to ensure that its phonological form complies with L1's phonological and morphological restrictions. In order to do so, it is necessary to alter non-compliant forms (§2.1.2). Alterations are either motivated phonologically or non-phonologically. In order to determine the nature of the phonological adaptation, it is necessary to weed out adaptations of a non-phonological nature.

2.2.1. Non-phonological aspects of loanword adaptation

The investigation of loanword phonology is essentially twofold. First of all, it is necessary to identify the loanwords (§2.1). Secondly, it is necessary to identify the phonological aspects of the adaptation. Not all adaptational processes can be attributed to phonological mechanisms, although all adaptational processes necessarily result in a word whose phonology is accepted by speakers of L1. Only adaptational processes which are grammatically grounded and which ignore all extra-grammatical influences can be attributed to phonological mechanisms. In order to determine which processes are phonological, it is essential to isolate those which are not.[8]

A comparison between the L2 phonetic form and the L1 form might indicate whether non-phonological phenomena are involved. Mismatches between the two forms not attributable to phonological processes are logically of two kinds:

a. The L1 phonetic output includes information not present in L2 which cannot be attributed to phonological processes (e.g. orthographically motivated epenthesis, §2.2.1.1 and §7.1.4);
b. The L1 phonetic output does not include information present in L2, the lack of which cannot be attributed to phonological processes (e.g. analogically motivated deletion, §2.2.1.4 and §7.3.2).

In both cases, it is clear that some non-phonological phenomena must be involved. The following §2.2.1.1-§2.2.1.5 refer to these non-phonological influences.

[8] This view is by no means uncontroversial. Paradis and LaCharité (1997), for example, hold that almost all adaptation is phonological. I discuss this in §2.2.2.1 and §7.

2.2.1.1. Orthographic influences

There are cases in which there is no possible explanation for the existence of a segment and/or its quality in L1 other than the orthographic representation of the word in L2 script (see also §7.1.4). The following examples in table (3) show how L2 (English) vowels and consonants with identical phonetic forms surface as different L1 (Hebrew) forms because of their different English spellings:

(3) *Orthographically conditioned adaptation of vowels and consonants*

	Orthography	English (L2)	Hebrew (L1)[9]
a.	Ev**a**n (name)	[ˈɛv.**ə**n]	[ˈev.**a**n]
	Kev**i**n (name)	[ˈkɛ.v**ə**n]	[ˈke.v**i**n]
b.	spons**o**r	[ˈspɔn.s**ə**ɹ]	[ˈspon.s**o**ʁ]
	us**e**r	[ˈju.z**ə**ɹ]	[ˈju.z**e**ʁ]
c.	r**e**spect	[ɹ**ɪ**.ˈspɛkt]	[ʁ**i**.ˈspekt]
	r**e**verse	[ɹ**ɪ**.ˈvɜɹs]	[ʁ**e**.ˈveʁs]
	Or**a**nge (name)	[ˈɔ.ɹ**ɪ**nd͡ʒ]	[ˈo.ʁ**a**nd͡ʒ]
d.	fl**i**rt	[fl**ɜ**ɹt]	[fl**i**ʁt]
	netw**o**rk	[ˈnɛt.w**ɜ**ɹk]	[ˈnet.w**o**ʁk]
e.	d**u**nk	[d**ʌ**ŋk]	[d**a**ŋk]
	fr**o**nt	[fɹ**ʌ**nt]	[fʁ**o**nt]
	minib**u**s	[ˈmɪ.ni.b**ʌ**s]	[ˈmi.ni.b**u**s]
f.	Linc**ol**n (name)	[ˈlɪŋ.k__ən]	[ˈliŋ.k**o**.**l**en]

[9] The forms [ˈɛ.v**ɛ**n], [ˈkɛ.v**ɛ**n], [ˈspon.s**e**ʁ], [ˈo.ʁ**e**nd͡ʒ], [ˈnet.w**e**ʁk] have also been attested, but these are clearly not orthographically related. In the following sections, particularly §7.1.1, I will show these to be perceptually motivated adaptations.

In the two words in (3a), the vowel in the final syllable of the English form is phonetically [ə]. The difference in the Hebrew adaptation can only be attributed to the difference in the English orthography, <a> vs. <i>. The suffixes <or> and <er> in (3b) are pronounced exactly the same in English. Once again, the different Hebrew pronunciation suggests that at least one (if not both) of the cases must refer to the orthography. In (3c), the English vowel [ɪ] has two different orthographic representations, <e> and <a>, and three different Hebrew adaptations, [i], [e] and [a], with the latter two most likely being due to orthography. In (3d), the identical [ɜɹ] sequences are represented differently in the orthography and adapted differently in Hebrew, a direct consequence of their different orthography. In (3e), [ʌ] is represented by two different graphemes in English, <u> and <o>, yet adapted into three different Hebrew vowels, [a], [o] and [u], with the latter two most likely attributable to orthography. Finally, in (3f), the orthographic <ol> sequence in 'Lincoln' has no phonetic realisation in English. Furthermore, there is no inflectional or derivational paradigm which a speaker might access in order to retrieve the <ol>. The only way [ol] could possibly surface in the Hebrew form is if the Hebrew speaker referred to the orthography.

I follow Paradis and LaCharité (1997) in saying that one should not ignore the phonological regularity of the adaptation of loanwords (or, indeed, any regularity in any system), just because of some apparent infrequent irregularity. Although there are orthographic interferences in adaptation, the strong tendencies in the system should still be examined.

So what is the extent of the orthographic influence on loanword adaptation? Paradis and LaCharité (1997) claim that while orthography cannot be completely controlled in the adaptation, it only plays a *minor* role. The example they present is from Fula, spoken in Senegal, where only 4.6% of the segmental changes in loanwords are attributed to orthography. However, they add that 80% of the Fula-French speaking population are illiterate. Therefore, it is hardly surprising that the

French orthography does not affect the Fula pronunciations. Indeed, in a largely illiterate society, it would be surprising to find orthographic effects in anything. Continuing along these lines, LaCharité and Paradis (2005) claim that loanwords from English in Quebec French (a largely literate society) are not affected by orthography. A similar view rejecting the orthographic influence on loanwords is adopted in Silverman (1992), who claims that there exists both experimental and theoretical evidence that speakers do not employ their knowledge of English orthography in incorporating English loans into Mandarin Chinese.

However, other studies, especially experimentally based researches, have reached different conclusions. For example, Vendelin and Peperkamp (2006) show how orthography necessarily affects adaptations in Quebec French. They support their claims with experimental data showing that speakers adapt 8 English vowels differently, depending on whether they are exposed to orthography, pronunciation or both. English flaps (underlying /t/ or /d/) are adapted with reference to the orthography too.

Vendelin and Peperkamp's (2006) conclusions are further supported by data regarding the adaptation of English [ə] (underlyingly, any unstressed vowel) in Hebrew adaptations. It is often adapted, as in the above table (3), according to its orthographic representation (see also §7.1.3 for discussion of [ə] adaptation). Further backing for Vendelin and Peperkamp's approach can be found in Escudero et al.'s (2008) experimental study of novel English words learnt by Dutch speakers.

An extreme case of orthographic influence can be found in Japanese loanword adaptation. Lovins (1975:48) explains how the influx of written loans into Japanese makes it difficult, if not impossible, to distinguish orthographic factors from phonetically-motivated variations. This is supported by Schmidt (2008), who demonstrates how the selection of the type of script used for words in Japanese affects the phonological behaviour of words.[10] Also working on Japanese, Smith (2005) presents loan couplets, showing how adaptations differ when speakers are exposed to orthography. When exposed to the orthography, consonants are saved by epenthesis. Without orthography, consonants are deleted, as seen in the following data from Smith in table (4):

(4) *Loan couplets in Japanese – epenthesis vs. deletion*

English	with orthography	without orthography_
'pocke**t**'	[poke**tt**o]	[pokke_]
'bee**f**steak'	[biː**fɯ**sɯteːki]	[bi_sɯteki]
'lemona**de**'	[ɾe.mo.neː.**d**o]	[ɾa.mɯ.ne_]

In light of all these data, which approach is supported by the data in Hebrew? On the one hand, <gh> sequences in English orthography surface in Hebrew according to their English pronunciation, or lack thereof (e.g. [bæk l**aɪ_t**] 'back light' → [bek l**ai_t**] vs. [ɹʌ**f** kʌt] 'rough cut' → [ʁa**f** kat]), and never surface as [g] or suchlike. Vowel sequences in English orthography pronounced as monophthongs in English surface as monophthongs in Hebrew (e.g. [ˈdæʃ.b**ɔ**ɹd] 'dashb**oa**rd' → [ˈdeʃ.b**o**ʁd] and not *[ˈdeʃ.b**o.a**ʁd]). Indeed, such examples are given in Paradis and LaCharité (1997) and LaCharité and Paradis (2005) regarding English loans in French as proof that there is no reference to the orthography. On the other hand, however, Hebrew loans also include several cases in which the influence of the orthography is clear. In fact, in the corpus presented in §6.1, ~25% (346/1383) of the words are necessarily affected by the orthographic forms. The abovementioned examples in

[10] Roughly speaking, three different scripts are used for three different strata in the Japanese lexicon. Hiragana is used for native words, Katagana is used for loanwords, and Kanji is used for Chinese words. Each stratum of the Japanese lexicon has different grammatical characteristics (Itô and Mester 1999).

table (3) are not the only such cases. Evidence for orthographic influence can be found in the many cases in which English phonetically produces a schwa [ə]. In English, unstressed vowels are often reduced to schwas, yet these may surface in Hebrew pronounced according to their English orthography as shown in the following table (5). Note how the five cases of English [ə] all have different English orthographic representations in (5a-e) and are all adapted according to this orthography into Hebrew.

(5) *Variable schwa adaptation*

	Orthography	English (L2)	Hebrew (L1)
a.	Evan (name)	[ˈɛ.v**ə**n]	[ˈe.v**a**n]
b.	Kevin (name)	[ˈkɛ.v**ə**n]	[ˈke.v**i**n]
c.	station (wagon)	[ˈsteɪ.ʃ**ə**n]	[ˈstei.ʃ**e**n]
d.	Lincoln	[ˈlɪŋ.k**ə**n]	[ˈliŋ.k**o**.len]
e.	syllabus	[ˈsɪ.l**ə**.b**ə**s]	[ˈsi.l**a**.b**u**s]

How can all the above conflicting approaches be reconciled? Two things need to be taken into account. First of all, just because some orthographic symbols are realized phonetically while others are not does not mean there is no reference to the orthography. It only means that the reference to the orthography follows strict rules of which the educated literate reader is fully conscious. Secondly, the difference between the percentage of orthographically influenced loans in Mandarin and Fula as opposed to Hebrew may also be due to degrees of literacy in given societies (e.g. Fula speakers) as well as the orthographic systems employed (e.g. Chinese script). Finally, and probably most importantly, the orthography often agrees with the pronunciation in L2, and both might predict similar outputs. Therefore, just because a word's pronunciation in L1 is similar to its pronunciation in L2 does not mean that the word was adapted on the basis of its pronunciation. The orthographic influence in such cases is impossible to isolate (see also Lovins 1976).

It seems orthography is relevant when the speaker borrowing the word from L2 has access to L2's orthography and decides (consciously or otherwise) to refer to it, within certain rule-based boundaries. While orthography per se might not influence the grammar, it could artificially override the grammar (Paradis 1996). In order to do away with orthographic influences on loanword adaptation, my research focuses on those cases in which the speaker does not have access to the orthography or does not make reference to the orthography but rather relies on the L2 source word's phonetic form.

It is important to determine which segments necessarily have an orthographic source in order to exclude them from the corpus when considering the speakers' phonological knowledge. I propose three necessary conditions for determining whether a segment's source is orthographic (I discuss these in detail in §7.1.4):

a. When no *paradigmatic relationships* can be exploited to recover a segment: For example, all the schwas in the above table (5) cannot be recovered via some paradigmatic relationship as the words in (5) have no paradigms or have paradigms in which the schwa does not vary.

   If a paradigmatic relationship can be exploited to recover a segment, then orthography cannot be shown to be a necessary source of the segment. For example, the second schwa in English [ˈsɪ.nə.m**ə**] 'cinema' could be recovered via [sɪ.nə.ˈm**æ**.tɪk] 'cinematic' which might explain its adaptation into Hebrew as [a] (assuming speakers are aware of the paradigm).[11] In this case, the paradigmatic relationship between 'cinema' and 'cinematic' could explain the adaptation, without reference to orthography, thereby rendering the orthography redundant.

b. When the English *pronunciation* is not "similar" to the Hebrew form: If the English pronunciation is not "similar" to the Hebrew form, this may be a case of

[11] It could also be attributed to alternate pronunciations of 'cinema' in English, which do not reduce the final vowel to a schwa.

the orthography influencing the adaptation. For example, the case of [ˈmɪ.ni.bʌs] 'minibus', which is adapted as [ˈmi.ni.b**u**s], requires reference to the orthography as the English and Hebrew pronunciations are not "similar". On the other hand, when the two pronunciations are "similar", no reference to the orthography can be proven. For example, English [ɛ] is identical acoustically to Hebrew [e], so the adaptation of [s**ɛ**t] 'set' as [s**e**t] can rely fully on the phonetic form and does not require reference to the orthography.

c. When the English *orthography* is "similar" to the Hebrew pronunciation:[12] As is the case in [ˈmi.ni.b**u**s] mentioned in the above (b). <u> is similar to [u], therefore the adaptation of orthographic <u> as [u] is not surprising.

2.2.1.2. Explicit knowledge of L2/L1 morpho-phonology

Alongside the orthography-related effects in loanword adaptation are the morpho-phonological issues. I am referring to the conscious knowledge of L2's morphology, rather than to its implicit knowledge.

Silverman (1992) claims that knowledge of English morphology is necessary to explain extra-phonological influences on analyses. For example, speakers often refer to morpheme boundaries in the adaptation of loanwords. I will not discuss this point at length, but suffice it to say that inflectional affixes are seldom borrowed. This would require the speakers to have knowledge of L2 morphology, otherwise why else would they ignore such affixes?

In a few cases, however, the affixes may be part of the L2 phonetic material adapted into L1. When these affixes undergo phonetic adaptation, they usually lose their grammatical function. For example, the plural morpheme /s/ is sometimes borrowed into Hebrew, but is largely ignored grammatically. The English [t͡ʃɪp**s**] 'potato chips' is adopted by some speakers as [ˈt͡ʃip.s-**im**]. The suffix [-**im**] is the

[12] I use "similar" in inverted commas because this is not really a similarity-based relationship, but rather a complex relationship between orthography and pronunciation (spelling pronunciation, §7.1.4).

Hebrew masculine plural morpheme and the English plural suffix [-**s**] loses its grammatical function. The same holds for the English [bɹeɪks] 'brakes' becoming [ˈbʁek.s-**im**] in Hebrew, and the English [ˈɛs.kə.moʊs] 'Eskimos' becoming [es.ki.ˈmo.s-**im**].[13] Irregular plural forms are also, by and large, adapted as monomorphemic singular forms into Hebrew. For example, the English plural noun [ˈmi.diə] 'media' was borrowed into Hebrew as a singular noun, [ˈmed.ja], which in turn can be pluralised to [ˈmed.j-**ot**] ([-**ot**] is the Hebrew feminine plural morpheme). The English [bɪg mɛn] 'big men (basketball)' becoming [ˈbig.me.n-**im**], all adding the Hebrew plural morpheme to the English form.[14] If and when grammatical morphemes are borrowed, they lose their status as distinct morphemes and are borrowed as if they were part of the base.[15]

There are cases which show the morphological reanalysis of monomorphemic source words according to Hebrew grammar. For example, the English [siɫ b**im**] 'seal beam (automechanics)' is adopted as [silb] in Hebrew (via back formation). The deletion of the English [**im**] results from its reanalysis as a Hebrew plural morpheme. Of course, the plural form in Hebrew in such cases would be [ˈsil.b-im].

2.2.1.3. Sociological issues

The register into which a word is borrowed and the frequency and contexts of its use may affect the adaptation process.

The degree of adaptation is a function of the frequency and extent of a word's use. This was identified in Holden (1976), who claims that the degree of adaptation may be connected to the frequency of a word's use and is a function of time and

[13] According to Even-Shushan (1993), the normative form of [ɛs.kə.moʊs] 'Eskimos' is [es.ki.mo.-im] though when carrying out a web search, the substandard [es.ki.mo.s-im] is more than twice as likely to be used.

[14] Note, both [mæn] 'man' and [mɛn] 'men' are predicted to adapt as [men] in Hebrew, so it is hardly surprising that the grammatical distinction between the two forms in English is lost during adaptation.

[15] See also Schwarzwald's (2002) discussion regarding the categories of loanwords.

sociological-psychological factors. The more frequent a word's use is, the greater the degree of adaptation is.

The register into which a loanword enters may depend on the identity of L2 (Schwarzwald 1998). For example, Hebrew curses or slang are largely adapted from Arabic, Russian, Ladino inter alia, while scientific terms come from English, French, Latin etc. In addition, high-register words, so to speak, such as terms used in formal or written language often make reference to the original orthography, whereas curses and slang rarely do.

Although the register into which a word enters and its frequency of use may indeed affect the nature of the adaptation (different grammars may apply in different registers, grammar is affected by frequency), I will not dwell on this specific aspect of adaptation.

2.2.1.4. Analogy and semantic assimilation

Loanword adaptation may also be affected by existing loanwords or by morphological (pseudo-)paradigms in L1 (see §7.3.2). In the following table (6), the comparison to existing loanwords via some sort of analogy can be shown to affect adaptation:

(6) *Analogically determined adaptation*

	English (L2)	Hebrew (L1)	
a.	[ˈswɛ.təɹ]	[ˈsve.deʁ]	'sweater'
b.	[ˈswɛt.ʃɜɹ**t**]	[ˈswe.t͡ʃeʁ_]	'sweatshirt'
c.	[ˈti.ʃɜɹ**t**]	[ˈti.ʃeʁ**t**]	'T-shirt'
d.	[ˈk**æ**.fin]	[k**o**.fa.ˈin]	'caffeine'

The deletion of the word-final [t] in (6b) cannot be explained phonologically, since it is not omitted in (6c). One possible explanation, and I currently have no other, is the similarity between (6a) and (6b) both semantically and phonologically. Since (6a) is an established loanword, much older than (6b), the adaptation of (6b) was most likely affected by the presence of (6a) in the Hebrew lexicon when (6b) was adopted.[16] An additional example appears in (6d). The word 'caffeine' is reanalysed as being directly connected to 'coffee'. Hence, the first vowel in the Hebrew adaptation [k**o**.fa.ˈin] 'caffeine' comes from the English [ˈk**ɔ**.fi] 'coffee' (and not the Hebrew [k**a**.ˈfe] 'coffee'), while everything else in the Hebrew word comes from the word [ˈk**æ**.fin] 'caffeine'. Note, the form [k**a**.fe.ˈin] also exists in Hebrew, either directly via adaptation from the English phonetic or orthographic form or with reference to the Hebrew [k**a**.ˈfe] 'coffee'.

2.2.1.5. Summary

When investigating the phonological nature of loanword adaptation, it is necessary to isolate the problematic words, those showing non-phonological influences. Since this study focuses on phonological processes synchronically active in Hebrew, care is taken to exclude words (or parts of words) with the above extra-phonological influences.

2.2.2. Phonological aspects of loanword adaptation

There are two major issues regarding the nature of the grammar of loanword adaptation. Researchers differ as to whether loanword adaptation is primarily phonetically (articulatorily and/or acoustically) or phonologically (representationally) grounded (§2.2.2.1). Those who hold the phonological view still differ as to whether loanword phonology is distinct from native phonology, i.e. how many phonologies a native speaker has (§2.2.2.2).

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[16] Note that the [w] in 'sweater' is adapted as [v], but this is not the case in 'sweatshirt', indicating that 'sweater' is a much older loanword than 'sweatshirt', as [w] is currently almost invariably borrowed as [w]. See also §3.1.

2.2.2.1. Phonological or phonetic adaptation

I start by addressing the first issue, i.e. whether the adaptation is phonetic or phonological by nature. There are two possible extreme points of view. Adaptation can be purely phonetic, or adaptation can be purely phonological. Then, of course, there is the view that both phonetics and phonology play a role.

One of the prominent advocates of the phonetic nature of loanword adaptation is Silverman (1992), who claims that the L2 input is "a superficial non-linguistic acoustic signal" perceived within "an indigenous phonological system" and fitted "into the native phonological system as closely as possible" (p. 289). The difference between languages insofar as adaptation is concerned lies on the language-dependent perception of phonetic material, perception which, according to Silverman, is constrained by the native segment inventory. According to Silverman's (1992) Perceptual Uniformity Hypothesis, the native segment inventory constrains segmental representations in a uniform fashion, regardless of string position. The whole process of adaptation, briefly put, boils down to the perception of L2 segments and their matching to L1 segments "as closely as possible". As proof of the language specific segmental perception, Silverman cites an experiment in which it was shown that English-Spanish bilinguals perceive isolated syllables differently, depending on which language an experiment is set in.

A similar view is supported in Peperkamp et al. (2008), who claim that non-native sounds are mapped onto the phonetically closest native sounds, computed by an acoustic distance metric. However, they note that the nature of this metric remains to be specified (see §5.4 for my proposal regarding this metric). Adaptations are not computed by the phonological grammar, though they are influenced by it in that the phonology determines which sounds are available for non-native ones to be mapped onto. The exact extent of this influence is not clear from the paper, however, they admit that the phonological encoding model and even the orthography can affect the adaptation.

At the other extreme, Paradis and LaCharité (1997) give evidence for the phonological nature of adaptation, holding that loans, as opposed to switching back and forth between L1 and L2, have mental representations in L1 and that all L2 forms are immediately interpreted as phonological representations in L1 and handled by L1's constraint set.

The phonological approach is also supported by Hyman (1970), who claims that the mere notion of "closeness" in adaptation is problematic and cannot be defined on the basis of phonetics. For example, is the English interdental voiced fricative [ð] closer to the alveolar voiced fricative [z] or the alveolar voiced stop [d]? French loanwords from English prefer the fricative [z], while Serbo-Croatian loanwords from English prefer the stop [d]. French and Serbo-Croatian have both the fricative [z] and the stop [d] in their inventories. Incidentally, Hebrew is an interesting case since some native speakers prefer the fricative [z] while others prefer the stop [d].[17] Sound adaptation, claims Hyman, is dependent on Sprachgefühl (literally: language feeling), native intuitions of the speaker, and is mental in nature rather than phonetic. See a similar case in Kenstowicz (2001), in which Fon adapts palato-alveolar fricatives as palato-alveolar affricates rather than alveolar fricatives. Along the same line, Silverman (1992) suggests that adaptation is a function of phonemic approximation, the perception of sounds in terms of underlying forms, rather than a superficial non-linguistic acoustic signal.

A dual approach, one that proposes that both phonetics and phonology play a part in adaptation (contrary to Silverman's (1992) Perceptual Uniformity Hypothesis) is presented in Kenstowicz (2001), where it is claimed that adaptation is not context-free (phonology-wise) and matching is followed by an imposition of phonological constraints. A similar view is presented in Yip (2006), where phonological structural constraints operate alongside phonetic perception to produce loanwords in Cantonese.

[17] The two groups differ both in age – younger speakers preferring the stop [d] – and in ancestral origin – speakers of Eastern European descent preferring the fricative [z].

Kang (2003) reaches the same conclusions working on Korean loans, showing how phonetic perception and native morpho-phonemic constraints work together in the production of loanwords. Shinohara (2006) also presents data from various languages showing the interaction between phonetic perception and phonological structural constraints.

Gerrits and Schouten (2004) present experimental evidence supporting the dual nature of loanword adaptation. Speakers operating in discrimination mode rely on auditory cues and differ in performance (good vs. poor listeners). Tasks requiring discrimination do not access the phonological system of the language. On the other hand, speakers operating in categorisation mode (e.g. categorising foreign phones into native classes) perform similarly, just as they would be expected to do in everyday speech situations. Categorisation and discrimination, therefore, are two different tasks, each utilising different mental capacities. This is similar to the results presented in Best et al. (2001), who provide experimental evidence that the acoustic signals, while categorised similarly, may be heard differently. This shows that two modules, the phonetic and the phonological, work side by side.

Following Hyman (1970), Paradis and LaCharité (1997/2000), Best et al. (2001), Kenstowicz (2001/2007), Gerrits and Schouten (2004) inter alia, I adopt the view that loanword adaptation is largely phonological, rather than phonetic (I present a formal model of the phonological module of adaptation in §5). However, the auditory phonetic nature of the L2 input into L1 plays a role in the phonological categorisation and adaptation.

2.2.2.2. One or two phonologies

What then is the nature of the phonological module in the borrowing of loanwords? Do speakers have one or two phonologies? Logically, there are two answers to this question: (a) There is one operative phonology; (b) There are two distinct operative phonologies, loanword phonology and native phonology. A similar view would be that there is one stratified phonology in which loanwords and native words are on different strata, subsequently undergoing different processes as well as shared processes (e.g. Itô and Mester 1999, inter alia). I cannot find any substantial differences between these two approaches, though the stratified approach seems to allow for fewer differences than two separate phonologies would.

Supporting a two-system approach, Silverman (1992) claims that phonological processes differentiate between loanwords and native vocabulary, and some processes are peculiar to loanword phonology. In essence, two phonologies (or one stratified phonology) operate in loanword adaptation.

At the other extreme, supporting a single phonology approach, Holden (1976) suggests that there is only one phonology. Differences between loanword and native vocabulary are derived via constraint interaction. In principle, there is a hierarchy of 'strengths' of native constraints which conflict with one another, the outcome decided by the relative strengths of the constraints. Different rates of assimilation of certain foreign sequences and segments are a direct measure of the strength (or productivity) of the native constraints which serve as targets for the assimilation process (a notion largely similar to Optimality Theory – see §4.1). A similar view is held by Boersma and Hamann (2008), who claim that a single L1 system is responsible for loanword adaptation.

The facts are clear. Loanwords often behave differently from native lexical items. How does one resolve the apparent differences?

One possible approach is suggested in Smith (2005), who discusses the different behaviour of native vs. loanword clusters in Japanese. While native clusters are simplified by deletion, loanword clusters are simplified by epenthesis. At first, this sort of example seems to be evidence for two different phonologies (or one stratified phonology) working side by side. Indeed, that is the sort of evidence brought forward by advocates of the two-phonology approach, such as Silverman (1992). However, as Smith says, this is not the only possible conclusion. The apparent conflict can be solved within a *single* phonology, says Smith, if output-output constraints are introduced, requiring loanwords to be phonetically similar to the original L2 form. In effect, a single constraint set applies to the whole vocabulary, both native words and loanwords, but some constraints are simply not relevant insofar as native vocabulary is concerned. Reinterpreted, loanwords prefer to preserve segments rather than delete them (Paradis 1996, Paradis and LaCharité 1997, Peperkamp et al. 2008), while native words might not do so, because native words' segments are often recoverable via paradigms, whereas the only way to recover the loanwords' full form is via the phonetic form in L2.

There is also another possible approach suggested in Paradis and LaCharité (1997). In principle, there is only one set of language-specific constraints. Without elaborating on the theoretical framework within which Paradis and LaCharité's analyses are set, the central idea is the notion of Core and Periphery (similar to Itô and Mester's 1999 stratified lexicon). In the Core, all of a language's constraints are activated. In the Periphery, a subset of a language's constraints are contained. Most loanwords (but not only loanwords) are found in the Periphery. In such a way, loanwords allow us to observe "otherwise latent constraints in action" (pp. 382). Loanwords observing the full set of a language's constraints are found in the Core. Lexical items observing but a subset of the language's constraints (e.g. neologisms, nonces, most loanwords etc.) are found in the Periphery. In essence, loanwords are made to conform to at least the outermost constraints in the Periphery. An overall gradient approach is adopted with regard to the classification of lexical items with respect to constraints, rather than a straightforward two-way split in the lexicon/grammar.

A similar conclusion to this can be reached from Kenstowicz (2001/2007), who discusses active phonological processes, suggesting there may be those which are inactive. Although adaptation patterns may, in fact, contradict L1 grammar, these contradictions typically coincide with cross-linguistically natural and well-attested processes and constraints. This supports a claim that adults may be capable of calling on aspects on UG in adulthood (The Emergence of The Unmarked – TETU - see also Shayovits 1978, Lovins 1975, Shinohara 2004, and §7.1.2 in this study for more on the role of UG in loanword adaptation). Kenstowicz goes on to say that processes which are not active in L1 may systematically appear in L2 adaptations.

When examining the corpus before us, it becomes apparent that there are indeed processes visible in L1 native phonology which do not seem to operate in loanwords. In addition, it appears that processes operating in adaptations from L2 are present in L1 in one form or another. However, when the synchronic issue of productive vs. non-productive phonologies is raised, this notion must be rephrased. First of all, the Peripheral constraints are certainly productive, since they are relevant to all lexical items in the language, L1 vocabulary, neologisms, acronym words, nonces, loanwords etc. What about the Core constraints? They appear relevant only for fossilized forms in a language. Why then claim that these constraints are indeed an active and productive part of the phonology of L1? I suggest that constraints which are non-productive insofar as neologisms, loans etc. are concerned are inactive or dormant constraints, historical remnants of some past phonology. They may be relevant to large portions of the lexicon, however, this relevance if mainly via paradigm levelling allowing for analogy, or meta-linguistic knowledge rather than evidence of the activity of grammatical constraints.

An example of non-productive phonology is Hebrew post-vocalic spirantisation (§2.1.3). Loanwords do not ordinarily undergo post-vocalic spirantisation in adaptation (e.g. [d͡ʒi**p**] 'jeep' and [bo**b**] 'Bob'). This would suggest that post-vocalic spirantisation is non-productive. However, spirantisation is widespread in Hebrew paradigms (e.g. [**b**a] 'he came' vs. [la.ˈ**v**o] 'to come', [**p**a.ˈtax] 'he opened' vs. [li**f**.ˈto.ax] 'to open'). However, such cases may be lexically encoded or analogically based. Evidence of such analogies can be found in "sub-standard" Hebrew. Some speakers produce the full array of phenoma: (a) hypercorrective loans undergoing post-vocalic spirantisation (e.g. [sɛ**p**.ˈtɛm.bəɹ] 'September' → [se**f**.ˈtem.beʁ]); (b) occlusivised post-vocalic fricatives ([kæ.**f**ɪ.ˈtɪə.ɹi.ə] 'cafeteria' → [ka.**p**i.ˈte.ʁi.a]); (c) native Hebrew paradigms with and without stop-fricative alternations (e.g. [**v**i.ˈkeʃ] - [le.**v**a.ˈkeʃ] 'asked-to ask'), and more.

On the other, there are productive phonological phenomena which apply to the entire lexicon. For example, tautosyllabic sonorants are dispreferred in Hebrew, and such clusters are almost always broken up by an epenthetic vowel (see §3.3.1). Both loanwords and native words with such clusters undergo epenthesis.

If indeed loanwords, neologisms, acronym words and various other word-generating processes follow one set of rules, and the only words which follow the other set of rules are frozen forms, why would we insist on two productive phonologies? Would it not be simpler to define the frozen forms as following a dormant non-productive phonology and, in essence, accept that the language only has one productive and active phonological system, the one used for generating *new* words? If some native processes are only relevant for established words while others apply to all new words, it is theoretically superior to say the former are non-productive phonologically, and that the productive and active phonology is that which generates the *new* lexical items.

I follow the view that the phonological module in loanword adaptation is based on the phonology of L1. There may be certain aspects of L1 phonology which are inapplicable in adaptation, but these are not productive components of the system. In addition, universal principles may also operate alongside the native phonological system, although their effect is not apparent otherwise. An extensive discussion of the various components in loanword adaptation appears in §7.

Chapter 3. Language background

Every language is a subset of the universal phonological inventories, allowing only certain segments to surface, and limiting itself to particular syllabic structures and stress patterns. The bulk of loan phenomena are a direct result of the incompatibility of an L2 structure with L1's segmental inventory and prosodic structure. Therefore, understanding loan phenomena requires an in-depth analysis of the segmental inventories and prosodic structures of L1.

In this section, I discuss the phonological representation of Hebrew, focusing on vowels and prosody and referring to related loanword issues, particularly from English. An extensive discussion on the effects of Hebrew phonological restrictions in loanword adaptation appears in §7.

3.1. Hebrew consonants

Hebrew consonant categories, with few exceptions, are almost the same as English consonant categories, although the specific allophones may differ. The following table, modified from Laufer (1992), includes all the consonant categories in Hebrew, regardless of dialect marginality or source:

(7) *Hebrew consonant categories – the most permissive table*

	Bilabial	Labio-dental	Alveolar	Palato-alveolar	Palatal	Velar	Uvular	Pharyngeal	Glottal
Plosive	p b		t d			k g			ʔ
Fricative		f v	s z	ʃ ʒ		x	ʁ	ħ ʕ	h
Affricate			t͡s	t͡ʃ d͡ʒ					
Nasal	m		n			[ŋ]			
Liquid			l						
Glide	w				j				

The pharyngeals and the glottals, all native consonants, are currently unstable. The pharyngeals /ħ/ and /ʕ/ appear in the speech of a few speakers of oriental descent, and are often not even considered part of the Hebrew consonant inventory. As for the glottals /ʔ/ and /h/, they appear only in careful speech, and are omitted in rapid speech.

The gradual demise of the pharyngeals and glottals is accompanied by an expansion of the palato-alveolars, out of which only /ʃ/ is a native phoneme. The fricative /ʒ/ and the affricate /t͡ʃ/ appear as allophones in the language, due to voicing assimilation for /ʒ/, as in /**ʃ**gia/→[**ʒ**gi.ˈa] 'an error' (cf. [**ʃ**a.ˈga] 'to err'), and truncation (Bolozky 1979, Bat-El 2002) for /t͡ʃ/, as in /tiʃava/→[**t͡ʃ**a.ˈva] 'swear!' (cf. [niʃ.ˈba] 'swore'). The allophonic status of these consonants has allowed them to enter the phonemic system of Hebrew with unassimilated loans (e.g. [t͡ʃips] 'chips', [ga.ˈʁaʒ] 'garage') and to bring along the voiced affricate /d͡ʒ/ (e.g. [d͡ʒip] 'jeep', [ˈd͡ʒen.tel.men] 'gentleman', [ˈin.ti.d͡ʒeʁ] 'integer'), which survives in derived forms (e.g. [sin.ˈd͡ʒeʁ] 'exploited someone' from [ˈme.sen.d͡ʒeʁ] 'messenger', [mu.ˈd͡ʒa.jef] 'filthy' from [ˈd͡ʒi.fa] 'filth'). See also §2.1 and Ussishkin and Wedel (2003) for discussion on the expansion of phonemic inventories.

Another rather new phoneme in the language is /w/, which appears only in loanwords (e.g. [ˈwo.ʃiŋg.ton] 'Washington', [wau] 'wow', [a.ˈwan.ta] 'show-off') and in a handful of neologisms with obscure origins (e.g. [mit.ˈwak.wek] 'to maliciously gossip about someone', possible related to the onomatopoeic [kwa kwa] 'quack quack (duck sound)').[18]

An allophone which did not attain phonemic status despite the unassimilated loans in [ŋ], which appears in native Hebrew words as an allophone of /n/ before the velar stops [k] and [g] (e.g. /pi**n**ku/→[pi**ŋ**.ˈku] 'they spoilt' vs. [pi.ˈnek] 'he spoilt';

[18] Some speakers systematically adapt [w] in loanwords as /v/ in Hebrew (e.g. [ˈsik.vens] 'sequence'). Some words have variable pronunciations, such as [ˈki.wi] ~ [ˈki.vi] 'kiwi fruit'. Generally speaking, the older the speaker, the more likely s/he is to adapt /w/ as /v/.

/ma**n**gina/→[ma**ŋ**.gi.ˈna] 'tune' vs. [**n**i.ˈgen] 'he played (music)'). Because of the allophonic distribution of [ŋ] in Hebrew, all instances of [ŋ] in English are borrowed as [ŋ], but a velar stop is epenthesised after the nasal. This velar stop is ordinarily voiced (e.g. [ˈkas.ti**ŋɡ**] 'casting'), but can be voiceless before voiceless obstruents as a result of voicing assimilation (e.g. [lo**ŋk** ʃot] 'long shot'). As [ŋ] always appears before a velar stop, it is not necessary to assume that it has become a phoneme in Hebrew.

Loanwords with any of the above phonemic categories do not require modification of the consonantal segments. The only consonantal phonemic categories in loanwords from English requiring modification are the interdental fricatives and the rhotics, as in the following table (8):

(8) *Consonantal category differences: English and Hebrew*

English category	Hebrew adaptation
[ð]	[d]~[z]
[θ]	[t]~[s]
[ɹ/ɻ]	[ʁ]

Variation in the adaptation of interdentals depends on the age and/or ancestral background of the speakers, with individual speakers performing systematically. Younger speakers prefer the stops [d]/[t], while older speakers lean towards the fricatives [z]/[s]. In addition, speakers of Eastern European descent prefer fricatives [z]/[s], while other speakers usually produce stops [d]/[t].

Hebrew and English rhotics are very different. The Hebrew /ʁ/ is a uvular approximant with a certain degree of frication or trillness (Bolozky and Kreitman

2007, Ben-David and Berman 2007, Bolozky to appear).[19] The English rhotic, however, is a labialised coronal approximant, retroflexed or not, depending on the dialect (Ladefoged and Maddieson 1996:233-236).[20] In idiosyncratic productions, [ɹ/ɻ] is sometimes adapted by speakers as [w], but this is never the case in more established forms.

Since the adaptation of consonant categories is rare in English-to-Hebrew loans, and whatever adaptation there may be is amazingly systematic, I only discuss them with respect to their effect on vowels (see §7.1.2). Henceforth, my discussion focuses on vowels and prosody.

3.2. Hebrew vowels

The Hebrew vowel system consists of five vowel phonemes, all voiced and oral and without contrastive duration: /*i, e, a, o, u*/ (Chen 1972). As shown in the following table (9), the most frequent vowel in Hebrew is /a/, regardless of whether the noun type is a stem or a derived form (see also Adam and Bat-El 2008). The table below presents the frequency of stressed vowels in Hebrew nouns, separating singular and plural forms. Note, the high frequency of /i/ in masculine plurals and /o/ in feminine plurals reflects the fact that the plural suffixes (masculine /-im/ ; feminine /-ot/) are almost always stressed in native Hebrew words. The high frequency of /u/ in feminine singular nouns may stem from the fact that many of these are formed by adding the stressed suffix /-ut/ to a masculine base:

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[19] I adopt the analyses of Bolozky and Kreitman (2007) and Ben-David and Berman (2007), as these are based on extensive acoustic and articulatory investigations alongside considerable phonological theory, rather than older analyses of the Hebrew rhotic as a uvular or alveolar trill (Gottstein 1948), a uvular fricative (Bolozky 1997), or as a velar fricative (Blanc 1964).

[20] There are many different rhotics in various dialects of English. In Southern British English, the rhotic is an alveolar approximant. In American English, it may be retroflexed with lip rounding and, possibly, pharyngeal constriction. Some South African dialects have an alveolar fricative or trill. In Scots English, it may be an alveolar trill or flap. There are some dialects in northwest England in which it is a uvular fricative or trill (Ladefoged and Maddieson 1996:233-236).

(9) *Stressed vowels (absolute values) in Hebrew nouns (Bolozky and Becker 2006)*

	/i/	**/e/**	**/a/**	**/o/**	**/u/**
Stressed V in masc. sg.	967	1359	1860	894	1204
Stressed V in fem. sg.	428	540	2652	230	1656
Total stressed V in sg.	**1395**	**1899**	**4512**	**1124**	**2860**
Stressed V in masc. pl.	4640	324	462	574	93
Stressed V in fem. pl.	209	181	437	4533	75
Total stressed V in pl.	**6244**	**2404**	**5411**	**6231**	**3028**

In the following §3.2.1, I present a featural model of the phonological representation of Hebrew vowels. This is followed by an acoustic analysis of the system in §3.2.

3.2.1. A featural model of Hebrew vowels

Articulatorily, Hebrew vowels can be described as follows:

/i/ - high front vowel,

/u/ - high back vowel,

/e/ - mid front vowel,

/o/ - mid back vowel,

/a/ - low back vowel.

It should be noted that Laufer (1992) classifies /a/ as a central vowel, but acoustic evidence (see vowel chart in (12) below) suggests it may be a back vowel (note that this point is not relevant to my discussion).

In a binary feature model, the vowel system in Hebrew clearly contrasts at least two degrees of height and backness as shown in table (10) below. In addition, there is either a third degree of height or a roundness distinction in order to represent the [a/o] contrast. I follow Chen (1972) and Most et al. (2000) in saying that Hebrew distinguishes three degrees of height (i.e. [low] rather than [round] to distinguish /a/ from /o/). A roundness distinction would technically do the job just as well (§3.2.2.1), however, there are perceptual reasons to believe this is not the case, and that the distinction is height based (§3.2.2.5):

(10) *Contrastive features in the Hebrew vowel system*

	/i/	**/e/**	**/a/**	**/o/**	**/u/**
high	+	-	-	-	+
back	-	-	+	+	+
low	-	-	+	-	-
(round)	(-)	(-)	(-)	(+)	(+)

3.2.2. An acoustic analysis of Hebrew vowels

I have taken all my acoustic measurements of the Hebrew vowels from Most et al. (2000). Their analysis of Hebrew vowels is based on data from 3 groups of 30 participants each: adult males, adult females, 9-year-old children (15 of each gender). Each participant had to pronounce five CVC nonce words (/pVp/) five times each.[21] The fundamental frequency (F0), the formants (F1-F4) and the vowel duration were all measured. Formant frequencies were measured in the middle, steady state part of the vowel. Data taken from Most et al. 2000 are presented in table (11) below. I have not included details of F4, as it is considered irrelevant for contrasting vowels in Hebrew (Most et al. 2000). The numbers in brackets refer to standard deviations (SD). I only refer to adult male productions unless stated otherwise.[22]

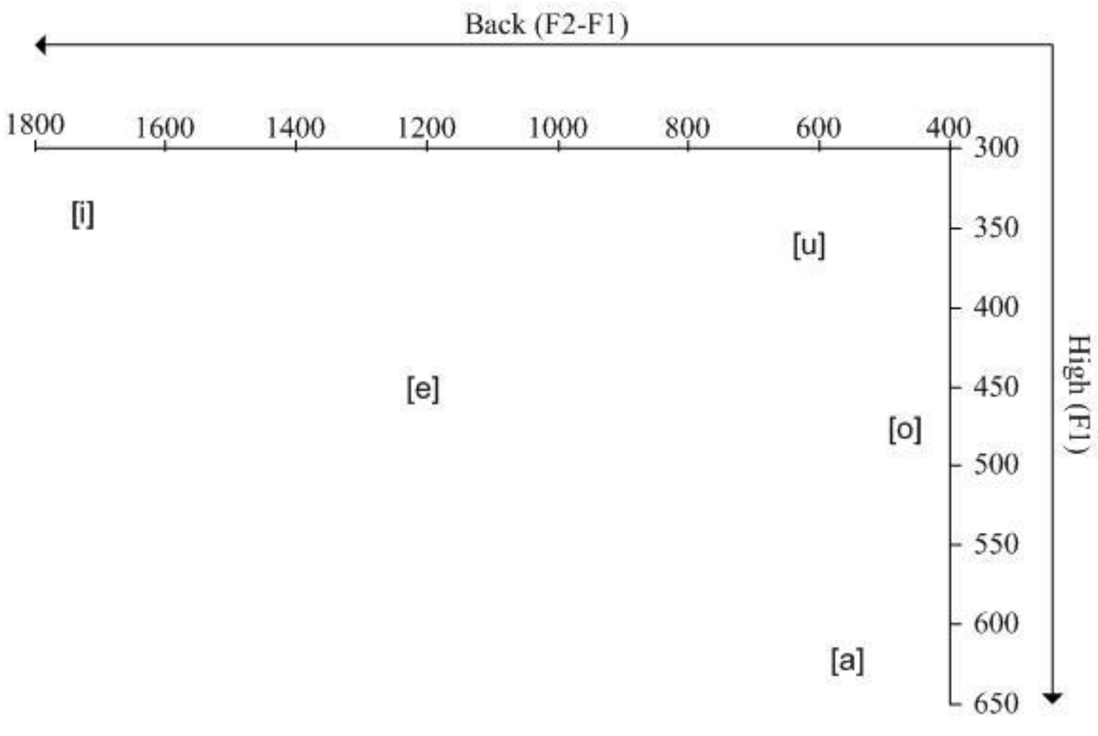
[21] The consonant /p/ was chosen because it has a short transitional period when coarticulated with vowels and thus affects the vowel characteristics to a lesser degree than other Hebrew consonants.
[22] My reference to adult male productions is by no means gender or ageism biased. It is simply because adult males are the only group covered by all the acoustic studies of vowels I refer to.

(11) *Hebrew vowel formant frequencies and duration*

	/i/		/e/		/a/		/o/		/u/	
F1	342	(30)	455	(40)	626	(48)	478	(46)	359	(31)
F2	2068	(142)	1662	(171)	1182	(90)	944	(105)	979	(91)
F2-F1	1726		1207		556		466		620	
F3	2562	(172)	2506	(156)	2417	(185)	2423	(173)	2445	(151)
Duration	78	(18)	82	(16)	90	(19)	82	(18)	75	(21)

The vowel chart below is based on values from the above table, where, as detailed below, F1 is taken as the relevant value for backness and F2-F1 is taken as the relevant value for height.

(12) *Hebrew vowel chart – height and backness (values from above table)*



3.2.2.1. F1 values

F1 values are an indication of vowel height (Ladefoged 1982:178-179, Rosner and Pickering 1994:13). Hebrew is traditionally viewed as a language that contains two high vowels, /i/ and /u/, two mid vowels, /e/ and /o/, and one low vowel, /a/ (Chen 1972). The values for F1, which relates to vowel height, show, as expected, no significant differences between /i/ and /u/ with respect to vowel height (342 v. 359 respectively, the difference being smaller than the SD), and no significant differences between /e/ and /o/ (455 and 478 respectively, the difference being smaller than the SD). Each of the two groups differs significantly from one another and from the vowel /a/, which averages 626 ($F(4,82)=733.63$, $p<0.0001$). Most et al. (2000) therefore conclude that there is a three-way distinction with respect to vowel height in Hebrew: high, mid and low (see §3.2.2.5 for additional support for this analysis).

3.2.2.2. F2 values

The F2 values are usually indicative of vowel backness, with lower values for back vowels and higher values for front vowels (Ladefoged 1982:179-180, Rosner and Pickering 1994:13). Actually, the F2-F1 difference is considered to be the relevant value in determining vowel backness (Ladefoged 1982:179-180, Most et al 2000, Rosner and Pickering 1994:13). While F2 values differ across groups (male, female, children), F2-F1 differences are more or less similar, indicating that this is the value which plays a role in normalisation.

As can be seen in table (11) above, each vowel was generally characterized by a different F2 value, with the exception of /u/ and /o/, which have similar F2 values. Note, /u/ and /o/ differ significantly in their F1.

In addition, the F2-F1 differences for the five vowels also differ significantly – $F(4,82)=760.02$, $p<0.0001$ for all five categories.

3.2.2.3. F3 values

With the exception of /u/ and /o/, all vowels differ significantly from one another with respect to F3 values. As I explain in §3.2.2.5 in my discussion of Bark transformations, backness in Hebrew is determined by the F3-F2 difference rather than the F2-F1 difference (Most et al. 2000). The importance of F3 can also be seen in the categorisation experiment in §6.2.2, where the F3 of non-native vowels can be shown to influence their categorisation. F3 is also considered crucial in making roundness distinctions (Rosner and Pickering 1994:159, 177), which Hebrew might not make (see §3.2.1).

3.2.2.4. Duration

As table (11) above shows, vowel duration in Hebrew is a function of vowel height, such that the lower the vowel, the greater the vowel's duration. Although the five vowels differ with respect to their duration, this difference is insignificant. The difference between the longest vowel /a/ and the shortest vowel /u/ is smaller than the standard deviation (/a/=90ms, SD=18 ; /u/=75ms, SD=21). Duration is not considered phonemically contrastive in Hebrew (Chen 1972).

3.2.2.5. Bark transformations

Most et al. (2000) base their analyses on Syrdal and Gopal's (1986) model in an attempt to characterize the Hebrew vowels, while minimizing group differences and normalising data. This model transforms physical frequency measures (Hertz) to an appropriate auditory scale (Bark). The Bark scale, proposed by Zwicker (1961), divides the human auditory range into 24 critical units (barks). Frequencies of vowel formants can be converted into the critical band scale (see formula in §4.3).

According to Syrdal and Gopal's (1986) model, vowels are classified into two categories in each bark difference dimension, according to whether or not they exceed a 3-bark critical difference. Observe the following table (13). When applying this model to Hebrew, the F1-F0 values for the vowel /a/ (4.32) are greater than the critical difference of 3-barks while the F1-F0 values for the vowels /i/ (1.84) and /u/ (1.99) are less than the critical distance of 3-barks. This would put /i/ and /u/ into one category, while putting /a/ into another category. The F1-F0 value for /e/ (2.86) is almost equal to the critical distance and the F1-F0 value for /o/ (3.07) is just beyond the critical distance (for other groups (women, boys and girls), a similar picture emerges for /a/, /i/ and /u/). The vowels /e/ and /o/, however, cannot be distinctively classified in this dimension, as they differ in the four age/gender groups, therefore requiring additional dimensions. This analysis supports the height distinction in Hebrew (§3.2.1).

The transformation procedure includes the conversion of the frequency scale to the critical band scale and the representation of each vowel as a pattern of differences between the frequency components. The analysis is presented in table (13) (Most et al. 2000). Once again, I focus only on the male subjects and the values relevant for my study:

(13) *Bark transformation mean values of the first three formants, and bark differences for three dimensions: F1-F0, F2-F1 and F3-F2*

Vowel	F0	F1	F2	F3	F1-F0	F2-F1	F3-F2
					Height		Backness
/i/	1.48	3.31	13.32	14.66	1.84	10.01	1.34
/e/	1.48	4.34	11.89	14.52	2.86	7.55	2.64
/a/	1.48	5.80	9.60	14.30	4.32	3.80	4.70
/o/	1.48	4.54	8.15	14.32	3.07	3.60	6.17
/u/	1.48	3.47	7.12	14.37	1.99	3.65	7.25

From this table, the following patterns emerge. The F1-F0 dimension reflects vowel height quite well in Hebrew, with height categories patterning according to the

3-bark critical distance. The F2-F1 values for all five vowels in all groups exceed the 3-bark distance and, therefore, cannot distinguish between backness categories. Thus, Hebrew vowels are not separated into front and back categories along this dimension and therefore the F2-F1 dimension cannot be said to relate universally to front-back distinctions. The F3-F2 dimension, however, clearly distinguishes among the front and back vowels, the front vowels being under the critical 3-bark distance, the back vowels being over the critical 3-bark difference. In short, vowel height in Hebrew is defined through the F1-F0 dimension, while backness is defined through the F3-F2 dimension. Additional discussion of these issues appears in §4.3.

3.3. Prosody

Since prosody plays an important role in the adaptation of loanwords, both with respect to syllabic structure and prominence, understanding adaptation requires an in-depth understanding of L1's prosody, the licit syllable structures and possible stress patterns. I discuss syllable structure in Hebrew in §3.3.1 and stress in §3.3.2.

3.3.1. Syllable structure

Native Hebrew words may contain the syllable structures in the following table (14):

(14) *Syllable structure in native Hebrew words*

	Syllable	Word Initial		Word medial		Word final	
a.	CV	**la**.ˈkax	'he took'	ka.**ta**.ˈva	'article'	ka.ˈ**ʁa**	'happened'
b.	CVC	**ʃul**.ˈxan	'table'	hit.**kaʁ**.ˈbel	'snuggled'	ʃad.ˈ**xan**	'stapler'
c.	V	**a**.ˈbiʁ	'knight'	no.**a**.ˈlim	'locking'	ka.ˈvu.**a**	'permanent'
d.	VC	**of**.no.ˈim	'motorbikes'	ne.**ez**.ˈvu	'were left'	bo.ˈ**eʃ**	'skunk'
e.	CCV	**tku**.ˈfa	'period'	---		---	
f.	CVCC	---		---		ka.ˈ**tavt**	'you (fem.) wrote'

Complex margins are noticeably rare in native Hebrew words. Complex onsets, as in (14e), appear only word initially, and complex codas, as in (14f), appear only word finally in 2nd person feminine singular past. Native Hebrew onsets are restricted to two (or fewer) consonants for historical reasons and Hebrew morphology offers no processes which might change this dramatically. All complex edges respect the Sonority Sequencing Generalisation (Steriade 1982) by allowing sonority rises toward the vocalic nuclei and plateaus, but never sonority falls (Rosen 1973, Bolozky 1978, Bat-El 1994). In addition, complex onsets consisting of sonorants are limited to [m] plus a coronal non-glide in onset position (e.g. [**ml**ai] 'inventory', [**mn**a.ˈjot] 'shares'); otherwise, two adjacent tautosyllabic sonorants are prohibited (*[mʁ], *[lʁ], *[ʁl]).

Loanwords, however, have a richer syllabic inventory (Schwarzwald 2002, 2004, Bat-El 1994 inter alia). Triconsonantal sequences may appear (Laufer 1992), provided they respect the Sonority Sequencing Generalisation (SSG) and do not have illicit sonorant sequences (e.g. [**stʁ**uk.ˈtu.ʁa] 'structure', [te**kst**] 'text', [ʔab.ˈ**stʁ**ak.ti] 'abstract').

The preservation of clusters in Hebrew loans, while following the SSG and the ban on sonorant clusters, has effectively increased the possible clusters in Hebrew, as seen in the following examples from Schwarzwald (2004):

(15) *Cluster retention in loanwords*

	Hebrew	
a.	[za**mʃ**]	'suede'
b.	[**stʁ**eit]	'straight'
c.	[pʁo.ˈje**kt**]	'project'
d.	[go**lf**]	'golf'
e.	[**xl**oʁ]	'chlorine'

The highlighted clusters in (15) above do not exist in native Hebrew words. Nevertheless, they are preserved in Hebrew loanwords. The data indicate that Hebrew has in fact expanded its syllabic inventory to include all clusters, provided: (a) there is falling or level sonority towards the syllable margin (Hebrew strictly observes the SSG); (b) sonorants are not syllabic; and (c) there is not a sequence of tautosyllabic sonorants (Bat-El 1994, Graf and Ussishkin 2002, Schwarzwald 2002/2004). See also §2.2.2.2 for discussion of productive and non-productive phonology.

If, however, potential loanwords deviate from the abovementioned restrictions on syllable structure, they necessarily undergo modification, usually via epenthesis (see also §7.2.1), as shown in the following table (16):

(16) *Modification of syllable structure via epenthesis*

	English (L2)	Hebrew (L1)	
a.	[ˈɜɹɫ gɹeɪ]	[ˈe.ʁ**e**l gʁei]	'Earl Grey'
b.	[fɪlm]	[ˈfi.l**i**m]	'film'
c.	[ˈpɒp.kɔɹn]	[ˈpop.ko.ʁ**e**n]	'popcorn'
d.	[ˈaɪ.dl̩]	[ˈai.d**e**l/d**o**l]	'(American) Idol'
e.	[ˈd͡ʒɔɹ.dn̩]	[ˈd͡ʒoʁ.d**e**n/d**o**n]	'(Michael) Jordan'

In the above (16a-c), an epenthetic vowel is necessary in Hebrew because of the language's avoidance of sonorant clusters in coda position (Schwarzwald 2004, Ussishkin and Wedel 2003). In (16d-e), an epenthetic vowel modifies the syllabic consonants in the input, as Hebrew only allows vocalic nuclei (Graf and Ussishkin 2002, Schwarzwald 2002/2004). Note the different possible epenthetic vowels, which, as discussed in §7.1.2, are a result of various phenomena such as vowel harmony.

3.3.2. Stress

Hebrew nouns can be accented (lexical immobile stress) or unaccented (mobile stress).[23] In unaccented nouns, stress is word-final or penultimate in the bare stem, and shifts to the final syllable in inflectional paradigms (Bat-El 1993, Becker 2003) as shown in the following table (17):

(17) *Unaccented noun paradigms*

	Final			Penultimate		
σ	ˈgiʁ	gi.ˈʁim	'chalk/s'			
σσ	ka.ˈduʁ	ka.du.ˈʁim	'ball/s'	ˈxe.deʁ	xa.da.ˈʁim	'room/s'
σσσ	a.vi.ˈʁon	a.vi.ʁo.ˈnim	'aeroplane/s'	miʃ.ˈla.xat	miʃ.la.ˈxot	'delegation/s'

In Bolozky and Becker's (2006) dictionary, stress is word-final in 86.8% (7790/8978) of the cases and penultimate in 13.2% (1188/8978) of the cases of unaccented nouns. Unaccented finally-stressed nouns are often recognised as the Hebrew norm (Bat-El 1993, Schwarzwald 2002, Graf and Ussishkin 2002).

Fainleib's (2008) experimental study of Hebrew stress shows that the default stress in nonce words within syntactic context differs from the Hebrew "norm". She reports on a significant preference for penultimate stress in vowel-final words and ultimate in consonant-final words. As for the inflectional paradigm, Fainleib found a significant preference for immobile stress.

In accented nouns, stress can appear on any syllable in the word and may shift in inflectional paradigms only to avoid staying outside the trisyllabic window (Bat-El 1993, Becker 2003, Fainleib 2008), as in [ˈte.le.fon]→[te.le.ˈfo.nim] 'telephone/s' (cf.

[23] I refer here only to primary stress. There is no acoustic evidence of secondary stress in Hebrew (Becker 2002) and although some speakers do feel that they hear some prominence associated with every second syllable to the left of the main stress, it is possible that this is a psychological correlate of the rhythmical processing mechanism without a parallel acoustic correlate (Bolozky 1982, Pariente and Bolozky in progress).

[ˈti.ʁas]→[ˈti.ʁa.sim] 'corn'). Lexical stress is abundant, particularly in non-templatic novel productions, loanwords, child speech and more (Pariente and Bolozky in progress). In Bolozky and Becker's (2006) corpus, stress is lexically assigned in 23.7% (2795/11773) of all nouns.

However, this deviation is found only in nouns, where stress is contrastive and thus needs to be lexically specified (Bat-El 1993, Becker 2003). The stress system in verbs is regular and predictable, and all loan verbs conform to the native system (Graf and Ussishkin 2002).[24]

With respect to loanwords, preserving stress patterns in adaptation does not necessarily require a violation of Hebrew phonological principles governing stress assignment, since lexical stress is so abundant. In general, a large variety of languages, and Hebrew is apparently no exception, show that prominence in loanwords is preserved, sometimes even if this violates basic prominence patterns in L1 (Silverman 1992 for Mandarin, Kenstowicz 2001 for Fon, Kenstowicz 2007 for Fijian, Shinohara 2004 for Japanese and more).

Given this, the few cases in which the stress pattern of English borrowings is not preserved in the Hebrew adaptation are of particular interest, requiring further study. For example, the initially-stressed English [ˈfɛs.tə.vəl] ‘festival’ is adapted as stress-final [fɛs.ti.ˈval], the penultimate-stressed [məs.ˈkæ.ɹə] ‘mascara’ and [gɹə.ˈfi.ti] ‘graffiti’ are adapted as the initially-stressed [ˈmas.ka.ʁa] and [ˈgʁa.fi.ti].[25] I discuss stress related issues in adaptation in §7.2.2.

[24] All Hebrew verbs, loans included, are also subject to other prosodic constraints (syllable structure, number of syllables) to which other words in the language are not subject (Bat-El 1993, Schwarzwald 1998, 2002). Almost all loan verbs are derived from loan nouns already adapted into L1, rather than directly from the L2 source. There are only a tiny number of verbs derived directly from L2 without the L2-L1 noun transition (e.g. [dis.ˈkes] from English [dɪs.ˈkʌs] 'discuss', [ʁif.ˈʁeʁ] from English [ɹɪ.ˈfɜɹ] 'refer' (Schwarzwald 2002).

[25] Since some loanwords may have multiple sources and others' origins may be unclear, I focus on words whose sole source is English. This may not be the case for some of the examples presented above.

Chapter 4. Theoretical frameworks

My model of similarity in general and loanword adaptation in particular is couched within a number of theoretical frameworks, related to the organisation of grammar and perception.

On the one hand, the grammar I propose in §5 and §7 operates within an Optimality Theoretical (henceforth: OT) framework (§4.1). However, instead of adopting the traditional OT approach, I adopt a Stochastic OT (StOT) approach (§4.2). The constraints within the StOT grammar I adopt are perceptually based (see extensive discussion in §5.4). I discuss the nature of perception in §4.3 within the framework of the model I propose, along the lines of Cohen (to appear) and Cohen et al. (in progress), adhering also to Steriade's (2001a,b) perception-based model (§4.4).

4.1. Traditional Optimality Theory

The model presented in this study is couched within an OT approach (Prince and Smolensky 1993).

In an OT grammar, outputs are a result of the interaction among constraints. The OT grammar consists of a generator, GEN, and an evaluator, EVAL. GEN generates all possible outputs for a given input, and EVAL compares these possible output forms, evaluating them with a series of ranked constraints, which determine how "bad" each candidate is. This evaluation starts with the highest ranked constraint. Candidates violating this constraint are the worst and are eliminated immediately. Then the surviving candidates are evaluated against the other constraints, ranked in descending order. Each violation incurred results in the elimination of the candidate in question, until all but one candidate are eliminated. The remaining candidate is the optimal one and the selected output, regardless of whether it violates constraints or not. This is the least bad candidate in the given set of candidates, the most harmonic and optimal candidate (see §5.4).

An OT system, such as the one described above, selects a single optimal candidate for every input and every constraint set, unless two or more constraints are crucially not ranked with respect to one another, i.e. freely ranked.[26] If two constraints are freely ranked or crucially not ranked (i.e. their ranking may alternate in any given evaluation), then each individual ranking might produce a different output, something which could result in variation in a language. As real-life loanword data show, inputs are rarely (if ever) adapted uniformly (§6.1). Therefore a model which produces uniform outputs (i.e. a strictly-ranked model) would not be appropriate in the analysis of a loanword grammar and there are necessarily fluctuations in the ranking of constraints. This fluctuation can be accounted for within a StOT system explained in the following §4.2.

4.2. Stochastic Optimality Theory

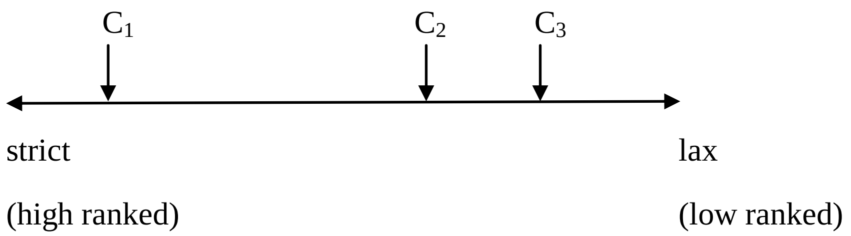
As explained, traditional OT evaluates a set of candidates with a set of fixedly ranked constraints. There is a unique output for any given constraint evaluation of a candidate set. The optimal candidate is then selected.

StOT, on the other hand, assumes a continuous scale of constraint strictness (Boersma 1998, Boersma and Hayes 2001). The grammar of a stochastically ranked system defines a probability distribution over the set of candidates (Jäger 2007). Every time a candidate is evaluated, a small noise component is temporarily added to the ranking value of each constraint and the grammar produces variable outputs.
The basics of StOT are similar to those of OT. There is a generator component and a set of ranked and violable constraints for the grammatical evaluation of all possible candidates. However, rather than ranking the constraints on an ordinal scale (i.e. strict ranking), each constraint is assigned a value which expresses its ranking. Constraints are not merely ranked from high to low, but rather the distance between two

[26] Free ranking, or crucially non-ranking between constraints A and B is a case where A>>B and B>>A select different optimal candidates.

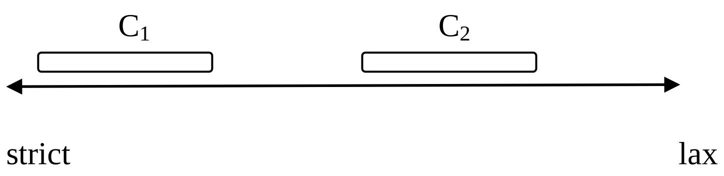
constraints can be expressed in a meaningful and quantitative way, as the constraints are ranked along a continuous scale with real values (Boersma 1998:271-272). The following diagram (18), taken from Boersma and Hayes (2001), depicts the situation with non-variable categorical ranking (=traditional OT) in which C_1>>C_2>>C_3:

(18) *Categorical ranking along a continuous scale*



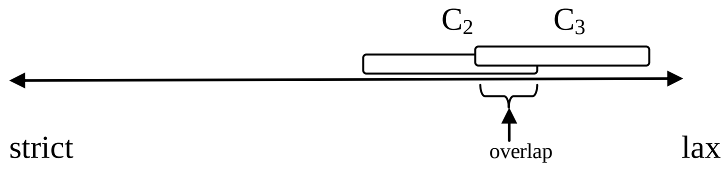
The shorter the distance between constraints is (e.g. C_2 is closer to C_3 than C_1 is to C_2), the less fixed the relative ranking of the constraint pair is. During evaluation, the ranking value of the constraint may fluctuate, thereby producing a range within which each constraint is applied, rather than a fixed point, as shown in the following diagram (19) (Boersma and Hayes 2001). The range of the fluctuation is determined by the size of the noise component mentioned above:

(19) *Categorical ranking with ranges*



In this case, the ranges of C_1 and C_2 overlap with vanishing tiny probability (i.e. effectively, do not overlap), therefore the ranking scale merely recapitulates the ordinary categorical ranking. However, if constraints are close enough, then their ranges may overlap, as in the following diagram (20) (Boersma and Hayes 2001):

(20) *Free ranking*



Since the selection points of each constraint may be taken from anywhere within the constraints' range, and because the ranges overlap, it is possible the C_3 will outrank C_2 in some cases. Note, however, that since most of C_2's selection points outrank most of C_3's selection points, the chances that C_2 will be ranked below C_3 are smaller than vice versa.

If the distances between constraints are high, the probability of the ordinal ranking switching between the constraints is very low. In other words, the further apart two constraints are, the less likely they are to "switch" in position in the evaluation of the candidates. In such a case, the output of the Stochastic and traditional OT grammars would be similar, or even identical, and there would be no variation whatsoever (at least not noticeably distinguishable from the background noise of speech errors). However, if two constraints are relatively close to one another, then they are likely to "switch" in position in a certain number of cases, outputting different candidates in each case, and resulting in grammatical variation.

Violated constraints, just as in traditional OT, "protest" against their violation by marking the candidate as bad. However, unlike traditional OT, the ranking of constraints fluctuates according to their relative values ("the loudness of each protest") in such a way that several instances of the same event produce different outputs. In most cases, the constraint with the higher value is ranked at the top. However, depending on the constraints' relative values, other constraints are ranked at the top in a certain (albeit, lower) number of the cases.

Even the relative values may fluctuate depending on different pragmatic circumstances (Boersma 1998:345). For example, if a speaker wants to speak more clearly, s/he may "push" the faithfulness constraints a little higher along the scale by "increasing" their value. An example of such pragmatic reranking can be found in dialects of American English, which ordinarily "flap" the alveolar stops /t, d/ intervocalically, and both surface as [ɾ]. However, in careful speech, these intervocalic stops may be produced as stops rather than as flaps, with speakers distinguishing them from one another, pronouncing /d/ as [d], and /t/ as [t]. In effect, this is a reranking of the faithfulness constraint preserving the underlying voicing distinction above the structural constraint banning intervocalic alveolar stops and this reranking is done by "increasing" the value of the faithfulness constraint.[27]

4.3. Just noticeable differences (*jnd*s)

Since I assume, following Steriade (2001a,b) which I discuss in §4.4, that the categorisation of phones is based on auditory comparisons, it is necessary to instantiate this categorisation in auditory terms. The auditory units I refer to are *just noticeable differences* (*jnd*s). *jnd*s are the minimum amount by which a stimulus intensity must be changed in order to produce a noticeable variation in sensory experience. First formulated as Weber's Law in 1834, Ernst Weber stated that the size of the *jnd* (ΔI) is a constant proportion of the original stimulus value:

(21) *Weber's Law*

$\Delta I/I=k$ (ΔI=difference threshold, I=initial stimulus), k=constant.

For example, let us assume the sense of touch, more specifically, the ability to detect weight differences, is the relevant sense. If a person holds one kilogramme in each hand, would s/he detect the addition of 1 gramme to the left hand? Probably not. If the minimum weight difference one could detect in such a situation is 100

[27] Whether this is based on paradigm leveling, reference to the orthography, reference to underlying forms (LaCharité and Paradis 2005, Shinohara 2006) or a result of register or lexical frequency is irrelevant. Some reranking must occur in the changing pragmatic situation.

grammes, then $\Delta I/I$=100/1000=0.1=k. So if a person is holding two kilogrammes, 100 grammes will not suffice in order to detect a difference. Instead, s/he will need 200 grammes, as k is constant.

Audition is no different from other senses, in this respect. All the physical characteristics of the incoming auditory signals (e.g. F1, F2, F3, length, intensity etc.) can be measured and subsequently evaluated in terms of *jnd*s. However, it is not the physical aspects of the vowel formants one attends to in *jnd* evaluations, but rather the vowels' acoustic parameters, expressed in units such as Barks (see also §3.2.2.5). Barks are seen as better predictors of perceived acoustic proximity (Traunmüller 1990, Kewley-Port 2001) and can be calculated according to the following formula (Traunmüller 1990, Brown 2002):

(22) *Bark formula*

Bark=z, Hertz=f: $z=26.81f/(1960+f)-0.53$;

if $z<2$, $z'=z+0.15(2-z)$; if $z>20.1$, $z'=z+0.22(z-20.1)$.

It has been found that the *jnd* for vowel formants is 0.3 Bark (Kewley-Port 2001). Note, however, that although F1 and F2 are both measured in Hertz, people pay less attention to F2 than to F1, probably because F1 is more audible than F2 in background noise (it ordinarily has a higher peak). Therefore, factoring in these differences between F1 and F2 would create a more accurate model of auditory perception, better matching the facts. This could be done by saying, for example, that the *jnd* for F1 is 0.6 Bark, while the *jnd* for F2 is 1.5 Bark (cf. the modelling by ten Bosch 1991). Indeed, Holt and Lotto (2006) address the necessity for weighting phonetic cues with respect to similarity judgements in second language acquisition.

4.4. P-map

Steriade's (2001a,b) P-map deals with the relative and absolute perceptibility of different phonetic contrasts depending on the contexts in which they appear. For example, the [p]-[b] contrast is better perceived before vowels (e.g. [apa] vs. [aba]) than before consonants (e.g. [apta] vs. [abta]), and [æ]-[ɛ] contrast is better perceived in primary stressed syllables than in secondary stressed syllables.

P-map excludes feature-based models as a basis for determining similarity (see §5.2). For example, using the features [high] and [nasal], cumulative similarity effects would classify [ɪn]-[ɛn] as more similar than [ɪn]=[ɛd]. Any feature-based system would predict this. However, how can a feature-based system determine that [ɪm]-[ɪn] are more similar to one another than [ɪb]-[ɪd]? It cannot, since a single feature, the feature of labiality, separates the two sequences in each pair.

The notion of similarity is closely tied to the notion of confusability. The more confusable two sounds are in a give context, the more perceptually similar they are to one another. When speakers construct an algorithm for determining similarity, it is based on their observations about confusion. The algorithm constructed is then independent from the observed confusion and becomes the unique source for similarity judgements.

The following table (23) from Steriade (2001a,b) is a sample fragment of the P-map:

(23) *Hypothetical fragments of the P-map*

Obstruent voicing	V_V	C_V	V_R	V_]	V_T	C_T
p/b	p/b	p/b	p/b	p/b	p/b	p/b
t/d	t/d	t/d	t/d	t/d	t/d	t/d
k/g	k/g	k/g	k/g	k/g	k/g	k/g
s/z	s/z	s/z	s/z	s/z	s/z	s/z

Every row in table (23) corresponds to some contrast and every column represents a specific context in which this contrast may occur. The larger the letter-size, the more distinct the contrast is. C/V represent consonants and vowels respectively,] represents a word-edge, R represents rhotic consonants, T represents voiceless stops. Hence, voicing contrasts in otherwise identical obstruents are best distinguished between vowels. The intervocalic context is that in which the two are least similar to one another and the context in which the confusability rate would be the lowest. Conversely, voicing contrasts are worst distinguished in the C_T context, i.e. this context is the one in which the two are most similar to one another and in which the confusability rate would be the highest.

In Steriade (2001a,b), the substantiation of claims regarding similarity relevant to P-map can be based on direct speaker judgements of similarity, implicit judgements in rhyming practices, confusability studies and observing acoustic correlates in various environments and the presence, or lack thereof, of phonetic cues. Similarity judgements are also affected by the specific phonological system in question, i.e. they are not claimed to be universal.

Following Steriade's (2001a,b) P-map, Shinohara (2006) discusses the universality of perceptual scales and their interaction with structural constraints. Determining similarity is, therefore, not a matter of some abstract notion of similarity or some concrete feature counting, but rather, it is a scalar process on the basis of perceptibility. However, Steriade (2001a,b) clearly states that she does not determine the source of the similarity knowledge and the reason for ranking the scales as they are ranked. The model is primarily descriptive and does not define how closeness is determined. Only the fact that the similarity knowledge exists in the minds of speakers is relevant. Shinohara (2006) adds that P-maps are constructed on the basis of universal perceptibility scales defined through auditory perception and encoded into the grammatical component in each language, interacting with each language's individual grammar. While P-maps are universal, language specific differences are the result of interaction between perceptual (P-map) constraints and structural constraints.

Chapter 5. Segmental similarity

What makes two entities similar in the eyes (or ears) of the beholder? This age-old question has intrigued researchers with respect to a broad scope of linguistic (and non-linguistic) phenomena, such as loanword adaptation, poetic rhyming, assimilation patterns and speech errors (slips of the tongue).

Linguistic literature in general and loanword literature in particular refer to similarity extensively, often quite abstractly, with little or no formal definition of the notion itself. Discussing segmental adaptation in loanwords, Hyman (1970:11) identifies that sound adaptation is "mental by nature". Speakers adapt non-native sounds to the "closest phoneme" in their language, the "equivalent…native segments", on the basis of Sprachgefühl. Similarity is all about the speaker's "feel" rather than a quantifiable concrete notion. It is certainly not based on a straightforward feature count.

Continuing this line of argument in his discussion of rhyming in rock music, Zwicky (1976) shows how word-final nasals with different places of articulation rhyme better than word-final oral stops with the same distinction. Nasals are deemed to be more similar to one another than comparable oral stops are to one another (of course, assuming we rhyme similar entities). Zwicky decides on the quality of the rhyming couplets according to their frequency in his corpus. However, nasals do not behave uniformly when it comes to rhyming with one another. The pairs [n]-[m] and [n]-[ŋ] often rhyme, while the pair [ŋ]-[m] hardly ever does. Note, all pairs are only a single feature (place) apart.[28] In addition, voiced-voiceless couplets (one feature apart) rarely rhyme, while [d]-[v] and [b]-[z], at least two features apart (place and manner), often do.

But such anomalies are not only found with respect to consonants. More relevant to my discussion, Zwicky adds that front lax vowels differing in height, [ɛ]

[28] Zwicky only refers to unary and binary features and does not refer to the distance between segments in the oral tract (labials are further away from velars than from alveolars) or acoustic measurements. The definitions of features are based on those in Chomsky and Halle (1968:302-329).

vs. [ɪ], rhyme better than front tense vowels differing in height, [e] vs. [i]. Some pairs only one feature apart hardly ever rhyme, while other which are several features apart rhyme quite well. So clearly, it is not merely feature counting we have here. Zwicky leaves to future study the questions of which features play a role in rhyming similarity and how they do so.

Taking this notion a step further, Steriade (2001a,b), in her discussion of place assimilation, argues that speakers select the targets for assimilation on the basis of a hierarchy of perceived similarity between input and output strings, rather than referring to or counting articulatory features. The target selected is the one most similar to the input, and this similarity is not determined according to articulatory features, but rather according to the P-map (§4.4). For example, given a string C_1C_2V, in which C_1 and C_2 differ in place, if place assimilation occurs, there are logically two possible outputs: (a) C_1 assimilates to C_2 (one feature change) ; or (b) C_2 assimilates to C_1 (one feature change). Both resulting sequences would be one feature apart from the original C_1C_2V, so by counting features, they should be equally similar to the input. However, place assimilation for major place features is typically regressive in languages (i.e. C_1 assimilates to C_2). This is because the predominant *acoustic* cues for place are better perceived pre-vocalically (i.e. for C_2) rather than preconsonantally (i.e. for C_1). Therefore, similarity is based on the acoustics, and is auditory in nature. Auditory similarity is based on the perception and confusability of phonological features. Steriade holds that similarity is determined by the P-map (§4.4), but the source of the similarity knowledge contained in the P-map is left open. All that matters for the P-map is that this knowledge exists in the minds of speakers.

Shinohara (2006), adopting Steriade's P-map, says that the construction of P-maps is on the basis of universal perceptibility scales defined via auditory perception and encoded into language-specific grammars, without going into the specifics of how this encoding takes place.

A different approach to determining similarity is presented in Best et al. (2001). Best's perceptual assimilation model (PAM) presents a non-scalar approach to the perception of and distinction among non-native (consonantal) contrasts with respect to their phonetic similarity to native segments based on native articulatory featural distinctions.[29] Simply put, adaptation patterns of sounds reflect their similarity to one another. These patterns can be divided into three primary types:

a. *Two Category (TC)*: The first type of assimilation pattern is termed two-category. L2 consonantal contrasts are adapted as two different categories in L1. For example, the Zulu voiceless lateral fricative [ɬ] adapts as the English voiceless post-alveolar fricative [ʃ], while the Zulu voiced lateral fricative [ɮ] adapts as the English voiced post-alveolar fricative [ʒ].

b. *Category Goodness (CG)*: The second type of assimilation pattern is termed category-goodness. L2 consonantal contrasts are adapted as a single category in L1, but one is deemed to be a better match than the other. For example, ejectives such as [k’] and aspirated stops such as [kʰ] are both adapted as English [k] (which might itself be aspirated). However, [kʰ] is deemed by English speakers to be a much better match to the English category than [k’].

c. *Single Category (SC)*: The third type of assimilation pattern is termed single-category. L2 consonantal contrasts are adapted as a single category in L1, and neither is deemed to be significantly "closer" to the L1 output. For example, implosives such as [ɓ] and regular pulmonic voiced stops such as [b] are both adapted as a single category in L1, and neither is deemed to be a better match (this according to Best et al. 2001).

The model predicts that TC are the least similar to one another while SC are the most similar to one another. It should be noted, however, that the experiment design in Best et al. (2001) does not distinguish between categorisation and

[29] Best et al. (2001) do admit that even non-contrastive phonetic detail is detected by speakers, but this is deemed irrelevant by them for their analysis.

discrimination, something which might weaken the conclusions one is able to draw from the data (see discussion in §6.2). Furthermore, the model does not attempt to explain why two non-native categories should follow a certain assimilation path (TC, CG or SC). It only states that the path they follow reflects their similarity to one another. They conclude by stating that although the model can evaluate segment similarity, the basis for predicting the most likely assimilations of non-native contrasts requires further examination.

Adhering to a feature-based approach, Frisch et al. (2004) suggest that the phonological similarity of consonants, such as in Arabic trilateral roots, can be expressed in the formula in which natural classes are defined on the basis or unary and binary features:

(24) *Frisch et al.'s phonological similarity formula*

$$\text{Similarity} = \frac{\text{number of shared natural classes}}{\text{number of shared natural classes} + \text{number of unshared natural classes}}$$

Following Frisch et al.'s model, Kawahara (2007), in his discussion of Japanese rap lyrics, states that consonant rhymability, based on similarity, directly correlates with the degree of similarity. Similarity is connected to the number of shared features. Unlike Frisch, however, Kawahara says that counting shared natural classes does not suffice and phonetic detail and the contexts in which consonants appear play a role in determining similarity. He suggests that psycho-acoustic similarity, along the lines of P-map, may be a better route to follow than featural similarity, but adds that this is beyond the scope of his paper.

Kenstowicz and Suchato (2006), following Kenstowicz (2001, 2004), demonstrate how formal feature structure and shared natural classes are insufficient to determine phonological similarity. Auditory similarity must be addressed. Kenstowicz (2007) postulates that a fixed UG ranking of identity constraints based on phonetic (acoustic) similarity accounts for segment quality in adaptation. However, Kenstowicz adds, although adaptation is based on some notion of auditory similarity (not native, but rather universal), further systematic study of this notion is required.

This is the point at which my study enters. In §5.1, I discuss the nature of similarity. Logically, similarity can either be partial identity or gradient identity. I explain in §5.2 why partial identity does not work. This follows Hyman (1970), Zwicky (1976), Steriade (2001a,b) and Kenstowicz (2007), not to mention countless others, who have long realised that feature counting simply does not suffice. I follow this in §5.3, suggesting that the notion of similarity is gradient. This is followed by a presentation of a formal model within the framework of OT for measuring similarity in §5.4. I conclude with a discussion in §5.5.

5.1. The nature of similarity

Similarity is a relative, rather than absolute, notion. Comparing X to Y and Z, it could be said that X is more similar to Y than X is to Z. X is never merely similar to Y. Rather, when one claims X is similar to Y, one is actually claiming that X is more similar to Y than other potential candidates. So, how does the speaker determine whether two entities, phonological or otherwise, are similar to one another, and can one decide *how* similar they are to one another, i.e. quantify similarity?

Regardless of the approach, one must first determine which properties are relevant for determining similarity. First, I present a non-linguistic example of similarity, demonstrating the subjectivity of similarity.

Given three objects, a white soccer ball, a yellow tennis ball and a white golf ball, one might say all three are similar in shape to one another (they are all spheres). However, the tennis ball and golf ball are more similar to one another in size (they are both "small") than they are to the soccer ball; the tennis ball and soccer ball are more similar to one another in hardness or texture than they are to the golf ball (the golf ball is "harder"); but the soccer ball and golf ball are more similar to one another in colour (both are white) than they are to the tennis ball.

So which of the three objects are more similar? That depends whether we are interested in their shape (they are equally similar to one another), their size (the tennis ball and golf ball are most similar), their texture (the soccer ball and tennis ball are more similar) or their colour (the soccer ball and golf ball are more similar).

The same would apply to linguistic similarity. For instance, are the two words [fæn] 'fan' and [lʌk] 'luck' phonologically similar to one another? Two answers are possible, each depending on the context in which the question is asked, i.e. depending on which criteria are relevant to similarity. If we are interested in prosodic structures, we could say both words consist of a CVC syllable and, therefore, are similar in this respect. If we are interested in segmental content, then the words are not similar to one another, as they do not share any segments. Either way, in order to determine whether the two words are similar, we first have to state which features we are evaluating. If we are evaluating syllabic structure, they are similar, but if we are evaluating segmental content, they are not similar. Of course, such questions become considerably more complicated when asked to determine whether the high front rounded vowel [y] is *more* similar to the high front unrounded vowel [i] than to the high back rounded vowel [u]. In the following §5.2 and §5.3, I discuss two possible approaches to this problem.

5.2. Similarity as partial identity

The first possible approach to the definition of similarity is defining similarity as partial identity. In other words, two things are similar to one another if some relevant features are identical. Note, if all relevant features were identical, then the two things would be identical, not similar. The term "features" does not necessarily refer to binary articulatory features, but rather to the broader notion of categories of comparison. Such similarity is *non-gradient* by nature as two entities either have the same feature or not.

Going back to the [y]/[i]/[u] example, let us assume similarity is determined by binary articulatory features. If the relevant feature is [round], then [y] is more similar to [u] than to [i]. If, however, the relevant feature is [back], then [y] is more similar to [i] than to [u].

Such feature-based approaches to similarity can be found in Best (2001), Frisch et al. (2004) and LaCharité and Paradis (2005), all discussed in the introduction to this chapter.

In LaCharité and Paradis' (2005) study of loanword adaptation, similarity, or in their terms, category proximity, is determined by the number of changes in terms of *structure* and *features* that an L2 phoneme must undergo to become a permissible L1 phoneme. Features, such as [high] and [ATR] are "counted" in order to determine proximity in the adaptation of English vowels into French. English /ʊ/ and /ɪ/ become French /u/ and /i/ respectively, rather than French /o/ and /e/, based on category proximity. Phonetic acoustic proximity, they claim, does not work and a 2-dimensional F1 and F2 chart would predict otherwise and is, therefore, a poor predictor of category proximity.

Indeed, a comparison of the F1 and F2 values for vowels does not seem to predict the categorisation patterns of vowels. However, it is not the values of F1 and F2 on which listeners rely for vowel categorisation (§3.2.2.2), but rather it is the *difference* between them (Ladefoged 1982:178-180, Most et al. 2000). Furthermore, at least in the case of American English vowels, F3-F2 distinguishes front from back vowels, and not F2 per se (Syrdal and Gopal 1986, Most et al. 2000). Specifically, the F3 of [ɪ] is shown to be extremely relevant for its categorisation by speakers (Cohen et al. in progress).

All this taken into account, the situation is still not as straightforward as is presented in LaCharité and Paradis (2005). It is not the distance in Hertz which determines the categorisation, but rather acoustic parameters (e.g. Barks), which are better predictors of perceived acoustic proximity (Traunmüller 1990, Kewley-Port 2001, §3.2.2.5 in this study). If the data in LaCharité and Paradis (2005) are reevaluated according to the F2-F1 difference in Barks, then the results are not as they claim, as can be seen in the following table (25). In the table, English /ʊ/ is acoustically closer to French /u/ than it is to French /o/ (observe the F2-F1 in Barks), contrary LaCharité and Paradis's (2005) claim, which is based on formants rather than acoustic parameters. English /ɪ/ is indeed closer to French /e/ than to French /i/, in accordance with LaCharité and Paradis (2005). However, this is *without* taking F3 into account (LaCharité and Paradis give no data for F3) and as mentioned above, F3 is critical in the categorisation of English /ɪ/ (Cohen et al. in progress). In the following table (25), the F1 and F2 data were taken as is from LaCharité and Paradis (2005). I carried out the Bark calculations based on Traunmüller (1990).

(25) *Vowel proximity for English and French vowels*

Vowel	F1	F1 (Bark)	F2	F2 (Bark)	F2-F1	F2-F1 (Bark)
English /ɪ/	375	4.304	1700	12.448	1325	10.810
French /i/	275	3.298	2400	14.752	2125	13.941
French /e/	400	4.542	2200	14.173	1800	12.830
English /ʊ/	425	4.776	1300	10.687	875	8.272
French /u/	275	3.298	775	7.594	500	5.447
French /o/	400	4.542	800	7.768	400	4.542

In addition, LaCharité and Paradis (2005) exclude orthography as a means for deciding among the various vowel choices. The vast majority of the examples presented for [ʊ] are orthographically <oo>. For [ɪ], examples such as <building>,

<busy> and <business> are presented. However, written sequences can follow a rule-based adaptation, for example <ui>→[i], <oo>→[u] and never [o] (See also §2.2.1.1. and §7.1.4.).[30]

Besides the difficulty in determining which features are relevant, something necessary for any model of similarity, approaching the issue of similarity as partial identity has two major shortcomings.

First, what if both features, [round] and [back], in the example [y]/[i]/[u] are relevant in the evaluation of vowel similarity? In other words, how can one compare two inherently different features? This problem could be solved by a hierarchical organisation of relevant features (e.g. [round]>>[back]) or by weighting the influence of each of the two features.

Additional evidence for the problematicity of the feature based approach is presented in Kenstowicz (2001), who shows with respect to the features [nasal] and [voice], that binary feature-based phonological models cannot adequately account for asymmetries in loanword data. For example, in Fon, CV sequences have to agree in nasality (i.e. [mĩ] and [bi] are possible, [mi] and [bĩ] are not). Fon adapts sequences such as [mi] in loanwords as [mĩ] rather than [bi], even though both would entail a single alteration of the binary feature [nasal]. Possibly, nasalised vowels are closer in phonetic space to oral vowels than nasal consonants are to oral consonants. However, phonetic space cannot be "measured" using a binary distinction.

Second, what if no two features are identical? It is *this* problem which logically eliminates partial identity as a viable approach to similarity. If no features are identical, does that mean that the two entities are not similar? For example, assuming manner of articulation is the relevant feature, is the affricate [t͡s] more similar to the stop [t] than to the fricative [s]? English speakers adapt Hebrew word-initial [t͡s] as [t] (e.g. Hebrew [t͡si.ˈpoʁ] 'bird' is pronounced as [tipɔɹ] by English

[30] As pointed out by a reviewer, the rules may be more complex. <ui> has quite a few realisations in English (e.g. [wɪ] 'quick', [waɪ] 'equine', [ɪ] 'building' and more). The point made here, though, is that written sequences' adaptation could still be rule-based, however complex the rule may be.

speakers), as word-initial [t͡s] is impossible in English.[31] Assuming speakers find [t͡s] to be more similar to [t] than to [s], and adaptation is based on this similarity, the only possible solution here would be to say that [t͡s]'s manner of articulation (affricate) is *closer* to [t]'s manner (stop) than to [s]'s manner (fricative).

Another example from Zwicky (1976) is the rhyming patterns of nasals. The bilabial nasal [m] is judged to be more similar to the alveolar nasal [n] than to the velar nasal [ŋ]. However, if we refer to the relevant feature (place), all three are different from one another to exactly the same extent (a single place feature).

Proximity (distance or closeness) is not identity. Furthermore, how does one measure the closeness of two different manners of articulation or two different places of articulation? It is precisely these types of example which show similarity is gradient rather than partial identity.

5.3. Similarity as gradient identity

Like the first approach, determining which features are relevant for defining similarity is a prerequisite. In fact, whatever one's approach to similarity is, determining the relevant features and their interaction is necessary. But even if we decide on the exact properties we are interested in, there is still the question of *how* one measures each individual property (recall the soccer ball, tennis ball and golf ball from in §5.1). Unlike the approach in the previous section, I suggest that features evaluating similarity are *gradient* rather than being defined in absolute terms.

To determine similarity, one must first decide what the relevant features are, and determine the scale on which they are quantified. Second, a model measuring the distances, and comparing the distances, must be constructed. Features could be weighted or organised hierarchically, but there is no need for an identity requirement between features. For example, given a single relevant feature *f* and three entities X, Y

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[31] There is some conflicting evidence here as [t͡su.ˈna.mi] is pronounced as [su.ˈnʌ.mi], [tsu.ˈnʌ.mi] or [tə.su.ˈnʌ.mi] in English, but this is largely irrelevant with respect to the point I am making here.

and Z: X is more similar to Y than X is to Z if the distance between the value of f(X) and f(Y) on the relevant scale is smaller than the distance between the values of f(X) and f(Z) on the same scale. If more than one relevant feature is involved, then the weighting of the features in some sort of featural hierarchy is necessary to determine similarity.

In the following §5.4, I present my formal model of similarity which answers the two key questions raised here:

(a) What are the relevant features for the evaluation of segmental (primarily vowel) similarity?

(b) How is the degree of similarity between two entities evaluated, preferably quantified?

5.4. A formal model of similarity

5.4.1. Basic assumptions

Following Hyman (1970), Zwicky (1976), Steriade (2001a,b) and Kenstowicz (2007), I assume that speakers determine segmental similarity on the basis of perception, rather than articulatory feature counting or calculations based on the number of articulatory features (Frisch et al. 2004). After all, it is the auditory signal one is exposed to, and whatever the mental process may be, the only input one has is auditory. When categorising sounds (in my case, vowels), listeners compare incoming auditory tokens to the values they are most used to, i.e. means of vowels in their language (Cohen to appear, Cohen et al. in progress). The speaker attends to the essential acoustic correlates which distinguish among categories in the language. This is no different from the P-map approach in Steriade (2001a,b) discussed in §4.4. Similarity judgements are, inter alia, dependent on the essential acoustic correlates distinguishing categories in a language, and it is precisely these correlates speakers must attend to.

This approach is supported by the psycholinguistic model based on experimental evidence in Peperkamp et al. (2008), suggesting that non-native sounds and sound structures are mapped onto the phonetically closest native ones, without specifying how closeness is defined. In addition, as shown in the introduction to §5, feature counting in order to determine closeness simply does not work. See also Kenstowicz (2001) for further evidence regarding a feature-counting based approach, in his case with respect to V-C asymmetry with the feature [nasal] (also discussed here in §5.2).

In my analyses, I refer to vowel categories. However, the same model is applicable to consonant categories (or any other acoustic categories), where different and additional features may be relevant.

The comparison speakers make is not based on articulatory features of any sort (see introduction to §5), but rather, it is based on acoustic qualities. Since I assume comparisons are auditory, I instantiate these comparisons in auditory terms, i.e. *just noticeable differences* or *jnd*s (§4.3). First suggested by Ernst Weber in 1834, the *jnd* (or "difference threshold") is the minimum amount by which stimulus intensity must be changed in order to produce a noticeable variation in sensory experience.

When comparing speech sounds, vowels in particular, the physical qualities we attend to are the formants. Of course, we attend to other acoustic qualities too (e.g. length), but for simplicity's sake, I refer here only to the formants. The *jnd* for vowel formants is 0.3 Bark (Kewley-Port 2001). All the physical characteristics of an incoming auditory signal (e.g. F1, F2, F3, length, intensity) can potentially be evaluated in terms of *jnd*s. I limit my discussion to F1 and F2 in the model presented here, as these are usually deemed to be sufficient in vowel categorisation in Hebrew (Most et al. 2000).

Note, however, that although F1 and F2 are both measured in Hertz, it has been found that people pay less attention to F2 than to F1, probably because F1 is more audible than F2 in background noise (it has a higher peak). Therefore, factoring in the difference between F1 and F2 would create a more accurate model, better matching the facts. This could be done by saying, for example, that the *jnd* for F1 is 0.6 Bark, while the *jnd* for F2 is 1.5 Bark (cf. the modelling by ten Bosch 1991). Indeed, Holt and Lotto (2006) address the necessity for weighting phonetic cues with respect to similarity judgements in second language acquisition.

There is no doubt that adding cues, such as F3 and length, and weighting cues (e.g. F1>>F2) would increase the model's accuracy. Of course, attending to the F2-F1 difference and to the F3-F2 difference would also increase the model's predictive powers (§3.2.2.3). However, for simplicity's sake, I only refer to F1 and F2 here, and weight the two formants equally.

5.4.2. Perception-based constraints

The constraints on sound categorisation are specified in terms of relative *jnd* distances. Perceptibility scales are universal (Shinohara 2006) and, therefore, *jnd*s are universal measures. However, auditory perception alone does not determine phonological patterns. Instead, the universal perceptibility scales map into language specific patterns. Therefore, the constraints crucially depend on language-specific distances, as they refer to the distributions of a specific language.

In order to calculate the relative *jnd* distances, I have chosen arbitrary reference points ensuring that all values along the *jnd* scale are positive. Negative values would not affect the model or its predictions. They would just make comparisons more difficult to instantiate.

For F1, I set 0 *jnd*s at 282Hz, two standard deviations below the mean F1 of Hebrew /i/, the vowel with the lowest F1 in Hebrew. For F2, I set 0 *jnd*s at 734Hz, two standard deviations below the mean F2 of Hebrew /o/, the vowel with the lowest F2 in Hebrew.

The following table (26) presents the mean formant frequencies and respective *jnd*s of Hebrew vowels (standard deviations appear in brackets):

(26) *Hebrew mean formant frequencies (Most et al. 2000) in jnds*

Vowel Category	Mean F1		Mean F2	
	Hz	*jnd*	Hz	*jnd*
/i/	342 (30)	2.04	2068 (142)	21.53
/e/	455 (40)	5.60	1662 (171)	16.66
/a/	626 (48)	10.39	1182 (90)	9.27
/o/	478 (46)	6.28	944 (105)	4.70
/u/	359 (31)	2.59	979 (91)	5.42

The constraints are formulated on the basis of the values in the above table. The constraint hierarchy is determined according to the size of the Δ*jnd* between the incoming formant frequency's *jnd* and the *jnd* of the formant frequency of the vowel's mean formant value. The bigger the Δ*jnd* is, the bigger the difference between the two vowels is. The more different (i.e. less similar) a native category is from an incoming vowel, the less likely that category will be chosen to adapt the incoming vowel. A sample constraint formulation is presented in the following §5.4.3.

5.4.3. Sample constraint formulation

In this section, I outline the various stages in the formulation of constraints. Since the constraints are formulated on the basis of the distances between incoming tokens and mean formant values, each incoming L2 token has a different set of constraints. The model assumes that all constraints are present at all times, but in any given acoustic event, only a small set of constraints actually have an effect.

All values for American English (henceforth: AE) vowels are taken from Hillenbrand et al. (1995). All values for Southern Standard British English (henceforth: SSBE) are taken from Deterding (1997).

Let's assume an input of AE[i]: F1=342Hz, *jnd*(F1)=2.04; F2=2322Hz, *jnd*(F2)=24.11. This input is evaluated with respect to each Hebrew vowel. For example, it is evaluated with respect to Hebrew [o]: F1=478Hz, *jnd*(F1)=6.28; F2=944Hz, *jnd*(F2)=4.70. Comparing AE[i] to Hebrew [o] yields Δ*jnd*(F1)=4.24 and Δ*jnd*(F2)=19.41. The constraints are stated negatively, and thus both Δ*jnd*(F1)≠4.24 and Δ*jnd*(F2)≠19.41 get a violation mark for the candidate [o] as the input of AE[i]. Given the 5 vowels in Hebrew, we get 10 such constraints (2 for each Hebrew vowel).

5.4.4. Constraint ranking

Constraints are ranked according to their *jnd* distances (Δ*jnd*), where the highest ranked constraint has the largest Δ*jnd*. The larger the distance is, the worse the match is between the incoming token and the category it is being compared to. For example, given AE[i] with a *jnd*(F1)=2.04 and the ranking ΔF1≠8.36(*/a/)>>ΔF1≠4.24(*/o/), the F1 of AE[i] is perceived to be more similar to the F1 of Hebrew /o/ than to that of Hebrew /a/, since the constraint ruling out /a/ is ranked higher due to the higher value of Δ*jnd*. Similarly, given AE[i] with a *jnd*(F2)=24.11 and the ranking ΔF2≠19.41(*/o/)>>ΔF2≠14.84(*/a/), the F2 of AE[i] is perceived to be more similar to the F2 of Hebrew /a/ than to that of Hebrew /o/. Each evaluation is determined by 10 constraints (5 vowels X 2 formants each).[32] The constraints for F1 and F2 are defined on the same scale (*jnd*s). Therefore, the apparently different features can, in fact, be evaluated with respect to one another. The ranking simply follows from the relative *jnd* values for each constraint.

Generally speaking, constraints can have a fixed ranking, which would yield the same output in every evaluation, or a stochastic (probabilistic) ranking, which has noisy evaluation and results in variable outputs, which can be expressed in percentages (§4.1 and §4.2).

[32] As mentioned, there are actually many more constraints (for F3, length etc.). I will stick to these 10.

5.4.5. Determining similarity: Fixed vs. stochastic constraint ranking

The universal (i.e. not language-specific warped) part of the perception of auditory events (both native and non-native) is measurable and quantifiable. Obviously, different distributions between dialects of a language (e.g. SSBE vs. AE) will necessarily lead to differences in similarity judgements in both fixed and stochastic grammars, as was proposed and demonstrated in Escudero and Boersma (2003, 2004).

I assume the correct model is stochastic in nature, an assumption supported by loanword data and experiments alike. Since the stochastic model is based on the fixed-ranking (non-stochastic) model, the latter is presented here alongside the predictions from a StOT model. In addition, the actual corpus data (see §6.1) and experiment results (see §6.2) which support the model are presented too.

5.4.5.1 Fixed constraint ranking model of similarity

In this section, I present the predictions made by a fixed ranking of constraints for the SSBE and AE vowel [æ]. A more detailed presentation appears in §7.1.1. The vowel [æ] is of particular interest, since it shows variable adaptation patterns in the corpus (49%=a ; 49%=e) and because AE and SSBE varieties of this vowel are perceived very differently by Hebrew speakers as shown in the categorisation experiment in §6.2.2. The categorisation results in table (49) in §6.2.2 show that AE[æ] is perceived to be more similar to /e/ in 99.3% (278/280) of the cases, whereas SSBE[æ] is perceived to be more similar to /a/ in 79.5% (219/280) of the cases and to /e/ in just 18% (52/219) of the cases.

For convenience, I repeat here the *jnd* values of the Hebrew vowels (§5.4.2) and the calculation of the Δ*jnd* for AE[æ] and SSBE[æ]:

(27) *Δjnd calculations for AE[æ](jnd F1=9.38 ; jnd F2=20.24) and SSBE[æ](jnd F1=12.03 ; jnd F2=15.21) with respect to the five Hebrew vowels*

	jnd F1 Hebrew	Δ*jnd* F1 AE[æ]	Δ*jnd* F1 SSBE[æ]	*jnd* F2 Hebrew	Δ*jnd* F2 AE[æ]	Δ*jnd* F2 SSBE[æ]
/i/	2.04	7.35	9.99	21.53	1.29	6.42
/e/	5.60	3.79	6.43	16.66	3.59	1.54
/a/	10.39	1.01	1.64	9.27	10.97	5.85
/o/	6.28	3.10	5.75	4.70	15.54	10.41
/u/	2.59	6.79	9.43	5.42	14.82	9.70

The constraints are then formulated (§5.4.3) and ranked (§5.4.4) according to their relative Δ*jnd* values. In the following two tableaux (28) and (29), I present OT evaluations of AE[æ] and SSBE[æ] according to the constraints:

(28) *Evaluation of AE [æ] by Hebrew speakers – fixed constraint ranking*

AE[æ]	**ΔF2≠ 15.54 */o/**	**ΔF2≠ 14.82 */u/**	**ΔF2≠ 10.97 */a/**	**ΔF1≠ 7.35 */i/**	**ΔF1≠ 6.79 */u/**	**ΔF1≠ 3.79 */e/**	**ΔF2≠ 3.59 */e/**	**ΔF1≠ 3.10 */o/**	**ΔF2≠ 1.29 */i/**	**ΔF1≠ 1.01 */a/**
/i/				***!**					*****	
☞/e/						*****	*****			
/a/			***!**							*****
/o/	***!**							*****		
/u/		***!**			*****					

(29) *Evaluation of SSBE [æ] by Hebrew speakers – fixed constraint ranking*

SSBE[æ]	ΔF2≠ 10.41 */o/	ΔF1≠ 9.99 */i/	ΔF2≠ 9.70 */u/	ΔF1≠ 9.43 */u/	ΔF1≠ 6.43 */e/	ΔF2≠ 6.42 */i/	ΔF2≠ 5.85 */a/	ΔF1≠ 5.75 */o/	ΔF1≠ 1.64 */a/	ΔF2≠ 1.54 */e/
/i/		*!				*				
/e/					*!					*
☞/a/							*		*	
/o/	*!							*		
/u/			*!	*						

In tableau (28), the evaluation of AE[æ], the worst possible match is the F2 of Hebrew /o/, as this has the greatest Δ*jnd*. Therefore, /o/ is eliminated as a viable candidate, followed by /u/ (next worst match, also by virtue of its F2), then /a/ (F2) and finally /i/ (F1). Note, the F2 and F1 constraints are ranked strictly according to their Δ*jnd*s. This leaves a single possible candidate /e/.

In tableau (29), the evaluation of SSBE[æ], the predictions are different. The first candidate eliminated is /o/ (F2), followed by /i/ (F1), /u/ (F2) and /e/ (F1) respectively, which leaves /a/ as the best candidate. Note, although the best match for SSBE[æ] is the F2 of Hebrew /e/ (the lowest Δ*jnd*), the candidate /e/ is eliminated much earlier because of its F1.

As can be seen in the above tableaux, the two vowels are predicted to be perceived differently, as they have different *jnd* values: AE[æ] is perceived to be most similar to /e/ and SSBE[æ] is perceived to be most similar to /a/.

However, the fixed ranking cannot account for the variability in the perception of vowels, variability which is supported by all corpus and experimental data. Such variability, however, can be captured by a stochastic model.

5.4.5.2. Stochastic constraint ranking model of similarity

Stochastically ranked constraints paint a different picture (see §4.2). Assuming the same vowel tokens as in §5.4.5.1, the variability surfaces here. A more detailed presentation of the predictions made by stochastic rankings appears in §7.1.1. For each incoming token (=English vowel), the distribution of possible outputs (=Hebrew vowels) was computer-generated from 100,000 tokens of each auditory input to a perception grammar with the constraints being distance-based and the constraint rankings being based on the native Hebrew L1 tokens. The evaluation noise was set to 2.0, similarly to Boersma (1998) and in subsequent studies (Escudero and Boersma 2003, Escudero and Boersma 2004, Boersma and Escudero 2004). The outputs of the stochastic perception grammar were then compared to the corpus data (§6.1) and experimental data (§6.2).

The following tables (30) and (31) present the predictions for AE[æ] and SSBE[æ] alongside the corpus and experimental data. The outputs are presented as percentages. For example, for AE[æ], the optimal candidate is Hebrew /i/ 16.7% of the time, Hebrew /e/ 82.8% of the time, and Hebrew /a/ 0.5% of the time. Hebrew /o/ and /u/ are never selected as the optimal candidates (the darker the shading, the less likely the candidate).

(30) *AE[æ] evaluation by Hebrew speaker – stochastic constraint ranking*

AE[æ]	Hebrew Model					Categorisation Experiment	Corpus	Discrimination Experiment
	/i/ 16.7%	/e/ 82.8%	/a/ 0.5%	/o/ 0.0%	/u/ 0.0%	/e/ 99% /a/ 0.5% /i/ 0.5%	/e/ 49% /a/ 49%	[ɛ] vs. [æ] 90%

(31) *SSBE[æ] evaluation by Hebrew speaker – stochastic constraint ranking*

SSBE[æ]	Hebrew Model					Categorisation Experiment	Corpus	Discrimination Experiment
	/i/ 1.5%	/e/ 40.6%	/a/ 56.2%	/o/ 1.2%	/u/ 0.5%	/a/ 79.5% /e/ 18% /o/ 2.5%	/a/ 49% /e/ 49%	[ɛ] vs. [æ] 90%

As (30) and (31) show, the perception of AE[æ] and SSBE[æ] is predicted by the StOT model to differ. AE[æ] is predicted to be most similar to /e/, but more similar to /i/ than to the other three vowels. SSBE[æ] is predicted to be most similar to /a/, but almost as similar to /e/ as it is to /a/, with the other three vowels trailing way behind.

Unlike the fixed ranking's prediction, the StOT model's predictions reflect the categorisation and corpus data to a much greater degree. Whereas fixed ranking dictates a single output for each event, stochastic ranking captures the variability found in the speakers' grammar. This is evident in both the discrimination and the categorisation experiments. In corpora, there is a much greater degree of regularity than that which a stochastic model would predict. For example, AE[æ] is predicted to be most similar to Hebrew /i/ in 16.7% of the cases, whereas in actual fact, it is never adapted as /i/. This is due primarily to the influence of non-phonological effects (e.g. orthography, convention). I discuss this in §7.

5.5. Discussion

Segmental similarity is gradient and essentially based on audition and perception. It is not absolute values or binary articulatory features one attends to when determining the degree of similarity, but rather gradient auditory values. When categorising and comparing incoming signals, speakers refer to categories they are most used to. In the case of vowels, these categories are the means of the vowels in their language.

Although audition and categorisation are universal, the base of categorisation is language-specific.

Since segment comparisons are based on audition, I instantiate them in auditory terms. Additional phonetic cues are necessary for consonants, but the basic idea remains that all things sensory (and, of course, auditory) can by translated into *jnd*s which would then allow their comparison. Different features can easily be compared to one another on the basis of their *jnd* values. If a feature is deemed to be more influential in similarity comparisons, phonological features can be weighted accordingly by increasing the relevant weight of their respective *jnd* values. The relevant features, translated into constraints, can easily be mapped into a formal OT phonological model. This does not contrast the Steriade's (2001a,b) P-map model (§4.4). On the contrary. This model completes the notion of P-map by determining how similarity is quantified and evaluated. The evaluations could then be applied with a P-map model of perception.

Chapter 6. Data sources

Loanword adaptation is, to a certain extent, a reflection of the speakers' perception and production grammars. These are captured in the theoretical model of similarity I propose in §5. In order to validate the model's predictions, it is necessary to examine data in light of this model.

In this chapter, I present the three empirical sources of data I used in order to construct the model and test its predictions: (a) a loanword corpus (§6.1); (b) a discrimination experiment (§6.2.1); and (c) a categorisation experiment (§6.2.2).

For now, I set aside the theoretical issues and focus on the facts as they emerge from the various data sources. I discuss the connection between the data and the theoretical model in §7.

6.1. Loanword corpus

Subject to my definition of loanwords (§2.1) as lexical items originating in L2 and used in L1 conversation in order to fill some semantic void, I constructed a corpus of 1383 words. I discuss the vowels in the L2 inputs and the possible Hebrew outputs in §6.1.1. This is followed by a discussion of the corpus' organisation in §6.1.2. I present the criteria used for the selection of the words in §6.1.3, and the various sources of the data in §6.1.4. Finally, in §6.1.5, I present quantitative analyses of the corpus.

6.1.1. Vowels in the corpus

There are several dialects of English, and vowel quality in the different dialects may vary. Even the two dialects on which I focus in this study, Southern Standard British English (Deterding 1997) and a Michigan dialect of American English (Hillenbrand et al. 1995) display variability to a certain degree. For example, although 'cat' is transcribed in both dialects as [kæt], the vowel quality (not to mention the consonant quality) is noticeably different. The SSBE [æ] is lower and further back than the AE[æ]. To maintain uniformity, the data in the corpus were transcribed according to http://dictionary.reference.com, although the same symbols used in different dialects may represent different vowel qualities.

The five Hebrew vowels, /a, e, i, o, u/ and the diphthongs containing them have 20 possible sources in the corpus: (a) 12 monophthongs; (b) 6 diphthongs; (c) syllabic consonants; and (d) clusters considered illicit in Hebrew.

There are 12 different monophthongs in the corpus. Granted, there are others in different dialects of English, but these 12 were the ones found in this particular corpus. The quality of the monophthongs varies from dialect to dialect, but I have used standard transcription methods and not referred to formant variation. I do not attend to allophonic variations, though I do address phonemic variability where present (§6.1.2.2). Examples of the monophthongs and their Hebrew adaptations appear in the following table (32):

(32) *English monophthongs in the corpus*[33]

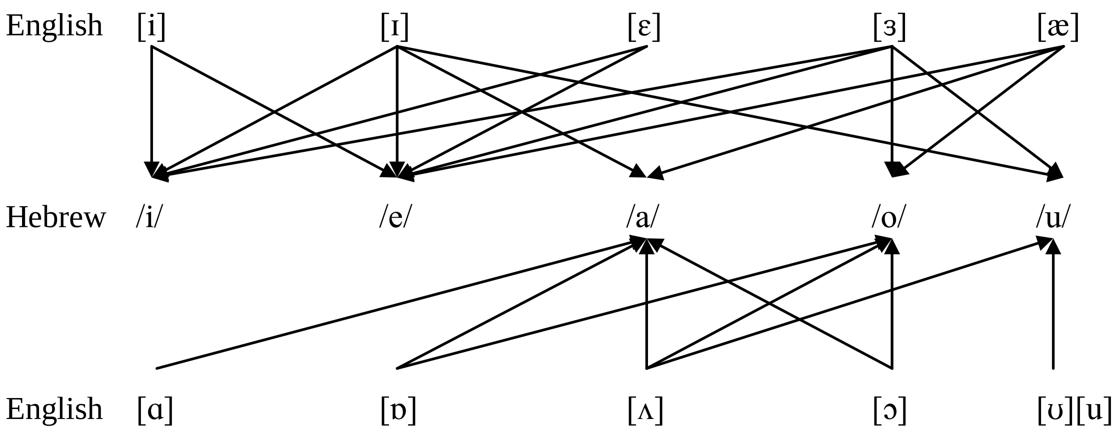
	English vowel	English (L2)	Hebrew (L1)	Hebrew vowel	
a.	**[i]**	[ˈm**i**d.jəm ʃɔt]	[ˈm**e**d.jum ʃot]	[e]	'medium shot'
	[i]	[h**i**p]	[h**i**p]	[i]	'heap'
b.	**[ɪ]**	[ˈɔ.ɹ**ɪ**nd͡ʒ]	[ˈo.ʁ**a**nd͡ʒ]	[a]	'Orange'
	[ɪ]	[ˈ**ɪ**.m**ɪ**d͡ʒ]	[ˈ**i**.m**e**d͡ʒ]	[i]	'image'
				[e]	
	[ɪ]	[l**ɪ**ɫ]	[l**u**l]	[u]	'Lil(lian)'
	[ɪ]	[ˈtɛm.pl**ɪ**t]	[ˈtem.pl**ei**t][34]	[ei]	'template'
c.	**[ɛ]**	[n**ɛ**t]	[n**e**t]	[e]	'net'
	[ɛ]	[ɪn.ˈt**ɛ**.lɪ.d͡ʒənt]	[in.t**i**.li.ˈgent]	[i]	'intelligent'
d.	**[ɜ]**	[ˈk**ɜ**ɹ.səɹ]	[ˈk**e**ʁ.seʁ]	[e]	'cursor'

[33] If words have variant English or Hebrew pronunciation, only one is given here.
[34] It is more likely that this pronunciation is orthography related or derived from the less common English pronunciation [ˈtɛm.pleɪt]

	English vowel	English (L2)	Hebrew (L1)	Hebrew vowel	
	[ɜ]	[fl**ɜ**ɹt]	[fl**i**ʁt]	[i]	'flirt'
	[ɜ]	[ˈnɛt.w**ɜ**ɹk]	[ˈnet.w**o**ʁk]	[o]	'network'
	[ɜ]	[ˈd͡ʒ**ɜ**ɹ.nl̩]	[ˈd͡ʒ**u**ʁ.nal]	[u]	'journal'
e.	**[æ]**	[ʃ**æ**k]	[ʃ**a**k]	[a]	'Shack (Shaquille)'
	[æ]	[k**æ**ʃ]	[k**e**ʃ]	[e]	'cache'
	[æ]	[k**æ**.ˈfin]	[k**o**.fa.ˈin]	[o]	'caffeine'
f.	**[ɑ]**	[b**ɑ**ɹz]	[b**a**ʁz]	[a]	'bars'
g.	**[ɒ]**	[ˈb**ɒ**.di ˈbɪl.dəɹ]	[ˈb**a**.di ˈbil.deʁ]	[a]	'body builder'
	[ɒ]	[ˈb**ɒ**.di]	[ˈb**o**.di]	[o]	'body (of car)'
h.	**[ʌ]**	[kl**ʌ**t͡ʃ]	[kl**a**t͡ʃ]	[a]	'clutch'
	[ʌ]	[fɹ**ʌ**nt]	[fʁ**o**nt]	[o]	'front'
	[ʌ]	[ˈmɪ.ni.b**ʌ**s]	[ˈmi.ni.b**u**s]	[u]	'minibus'
i.	**[ɔ]**	[ˈw**ɔ**.ʃɪŋ.tn̩]	[ˈw**a**.ʃiŋg.ton]	[a]	'Washington'
	[ɔ]	[l**ɔ**ŋ]	[l**o**ng]	[o]	'long'
j.	**[ʊ]**	[ˈɪn.p**ʊ**t]	[ˈin.p**u**t]	[u]	'input'
k.	**[u]**	[b**u**m]	[b**u**m]	[u]	'boom'
l.	**[ə]**	[ˈɛ.v**ə**n]	[ˈɛ.v**a**n]	[a]	'Evan'
	[ə]	[ˈæk.ʃ**ə**n]	[ˈek.ʃ**e**n]	[e]	'action'
	[ə]	[ˈkɛ.v**ə**n]	[ˈke.v**i**n]	[i]	'Kevin'
	[ə]	[ˈfɔɹ.w**ə**ɹd]	[ˈfoʁ.w**o**ʁd]	[o]	'forward'
	[ə]	[ˈkæŋ.g**ə**.ɹu]	[ˈken.g**u**.ʁu]	[u]	'kangaroo'

The following diagram (33) represents the adaptation patterns of English inputs:

(33) *English monophthong adaptation patterns*



Except for [u]/[ʊ], which are consistently adapted as Hebrew /u/, and [ɑ], which is consistently adapted as [a], all English vowels have variable adaptation patterns. I address this apparent inconsistency in §7.4.1. Note, [ə] can be adapted into any one of the five vowel categories in Hebrew.

In addition to the 12 monophthongs, there were 6 different diphthongs in the corpus. Examples of these and their Hebrew adaptations appear in the following table (34):

(34) *English diphthongs in the corpus*

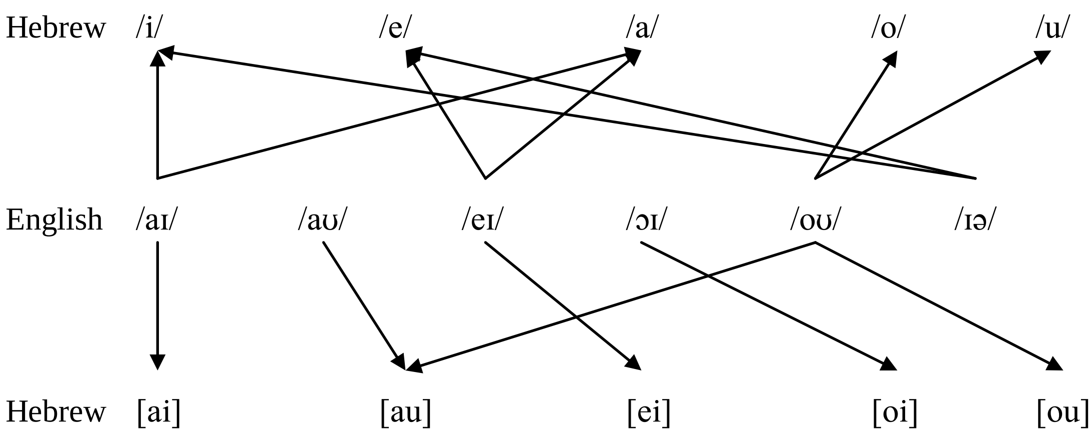
	English vowel	English (L2)	Hebrew (L1)	Hebrew vowel	
a.	**[aɪ]**	[ˈ**taɪ**.əɹ]	[ˈ**ta**.jeʁ]	[a]	'tire'[35]
	[aɪ]	[ˈd**aɪ**.ə.lɔg]	[d**i**.a.ˈlog]	[i]	'dialogue'
	[aɪ]	[ˈ**aɪ**.dl̩]	[ˈ**ai**.del]	[ai]	'(American) Idol'
b.	**[aʊ]**	[h**aʊ**s]	[h**au**s]	[au]	'house'
c.	**[eɪ]**	[ˈk**eɪ**.ɒs]	[ˈk**a**.os]	[a]	'chaos'
	[eɪ]	[bɹ**eɪ**ks]	[ˈbʁ**e**k.sim]	[e]	'brakes'
	[eɪ]	[b**eɪ**s dɹʌm]	[b**ei**s dʁam]	[ei]	'base drum'

[35] While the English vowel is ordinarily analysed as a diphthong or triphthong, Hebrew has two separate syllables here.

	English vowel	English (L2)	Hebrew (L1)	Hebrew vowel	
d.	**[ɔɪ]**	[d͡ʒ**ɔɪ**nt]	[d͡ʒ**oi**nt]	[oi]	'joint'
e.	**[oʊ]**	[l**oʊ** p**oʊ**st]	[l**ou** p**o**st]	[ou]	'low post'
				[o]	
	[oʊ]	[ˈt**oʊ**.nəɹ]	[ˈt**u**.neʁ]	[u]	'toner (ink)'
	[oʊ]	[ˈb**oʊ**.lɪŋ]	[ˈb**au**.liŋg]	[au]	'bowling'
f.	**[ɪə]**	[g**ɪə**ɹ]	[g**i**ʁ]	[i]	'gear'
	[ɪə]	[ˈst**ɪə**.ɹɔɪd]	[st**e**.ʁo.ˈid]	[e]	'steroid'

The following diagram (35) represents the adaptation patterns of English inputs:

(35) *English diphthong adaptation patterns*



Except for [aʊ] and [ɔɪ], English diphthongs have variable adaptations. Diphthongs are often simplified. The only diphthongs in native Hebrew words are [ai] and, arguably, [au] (see §3.2 for more on vowels in Hebrew). However, others have been incorporated due to borrowing in recent years.

English has sonorant-sonorant clusters and syllabic consonants which are impermissible in Hebrew (§3.3.1). Both of these trigger epenthesis in Hebrew. Examples of these clusters and syllabic consonants along with the Hebrew epenthesis appear in the following table (36):

(36) *Sonorant-sonorant clusters and syllabic consonants in the corpus*

	English input	English (L2)	Hebrew (L1)	Hebrew vowel	
a.	**none**	[ɜɹ_ɫ gɹeɪ]	[ˈe.ʁ**e**l gʁei]	[e]	'Earl Grey'
	none	[fɪɫ_m]	[ˈfi.l**i**m]	[i]	'film'
b.	**C̩**	[ˈd͡ʒɜɹ.n**l̩**]	[ˈd͡ʒuʁ.n**a**l]	[a]	'journal'
	C̩	[ˈaɪ.d**l̩**]	[ˈai.d**e**l]	[e]	'(American) Idol'
	C̩	[ˈd͡ʒɔɹ.d**n̩**]	[ˈd͡ʒoʁ.d**o**n]	[o]	'(Michael) Jordan'

Syllabic consonants and illicit clusters always trigger epenthesis. The quality of the epenthetic vowel varies. I address this in §7.1.

6.1.2. Corpus organisation

The words in the corpus are organised according to their English segmental content, the Hebrew adaptations, and the types of changes in the adaptation process. Examples of the various possible segmental contents appear in the previous subsection. In this subsection, I present some examples of the other organizational criteria applied.

6.1.2.1. Stress

In the corpus, Hebrew and English stress patterns almost always match one another. I discuss stress adaptation extensively in §7.2.2. In only 1.8% (25/1383) of the cases does stress shift occur. Almost all of the mismatches are the result of one of two factors:

(a) Variable stress patterns in English. In such cases, Hebrew matches one of the English patterns, but not the other, as in the English [ˈ**kæŋ**.ɡə.ɹu / kæŋ.ɡə.ˈ**ɹu**] 'kangaroo' adapted as Hebrew [ˈ**keŋ**.ɡu.ʁu].

(b) The influence of other languages (henceforth: L3). The Hebrew segmental content may follow English, but the stress pattern may follow L3, as in the English [ˈ**dɪs**.təns] 'distance' adapted as Hebrew [dis.ˈ**tans**], possibly influenced by L3-French ([ˈ**dis**.tans] is also attested in Hebrew).[36]

There are some cases, however, for which I have not been able to determine the source of the stress shift. It is possible an L3 has influenced the adaptation, but since the words were clearly borrowed from English, I have not been able to determine this with certainty. Another possibility is that the words were borrowed without phonetic input (i.e. via orthography). In this case, the borrower may simply be "guessing" where the stress might be and/or applying some default stress rule (§3.3.2 and Fainleib 2008). Either way, the source of the stress shift for the words in the following table (37) is open to speculation:

[36] Hebrew military terminology is largely borrowed from English for historical reasons. The word 'distance' as used in Hebrew is originally a military word describing a commander-soldier relationship.

(37): *Inexplicable stress shifts in the corpus*

	English (L2)	Hebrew (L1)	
a.	[ˈ**pæm**.flɪt]	[pam.ˈ**plet**]	'pamphlet'
b.	[tɹə.ˈ**fæl**.gəɹ]	[tʁa.fal.ˈ**gaʁ**]	'Trafalgar'[37]
c.	[ˈ**mɑɹʃ**.mɛ.loʊ]	[maʁʃ.ˈ**me**.low]/[ˈ**maʁʃ**.me.low]	'marshmallow'[38]
d.	[gɹə.ˈ**fi**.ti]	[ˈ**gʁa**.fi.ti]	'graffiti'[39]
e.	[ˈ**kæ**.nə.bɪs]	[ka.ˈ**na**.bis]	'cannabis'[40]
f.	[ˈ**fɔɹ**.mæt]	[foʁ.ˈ**mat**]/[ˈ**foʁ**.mat]	'format'
g.	[ˈ**ɹi**.baʊn.dəɹ]	[ʁi.ˈ**baun**.deʁ]	'rebounder'[41]
i.	[mæsˈ**kæ**.ɹə]	[ˈ**mas**.ka.ʁa]	'mascara'[42]

6.1.2.2. Phonemic variability in L2 source

In some cases, there was variability in the English input over and above the dialectal differences which exist in vowel quality, i.e. different possible phoneme categories and different possible stress positioning. This was taken into account when checking the adaptation patterns, and both English variants were considered. The following table (38) presents some examples of such variability as they appear in the corpus:

[37] The Spanish word 'Trafalgar' has final stress. However, Hebrew uses this word in connection with 'Trafalgar Square' (London), so it is unclear if or why there is Spanish influence here.
[38] The second source vowel varies ([ˈ**mɑɹʃ**.mæ.loʊ] is attested too), but this is irrelevant with respect to stress. One English speaker consulted pronounced the word [mɑɹʃ.ˈ**mæ**.loʊ], but this is not the standard English pronunciation in any dialect I am aware of.
[39] The Italian source of the English word also has penultimate stress. Therefore, the Hebrew stress pattern cannot be derived from the Italian.
[40] The Greek source of the English word also has initial stress, therefore, the Hebrew stress pattern cannot be derived from the Greek or the English.
[41] Note, there is no stress shift in the adaptation of English [ˈ**ɹi**.baʊnd] → Hebrew [ˈ**ʁi**.baund].
[42] Like 'Trafalgar', possible Spanish influence here. Etymologically, the English word comes from Spanish, however, the Hebrew term is borrowed from English, not Spanish.

(38) *Phonemic variability in English source words in the corpus*

		English (L2)	Hebrew (L1)	
a.	different vowels	[d**æ**ns / d**ɑ**ns]	[d**a**ns]	'dance'
b.	different vowels	[mæs.ˈk**æ**.ɹə / mæs.ˈk**ɑ**.ɹə]	[ˈmas.k**a**.ʁa]	'mascara'
c.	different vowels	[ˈtɛm.pl**ə**t / ˈtɛm.pl**eɪ**t]	[ˈtem.pl**ei**t]	'template'
d.	different stress	[ˈ**kæ**.fin / kæ.ˈ**fin**]	[ka.fe.ˈ**in** / ko.fa.ˈ**in**]	'caffeine'
e.	different stress	[ˈ**di**.fɔɫt / di.ˈ**fɔɫt**]	[ˈ**di**.folt]	'default'

The English variation of [æ/ɑ], as in (38a-b), is usually, though not exclusively, a US vs. UK dialectal difference. At least in the cases in the above table, the distinction is not dialect-dependent. The variation in (38c) is also not dialect-dependent, and neither are the variable stress positions in (38d-e).

6.1.2.3. Phonemic variability in L1 adaptation

There are also cases in which a single English source exists, but in which there are variable adaptations into Hebrew, as shown in the following table (39):

(39) *Phonemic variability in Hebrew outputs in the corpus*

	English (L2)	Hebrew (L1)	
a.	[ˈb**æ**.l**ə**ns]	[ˈb**a**.l**a**ns / ˈb**e**.l**e**ns]	'balance'
b.	[ˈb**æ**t.m**æ**n]	[ˈb**a**t.m**e**n / ˈb**e**t.m**e**n]	'Batman'
c.	[ɹ**æ**p]	[ʁ**a**p / ʁ**e**p]	'rap'
d.	[k**æ**.ˈ**fi**n]	[k**a**.**fe**ˈin / k**o**.**fa**.ˈin]	'caffeine'

	English (L2)	Hebrew (L1)	
e.	[ˈev**.ə**n]	[ˈe.v**a**n / ˈe.v**e**n]	'Evan'
f.	[ˈke.v**ə**n]	[ˈke.v**i**n / ˈke.v**e**n]	'Kevin'
g.	[ˈɪ.m**ə**d͡ʒ]	[ˈi.m**i**d͡ʒ / ˈi.m**e**d͡ʒ]	'image'
h.	[ˈd͡ʒɔɹ.dn̩]	[ˈd͡ʒoʁ.d**e**n / ˈdʒoʁ.d**o**n]	'(Michael) Jordan'
i.	[ˈsɪ.n**ə**.mə ˈsɪ.ti]	[ˈsi.n**i**.ma / ˈsi.n**e**.ma ˈsi.ti]	'Cinema City'[43]
j.	[ˈsɪ.l**ə**.bəs]	[ˈsi.l**a**.bus / ˈsi.l**i**.bus]	'syllabus'
k.	[ˈspɔn.s**ə**ɹ]	[ˈspon.s**e**ʁ / ˈspon.s**o**ʁ]	'sponsor'
l.	[ˈi.m**eɪ**l]	[ˈi.m**e**l / ˈi.m**ei**l]	'e-mail'
m.	[s**ɪ**.ˈmɛs.təɹ]	[s**e**.ˈmes.teʁ / s**i**.ˈmes.teʁ]	'semester'
n.	[l**ɪ**ɫ]	[l**i**l / l**u**l]	'Lil(lian)'
o.	[ˈɔ.ɹ**ɪ**nd͡ʒ]	[ˈo.ʁ**e**nd͡ʒ / ˈo.ʁ**a**nd͡ʒ]	'Orange'

The main cases in which there was variable pronunciation are English [æ], as in (39a-d), English [ə], as in (39e-k), and English [ɪ], as in (39m-o). Certain diphthongs are also adapted variably, as in (39l).

The sources of such variation, as well as the reasons certain vowels hardly ever vary (e.g. English [u] and [ʊ] are almost always adapted as Hebrew [u]) are discussed in §7.1. All cases in which there was variable pronunciation, both in the inputs and the outputs, are taken into consideration in the corpus.

6.1.3. Criteria in the selection of loanwords for the corpus

The words in the corpus comply with three important criteria: they are used by L1 speakers in L1 conversation (§2.1.5), they are not institutionalised loanwords (§2.1.4), and they were borrowed from English.[44]

[43] [ˈsɪ.n**ə**.mʌ] (US) and [ˈsɪ.n**ə**.mɑ] (UK) are attested, but this vowel is irrelevant here.
[44] I acknowledge the possibility that although some words may have been borrowed from English, they may nevertheless have been affected by L3.

First of all, the requirement that the words be used by L1 speakers in L1 conversation is essential, in order to avoid L2 words used in bilingual conversation, as these may reflect L2 grammar.

Secondly, institutionalised loanwords have been around for a while. The problem with them is that the circumstances of the borrowing process are often obscure. It is unclear who the adapting speakers were, whether they were native speakers of L1 and which language the adaptation was from. Furthermore, grammars may evolve over time, and when studying the current grammar of native speakers, only current adaptations should be examined.

Finally, for the sake of uniformity, only loanwords from English were examined. The similarity model I propose in §5 and §7 works just as well with other vowels from other languages. Cases in which the source language is unclear were avoided inasmuch as possible.

6.1.4. Sources of data

The corpus data was collected from three different sources: Elicitation from native speakers (§6.1.4.1); spontaneous productions (§6.1.4.2); and previous publications on loanwords (§6.1.4.3).

6.1.4.1. Elicited data

The backbone of the corpus is ~250 words elicited from three consultants, all native speakers of Hebrew with an excellent knowledge of English. The consultants were recorded while talking about their respective fields (cinematography, computers, sports) and clarifying the meaning of as much field-specific terminology as they could. They were not instructed specifically to refer to non-native Hebrew words and the whole conversation was in Hebrew, to avoid bilingual conversation. All transcriptions are my own.

The three fields were chosen as all three borrow heavily from American English. Both British and American English have contributed loanwords to Hebrew. However, for various sociological and political reasons, British English was the primary influence up until 1948, and American English supplanted British English around 1948 and has been the primary influence since then (Rosenhouse and Fisherman 2008). Therefore, older loanwords are often borrowed from British English, whereas current borrowing is primarily from American English.

B, an expert on cinematography, used 121 terms borrowed from American English. Many of the terms are phrases rather than single words. Some of these terms appear in the following table (40):

(40) *Cinematographic terms in the corpus*

	English (L2)	Hebrew (L1)	
a.	[ˈæk.ʃən]	[ˈek.ʃen]	'action!'
b.	[bæk laɪt]	[bek lait]	'back light'
c.	[ˈbæ.nəɹ]	[ˈba.neʁ]	'banner'
d.	[blæk]	[blek]	'black'
e.	[ˈɑɹt daɪ.ˈɹɛk.təɹ]	[ˈaʁt dai.ˈʁek.toʁ]	'art director'
f.	[bɑɹz]	[baʁz]	'bars'
g.	[bum]	[bum]	'boom'
h.	[ˈkæs.tɪŋ]	[ˈkas.tiŋg]	'casting'
i.	[ˈkloʊ.sʌp]	[ˈklo.zap]	'close up'
j.	[kən.ˈtɹoʊl]	[kon.ˈtʁol]	'control'
k.	[koʊ.pɹə.ˈdʌk.ʃən]	[ko.pʁo.ˈdak.ʃen]	'coproduction'
l.	[kʌt tə kʌt]	[kat tu kat]	'cut to cut'
m.	[ˈdɒ.li tɹæk]	[ˈdo.li tʁek]	'dolly track'

	English (L2)	Hebrew (L1)	
n.	[feɪd]	[feid]	'fade'
o.	[ˈlɒŋ ˈʃɒt]	[ˈloŋk.ʃot]	'long shot'

Note the variable adaptation of [æ] in (40a-d), the diphthong simplification in (40i-j) and the various enhancements of schwa in (40a), (40j) and (40l). I address these issues in §7.

N, a computer programmer, supplied 88 terms. Many of the terms are commonly used by all native speakers, not necessarily those dealing with computers on a regular basis. Most terms do not have native Hebrew equivalents. Some of these terms appear in the following table (41):

(41) *Computer terms in the corpus*

	English (L2)	Hebrew (L1)	
a.	[ˈbu.li.ən]	[ˈbu.li.an]	'Boolean'
b.	[baɪ ˈɹɛf.ɹəns]	[bai ˈʁe.fe.ʁens]	'by reference'
c.	[baɪ ˈvæl.ju]	[bai ˈvel.ju]	'by value'
d.	[kæʃ]	[keʃ]	'cache'
e.	[ˈæ.plɪt]	[ˈep.let]	'applet'
f.	[klæs]	[klas]	'class'
g.	[ˈdi.fɔɫt]	[ˈdi.folt]	'default'
h.	[dɪ.ˈlit]	[di.ˈlit]	'delete'
i.	[dɪsk]	[disk]	'disk'
j.	[ˈi.meɪl]	[ˈi.mel / ˈi.meil]	'e-mail'
k.	[ɪ.ˈskeɪp]	[e.ˈskeip]	'escape'
l.	[floʊt]	[flout]	'float'

	English (L2)	Hebrew (L1)	
m.	[ˈwɪn.doʊz]	[ˈwin.doz]	'Windows'
n.	[ˈɪn.tɪ.d͡ʒəɹ]	[ˈin.te.d͡ʒeʁ]	'integer'
o.	[θɹɛd]	[tʁed]	'thread'
p.	[ˈnɛt.wɜɹk]	[ˈnet.woʁk]	'network'

Once again, there is variable adaptation of [æ] in (41d-f). Compare the adaptation of [oʊ] in (41l) and (41m), the former being adapted to [ou], the latter being simplified to [o]. This can also be compared to the previous table's words (40i-j), where the diphthong is simplified. Note also the variable adaptation of [ɪ]; in (41e,k), it is adapted as [e], in (41h-i) it is adapted as [i], while in (41n), each [ɪ] is adapted differently. I address these issues in §7.

O, a basketball enthusiast, supplied 55 terms, mostly basketball related. Almost all the terms have native Hebrew equivalents, which few people use. Some of these terms appear in the following table (42):

(42): *Basketball terms in the corpus*

	English (L2)	Hebrew (L1)	
a.	[ə.ˈsɪst]	[a.ˈsist]	'assist'
b.	[blɒk ʃɒt]	[blak ʃat / blok ʃot / blak ʃot]	'block shot'
c.	[bɒks ənd wʌn]	[boks / baks end wan]	'box and one'
d.	[ˈsɛn.təɹ]	[ˈsen.teʁ]	'centre'
e.	[ˈdʌ.bəl ˈfɪ.gəɹz]	[ˈda.bel ˈfi.geʁz]	'double figures'
f.	[slæm dʌŋk]	[slem daŋk]	'slam dunk'
g.	[fæst bɹeɪk]	[fast bʁeik]	'fast break'
h.	[ˈfɔɹ.wəɹd]	[ˈfoʁ.woʁd]	'forward'

	English (L2)	Hebrew (L1)	
i.	[ˈsɛ.kənd gɑɹd]	[ˈse.kend gaʁd]	'second guard'
j.	[loʊ poʊst]	[lou post]	'low post'
k.	[pɪk ənd ɹoʊɫ]	[pik end ʁol]	'pick and roll'
l.	[ˈɹi.baʊnd]	[ˈʁi.baund]	'rebound'
m.	[ˈɹi.baʊn.dəɹ]	[ʁi.ˈbaun.deʁ]	'rebound'

Once again, diphthong adaptation shows erratic behaviour in (42j-k); [æ] surfaces as [e] (42f) and [a] (42g), schwa behaves somewhat unpredictably (42h) and some words show variable adaptation patterns (42b-c). I discuss these issues in §7. In (42m), as opposed to (42l), there is a rare case of stress shift in adaptation. In general, stress does not shift in adaptation in Hebrew (§3.3.2 and §6.1.2.1). Only 1.8% (25/1383) words in the corpus display such behaviour (§6.1.2.1). Most cases are due to the influence of other languages, such as French, but that is clearly not the case here. While I currently have no satisfactory explanation for the stress shift in (42m), it is possible that the stress shifts to the diphthong [au] rather than remaining on the monophthong [i]. The stress shift does not occur in (42l), possibly to avoid stressing a word-final syllable.[45]

6.1.4.2. Spontaneous productions

Much of the corpus was collected from spontaneous productions in conversations and data taken from television and radio broadcasts. I transcribed all of these words without recordings and later verified the pronunciation with native speakers. Some of the words taken from electronic media appear in the following table (43):

[45] As diphthongs in Hebrew are rare (§3.2), there are no studies regarding the stressing of diphthongs vs. monophthongs.

(43) *Words taken from electronic media broadcasts*

	English (L2)	Hebrew (L1)		Source
a.	[ɪ.ˈvɛnt]	[i.ˈvent]	'event'	radio
b.	[ˈmæ.nju.əl]	[ˈmen.ju.el]	'manual'	Chan. 2
c.	[ˈmæl.kəm]	[ˈmal.ko.lem]	'Malcolm'	Chan. 3
d.	[ˈɔ.ɹɪnd͡ʒ]	[ˈo.ɹand͡ʒ]	'Orange'	radio
e.	[pəɹ.ˈfɔɹ.məɹ]	[pʁi.ˈfoʁ.meʁ][46]	'performer'	radio
f.	[ˈhænd.wɜɹk]	[ˈhend.weʁk]	'handwork'	radio
g.	[ˈkeɪ.tə.ɹɪŋ]	[ˈke.te.ʁiŋg]	'catering'	Chan. 2
h.	[ˈdʒɔɹ.dn̩]	[ˈdʒoʁ.don]	'(Michael) Jordan'	Chan. 10
i.	[ˈtɹæ.vəl]	[ˈtʁa.vel]	'travel'	Chan. 3
j.	[ˈli.gəl]	[ˈli.gal]	'(Boston) Legal'	Chan. 3
k.	[ˈt͡ʃænd.ləɹ]	[ˈt͡ʃan.dleʁ]	'Chandler'	Chan. 2
l.	[ˈaɪ.dl̩]	[ˈai.del]	'(American) Idol'	Chan. 1
m.	[ˈfæ.mɪ.li]	[ˈfe.me.li]	'(AIG) Family'	radio ad

Many of the above words have variable pronunciations. The particular pronunciations above are not necessarily the norm. Often, TV and radio broadcasts tend to adhere to orthography, something I discuss in §7.1.4.

6.1.4.3. Previous publications

Some words were collected from previous publications on loanwords, primarily Schwarzwald (1998) and Rosenthal (2003). The transcriptions I adopt follow the Hebrew orthographic representations in the various publications. In all cases, the

[46] The metathesis here is not a typographical error. One possible explanation for the metathesis is the meta-linguistic reference to the English prefix <pre->, confusing it with <per->.

vowel diacritics were used. The only thing not indicated in the orthography is the stress, but I have no reason to believe it to be anything other than what the English input provides (§6.1.2.1 and §7.2.2).

The "problem" with words from previous publications is that they are primarily institutionalised loanwords, though in some cases, their variable pronunciation sheds some light on speakers' grammar.

6.1.5. Quantitative data

As the focus of this study is similarity and my model of similarity refers mainly to the adaptation of vowels, this section presents quantitative analyses of the corpus with respect to vowel adaptation. Other issues, such as consonant adaptation, stress shift and morphological influences are not discussed here.

The following analyses examine the source vowels of 690 Hebrew vowels in the corpus. The following categories of words in the corpus were not included in this analysis: (a) institutionalised loanwords (§2.1.4); (b) words with morphological interferences (§7.3.2); (c) words whose L2 was unclear or mixed. These categories of words are studied, but I have excluded them from the statistical analyses.

English vowels are adapted into Hebrew via several different routes. I do not discuss these in this chapter, but rather, I address them in §7. The following tables (44), (45) and (46) present the raw data showing the correlation between the English inputs and the Hebrew adapted forms:

(44) *Adaptation of English monophthongs into Hebrew (absolute values)*

	[i]	[ɪ]	[ɛ]	[ɜ]	[æ]	[ə]	[ɑ]	[ɒ]	[ʌ]	[ɔ]	[ʊ]	[u]
/i/	**48**	**67**	1	1		6						
/e/	1	20	**41**	**8**	**43**	**83**	1					
/a/		2			**43**	25	**23**	6	**27**	1		
/o/				3	1	20		**33**	2	**32**		
/u/		1		1		6			4		5	**18**
Total	49	90	42	13	87	140	24	39	33	33	5	18

(45) *Adaptation of English diphthongs into Hebrew (absolute values)*

	[aɪ]	[aʊ]	[eɪ]	[ɔɪ]	[oʊ]	[ɪə]
/i/	5					**1**
/e/			8			**1**
/a/	1	1	4			
/o/					**16**	
/u/					2	
/ai/	**20**		1			
/au/		**8**			1	
/ei/			**20**			
/oi/				**4**		
/ou/					6	
Total	26	9	33	4	25	2

(46) *Hebrew vowels with no vowel correspondent in English (epenthesis)*

	Ø	C̩
/i/	2	
/e/	**5**	**4**
/a/	1	2
/o/	1	3
/u/		

English source vowels, almost without exception, are never adapted one-to-one. Of course, vowels may have tendencies in adaptation (e.g. [i] is almost always adapted as /i/, [oʊ] is usually adapted as [ou], the most common epenthetic vowel is /e/ etc.), but these are no more than tendencies.

Why vowels have variable adaptation is answered mainly in §7. For now, suffice it say that there are various sources for each vowel (acoustics, orthography etc.).

In order to isolate the perceptual aspect of loanword adaptation, one cannot rely on a corpus, natural data which are "contaminated" by various non-perceptual sources. Experiments are necessary to facilitate focusing on this aspect of adaptation. Two such experiments I conducted are reported on in the following §6.2.

6.2. Experiments

Corpora do reflect loanword grammar to a certain extent, but since we never know the exact source of the word (i.e. which dialect, which pronunciation, presence of orthography, identity of borrower etc.), we do not know the exact grammatical processes involved in the adaptation. In order to identify these processes more accurately, we have to isolate them. The isolation and investigation of these processes is the sole purpose of the experiments I conducted, and they were designed specifically to answer the questions at hand.

Two kinds of experiment dealing with auditory inputs are categorisation experiments and discrimination experiments. Experimental tasks requiring categorisation differ from experimental tasks requiring discrimination. While discrimination has been shown to be based on sensory-auditory strategies (i.e. what the auditory mechanism detects, what one hears), categorisation is based on abstract phonological representations (i.e. how the linguistic module maps the auditory signals into phonological structures, what one thinks one hears). Gerrits and Schouten (2004) present experimental data showing how speakers operating in discrimination mode rely on auditory cues and differ in performance (good vs. poor listeners), whereas speakers operating in categorisation mode perform similarly, just as they would be expected to do in everyday speech situations. The fact that speakers categorise vowels similarly does not suggest they perceive the vowels similarly.

6.2.1. Discrimination experiment

Discrimination experiments focus on the sensory-auditory capabilities of the subjects. In such experiments, all the subject has to do is decide whether tokens differ from one another or not.

6.2.1.1. Description

I conducted a discrimination experiment testing the judgements of 57 native Hebrew speakers on natural English sounds. A native British speaker (non-rhotic dialect) produced 54 pairs of CVC and CVCi tokens displaying the following nine English contrasts: [i ɪ], [u ʊ], [ɛ ɛː], [ɒ ɒː], [æ ɛ], [ɒ ɔ], [ɛ ɪ], [ɛ ɜ], [ɒ ʌ]. None of the contrasts exist in Hebrew (§3.2). The complete list of pairs used appears in Appendix II.

Each contrast was represented in three different word pairs, four with different vowels (in two different orders) and two with identical vowels (control). The two words in each pair were pronounced in random order. The task was to state whether the words were the same or different.

6.2.1.2. Results

The subjects' results appear in the following table (47):

(47) *Same-Different experiment – contrast distinctions*

Vowels	Example			Contrast	Error
a. [i ɪ]	[tik] 'teak'	vs.	[tɪk] 'tick'	ATR/Length	0.4% (1/232)
b. [u ʊ]	[kud] 'cooed'	vs.	[kʊd] 'could'	ATR/Length	14.2% (33/232)
c. [ɛ ɛː]	[vɛɹi] 'very'	vs.	[vɛːɹi] 'vary'	Length	37.9% (88/232)
d. [ɒ ɒː]	[dɒk] 'dock'	vs.	[dɒːk] 'dark'	Length	23.7% (55/232)
e. [æ ɛ]	[pæk] 'pack'	vs.	[pɛk] 'peck'	Height	7.8% (18/232)
f. [ɒ ɔ]	[tɒːt] 'tart'	vs.	[tɔːt] 'taught'	Height	0.9% (2/232)
g. [ɛ ɪ]	[nɛt] 'net'	vs.	[nɪt] 'nit'	Height	35.8% (83/232)
h. [ɛ ɜ]	[tɛn] 'ten'	vs.	[tɜn] 'turn'	Back/Round	2.6% (6/232)
i. [ɒ ʌ]	[lɒk] 'lock'	vs.	[lʌk] 'luck'	Height/Round	7.3% (17/232)

It is immediately apparent that speakers are capable of detecting non-native phonemic contrasts to some extent. However, different contrasts are not detected equally well (or poorly).

A logistic regression analysis done on the various contrasts (ATR, length, height) shows that certain English vowel distinctions are perceived better than others, something not reflected by binary feature distinctions. This is evident in (47a) vs. (47b), where the same featural distinction, ATR/length is better perceived with [i ɪ] than with [u ʊ], and the difference is statistically significant ($p<0.0001$). The same holds for length distinctions in (47c) vs. (47d) with [ɛ ɛː] vs. [ɒ ɒː] ($p<0.0001$), and for height distinctions in (47e) vs. (47g) with [æ ɛ] vs. [ɛ ɪ] ($p<0.0001$). In addition, the degree of roundness may play a role too. In (47f), [ɔ] is more rounded than [ɒ], and speakers may attend to this distinction, something which cannot be captured within a binary feature distinction.

6.2.1.3. Discussion

It could be suggested that Hebrew speakers do not perceive phonetic L2 differences which are not phonemic in Hebrew. Therefore, the categorisation of foreign segments is due to poor perception. However, as the experiment clearly shows, non-native phonemic distinctions are detected in same-different experiments.

So why do speakers not produce borrowed forms exactly as they perceive them? Because there are articulatory constraints which prevent the production of foreign segments. Instead, the foreign segments have to be categorised into existing L1 phonemic categories using some sort of approximation mechanism. How is this done? By finding the category most similar to the incoming signal. This similarity is determined on the basis of the model I propose in §5. The categorisation experiment in §6.2.2 examines the question: which category is each English vowel adapted as?

6.2.2. Categorisation experiment

The categorisation experiment is designed to show how Hebrew speakers categorise various incoming signals.

6.2.2.1. Description

I conducted a categorisation experiment with 28 native Hebrew speakers. The participants heard 225 randomly ordered synthetic vowels generated using a PRAAT (Boersma and Weenink 2009) script used previously in Escudero et al. (2007). The tokens used in the experiment were: (a) 11 tokens (played 10 times each) resembling

Standard Southern British English vowels (SSBE – values from Deterding 1997); (b) 9 tokens (played 10 times each) resembling American English vowels (AE – values from Hillenbrand et al. 1995); (c) 5 tokens resembling Hebrew vowels (values from Most et al. 2000). Each token was categorised 280 times (10 times by each participant). All tokens were 128ms long. The tokens were randomly ordered in each experiment. The formant values for the synthetic tokens are presented in the following table (48):

(48) *Formant values (F1, F2 in Hertz) for vowel tokens*

Vowel	Hebrew		AE		SSBE	
	F1	F2	F1	F2	F1	F2
[i]	342	2068	343	2322	280	2249
[ɪ]			427	2034	367	1757
[e]	455	1662				
[ɛ]			580	1799	494	1650
[æ]			588	1952	690	1550
[a]	626	1182				
[ɑ]			768	1333	646	1155
[ʌ]			623	1200	644	1259
[ɔ]			652	997	558	1047
[o]	478	944				
[ʊ]			469	1122	379	1173
[u]	359	979	378	997	316	1191
[ɒ]					415	828
[ɜ]					478	1436

Before the experiment, each participant performed a trial in order to determine whether they had understood the task of forced categorisation, whether they could operate the selection mechanism correctly and whether their categorisation of Hebrew vowels was normal. In the trial (and in the subsequent experiment too), the participants had a screen on which Hebrew graphemes representing the 5 Hebrew vowels appeared. They heard a synthetic token of the Hebrew vowels in earphones and clicked on the vowel they had heard. If participants made an error in categorisation, they had to perform the trial a second time. The results of participants making who did not classify the Hebrew vowels correctly in the second trial were excluded from the experiment.

After completing the trial, the experiment was conducted. The participants were instructed to select one of five possible Hebrew vowel categories for each token heard, and if the token heard did not match a Hebrew category in the participant's opinion, they were told to categorise it to "the closest" possible Hebrew vowel.

6.2.2.2. Results

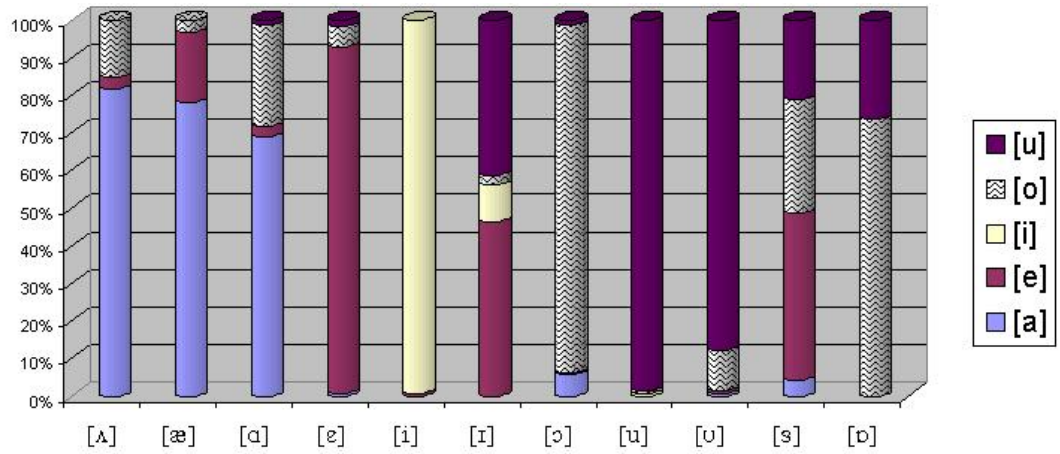
After removing the problematic subjects' results, the remaining results appear in the following table (49):

(49) *Confusion matrices for categorisation of SSBE and AE vowels by Hebrew speakers. Cell values are categorisation percentages of English vowels (absolute values appear in brackets).*

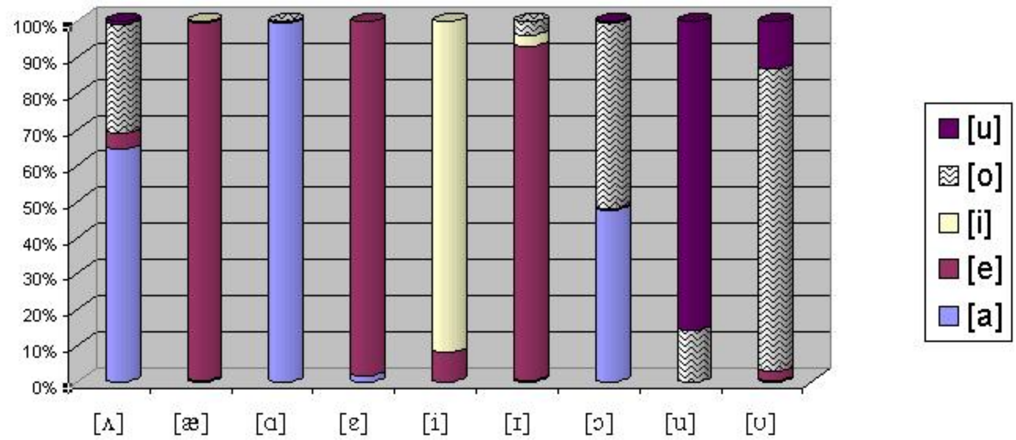
		Hebrew Categories				
↓Token		[a]	[e]	[i]	[o]	[u]
SSBE	[ʌ]	**81.8 (229)**	2.9 (8)		15.4 (43)	
AE	[ʌ]	**64.6 (181)**	4.3 (12)		30.4 (85)	0.7 (2)
SSBE	[æ]	**78.2 (219)**	18.6 (52)		3.2 (9)	
AE	[æ]	0.4 (1)	**99.3 (278)**	0.4 (1)		

		Hebrew Categories				
↓Token		[a]	[e]	[i]	[o]	[u]
SSBE	[ɑ]	**68.9 (193)**	2.9 (8)		26.8 (75)	1.4 (4)
AE	[ɑ]	**99.6 (279)**			0.4 (1)	
SSBE	[ɛ]	0.7 (2)	**92.1 (258)**		5.4 (15)	1.8 (5)
AE	[ɛ]	1.8 (5)	**98.2 (275)**			
SSBE	[i]		0.7 (2)	**99.3 (278)**		
AE	[i]		8.2 (23)	**91.8 (257)**		
SSBE	[ɪ]		**46.4 (130)**	9.6 (27)	2.5 (7)	41.4 (116)
AE	[ɪ]	0.4 (1)	**92.9 (260)**	3.2 (9)	3.6 (10)	
SSBE	[ɔ]	5.7 (16)	0.4 (1)		**92.5 (259)**	1.4 (4)
AE	[ɔ]	47.9 (134)	0.4 (1)		**51.4 (144)**	0.4 (1)
SSBE	[u]			0.7 (2)	0.7 (2)	**98.6 (276)**
AE	[u]				14.6 (41)	**85.4 (239)**
SSBE	[ʊ]	0.7 (2)	0.7 (2)		10.7 (30)	**87.9 (246)**
AE	[ʊ]	0.4 (1)	2.5 (7)		**84.3 (236)**	12.9 (36)
SSBE	[ɜ]	4.3 (12)	**44.3 (124)**		30.4 (85)	21.1 (59)
SSBE	[ɒ]				**73.6 (206)**	26.4 (74)

(50) *Graphic representation of confusion matrices for SSBE, values from table (49).*



(51) *Graphic representation of confusion matrices for AE, values from table (49).*



Two things are immediately apparent in the results in table (49): (a) categorisation is never 1-to-1. In no single instance is any vowel token categorised uniformly throughout; (b) despite the fact that categorisation is never 1-to-1, the F1 and F2 values of the vowels are nevertheless good predictors of the type of categorisation expected (§3.2.2). Note, most vowels are categorised as the Hebrew vowel with the "closest" values (e.g. SSBE[・], AE[æ]). In cases in which English vowels match one Hebrew vowel's F1 but another Hebrew vowel's F2 (e.g. AE[ɔ]), or in which English vowels are situated somewhere between two (or more) different

Hebrew vowels (e.g. SSBE[ɒ]), categorisation is split between these two (or more) categories. This closeness is measured according to the model in §5.4.

6.2.2.3. Discussion

Since AE and SSBE vowels are different, different perception results for the two are expected, and this is well reflected in the above table (49). I expect vowels to be categorised to the "closest" Hebrew vowel category, and I propose that closeness is measured according the model of similarity I present in §5.

In the following §7, I compare the predictions of my model of acoustic similarity in §5 to the experimental and corporal data in §6.

Chapter 7. The role of similarity in adaptation

Adaptation is primarily similarity-based (§2.2). In order to ensure mutual understanding among speakers, the newly coined loanword has to be as similar as possible to its source in L2. Similarity evaluations on both the segmental and the prosodic levels are not only influenced by perceptual effects. Orthographic information and various phonological constraints active in L1 affect the output (Smith 2005, Kang 2003).

Loanword adaptation cannot be explained solely on the basis L2-input→L1-output relationships based on segmental similarity defined in phonological and phonetic terms. Rather, segments in the output are a result of the interaction among a complex range of sources, something I refer to as Multi-sourcing. In §7.1, I discuss segmental similarity and the various influences on vowel selection in adaptation. The prosody of the output, i.e. the syllable structure and the stress patterns, also similarity based, is determined by the interaction among several sources. In §7.2, I discuss prosodic similarity. This is followed by additional phenomena in §7.3, and I conclude this section discussing the integration of the various components of loanword adaptation in §7.4.

7.1. Multi-sourcing: Segmental similarity

When forming the lexical representation of a loanword in L1 based on an L2 input, the distinct phonemes in L1 are not derived from a single source. There are two discrete input sources determining the quality of the L1 phonemes: (a) acoustic similarity evaluations (§7.1.1) and (b) orthographic similarity evaluations (§7.1.4). The quality of the vowel may also be affected by other sources, such as vowel harmony and UG (§7.1.2) and something I refer to as schwa enhancement (§7.1.3). In some cases, the source of the L1 vowel may have no correspondent whatsoever in L2, but rather it may be the product of various prosodic constraints (§7.2), which may serve as the source for certain vowels in the L1 lexical representation.

Note, in many cases, the various sources may converge. For example, the acoustic and orthographic inputs may predict the same L1 output. Only cases in which there is no convergence or in which one of the sources in unavailable to the adapting speaker allow us to determine unequivocally the identity of the source.

7.1.1. Perception-based adaptation: Acoustic similarity

An L1 speaker exposed to L2 auditory input classifies incoming segments according to the categories s/he is most used to, i.e. the phonemic categories in L1 (see §5.4.1). This classification is essentially based on approximation. The category chosen is the L1 category "most similar" to the input, closest to the input in perceptual terms. The formal perceptual phonological model I propose in §5.4 determines the phonological proximity between two categories on the basis of the auditory input. Subsequently, the model measures the proximity of the incoming signal to L1 categories and categorises the input accordingly, resulting in an L1 phonemic representation of the L2 input.

The different English vowels are categorised into the five Hebrew vowel categories (§3.2), something which predicts the Hebrew output in the vast majority of cases. The following table (52) presents vowels in AE found in the corpus (§6.1), the predicted adaptation patterns according to the model in §5.4, the results in the categorisation experiment (§6.2.2) and the actual patterning of the adaptation in the corpus (§6.1). The vowels in the table are those in AE, as this is currently considered the primary source of Hebrew loanwords from English (§6.1.4.1). Since AE and SSBE vowels are different acoustically, their adaptations are predicted to differ too (§5.4.5.1).

(52) *Similarity based adaptation – model's predictions vs. experimental and corporal data (values under 5% have been removed, fractions of a percent have been removed). Leading candidates appear in bold, shading show convergence*[47]

Eng.	Heb.	Model predictions	Categorisation experiment	Corpus adaptation	Examples from corpus
[i]	/i/	**95%**	**92%**	**98%**	[hip]→/hip/ 'heap'
	/e/	5%			[spid]→/spid/ 'speed'
[ɪ]	/i/	**73%**		**74%**	[dɪsk]→/disk/ 'disk'
	/e/	27%	**93%**	22%	[ɪn]→/ɪn/ 'in'
[ɛ]	/i/	10%			[nɛt]→/net/ 'net'
	/e/	**88%**	**98%**	**98%**	[wɛb]→/web/ 'web'
[æ]	/i/	17%			[t͡ʃæt]→/t͡ʃet/ 'chat'
	/e/	**83%**	**99%**	**49%**	[pæs]→/pas/ 'pass'
	/a/			**49%**	
[ɑ]	/a/	**93%**	**100%**	**96%**	[gɑɹd]→/gaʁd/ 'guard'
					[pɑm]→/palm/ 'palm'[48]
[ʌ]	/a/	**96%**	**65%**	**82%**	[kʌt]→/kat/ 'cut'
	/o/		30%		[plʌg]→/plag/ 'plug'
	/u/			12%	
[ɔ]	/a/	**67%**	48%		[tɔk]→/tok/ 'talk'
	/o/	32%	**51%**	**97%**	[ˈstɔɹi]→/ˈstoʁi/ 'story'
[ʊ]	/a/	26%			[ˈɪnpʊt]→/ˈinput/ 'input'
	/o/	**46%**	**84%**		[ˈæmbʊʃ]→/ˈembuʃ/ 'ambush'
	/u/	29%	13%	**100%**	
[u]	/o/	22%	15%		[fjuz]→/fjuz/ 'fuse'
	/u/	**78%**	**85%**	**100%**	[zum]→/zum/ 'zoom'

[47] Complete details without comparative tables appear in §6.
[48] This is the only word in the Hebrew corpus with a sonorant-sonorant cluster in coda position.

The data in the above table show clearly how the model's predictions, the corporal data and the experimental data converge in almost all the cases. The slight differences in percentages can be attributed to a few inherent methodological "problems" with each source.

One such "problem" is that the model's predictions are based on a theoretical algorithm and 100,000 iterations, but the model nonetheless only checked two of the vowel's physical characteristics (i.e. F1 and F2). In real life similarity judgements and adaptation, speaker decisions rely on additional acoustic attributes, such as F3 and length.

Secondly, the corporal data are not based solely on perception, unlike the model and the categorisation experiment. Other sources, such as convention and orthography, influence speaker choices too. For example, novel Hebrew nouns are always pluralised according to their grammatical gender, even though the language shows a tendency to pluralise masculine nouns with stressed /o/ with the feminine plural morpheme /-ot/ (Becker 2009). This tendency can be found by examining the overall pattern of noun pluralisation in Hebrew and is supported by experimental data. One should ask why such a tendency never surfaces with novel words, and the answer is probably connected to convention.

Finally, the categorisation experiment was conducted on a relatively small set of speakers. Each token was tested 280 times (10 per speaker), not even close to the 100,000 iterations carried out in the model.

Despite all the reservations, five of the nine vowels ([i], [ɛ], [ɑ], [ʌ], [u]) converge for all three sources. The other four converge for two sources.

The vowel [æ] (discussed extensively in §5) converges for the model's predictions and the categorisation experiment, predicting /e/ for the vast majority of the cases. The corpus, however, differs from the other two sources, offering /e/ and /a/ as equally good candidates. There are two possible explanations for this apparent discrepancy. First of all, recall from §5.4.3 that SSBE[æ] is predicted to be adapted as /a/. This is one of the few cases where SSBE and AE vowels are predicted to behave differently. The full extent of SSBE on the words cannot be evaluated, but convention over the years may have affected the adaptation of [æ]. In addition, there is the issue of orthography (§2.2.1.1 and §7.1.4). The vowel [æ] is invariably written as <a>, and if a speaker refers to orthography, the Hebrew category selected is likely to be /a/.

Two of the remaining problematic vowels, [ɔ] and [ʊ], are round vowels. Roundness distinctions are based on F3 differences (§3.2.2.3), and F3 is critical in the categorisation of round vowels. Since the categorisation experiment did not include F3, the discrepancies evident in the above table are expected. Roundness and degree of roundness may play a role in the perception and categorisation of these vowels, something the experiment does not address. In addition, the massive influence of English orthography is particularly prominent for the vowels [ɔ] and [ʊ]. The former is written as <o> and almost always adapted as /o/. The latter is almost always written as <u> and always adapted as /u/. The model's predictions and the categorisation experiment are, at best, confusing for both these vowels. One of the reasons probably stems from the nature of the vowels /u/ and /o/ in Hebrew. While /u/ is the highest back vowel, /o/ is the furthest back (see §3.2). In addition, there is considerable overlap between the two vowels (Most et al. 2000), creating much confusion in their categorisation patterns. Finally, the two have identical orthographic representations in Hebrew when diacritics are not used.

The final problem is the vowel [ɪ]. This vowel is orthographically represented as <i>, predicted by the model to be categorised as /i/ and appears in the corpus as /i/ in most cases. Nevertheless, the categorisation experiment selects /e/ in the overwhelming majority of the cases (93%). This is the only case where the categorisation experiment and the model make completely different predictions, and I have no satisfactory explanation as of yet regarding the reason for this discrepancy, though one possible explanation, offered in Cohen et al. (forthcoming), refers (once again) to the F3 of [ɪ] as having an effect on adaptation. This has yet to be tested. Another possible explanation is the conventionalisation of the adaptation process due to orthography, since [ɪ] is almost always spelt as <i>.

Similarity in adaptation is first and foremost acoustic in nature. The acoustic input is phonologically categorised, and if there are no other influences present, this categorisation can be predicted with remarkable accuracy. However, if other phonological influences, such as vowel harmony or UG are indeed present, they may affect the categorisation. I discuss these in the following §7.1.2.

7.1.2. Harmony and UG

In Hebrew, there is little, if any, evidence in native words of vowel harmony. Two instances in which vowel harmony has been referred to in Hebrew are segholate nouns (Bat-El 1989:180, Bolozky 1995) and plural affixation (Becker 2009).

The segholate nouns differ from other Hebrew nouns in that they bear penultimate stress in the uninflected form, but the stress is mobile, and in the inflected forms, it is word final (see also §3.3.2). Bat-El (1989) describes height harmony in the inflectional paradigm of these nouns (e.g. /digl/→digel→[degel] 'flag'). While it is historically correct that the penultimate vowel harmonised with the final (epenthetic) vowel, synchronically this can be seen as a vocalic pattern (i.e. XeXeX) rather than an active process of vowel harmony.

Becker (2009) provides some evidence for vowel harmony in plural affix selection in Hebrew based on an analysis of a corpus of Hebrew nouns (Bolozky and Becker 2006) and an experiment on nonce words (Becker 2009). However, this apparent tendency towards harmony is not productive, but rather only historical residue.

This being said, there is nevertheless no widespread harmony in the Hebrew noun system. Segholates are example of productive vocalic patterns rather than harmony, and the plural affix selection is non-productive. New segholate nouns are rarely formed and novel plurals display no evidence whatsoever of harmony, always pluralising strictly according to grammatical gender (with the sole exception of *dox→do.ˈxot* 'report/s'). Therefore, any harmony that these two categories seem to exhibit is not necessarily part of a synchronic grammar of Hebrew.

However, there is evidence in the adaptation of loanwords from English that vowel harmony may indeed play some role in Hebrew. While this may sound surprising, evidence for non-native processes in adaptation is not uncommon. Shinohara (2006), in her study of Japanese, attributes this to the possible emergence of UG or default settings in some cases (the emergence of the unmarked, TETU, McCarthy and Prince 1995). Adaptation may "set a novel course that lacks a precedent in the native grammar", as noted in Kenstowicz and Suchato (2006: 946) in their study of Thai.

Though not considered a native process in Hebrew, vowel harmony seems to be the deciding factor in vowel choice in Hebrew adaptation in 0.9% (13/1383) of the adapted forms in the corpus. In some cases, even fully specified stressed English vowels are adapted differently to what might be expected on the basis of perception, apparently solely due to the influence of vowel harmony. Note, I have ignored cases in which the vowel possibly undergoing harmony may have been adapted via orthography or by its substitution with /e/, the standard epenthetic vowel in Hebrew (§7.2.1). In cases in which several possible adaptations were attested, I have only put the forms with vowel harmony into the following table (53). The arrow indicates the direction of the harmony:

(53) *Vowel harmony in the adaptation of English words into Hebrew*

	English (L2)	English orthography	English pronunciation	Hebrew	
a.	[ˈsɪ.**nə**.mə]	<e>	[ə]	[ˈsi.n**i**.ma]	'cinema'[49]
b.	[ˈkæŋ.g**ə**.ɹu]	<a>	[ə]	[ˈkeŋ.g**u**.ʁu]	'kangaroo'
c.	[ˈsɪ.l**ə**.bəs]	<a>	[ə]	[ˈsi.l**i**.bus]	'syllabus'
d.	[ˈdɪ.z**ə**n.gɒf]	<e>	[ə]	[ˈdi.z**i**n.gof]	'Dizengoff '
e.	[ˈɪ.mədʒ͡]	<a>	[ə]	[ˈi.m**i**dʒ͡]	'image'
f.	[ˈfɔɹ.w**ə**ɹd]	<a>	[ə]	[ˈfoʁ.w**o**ʁd]	'forward'
g.	[ˈdʒɔɹ.d_n̩]	<a>	[no vowel]	[ˈdʒoʁ.d**o**n]	'(Michael) Jordan'
h.	[ˈfɪl_m]	<null>	[no vowel]	[ˈfi.l**i**m]	'film'
i.	[s**ɪ**.ˈmɛs.təɹ]	<e>	[ɪ]	[s**e**.ˈmes.teʁ]	'semester'
j.	[ˈfæ.m**ɪ**.li]	<i>	[ɪ]	[ˈfe.m**e**.li]	'(AIG) Family'
k.	[ɪn.ˈt**ɛ**.lɪ.dʒ͡ənt]	<e>	[ɛ]	[in.t**i**.li.ˈgent]	'intelligent'
l.	[ˈɹ**ɛ**.dɪŋ]	<e(a)>	[ɛ]	[ˈʁ**i**.diŋg]	'Reading'
m.	[ˈj**oʊ**.gəɹt]	<o>	[oʊ]	[ˈj**u**.guʁt]	'yoghurt'

Though there is too little data from which to draw far-reaching conclusions regarding the harmony in Hebrew, some observations can be made from the above table (53).

First of all, schwa enhancement (53a-f) and the choice of an epenthetic vowel (53g-h) can be determined via vowel harmony.

Secondly, harmony is also applied when the English source is a full vowel. In (53i-j), [ɪ] undergoes harmony. In (53k-l), [ɛ] undergoes harmony. In (53m), the

[49] [ˈsɪ.**nə**.mʌ] (US) and [ˈsɪ.**nə**.mɑ] (UK) are attested, but this vowel is irrelevant here.

diphthong [oʊ] undergoes harmony, the trigger of which is, in fact, an orthographically determined [u].

Third, stress does not seem to play a role in harmonisation patterns. In (53k-l), a stressed [ɛ] harmonises with an adjacent vowel (it is not certain which of the two flanking vowels triggers the harmony in (53k)). In (m), a stressed diphthong [oʊ] harmonises with the following vowel, which is, in itself, a [ə] in the English input.

Finally, the direction in which the vowel harmony applies seems to be random, rightward spreading in (53a, c, d, e, f, g, h, j), leftward spreading in (53b, i, l, m), unclear in (53k). Note, it has been suggested by my Russian consultants that L3 (Russian) may play a role here, as the harmony appears in the Russian 'kangaroo' too. However, Russian cannot account for the harmony in 'cinema', 'syllabus', 'Jordan', 'intelligent', 'Reading' and 'yoghurt', as these do not harmonise in Russian according to my Russian consultants.

Vowel harmony can only be identified with certainty as such if other possibilities are eliminated. If orthography, acoustic similarity (L2 to L1) or the use of standard epenthetic vowels (Hebrew /e/) produce the same results as harmony would, then harmony is not necessarily the source of the L1 vowel. While uncommon in adaptation in Hebrew, and unproductive in native Hebrew grammar, as the above cases show, vowel harmony nevertheless rears its head and is the only possible source of the L1 vowel in the above table (53).

7.1.3. Schwa (and [ɜ]) enhancement

In addition to harmony discussed in the previous section, there are quite a few cases in which the quality of the vowel in Hebrew is not determined by the corresponding vowel in the English form. The most common case is that of the English schwa.

Unstressed vowels in English are reduced to neutral, possibly featureless, vowels insofar as their phonological representation is concerned, i.e. schwa (Kenstowicz 1994:550 for English schwas, and Anderson 1982 for French schwas).

Note, not all schwas in English are created equal. For example, Davidson (2007) shows that lexical schwas differ acoustically from epenthetic schwas inserted to resolve illicit clusters in English. However, in this study, I do not investigate the differences among the different schwas. Phonetically, these phonologically "empty" unstressed vowels in English are considerably shorter than full vowels, which are always stressed.[50] Their pitch is also lower, by virtue of their being unstressed.

The Hebrew vowel acoustically most similar to the English schwa, based on my model of similarity, is /e/. If adaptation were based solely on acoustic similarity, English schwas would be adapted as [e] by Hebrew speakers. Indeed, Hebrew speakers usually adapt English [ə] and [ɛ] the same way in Hebrew, i.e. as /e/. However, recall the data in table (44) in §6.1.5., partially reproduced here in table (54):

(54) *[ə] vs. [ɛ] in adaptation*

	[ɛ]	[ə]
/i/	1	6
/e/	**41**	**83**
/a/	0	25
/o/	0	20
/u/	0	6
Total	42	140

This table shows that [ɛ] is consistently adapted as /e/, while [ə] has variable adaptation patterns. The only exception regarding the adaptation of [ɛ] is [ɪnˈt**ɛ**lɪdʒənt]→/int**i**liˈgent/ 'intelligent', a case of vowel harmony or L3 (see §7.1.2).

[50] Davidson (2007) also shows that epenthetic schwas resolving illicit clusters are even shorter than lexical schwas resulting from vowel reduction, which, in turn, are shorter than full vowels.

Hebrew speakers clearly treat schwa and [ɛ] differently, as their adaptation is different. Therefore, the only possible conclusion is that [ə] must be processed differently by Hebrew speakers, otherwise we would expect similar numbers.

Although my similarity model predicts [ə] and [ɛ] to be largely adapted as a single category in Hebrew, [e], they are perceived to match the category to different extents (see §5 for Best at al.'s 2001 Category Goodness). A possible explanation is that even though [ə] is closer to Hebrew [e] than to the other Hebrew vowels, it is clear to speakers that it is not /ɛ/, but rather some sort of "empty" V-slot, along the lines of Anderson's (1982) analysis of French schwas as syllabic nuclei without features. But how do speakers make this "transition" from the incoming phonetic cue to the phonologically "empty" V-slot? They rely on the phonetic cues at their disposal. Due to the fact that all English schwas are unstressed, they are considerably shorter than other English vowels and their pitch is substantially lower. These two cues set them apart from full vowels. Since Hebrew does not allow empty V-slots, it is necessary to enhance them with a full vowel. This enhancement can be done by using the standard epenthetic vowel in Hebrew, [e]. In fact, it appears that this is the preferred route. In table (54) above, 83/140 (~59%) of the schwas are adapted as [e]. However, adaptation may also be facilitated via orthography or even vowel harmony.

Note, there is no connection between the general frequency of vowels in Hebrew and the vowels chosen to enhance the "empty" [ə], as the following table (55), repeated partially from table (9) in §3.2, shows. I refer only to masculine singular forms here, as feminine suffixes (e.g. /-ut/) and plural suffixes (/-im/ and /-ot/) skew the numbers:

(55) *Stressed vowels (absolute values) in Hebrew nouns (Bolozky and Becker 2006)*

	/i/	**/e/**	**/a/**	**/o/**	**/u/**
Stressed V in masc. sg.	967	1359	1860	894	1204

The frequency of stressed vowels in masculine singular forms in descending order is: a > e > u > i > o, while the frequency of vowels adapted from schwas (table (54)) in descending order is e > a > o > i,u.

The best evidence for schwa enhancement as opposed to similarity-based adaptation comes from words with phonemic variability in Hebrew (§6.1.2.3). In the corpus, 2.9% (40/1383) English words had more than one possible output in Hebrew. There was not a single case in which [ɛ] had variable adaptations. On the other hand, words containing [ə] were adapted variably in 5.7% (8/140) of the cases, all of which appear in the following table (56):

(56) *Variable adaptation of schwa*

	English (L2)	Hebrew1 (L1)	Hebrew2 (L1)	
a.	[ˈbæ.l**ə**ns]	[ˈbe.l**e**ns]	[ˈba.l**a**ns]	'balance'
b.	[ˈsɪ.n**ə**.mə]	[ˈsi.n**e**.ma]	[ˈsi.n**i**.ma]	'cinema'
c.	[ˈkæŋ.g**ə**.ɹu]	[ˈkeŋ.g**e**.ʁu]	[ˈkeŋ.g**u**.ʁu]	'kangaroo'
d.	[ˈsɪ.l**ə**.bəs]	[ˈsi.l**a**.bus]	[ˈsi.l**i**.bus]	'syllabus'
e.	[ˈɛ.v**ə**n]	[ˈe.v**e**n]	[ˈe.v**a**n]	'Evan'
f.	[ˈd͡ʒɛn.tl̩.m**ə**n]	[ˈd͡ʒen.tel.m**e**n]	[ˈd͡ʒen.tel.m**a**n]	'gentleman'
g.	[ˈkɛ.v**ə**n]	[ˈke.v**e**n]	[ˈke.v**i**n]	'Kevin'
h.	[ˈspɔn.s**ə**ɹ]	[ˈspon.s**e**ʁ]	[ˈspon.s**o**ʁ]	'sponsor'

In (56a), the variable adaptation of [ə] is due to the variable adaptation of [æ]. The [ə] takes on the form of the previous vowel, possible via harmony, though one cannot ignore the possible influence of English orthography here. In (56b), although [ə] is ordinarily adapted as /e/, some speakers prefer enhancing [ə] via harmony, producing [sinima] rather than the more common [sinema]. The same holds for (56c). In (56d), [ə] is adapted via orthography ([silabus]) or harmony ([silibus]). In (56e-h), [ə] is adapted via perception as /e/ or via English orthography (<a>, <a>, <i> and <o> respectively).

Such variable adaptation appears to be a result of speakers' perception of [ə] as being different from other vowels. Otherwise, the variation in its adaptation and the reliance on orthography and the appeal to harmony in more cases than is the case with other vowels cannot be explained. The only other vowel with as much variation as [ə] is [æ], which is adapted variably in 10 cases. However, unlike [ə], this variability is predicted on the basis of my model as a result of the difference between the SSBE and AE possible source vowels (§5.4.5.1).

This analysis may be supported by evidence from another vowel with considerable variation in adaptation, the English vowel [ɜ]. This vowel is deemed to be extremely foreign-sounding to Hebrew speakers, more so than any other English vowel. This is possibly a result of the huge *jnd* differences between this vowel and all existing Hebrew categories. Briefly put, while the F1 (height cue) of the vowel is identical to Hebrew /o/ and close to Hebrew /e/, the F2-F1 (backness cue) is closest to Hebrew /a/. These "mixed" signals could cause speakers to have difficulties categorising the vowel in Hebrew.

(57) *[ɜ] in adaptation*

	English (L2)	Hebrew (L1)	
a.	[rɪ.ˈv**ɜ**ɹs]	[re.ˈv**e**ʁs]	'reverse'
b.	[ˈs**ɜ**ɹ.vəɹ]	[ˈs**e**ʁ.veʁ]	'server'
c.	[**ɜ**ɹɫ gɹeɪ]	[ˈ**e**.ʁel gʁei]	'Earl Grey'
d.	[ˈwɛnt.w**ɜ**ɹθ]	[ˈwent.w**e**ʁt]	'Wentworth (Miller)'
e.	[ˈk**ɜ**ɹ.səɹ]	[ˈk**e**ʁ.seʁ]	'cursor'
f.	[ˈti.ʃ**ɜ**ɹt]	[ˈti.ʃ**e**ʁt]	'T-shirt'
g.	[ˈswet.ʃ**ɜ**ɹt]	[ˈswe.t͡ʃ**e**ʁ]	'sweatshirt'
h.	[ˈhænd.w**ɜ**ɹk]	[ˈhend.w**e**ʁk]	'handwork'
i.	[ˈnɛt.w**ɜ**ɹk]	[ˈnet.w**o**ʁk]	'network'
j.	[ˈpæs.w**ɜ**ɹd]	[ˈpas.w**o**ʁd]	'password'
k.	[fl**ɜ**ɹt]	[fl**i**ʁt]	'flirt'
l.	[ˈd͡ʒ**ɜ**ɹ.nl̩]	[ˈdʒ**u**ʁ.nal]	'journal'

Although [ɜ] is adapted as /e/ in the majority of cases (57a-h), it may be adapted otherwise, probably due to orthography (57i-l). Note the adaptations in (57h-i), where the identical vowels are adapted differently. [ɜ] adaptation is similar to [ə] adaptation in its versatility. This may be due to acoustic proximity, however, although my similarity model finds [ə] to be overwhelmingly more similar to Hebrew [e] than to other Hebrew vowels, this is not the case for [ɜ]. Although the categorisation experiment in §6.2.2 shows speakers adapting [ɜ] as /e/ more than the other vowels, it is still more likely to be adapted as something other than /e/, as shown in table (58):

(58) *Categorisation of SSBE[ɜ] by Hebrew speakers*

	/i/	/e/	/a/	/o/	/u/
[ɜ]	0%	44.3%	4.3%	30.4%	21.1%
	0/280	124/280	12/280	85/280	59/280

Since [ɜ] is deemed to be extremely foreign sounding by Hebrew speakers (hence the erratic categorisation patterns, unrivaled by any other vowel in the experiment), they may classify it as having no Hebrew equivalent and simply use the standard epenthetic vowel instead. This scenario is more likely, in my opinion, based on the categorisation experiment's results.[51]

Phonologically constrained adaptation (perceptual similarity in §7.1.1, harmony in §7.1.2, enhancement in §7.1.3) is not the only source determining vowel quality. Orthography can be shown to play a major role too, as shown in the following §7.1.4.

7.1.4. Orthography-based adaptation: Spelling pronunciation

In addition to auditory inputs, speakers may be exposed to orthographic inputs. These, in turn, may affect the lexical form of the new L1 loanword (see §2.2.1.1 for further discussion of various approaches to orthography in loanword adaptation).

Although orthographic input is not phonological, it certainly has phonological implications via spelling pronunciation (Schwarzwald 1998). While the orthography per se might not influence the grammar, it could artificially override the grammar (Paradis 1996) when forming lexical representations. Vendelin and Peperkamp (2007) present experimental evidence showing that orthography indeed does have an effect on loanword adaptation. Speakers exposed to orthography adapt differently to

[51] Preliminary tests have shown that Hebrew speakers categorise what they judge to be extremely foreign sounding as /e/, such as is the case with [ɯ].

speakers not exposed to orthography. Similar evidence is presented in Escudero et al. (2008) for their experiments on novel L2 word learning with and without orthography. Loanword grammar, therefore, cannot focus solely on corpora of loanwords, but rather, experimental non-orthographic data is necessary to control for the effects of orthography.

I accept Vendelin and Peperkamp's (2007) view that the orthographic form in L2 may serve as the basis for the phoneme in L1. I repeat here two criteria I propose in §2.2.1.1 which can be used to determine whether the source of an L1 form is necessarily orthographic:

a. Lack of *paradigmatic* relationships: in some cases, segments can be recovered via an L2 paradigm. For example, English [ˈsɪ.nə.m**ə**] 'cinema' is adapted as /ˈsi.ni.m**a**/ or /ˈsi.ne.m**a**/ in Hebrew. The first schwa's adaptation could be attributed to the standard epenthetic vowel in Hebrew (§7.1.3), to perception (§7.1.1) or to vowel harmony (§7.1.2). The second schwa's adaptation (in bold) cannot be attributed to any of these three sources. So how come it is recovered as /a/? This could be attributed to the effect of [sɪ.nə.ˈm**æ**.tɪk] 'cinematic' or to an orthographic effect.[52] Therefore, it is not clear orthography plays a role in this word's adaptation, as reference to the paradigm could be influential here. When a paradigm might be exploited to recover "missing" segments, orthography cannot necessarily be claimed to be the only source of recovery, but only a possible source. On the other hand, the adaptation of the [ə] in [ˈɛ.vən] 'Evan' as /a/ can only be attributed to orthography as no paradigm exists from which the /a/ can be recovered.
b. The English *pronunciation* is not acoustically similar to the Hebrew output: For example, English [ʌ] is almost identical acoustically to Hebrew [a]. Since [k**ʌ**t] 'cut' is adapted as [k**a**t], this requires no reference to the orthography as the two

[52] It could also be attributed to alternate pronunciations of 'cinema' in English, which do not reduce the final vowel to a schwa.

are acoustically identical. However, in the case of [ˈmɪ.ni.b**ʌ**s] which is adapted as [ˈmi.ni.b**u**s], this requires reference to the orthography as the English and Hebrew pronunciations are not acoustically similar.

If a segment cannot be recovered via a paradigm and if its pronunciation is not acoustically similar to the L2 pronunciation, then its source cannot be perception-based, relying on acoustic similarity. Such cases may be evidence of orthographic input. In the corpus in §6.1, ~25% (346/1383) of the words are affected by orthographic input (i.e. the vowel source cannot be shown to be anything else).

Evidence for orthographic input can be found in the many cases in which English phonetically produces a schwa [ə]. In English, unstressed vowels are often reduced to schwas (e.g. Kenstowicz 1994:550), yet these may surface in Hebrew pronounced according to their English orthography as shown in the following table (59) repeated from §2.2.1.1:

(59) *Variable schwa adaptation*

	Orthography	English (L2)	Hebrew (L1)
a.	Ev**a**n (name)	[ˈɛ.v**ə**n]	[ˈe.v**a**n]
b.	Kev**i**n (name)	[ˈkɛ.v**ə**n]	[ˈke.v**i**n]
c.	Linc**o**ln	[ˈlɪŋ.k**ə**n]	[ˈliŋ.k**o**.len]
d.	syll**a**b**u**s	[ˈsɪ.l**ə**.b**ə**s]	[ˈsi.l**a**.b**u**s]

Regarding spelling-pronunciation, some who reject the orthographic influence in loanword adaptation base their arguments, inter alia, on examples such as <b**u**ilding> becoming [i] in French (LaCharité and Paradis 2005). Orthography, they say, should produce /u/. However, just because we have <ui> in orthography does not mean that we should get /ui/ in L1. Spelling-pronunciation refers to a set of rules used in the transfer of vowels from orthography to pronunciation. The convention could simply be that <ui>→/i/.

Yet another example is vowel sequences in English orthography. When pronounced as monophthongs in English, they surface as monophthongs in Hebrew (e.g. [ˈdæʃ.bɔɹd] 'dashb**oa**rd' → [ˈdeʃ.b**o**ʁd] and not *[ˈdeʃ.b**o**.**a**ʁd]). Indeed, such examples are given in Paradis & LaCharité (1997) and LaCharité and Paradis (2005) regarding English loans in French as evidence that there is no reference to the orthography.

Similarly to the above case, <oo> is not adapted as /oː/ or /o/ and orthographically word-final "silent" <e> in English is never pronounced (e.g. [beɪs] 'base' <base> would never become /ba.se/ in Hebrew).

In addition, if the orthography and pronunciation are "too" distant from one another, as is the case with <busy> and <business>, then there may be a stronger incentive to ignore orthography. Recall the discussion in §2.2.1.1.

The best examples of extreme orthographic-phonetic mismatches are the <gh> sequences in English orthography which invariably surface in Hebrew according to their English pronunciation, or lack thereof (e.g. [bæk l**aɪ_t**] 'back light' → [bek l**ai_t**] vs. [ɹʌ**f** kʌt] 'rough cut' → [ʁa**f** kat]), and never surface as [g] or suchlike.

On the other hand, some "silent" consonants in English may sometimes surface in Hebrew via the orthographic representation in English. For example, the second /l/ in the Hebrew [ˈmæl.kəm]→[ˈmal.ko.**l**em] 'Malcolm', the second /l/ in the Hebrew [ˈlɪŋ.kən]→[ˈliŋ.ko.**l**en] 'Lincoln', and the /l/ in [pɑm]→[palm] 'palm' can only be derived via the orthography.[53]

In sum, there are conventions and principles for orthographic adaptation. Granted, audition and phonology are responsible for the bulk of adaptation, but orthography can be shown to have a considerable effect on adaptation, as shown

[53] [palm] is the only word in the Hebrew corpus with a sonorant-sonorant coda cluster.

above. I further discuss the interaction between the orthographic and auditory inputs in §7.4.

7.2. Multi-sourcing: Prosodic similarity

In addition to ensuring segmental similarity, maintaining the L2-L1 similarity in adaptation requires the preservation of L2 prosodic structures during the transfer into L1. Syllable structure (§7.2.1) is not changed unless L1 prosodic constraints require this, and stress position is hardly ever changed (§7.2.2). Both syllable structure and stress position are preserved in order to respect a blanket constraint requiring input-output prosodic identity.

In the adaptation of English loanwords into Hebrew, however, the various components of the prosodic form are treated differently. While stress is preserved almost religiously, as Hebrew nouns have lexical stress and can potentially stress any syllable in a word, syllable structures are adjusted since English and Hebrew differ in their ranges of permissible structures.

7.2.1. Syllable structure similarity

In some cases, the source of the vowel in the output may not be the acoustic or orthographic input. Rather, the vowel may have no direct L2 segmental correspondent, i.e. it may be the product of various structural constraints. These constraints may serve as the source for certain vowels in the L1 lexical representation, overriding a general requirement for prosodic identity between the L2 input and L1 output. Note, while it may be that the epenthetic vowel is an illusory vowel "perceived" by L1 speakers even though it has no correspondent in the L2 phonetic form (Dupoux et al. 1999), this illusory perception is nevertheless a result of the L1 constraints on prosodic forms.

Epenthetic vowels in loanwords have no segmental correspondent in L2. Their quality, however, may be determined by the L2 input via harmony, enhancement or orthography (see §7.1).

Modification of syllable structure via epenthesis is almost invariably a direct result of the adaptation of illicit syllable structures. There are two ways for an L2 word to respect L1's syllable structure - vowel epenthesis and consonant deletion. I agree with Paradis (1996) and Paradis and LaCharité (1997) who claim that epenthesis (and, for that matter, deletion) is to be avoided so as to preserve the L2 input's prosodic structure, unless absolutely necessary to comply with L1's phonology. This maximizes the input-output similarity required in loanword adaptation. This is true for Kirgiz loanwords adapted from Russian (Gouskova 2002), Japanese loanwords (Shinohara 2004), Fijian (Kenstowicz 2007) and more.

Regarding epenthetic vowels, they themselves must be as "inconspicuous and thus closer to zero" (Kenstowicz 2007:323) if the output is to be as similar as possible to the input in which the vowel has no segmental correspondent, e.g. unstressed, short, lax vowels. In Hebrew, the standard epenthetic vowel used to resolve illicit clusters in native words is /e/. It is important to note that speakers can acoustically distinguish the consonant sequences in L2 from the CVC they produce after epenthesis even though they may not distinguish between them categorically (Davidson 2007).

Regarding consonant deletion, a consonant's susceptibility to deletion is scalar. The deletion of obstruents is preferred to that of sonorants, and the deletion in clusters is of the less prominent (acoustically) member (Kenstowicz 2007). Generally speaking, languages prefer epenthesis to deletion in cases of illicit syllable structures (Paradis and LaCharité 1997). This is supported by the data in Hebrew, and in my loanword corpus (§6.1) there is a single instance of consonant deletion, [ˈswɛt.ʃɜɹt]→[ˈswe.t͡ʃeʁ_] 'sweatshirt', but this motivated by morphological pseudo-paradigms (see §7.3.2). All illicit syllable structures in my corpus are resolved via epenthesis. Since I focus on vowels in this study, and since there are no cases of consonant deletion in loanword adaptation in Hebrew, I ignore this issue.

In principle, Hebrew's syllabic inventory (§3.3.1) includes clusters provided: (a) there is falling or level sonority towards the syllable margin (Hebrew strictly observes the Sonority Sequencing Generalisation); (b) sonorants are not syllabic; and (c) there is not a sequence of tautosyllabic sonorants (Bat-El 1994, Graf and Ussishkin 2002, Schwarzwald 2002/2004). Syllable structure in adaptation is not modified unless the L2 input's prosodic structure cannot comply with L1's phonology. Therefore, if these principles are violated in the L2 input, the result is almost invariably vowel epenthesis.[54]

Kenstowicz (2007) discusses epenthetic vowels as phonologically lacking their own inherent features (see also Anderson 1982 for schwa in French) and acquiring them from the local context instead, another strategy to render them inconspicuous and thus closer to zero, maximizing the input-output similarity. Kito and de Lacy (1999) discuss the realisation of cross-linguistic nature of epenthetic segments which, according to their account, are realised either as copies of nearby segments (Vowel Harmony), or as default segments. Note, in Hebrew, both strategies may apply (see following table (60)). According to de Lacy (2002:151), a certain configuration of constraints could result in the selected vowel as being neither the most sonorous (in Hebrew – [a]), nor the least sonorous (in Hebrew – [i] and [u]). In such a case, the language might select [e] as its epenthetic vowel. Why certain languages select full vowels (e.g. Hebrew's [e]), and others select schwas, reduced vowels, or "underspecified" and unmarked vowels (English [ə], Japanese [ɯ], Turkish [+high]) as their epenthetic vowels is beyond the scope of this paper.

The following table (60) includes examples of epenthesis from the corpus in §6.1:

[54] There are a handful of cases in which epenthesis is **not** motivated by syllable structure, but instead, is a direct result of reference to the orthographic representation, such as in the cases of [ˈmæl.kəm]→[ˈmal.ko.**l**em] 'Malcolm', [ˈlɪŋ.kən]→[ˈliŋ.ko.**l**en] 'Lincoln', and [pɑm]→[palm] 'palm'.

(60) *Vowel Epenthesis in Hebrew loanwords from English*

	English (L2)	Hebrew (L1)	
a.	[ɜɹ_ɫ gɹeɪ]	[ˈe.ʁ**e**l gʁei]	'Earl Grey'
b.	[fɪɫ_m]	[ˈfi.l**i**m]	'film'
c.	[ˈd͡ʒɛn.t_l̩.mən]	[ˈd͡ʒen.t**e**l.man]	'gentleman'
d.	[ˈaɪ.d_l̩]	[ˈai.d**e**l]/[ˈai.d**o**l]	'(American) Idol'
e.	[ˈd͡ʒɔɹ.d_n̩]	[ˈd͡ʒoʁ.d**e**n]/[ˈdʒoʁ.d**o**n]	'(Michael) Jordan'
f.	[ˈpɛ.dəs.t_ɫ̩]	[ˈpe.des.t**a**l]	'pedestal'

In (60a-b), sonorant sequences are resolved by epenthesis, and in (60c-f), illicit syllables with syllabic consonants are resolved by epenthesis. While in all cases in the above table the epenthesis is triggered by illicit syllable structure, the quality of the vowel may vary. First of all, although the epenthetic vowel is often /e/, the standard epenthetic vowel in Hebrew, as in (60a), (60c), (60d), and (60e), it is not always the case. Secondly, in (60d-e), speakers differ in the production of the epenthetic vowels.

In (60a) and (60c), the epenthetic vowel follows the Hebrew norm. In (60b), the quality of the vowel is affected by the previous vowel via vowel harmony (see §7.1.2). In (60d), variable pronunciations of the vowel are attested. While the standard epenthetic vowel is an option, /o/ is also a possibility, probably triggered by orthography. In (60e), we once again have variable pronunciations, /e/ following the standard and /o/ probably triggered by vowel harmony. Finally, the epenthetic vowel in (60f) is orthography based and does not follow the Hebrew norm.[55]

[55] It may be that there is an L3 effect here (see §6.1.2.1) insofar as the vowel is concerned. The reason I assume the vowel is nevertheless from the English source is that the word used in cinematography, which borrows heavily from US English.

7.2.2. Stress similarity

A general observation in loanword adaptation is that prominence patterns are religiously preserved, their preservation primarily motivated by their acoustic accessibility. Silverman (1992) shows that not only are prominence patterns preserved, but in languages such as Mandarin, where prominence may be a question of degree, even such degrees are preserved. In particular, English primary stress ordinarily corresponds to a high tone in Mandarin adaptations, secondary stress is often adapted as a mid tone, and unstressed syllables are adapted as toneless. The same applies in Fon (Kenstowicz 2001), Fijian (Kenstowicz 2007), Japanese loans from English (Shinohara 2004), and more. Hebrew is no different, and prominence (stress) patterns are preserved almost without exception.

Preserving stress patterns in adaptation does not necessarily require a violation of Hebrew phonological principles governing stress assignment (§3.3.2), since lexical stress is so abundant in Hebrew nouns. In general, a large variety of languages, and Hebrew is no exception, show that prominence in loanwords is preserved, sometimes even if this violates basic prominence patterns in L1.

Stress in Hebrew adaptations is, therefore, largely uneventful, with nothing much of interest taking place. Given this, the few cases (25/1383, ~1.8%) in which the stress pattern of English borrowings is *not* preserved in the Hebrew adaptation are of particular interest (see also §6.1.2.1). While some may be attributed to L3 influences (e.g. French influence in [ˈfɛs.tə.vəl]→/fes.ti.ˈval/ 'festival', [ˈnæ.ɹə.tɪv]→/na.ʁa.ˈtiv/ 'narrative'), or the Hebrew standard norm (final stress, §3.3.2), there are a number of adaptations in which the stress shift has no apparent trigger, as in the following table (61):[56]

[56] Spanish, Italian, Russian, German and others might be shown to influence the form in Hebrew even though the word itself was borrowed from English. In addition, semantics may play a role here too.

(61) *Weird stress shifts in adaptation*

	English (L2)	Hebrew (L1)		cf. (no shift)
a.	[məs.ˈ**kæ**.ɹə]	[ˈ**mas**.ka.ʁa]	'mascara'	[dɪs.ˈtɔɹ.ʃən]→[dis.ˈtoʁ.ʃen] 'distortion'
b.	[gɹə.ˈ**fi**ti]	[ˈ**gʁa**.fi.ti]	'graffiti'[57]	
c.	[ˈ**kæ**.nə.bɪs]	[ka.ˈ**na**.bis]	'cannabis'	[ˈdɪ.zən.gɒf]→[ˈdi.zin.gof] 'Dizengoff'
d.	[ˈ**dɪs**.təns]	[dis.ˈ**tans**]	'distance'[58]	[ˈbæ.ləns]→[ˈbe.lens] 'balance'
e.	[kɒm.ˈ**poʊ**.nənt]	[kom.po.ˈ**nent**]	'component'[59]	
f.	[ˈ**ɹi**.baʊn.dəɹ]	[ʁi.ˈ**baun**.deʁ]	'rebounder'[60]	[ˈsu.pəɹ.boʊl]→[ˈsu.peʁ.bol] 'Superbowl'
g.	[ˈ**mɑɹ**ʃ.mɛ.loʊ]	[maʁʃ.ˈ**me**.lou]	'marshmallow'[61]	
h.	[ˈ**pæm**.flɪt]	[pam.ˈ**plet**]	'pamphlet'	[ˈt͡ʃæn.dləɹ]→[ˈt͡ʃen.dleʁ] 'Chandler'

Although (61a) may be influenced by Spanish (where the English word comes from etymologically), the Hebrew term is borrowed from English, not Spanish. In (61b), the Italian source of the English form also has penultimate stress, like the English form. Therefore, the Hebrew stress pattern cannot be derived from the Italian form. In (61c), the Greek source of the English word also has initial stress. Therefore, the Hebrew stress pattern cannot be derived from the Greek or the English forms. In (61d-e), it is possible that the Hebrew stress pattern is determined on the basis of

[57] There are no other words in the corpus with a comparable prosodic structure in English (CVCVCV).
[58] Hebrew military terminology is largely borrowed from English for historical reasons. The word 'distance' as used in Hebrew is originally a military word describing a commander-soldier relationship.
[59] There are no other words in the corpus with a comparable prosodic structure in English (CVCCVCVCC).
[60] Note, [ˈɹi.baʊnd] adapts as [ˈʁi.baund], without stress shift.
[61] There are no other words in the corpus with a comparable prosodic structure in English (CVCCCVCVV). See also page 87 for discussion of English pronunciation.

some default stress rule (§3.3.2 and Fainleib 2008) as in both cases, the stress shifts to the final syllable which happens to be super-heavy. In (61f), the stress shifts to the super-heavy syllable too, but it is penultimate in this case. In (61g), the stress shifts to the penultimate syllable, something also attributable to the default stress pattern (Fainleib 2008 shows that final open syllables are less likely to be stressed). Closed final syllables, on the other hand, are more likely to be stressed in Hebrew (Fainleib 2008), which might explain (61h).

Note, however, that assuming some of the above cases of stress shift can be attributed to a Hebrew default or norm overriding the similarity requirements, it is not clear why the default or norm override the similarity requirements so rarely, which makes the few cases of stress shift all the more puzzling.

7.3. And now for something completely different

Despite all the above, there are cases in adaptation which seem to escape a straightforward linguistic analysis, but these are few and far between, and though their contribution to my theoretical analysis may be minimal, they are nevertheless worthy of mention.

7.3.1. Determining the similarity source: Perception and orthography in one word

In many cases, it is possible to determine unequivocally that the source of the adaptation is either perception or orthography. An L1 speaker not exposed to orthography has to rely on perception alone as the input. Extensive experimental evidence has shown that the introduction of orthography might affect the adaptation (Vendelin and Peperkamp 2007, Escudero et al. 2008 and more). In many cases, since orthographic and perceptual sources converge, it is impossible to determine the source of adaptation. However, in some cases, both perception and orthography may play a role in adaptation in a single word. There are three such cases in the corpus (§6.1):

(62) *Two-in-one: Orthographic and perceptual influences in a single word*

	English (L2)	Hebrew (L1)	
a.	[ˈli.gəɫ]	[ˈli.gal]	'(Boston) Legal'
		*[ˈli.gel]	
		*[ˈle.gal]	
b.	[ˈæ.dæks]	[ˈa.deks][62]	'addax (antelope)'
		*[ˈe.deks]	
c.	[ˈsɪ.lə.bəs]	[ˈsi.li.bus]	'syllabus'

In (62a), the adaptation of [ˈli.gəɫ] (as pronounced on Israeli television promos) requires reference to the perception of the first vowel, [i], and the orthographic representation of the second, [a]. A purely perceptual analysis would produce the *[ˈli.gel], while a purely orthographic analysis would produce *[ˈle.gal]. The case of 'addax' in (62b) is particularly interesting, as the quality of the two vowels is identical, yet the first is adapted as [a] due to orthography, while the second is adapted as [e], following perception (stress could possibly play a role here). And finally, the three vowels in (62c) 'syllabus' can be shown to come from three different sources. A perceptual analysis would explain the adaptation of the first vowel [ɪ] as [i]. The second vowel in the Hebrew form, [i] can only be the result of vowel harmony (orthography would produce [a], perception would produce [e]). The final Hebrew vowel [u] must come from the orthography (perception would produce [e]).

7.3.2. Pseudo-paradigm levelling

A handful of words seem to have undergone pseudo-paradigm levelling. Paradigm levelling is when various forms in a morphological paradigm are adjusted in order to

[62] Also adapted as [ˈa.daks]

be similar to one another. By pseudo-paradigm levelling I am referring to cases in which there is no true morphological or lexical paradigm, but rather, the paradigm is a figment of the speaker's imagination. In these cases, what should have been a straightforward case of adaptation via perception or orthography, is complicated by referring to lexical items *assumed* to be part of a morphological or lexical paradigm, as shown in the following table (63):

(63) *Pseudo-paradigm leveling*

	English (L2)	Hebrew (L1)	
a.	[ˈsu.pəɹ.boʊɫ]	[ˈsu.peʁ.**bol**]	'Superbowl'
	[ˈfʊt.bɔɫ]	[ˈfut.**bol**]	'football'
	cf. [ˈboʊ.lɪŋ]	[ˈbau.liŋg]	'bowling'
b.	[ˈswɛ.təɹ]	[ˈsve.**deʁ**]	'sweater'
	[ˈswɛt.ʃɜɹt]	[ˈswe.**t͡ʃeʁ**]	'sweatshirt'
	[ˈti.ʃɜɹt]	[ˈti.**ʃeʁt**]	'T-shirt'
	[flɜɹt]	[fliʁt]	'flirt'
c.	[ˈtju.nər]	[ˈ**tu**.neʁ]	'tuner (music)'
	[ˈtoʊ.nər]	[ˈ**tu**.neʁ]	'toner (ink)'
	[toʊn]	[ton]	'tone'
d.	[kæ.ˈfin]	[**ko**.fa.ˈin]	'caffeine'
	[ˈ**kɔ**.fi]		'coffee'
		[ka.ˈfe]	'coffee'

In (63a), the semantic association of 'Superbowl' with 'football' may trigger speakers to "level" the two, producing a single output [-bol] for [-boʊɫ] and [-bɔɫ]. Although the two are categorised similarly by speakers, we can nevertheless observe that in the semantically unrelated [ˈboʊ.lɪŋ], speakers distinguish the diphthong from the monophthong in [-bɔɫ] so the lack of distinction between the final syllable in 'Superbowl' and 'football' cannot be attributed to perception or orthography. It is also possible that stress plays a role here, the unstressed diphthong in 'Superbowl' adapted as a monophthong, while the stressed diphthong in 'bowling' is adapted as a diphthong. I have insufficient evidence for the effect of stress on diphthong adaptation.

The examples in (63b) show a similar levelling effect to (63a). While 'T-shirt' and 'sweatshirt' are clearly morphologically related, the latter's association with the word 'sweater' (considerably older than both 'T-shirt' and 'sweatshirt', something the [w]→/v/ adaptation reveals), may be the trigger for the deletion of the final [t] in [ˈswe.t͡ʃeʁ]. It cannot be based on perception or orthography, as 'flirt' and 'T-shirt' demonstrate.

The next example in (63c) is a little trickier. The much older 'tuner', together with the Hebrew orthography which does not distinguish /u/ from /o/ may be the reason for the adaptation of 'toner' as [ˈtu.neʁ], even though the two ('tuner' and 'toner') are unrelated semantically, the phonological similarity is striking. Note, 'tone', semantically related to both words, is adapted as [ton], suggesting that 'toner' should have been adapted as *[ˈto.neʁ] if perception and English orthography were the deciding factors.

The final example in (63d) is indeed weird. The Hebrew word for 'caffeine' seems to have been affected by the English word for 'coffee', even though Hebrew has its "own" form for coffee, borrowed from Arabic. So the pseudo-levelling in this case is between the adapted 'caffeine' and the English form of 'coffee'.

7.4. Integrating the various components: Dividing the workload

Once a speaker has made the conscious decision to fill a semantic void with an L2 form, the adaptation process can begin. Adaptation of an L2 input to its L1 output depends on a multitude of factors, from perceptual inputs, to the affects of native structural constraints and even UG. Alongside these phonetic and phonological phenomena, orthography and pseudo-paradigm levelling may play a role too.

How do the various discrete components of loanword adaptation interact with one another – the grammatical and the extra-grammatical, the abstract and the concrete? I discuss the interaction between the perceptual module and the orthographic module in §7.4.1. In §7.4.2, I address the role of L1 structural constraints and UG in the adaptation. I conclude with a graphic representation displaying the integration of the various components in §7.4.3.

7.4.1. Integrating perception and orthography

The L1 lexical representation is based on L2 input. This input, however, may have perceptual or orthographic sources (or even both, as in §7.3.1). The L1 lexical representation, therefore, has *two* possible input sources as follows:

(64) *Input sources*

[L2 Acoustic signal] $\Rightarrow$ /Input to L1/ $\Leftarrow$ <L2 Orthographic representation>

Given this, how do speakers decide which source to refer to? There are several possible factors in the decision (which may or may not be conscious).

The first factor is the presence (or lack thereof) of the sources. One of the sources may be absent. For example, in the categorisation experiment (§6.2.2), there was no orthographic representation on which the speakers could rely, and the formation of L1 categories was based solely on the perceptual input.

The second possibility is that both the acoustic and the orthographic input converge, i.e. the vowel in Hebrew acoustically closest to the incoming signal is also the vowel in Hebrew which "matches" the orthography. In such cases, regardless of which source is referred to, a single output is produced. Indeed, vowels which are adapted extremely consistently (e.g. [ʊ] <u>/<oo> → /u/, LaCharité and Paradis 2005) are precisely those for which the two inputs converge.

The third possibility is the problematic one. In some cases, even though both sources are present and predict different adaptations, i.e. clash with one another and do not converge, speakers are forced to ignore one or the other. The *perceptual* input may be rejected when the incoming auditory category is not close enough to native categories (see §7.1.3 regarding schwa and [ɜ]). Alternatively, the *orthographic* input may be rejected when the perceptual input is almost a perfect match to a native category (e.g. English [ʌ] <u> = Hebrew /a/ */u/). When all else is equal, either of the two sources may be selected. This may vary from speaker to speaker or even from word to word, and may be affected by established convention. In such cases, variable outputs are expected ([ˈɛ.vən] <Evan> = /ˈe.ven/, /ˈe.van/).

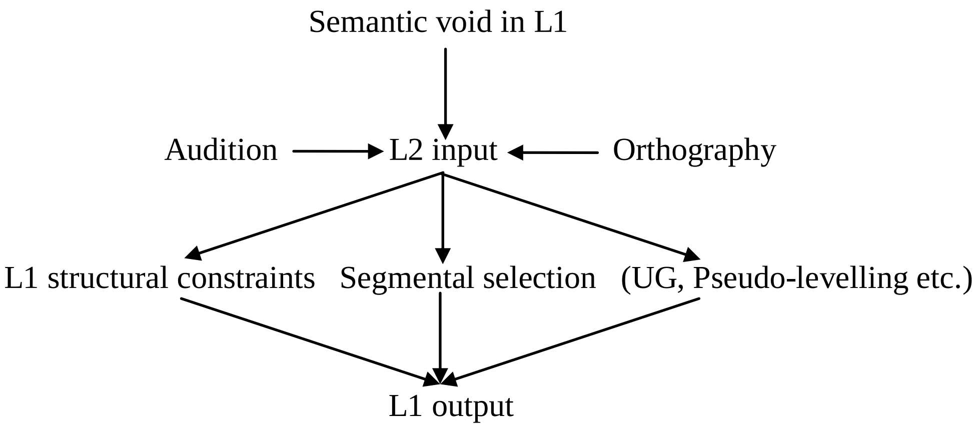
7.4.2. Integrating the input with structural constraints and UG

The suitability of the segmental input to L1 structural constraints has to be determined (stress, syllable structure). This can include epenthetic vowels in illicit structures, deletion, morphological modification etc. In addition, even further segmental adaptation may follow from the structural adaptation, such as in the case of vowel harmony. Where processes such as vowel harmony occur is by and large unpredictable.

7.4.3. A model of loanword adaptation

The process of loanword adaptation can be described as in the following diagram:

(65): *Various components in loanword adaptation*



As is the case with loanwords, the pragmatic necessity is the trigger for the adaptation. The lexical item in L2 suitable for filling the void may have two, possibly conflicting, forms, the auditory and orthographic. These forms undergo modification in order to ensure that they comply with L1 segmental and structural constraints. Schwa enhancement, epenthesis, deletion etc. are products of such constraints.

However, additional forces may play a role too, and their participation in the adaptation process is unpredictable (albeit minor). These forces, such as UG, analogical pseudo-levelling and L3 influences may affect the final output in L1.

Chapter 8. Concluding remarks

It all began with a generalization and an observation.

The *generalization* reached by many scholars of loanword adaptation is that adapting speakers strive to preserve the incoming form inasmuch as possible, to facilitate the recovery of its semantic content (§2.1) by others. Since languages do not permit all possible phonetic forms, incoming loans may have to be modified in some cases (§2.2) whilst maintaining this semantic transparency. This transparency can only be guaranteed if the modification of the loanword is minimal, and the output is as similar as possible to the incoming form. Most studies leave the formal definition of similarity to future studies, though some have addressed this issue, presenting various models for the quantification of similarity (§5).

The *observation* made is that the adaptation produces variable results, and the same incoming form may surface differently (§6.1). More specifically, when I began investigating Hebrew loanwords from English, I immediately noticed that English [æ] was equally as likely to be adapted as [a] or [e]. At first, this was a somewhat puzzling finding, since other vowels did not display such 50-50% patterns, though most vowels did have some variation (a puzzling finding in itself).

The formal model I propose (§5.4), therefore, has a twofold purpose. First of all, I presented a *quantifiable* definition of the notion of phonological similarity (§5). Secondly, I explained the variation in outputs which the model predicts. Loanwords in a language are the product of various inputs (whether they be orthographic or phonetic) and a grammar governing adaptation (§7). Phonological adaptation is the result of sound categorisation according to acoustic similarity to existing categories in a language.

The proposed model of similarity is tested with three different sets of data, all of which are assumed to be affected by similarity: (a) a corpus of Hebrew loanwords borrowed from English (§6.1); (b) experimental evidence testing category discrimination by Hebrew speakers (§6.2.1); and (c) experimental evidence testing categorisation of non-native segments by Hebrew speakers (§6.2.2).

The three sets of data provide ample support for the formal model, to varying degrees. The loanword data confirm the models' predictions to a large extent, with discrepancies being explained by the "contamination" of the corpus by non-phonological influences, or by additional phonological factors which the study did not focus on. The experimental data, devoid of any such contamination, support the model almost perfectly.

Finally, the grammar governing adaptation is a complex one (§7.4). It is insufficient to focus on phonetic input in order to predict adaptation patterns. Several additional factors play a role in adaptation. Orthography (§7.1.4), UG (§7.1.2), and meta-linguistic knowledge about L2's morphology (§2.2.1.2), inter alia, can be shown to influence adaptation. Therefore, the grammar has to incorporate, at the very least, the most influential factors, orthography and perception. Other influences may not be grammatically encoded, even though they may influence the grammar's output.

The model of similarity presented and tested in this study focuses on the adaptation of vowels from English into Hebrew. The acoustically based constraints presented here are by no means the only acoustically based constraints necessary for segmental and prosodic adaptation. Consonants would require additional constraints over and above those necessary for vowels. While it is possible to categorise Hebrew vowels on the basis of their first and second formants (adding the third formant in some cases), consonants differ from one another in additional aspects such as duration of closure, the absence or presence of aspiration and more. As these are all perceptually detectable characteristics of consonants, they can all be translated into a perception-based grammar by using *jnd*s. Constraints comparable to those presented for the vowels, can then be formulated.

Appendix I: Loanwords cited in dissertation

The following is a table of all the Hebrew loanwords cited in the dissertation. Capitalised words are proper nouns. Words without English phonetic forms were not borrowed from English. Variable pronunciations are separated by /. Primary stress is indicated in all polysyllabic words.

	English (orthography)	English (phonetic)	Hebrew (phonetic)
1.	abstract	ˈʔæb.stɹækt	ʔab.ˈstʁak.ti
2.	action	ˈæk.ʃən	ˈek.ʃen
3.	addax (antelope)	ˈæ.dæks	ˈa.deks / ˈa.daks
4.	ambush	ˈæm.bʊʃ	ˈem.buʃ
5.	applet	ˈæ.plɪt	ˈe.plet
6.	art director	ɑɹt daɪ.ˈɹɛk.təɹ	aʁt dai.ˈʁek.toʁ
7.	assist	ə.ˈsɪst	a.ˈsist
8.	back light	bæk laɪt	bek lait
9.	balance	ˈbæ.ləns	ˈbe.lens / ˈba.lans
10.	banner	ˈbæ.nəɹ	ˈba.neʁ
11.	bars	bɑɹz	baʁz
12.	base drum	beɪs dɹʌm	beis dʁam
13.	Batman	ˈbæt.mæn	ˈbat.men / ˈbet.men
14.	big men (basketball)	bɪg mɛn	ˈbig.me.n-im
15.	black	blæk	blek
16.	block shot	blɒk ʃɒt	blak ʃat / blok ʃot / blak ʃot
17.	Bob	bɒb	bob
18.	body (of car)	ˈbɒ.di	ˈbo.di
19.	body builder	ˈbɒ.di ˈbɪl.dəɹ	ˈba.di ˈbil.deʁ
20.	Boolean	ˈbu.li.ən	ˈbu.li.an
21.	boom	bum	bum
22.	bowling	ˈboʊ.lɪŋ	ˈbau.liŋg
23.	box and one	bɒks ənd wʌn	boks / baks end wan
24.	brakes	bɹeɪks	ˈbʁek.s-im
25.	by reference	baɪ ˈɹɛ.fɹəns	bai ˈʁe.fe.ʁens
26.	by value	baɪ ˈvæl.ju	bai ˈvel.ju
27.	cache	kæʃ	keʃ
28.	cafeteria	kæ.fɪ.ˈtɪə.ɹi.ə	ka.pi.ˈte.ʁi.a / ka.fi.ˈte.ʁi.a
29.	caffeine	ˈkæ.fin / kæ.ˈfin	ka.fe.ˈin / ko.fa.ˈin
30.	cannabis	ˈkæ.nə.bɪs	ka.ˈna.bis
31.	cash	kæʃ	keʃ
32.	casting	ˈkæ.stɪŋ	ˈka.stiŋg
33.	catering	ˈkeɪ.tə.ɹɪŋ	ˈke.te.ʁiŋg
34.	centre	ˈsɛn.təɹ	ˈsen.teʁ

	English (orthography)	English (phonetic)	Hebrew (phonetic)
35.	Chandler	ˈt͡ʃæn.dləɹ	ˈt͡ʃan.dleʁ / ˈt͡ʃen.dleʁ
36.	chaos	ˈkeɪ.ɒs	ˈka.os
37.	chat	t͡ʃæt	t͡ʃet
38.	chips (potato)	t͡ʃɪps	t͡ʃips / ˈt͡ʃip.s-im
39.	chlorine		xloʁ
40.	cinema	ˈsɪ.nə.mə /-ʌ /-ɑ	ˈsi.ne.ma / ˈsi.ni.ma
41.	Cinema City	ˈsɪ.nə.mə ˈsɪ.ti	ˈsi.ne.ma / ˈsi.ni.ma ˈsi.ti
42.	class	klæs	klas
43.	close up	ˈkloʊ.sʌp	ˈklo.zap
44.	clutch	klʌt͡ʃ	klat͡ʃ
45.	cockroach		d͡ʒuk
46.	coffee		ka.ˈfe
47.	component	kɒm.ˈpoʊ.nənt	kom.po.ˈnent
48.	control	kən.ˈtɹoʊl	kon.ˈtʁol
49.	coproduction	koʊ.pɹə.ˈdʌk.ʃən	ko.pʁo.ˈdak.ʃen
50.	cursor	ˈkɜɹ.səɹ	ˈkeʁ.seʁ
51.	cut	kʌt	kat
52.	cut to cut	kʌt tə kʌt	kat tu kat
53.	dance	dæns / dɑns	dans
54.	dashboard	ˈdæʃ.bɔɹd	ˈdeʃ.boʁd
55.	default	ˈdi.fɔɫt / diˈ.fɔɫt	ˈdi.folt / di.ˈfolt
56.	delete	dɪ.ˈlit	di.ˈlit / de.ˈlit
57.	dialogue	ˈdaɪ.ə.lɔg	di.a.ˈlog
58.	disk	dɪsk	disk
59.	distance[63]	ˈdɪs.təns	disˈtans
60.	distortion	dɪs.ˈtɔɹ.ʃən	dis.ˈtoʁ.ʃen
61.	Dizengoff	ˈdɪ.zən.gɒf	ˈdi.zin.gof / ˈdi.zen.gof
62.	dolly track	ˈdɒ.li tɹæk	ˈdo.li tʁek
63.	double figures	ˈdʌ.bəl ˈfɪ.gəɹz	ˈda.bel ˈfi.geʁz
64.	dunk	dʌŋk	daŋk
65.	Earl Grey	ˈɜɹɫ gɹeɪ	ˈe.ʁel gʁei
66.	e-mail	ˈi.meɪɫ	ˈi.mel / ˈi.meil
67.	escape	ɪ.ˈskeɪp	e.ˈskeip
68.	Eskimos	ˈɛs.kə.moʊs	es.ki.ˈmo.s-im
69.	Evan	ˈe.vən	ˈe.van / ˈe.ven
70.	event	ɪ.ˈvɛnt	i.ˈvent
71.	fade	feɪd	feid
72.	fairy		fe.ˈja
73.	(AIG) Family	ˈfæ.mɪli	ˈfe.me.li
74.	fast break	fæst bɹeɪk	fast bʁeik

[63] Originally military term

	English (orthography)	English (phonetic)	Hebrew (phonetic)
75.	festival	ˈfɛs.tə.vəl	fɛs.ti.ˈval / pɛs.ti.ˈval
76.	film	fɪɫm	ˈfi.lim
77.	filth		ˈd͡ʒi.fa
78.	fine cut (cinema)	faɪn kʌt	fain kat
79.	flirt	flɜɹt	fliʁt
80.	float	floʊt	flout
81.	football	ˈfʊt.bɔɫ	ˈfut.bol
82.	format (computers)	ˈfɔɹ.mæt	foʁ.ˈmat / ˈfoʁ.mat
83.	forward	ˈfɔɹ.wəɹd	ˈfoʁ.woʁd
84.	front	fɹʌnt	fʁont
85.	fuse	fjuz	fjuz
86.	garage	gə.ˈɹɑʒ / gə.ˈɹɑd͡ʒ	ga.ˈʁaʒ
87.	gear	gɪəɹ	giʁ
88.	gentleman	ˈd͡ʒɛn.tl̩.mən	ˈd͡ʒen.tel.men / ˈd͡ʒen.tel.man
89.	golf	gɔlf / gɒlf	golf
90.	graffiti	gɹə.ˈfi.ti	ˈgʁa.fi.ti
91.	guard	gɑɹd	gaʁd
92.	handwork	ˈhænd.wɜɹk	ˈhend.weʁk
93.	heap (computers)	hip	hip
94.	house (music genre)	haʊs	haus
95.	ID (computers)	aɪ di	ai di
96.	(American) Idol	ˈaɪ.dl	ˈai.del / ˈai.dol
97.	image	ˈɪ.məd͡ʒ	ˈi.mid͡ʒ / ˈi.med͡ʒ
98.	in (trendy)	ɪn	in
99.	input	ˈɪn.pʊt	ˈin.put
100.	integer	ˈɪn.tɪ.d͡ʒəɹ	ˈin.te.d͡ʒeʁ / ˈin.ti.d͡ʒeʁ
101.	intelligent	ɪn.ˈtɛ.lɪ.d͡ʒənt	in.ti.li.ˈgen.ti
102.	jeep	d͡ʒip	d͡ʒip
103.	joint	d͡ʒɔɪnt	d͡ʒoint
104.	(Michael) Jordan	ˈd͡ʒɔɹ.dən	ˈd͡ʒoʁ.den / ˈdʒoʁ.don
105.	journal[64]	ˈd͡ʒɜɹ.nl̩	ʒuʁ.ˈnal / ˈd͡ʒuʁ.nal
106.	kangaroo	ˈkæŋ.gə.ɹu / kæŋ.gə.ˈɹu	ˈkeŋ.ge.ʁu / ˈkeŋ.gu.ʁu
107.	Kevin	ˈke.vən	ˈke.vin / ˈke.ven
108.	kiwi (fruit)	ˈki.wi	ˈki.wi / ˈki.vi
109.	laser	ˈleɪ.zəɹ	ˈlej.zeʁ
110.	(Boston) Legal	ˈli.gəl	ˈli.gal
111.	Lil(lian)	lɪɫ	lil / lul
112.	Lincoln	ˈlɪŋ.kən	ˈliŋ.ko.len

[64] [ʒuʁ.ˈnal] refers primarily to women's magazines, while [ˈd͡ʒuʁ.nal] refers to professional periodicals (e.g. the Wall Street Journal). The former was probably borrowed from or influenced by the French pronunciation, whereas the latter is truer to the English form.

	English (orthography)	English (phonetic)	Hebrew (phonetic)
113.	long	lɔŋ	long
114.	long shot	ˈlɒŋ ˈʃɒt	ˈloŋk.ʃot
115.	low post	loʊ poʊst	lou post
116.	Malcolm	ˈmæl.kəm	ˈmal.ko.lem
117.	manual	ˈmæ.nju.əl	ˈmen.ju.el
118.	marshmallow	ˈmɑɹʃ.mæ.loʊ / ˈmɑɹʃ.mɛ.loʊ / mɑɹʃ.ˈmæ.loʊ	maʁʃ.ˈme.low / ˈmaɹʃ.me.low / ˈmaʁʃ.me.low
119.	mascara	mæs.ˈkæ.ɹə / mæs.ˈkɑ.ɹə	ˈmas.ka.ʁa
120.	media	ˈmi.di.ə	med.j-ot
121.	medium shot	ˈmid.jəm ʃɔt	ˈmed.jum ʃot
122.	messenger	ˈmɛ.sən.d͡ʒəɹ	ˈme.sen.d͡ʒeʁ
123.	minibus	ˈmɪ.ni.bʌs	ˈmi.ni.bus
124.	narrative	ˈnæ.ɹə.tɪv	na.ʁa.ˈtiv
125.	net	nɛt	net
126.	network	ˈnɛt.wɜɹk	ˈnet.woʁk / ˈnet.weʁk
127.	Orange	ˈɔ.ɹɪnd͡ʒ	ˈo.ʁend͡ʒ / ˈo.ʁand͡ʒ
128.	palm	pɑm	palm
129.	pamphlet	ˈpæm.flɪt	pam.ˈplet
130.	pass	pæs / pɑs	pas
131.	password	ˈpæs.wɜɹd	ˈpas.woʁd
132.	pedestal	ˈpɛ.dəs.tḷ	ˈpe.des.tal
133.	performer	pəɹ.ˈfɔɹ.məɹ	pʁi.ˈfoʁ.meʁ
134.	pick and roll	pɪk ənd ɹoʊɫ	pik end ʁol
135.	popcorn	ˈpɒp.kɔɹn	ˈpop.ko.ʁen / pop.ˈko.ʁen
136.	project	ˈpɹɒ.d͡ʒɛkt	pʁo.ˈjekt
137.	puncture	ˈpʌŋk.t͡ʃəɹ	ˈpan.t͡ʃeʁ
138.	rap	ɹæp	ʁap / ʁep
139.	Reading	ˈɹɛ.dɪŋ	ˈʁi.diŋg / ˈʁe.diŋg
140.	rebound	ˈɹi.baʊnd	ˈʁi.baund
141.	rebounder	ˈɹi.baʊn.dəɹ	ʁi.ˈbaun.deʁ
142.	respect	ɹɪ.ˈspɛkt	ʁi.ˈspekt / ʁe.ˈspekt
143.	reverse	ɹɪ.ˈvɜɹs	ʁe.ˈveʁs
144.	rough cut	ɹʌf kʌt	ʁaf kat
145.	seal beam (automechanics)	siɫ bim	silb
146.	second guard	ˈsɛ.kənd gɑɹd	ˈse.kend gaʁd
147.	semester	sɪ.ˈmɛs.təɹ	se.ˈmes.teʁ / si.ˈmes.teʁ
148.	September	sɛp.ˈtɛm.bəɹ	sef.ˈtem.beʁ / sep.ˈtem.beʁ
149.	sequence	ˈsi.kwəns	ˈsi.kvens
150.	server	ˈsɜɹ.vəɹ	ˈseʁ.veʁ
151.	set	sɛt	set
152.	Shack (Shaquille)	ʃæk	ʃak

	English (orthography)	English (phonetic)	Hebrew (phonetic)
153.	show-off		a.ˈwanta
154.	slam dunk	slæm dʌŋk	slem daŋk
155.	speed (narcotic)	spid	spid
156.	sponsor	ˈspɔn.səɹ	ˈspon.seʁ / ˈspon.soʁ
157.	station (wagon)	ˈsteɪʃən	ˈstei.ʃen
158.	steroid	ˈstɪə.ɹɔɪd	ste.ʁo.ˈid
159.	story	ˈstɔ.ɹi	ˈsto.ʁi
160.	straight	stɹeɪt	stʁeit
161.	structure	ˈstɹʌk.tʃəɹ	stʁuk.ˈtu.ʁa
162.	suede		zamʃ
163.	Superbowl	ˈsu.pəɹ.boʊɫ	ˈsu.peʁ.bol
164.	sweater	ˈswɛ.təɹ	ˈsve.deʁ
165.	sweatshirt	ˈswɛt.ʃɜɹt	ˈswe.t͡ʃeʁ
166.	syllabus	ˈsɪ.lə.bəs	ˈsi.la.bus / ˈsi.li.bus
167.	talk	tɔk	tok
168.	template	ˈtɛm.plɪt] / tɛm.pleɪt	ˈtem.pleit
169.	test	tɛst	test
170.	text	tɛkst	tekst
171.	thread	θɹɛd	tʁed
172.	tire	ˈtaɪ.əɹ	ˈta.jeʁ
173.	tone	toʊn	ton
174.	toner (ink)	ˈtoʊ.nəɹ	ˈtu.neʁ
175.	Trafalgar	tɹə.ˈfæl.gəɹ	tʁa.fal.ˈgaʁ
176.	travel	ˈtɹæ.vəl	ˈtʁa.vel
177.	T-shirt	ˈti.ʃɜɹt	ˈti.ʃeʁt
178.	tuff (volcanic rock)	tuf	tuf
179.	tuner	ˈtju.nəɹ	ˈtu.neʁ
180.	user	ˈju.zəɹ	ˈju.zeʁ
181.	Washington	ˈwɔ.ʃɪŋ.tn̩	ˈwa.ʃiŋg.ton / ˈwo.ʃiŋg.ton
182.	web	wɛb	web
183.	Wentworth (Miller)	ˈwɛnt.wɜɹθ	ˈwent.weʁt
184.	Windows	ˈwɪn.doʊz	ˈwin.doz
185.	wow	waʊ	wau
186.	yoghurt	ˈjoʊ.gəɹt	ˈju.guʁt
187.	zoom	zum	zum

Appendix II: Tokens in discrimination experiment

The following is a table of the tokens used in the discrimination experiment (§6.2.1). The tokens were naturally produced by a native British speaker (non-rhotic dialect) and are transcribed accordingly. The words in each pair, and the pairs themselves were randomly ordered. Each contrast is represented in four different pairs and two identical pairs (control).

Group	Token #1		Token #2	
[ɪ] [iː]	mɪd	'mid'	mɪd	'mid'
	miːd	'mead'	miːd	'mead'
	tɪk	'tick'	tiːk	'teak'
	lɪp	'lip'	liːp	'leap'
	wɪt	'wit'	wiːt	'wheat'
	lɪd	'lid'	liːd	'lead'
[ʊ] [uː]	ɹʊk	'rook'	ɹʊk	'rook'
	fuːd	'food'	fuːd	'food'
	lʊk	'look'	luːk	'Luke'
	wʊd	'would'	wuːd	'wooed'
	kʊd	'could'	kuːd	'cooed'
	pʊl	'pull'	puːl	'pool'
[ɛ] [ɛː]	ˈmɛɹi	'merry'	ˈmɛɹi	'merry'
	stɛːd	'stared'	stɛːd	'stared'
	hɛd	'head'	hɛːd	'haired'
	ˈvɛɹi	'very'	ˈvɛːɹi	'vary'
	wɛd	'wed'	wɛːd	'wared'
	flɛd	'fled'	flɛːd	'flared'
[ɒ] [ɒː]	tɒt	'tot'	tɒt	'tot'
	hɒːt	'heart'	hɒːt	'heart'
	skɒf	'scoff'	skɒːf	'scarf'
	dɒk	'dock'	dɒːk	'dark'
	kɒt	'cot'	kɒːt	'cart'
	hɒd	'hod'	hɒːd	'hard'
[ɒ] [ʌ]	tɒf	'toff'	tɒf	'toff'
	rʌf	'rough'	rʌf	'rough'
	lɒk	'lock'	lʌk	'luck'
	pɒd	'pod'	pʌd	'pud'
	mɒk	'mock'	mʌk	'muck'
	tɒp	'top'	tʌp	'tup'

Group	Token #1		Token #2	
[æ] [ɛ]	dæm	'dam'	dæm	'dam'
	fɛn	'fen'	fen	'fen'
	sæk	'sack'	sɛk	'sec'
	kæt	'cat'	kɛt	'ket'
	æt	'at'	ɛt	'ate'
	pæk	'pack'	pɛk	'peck'
[ɒ] [ɔ]	lɒ:k	'lark'	lɒ:k	'lark'
	kɔ:n	'corn'	kɔ:n	'corn'
	kɒ:t	'cart'	kɔ:t	'caught'
	tɒ:t	'tart'	tɔ:t	'taught'
	pɒ:d	'parred'	pɔ:d	'pawed'
	ɒ:k	'arc'	ɔ:k	'auk'
[ɛ] [ɪ]	fɛt	'fet'	fɛt	'fet'
	pɪt	'pit'	pɪt	'pit'
	nɛt	'net'	nɪt	'nit'
	tɛk	'tech'	tɪk	'tick'
	lɛt	'let'	lɪt	'lit'
	sɛt	'set'	sɪt	'sit'
[ɛ] [ɜ]	zɛn	'Zen'	zɛn	'Zen'
	kɜn	'kern'	kɜn	'kern'
	hɛd	'head'	hɜd	'heard'
	tɛn	'ten'	tɜn	'turn'
	spɛnd	'spend'	spɜnd	'spurned'
	nɛd	'Ned'	nɜd	'nerd'

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תקציר

1. הקדמה

במחקר זה אני חוקר את מושג הדמיון (similarity) בפונולוגיה, תוך התמקדות ברלוונטיות של הדמיון לתהליך ההסגלה (אדפטציה, adaptation) של מילים שאולות, לקטגוריזציה של הגאים (סגמנטים, segments), ולהבחנה בין הגאים שונים בשפה.

המחקר מציע מודל פורמלי לכימות הדמיון ומציע מנגנון דקדוקי המנבא תהליכי שאילה ותפישה. על מנת לבנות את המודל המדובר, אני פונה למילים שאולות, שכן הסגלתן זוהתה זה מכבר כתהליך המבוסס על דמיון.

1.1. מדוע לחקור מילים שאולות?

ניתן לתהות מדוע מחקר של מילים שאולות רלוונטי במחקר מערכות פונולוגיות. היות שמקור השאילה הוא, בהגדרה, זר, לא ילידי, האם יש טעם כלשהו במחקר מילים שאולות בבואנו לעסוק במערכות לשוניות *ילידיות*?

למרות מקורן הזר, מילים שאולות משתלבות בתוך הלקסיקון המנטלי הילידי. לכן חקירת המילים השאולות יש בה כדי לשקף את אילוצי המבנה החלים על מבנים פונולוגיים, אילוצים הרלוונטיים לכל המילים בלקסיקון. הואיל וכל השפות החיות ממשיכות לשאול מילים, ומילים אלה ממשיכות לעבור הסגלה, תהא מערכת ההסגלה אשר תהא, הרי שמערכת זו חייבת להיות מערכת פעילה.

אעסוק בקצרה בלבד בשאלה אם המערכת האחראית להסגלה היא אותה המערכת הילידית (§2.2.2). מה שחשוב הוא שקיימת מערכת הסגלה, וכי היא מושתתת על דמיון.

1.2. דמיון

בבואנו לקרוא כל מחקר על הסגלת מילים שאולות, נראה כי הסגלה של הגאים היא שיטתית, לא שרירותית. הסגלה שיטתית מושתתת על דמיון. אנחנו הופכים את הגה א ל-ב ולא ל-ג, כי א דומה יותר ל-ב מאשר ל-ג. השאלה שעומדת בבסיס מחקר זה היא מה מדוע א דומה יותר ל-ב מאשר ל-ג. האם ניתן לתפוש את התכונה החמקמקה הזו במסגרת פורמלית, והאם היא ניתנת לכימות?

מושג הדמיון הפונולוגי מובא בשורה של מחקרים לשוניים כדי לתאר ולהסביר תופעות שונות. הסגלה של מילים שאולות מסתמכת על דמיון סגמנטלי ופרוזודי (למשל: Hyman 1970, Steriade 2001a,b, Kenstowicz 2001, Shinohara 2006, ועוד רבים אחרים), דפוסי חריזה בשירה תלויים בדמיון בין הגאים (למשל: Zwicky 1976, Kawahara 2007). יתרה מזו, היכולת שלנו להבחין בין קטגוריות שונות של הגאים תלויה במידת הדמיון בין ההגאים (למשל: Best et al. 2001, Escudero et al. 2007, Cohen et al. in progress). רשימת התופעות הפונולוגיות תלויות הדמיון עוד ארוכה.

נדמה, אם כן, שמושג הדמיון הינו רלוונטי ביותר לתאוריה פונולוגית. אני אדון בגישות השונות לדמיון ב-5§.

2. מבנה המחקר

2.1. מהן מילים שאולות?

כל מחקר על מילים שאולות חייב להתמודד תחילה עם זיהוי המילים האלה. השפה, הרי, משופעת במילים שמקורן אינו מתוכה, כגון מילים שהן חלק משיחה דו-לשונית, הפקות אידיוסינקרטיות של דוברים מסוימים, או מילים שהן חיקוי של הגייה זרה. מילים כאלה אינן מילים שאולות.

אני נוקט בגישתם של Paradis (1996) ושל Kenstowicz (2001), ומגדיר מילים שאולות כפריטים לקסיקליים שמקורם בשפה זרה (להלן: L2), והמופיעים בשיח בשפה השואלת (להלן: L1) על מנת למלא פער סמנטי. המילים משמשות בשיח L1 גם דוברים שהם חד-לשוניים, ושאינם מודעים בהכרח למקור המילה.

לעתים, מילים שאולות הן הלימות (compliant loanwords), כלומר מצייתות לעקרונות הדקדוק של L1 (2.1.1§). במקרים כאלה, המילים אינן דורשות שום הסגלה. למשל, המילה האנגלית [klʌt͡ʃ] 'clutch' נכנסה לעברית כפי שהיא, ללא שינויי הגייה, לקבלת הצורה [klat͡ʃ] 'מצמד', שכן הצורה האנגלית אינה מפרה את עקרונות הדקדוק של העברית (המבנה ההברתי תקין, ההגאים כולם קיימים בעברית, וכן הלאה). המילה האנגלית [sɛt] 'set' אף היא אינה עוברת הסגלה, ונכנסה לעברית כ-[set] 'מערכה'. הבדלי התעתיק ([ʌ]-[a] ו-[ɛ]-[e]) הם אורתוגרפיים בלבד, ומקורם במוסכמות התעתיק המקובלות לתנועות בעברית ובאנגלית. ההגאים בשני זוגות המילים זהים.

אולם, מה קורה למילים שאולות שאינן הַלימוֹת (non-compliant loanwords), כלומר מילים שצורתן אינה מצייתת לעקרונות של L1 (§2.1.2)? ובכן, מילים כאלה עומדות בפני שלוש אפשרויות: (א) **חסימה**, המילים לא ייכנסו ל-L1; (ב) **השתלבות**, המילים ייכנסו ל-L1 למרות חריגת המבנה. התוצאה היא מילה שאינה מצייתת לעקרונות של L1 לפני שאילת המילה, ואולם, עצם השאילה גורמת להרחבת המערכת של L1; (ג) **הסגלה**, המילה עוברת שינויים נדרשים על מנת להתאים למערכת של L1.

ההסגלה היא המוקד של המחקר הזה. דוגמאות למילים העוברות הסגלה מופיעות בטבלה (1) הבאה:

(1) *הסגלה סגמנטלית ופרוזודית*

	מקור באנגלית (L2)	עברית (L1)	
א.	[**θɹ**ɛd]	[**tʁ**ed]	'אשכולי'
ב.	[ˈk**ɜ**ɹ.səɹ]	[ˈk**e**ʁ.seʁ]	'סמן'
ג.	[ˈb**æ**.ləns]	[ˈb**e**.lens]	'איזון'
ד.	[g**ɪə**ɹ]	[g**i**ʁ]	'הילוך'
ה.	[ˈd͡ʒɜɹ.**nl̩**]	[ˈd͡ʒuʁ.**nal**]	'כתב עת'
ו.	[fɪ**łm**]	[ˈfi.**lim**]	'סרט צילום'

בדוגמאות לעיל ההגאים באנגלית שאינם חלק ממערך ההגאים בעברית עוברים הסבה להגאים המצייתים לעקרונות של העברית (**[t]**←**[θ]**, **[e]**←**[ɜ]**, **[ʁ]**←**[ɹ]**, **[e]**←**[æ]**, **[i]**←**[ɪə]**). המבנים ההברתיים באנגלית שאינם אפשריים בעברית עוברים אף הם הסבה. בדוגמה ה, הברה ללא תנועה באנגלית זוכה להחדרת תנועה בעברית (Graf and Ussishkin 2002, Schwarzwald 2002). בדוגמה ו רצף של עיצורים סונורנטיים, שאינו בר-ביצוע בעברית, זוכה אף הוא להחדרת תנועה (Ussishkin and Wedel 2003, Schwarzwald 2002).

בהמשך §2 אני דן בהגדרות פורמליות של מילים שאולות (§2.1.3, §2.1.4), ובמקורות השונים של המילים השאולות (§2.1.5).

ב-§2.2 אני עובר לדיון בהסגלה. תהליך ההסגלה מושפע ממספר רב של מקורות, והדיון פותח בהשפעות לא פונולוגיות על תהליך ההסגלה (§2.2.1), כגון אורתוגרפיה, ידע מורפולוגי מודע של L2 ו-L1 ועוד.

לעתים, הדרך היחידה להסביר את ההגאים ב-L1 היא על ידי התייחסות לאורתוגרפיה של L2 (§2.2.1.1). למשל, השם באנגלית [ˈlɪŋ.kən] 'Lincoln' מופיע בעברית כ-[ˈliŋ.k**o**.**l**en] 'לינקולן'. הופעת ההגה [l] בצורה העברית מקורה באורתוגרפיה האנגלית, שכן לרצף [ol] אין שום מימוש בהגייה האנגלית.

קיום או היעדר ידע מורפולוגי של הדוברים לגבי L2 יכול להשפיע על צורת המילים ב-L1. למשל, מוספיות נטייה בדרך כלל אינן עוברות בשאילה, דהיינו הדובר מפריד בינן לבין הבסיס, ורק הבסיס עובר שאילה (Silverman 1992). ואולם, לעתים מוספיות אלה נתפשות כחלק מן הבסיס והן עוברות הסגלה בשאילה, אך מאבדות את תוכנן הסמנטי. למשל, הצורה האנגלית [bɹeɪks] 'brakes' נכנסה לעברית כ-[ˈbʁek.s-**im**] 'בלמים'. מוספית הרבים של האנגלית [-**s**] מאבדת את תפקידה הסמנטי, ומוספית הרבים של העברית [-**im**] מצורפת לצורה השאולה.

אחרי הדיון בהשפעות לא פונולוגיות של השאילה, אני עובר לדיון העיקרי, האספקטים הפונולוגיים של השאילה (§2.2.2). עיקר הדיון בפרק זה עוסק בשאלה אם הפונולוגיה של המילים השאולות שונה מזו של מילים אחרות בשפה, דהיינו אם יש שתי מערכות פונולוגיות נפרדות, או שיש מערכת פונולוגית אחת המשמשת גם את המילים השאולות וגם את המילים הילידיות. שאלה זו נדונה באריכות בספרות (Itô and Mester 1999, Silverman 1992, Holden 1976, Boersma and Hamann 2008 ועוד רבים). העובדות ברורות. לעתים קרובות מילים שאולות מציגות תופעות השונות מאלה הקיימות במילים הילידיות, ואולם הנחת העבודה היא כי אין זה מחייב שתי מערכות שונות.

Smith (2005) מייצגת את הגישה האומרת שקיימת מערכת פונולוגית אחת בשפה, ושההבדל בין המילים השאולות לבין המילים הילידיות ניתן להסבר באמצעות עקרונות ואילוצים הדורשים דמיון בין המילים השאולות לבין שפת המקור שלהן. עקרונות אלה אינם משפיעים על המילים הילידיות, מן הסתם.

Kenstowicz (2001/2007) ו-Shinohara (2004) מייחסים את ההבדלים בין המילים השאולות לבין המילים הילידיות לעקרונות אוניברסליים.

2.2. הפונולוגיה של העברית

לאחר הגדרת המילים השאולות והסברים על מהותן, אני עובר לחקור את הסגלת המילים השאולות בעברית בת-זמננו (להלן: עברית). לצורך העניין, אני מציג סקירה מקיפה של המערכת הפונולוגית של העברית ב-§3.

תחילה, מוצג רקע פונולוגי כללי של השפה עם התייחסות נפרדת לעיצורים ולתנועות. מכיוון שהמחקר שלי עוסק בעיקר בדמיון בין תנועות, סקירת העיצורים (§3.1) הינה מצומצמת. סקירת התנועות (§3.2) כוללת דיון בתכוניותיהן הפונולוגיות ובמאפיינים האקוסטיים השונים של התנועות.

לאחר הצגת מערכת ההגאים בעברית, מוצגים העקרונות הפרוזודיים של השפה (§3.3) שלהן השלכות על מערכת הטעם ומבנה ההברות בעברית.

2.3. המסגרת התאורטית של המחקר

הפרק הבא (§4) מציג את התאוריות שבמסגרתן נערך מחקרי. במרכז עומדת תאוריית האופטימליות (§4.1) והגרסה הסטוכאסטית שלה (§4.2).

תאוריית האופטימליות (Prince and Smolensky 1993) היא תאוריה של דקדוק המבוססת על אילוצים ועל האינטראקציה ביניהם. המודל הדקדוקי של האופטימליות מניח שני מרכיבים עיקריים: GEN (generator), המייצר את כל הצורות האפשריות של מילה, ו-EVAL (evaluator), המשווה בין הצורות האפשריות השונות ובוחר את האופטימלית מביניהן. ההנחה היא ש- GEN יכול לייצר אינסוף צורות שונות, אבל EVAL ישווה בין הצורות האלה ויכריע בעד "הטובה", המתאימה, ביותר לשפה. הערכה זו נעשית על ידי שימוש באילוצים מדורגים. המועמדים מושווים כנגד האילוצים, החל מן האילוץ המדורג גבוה ביותר, ובסדר יורד, כנגד כל אחד מן האילוצים הבאים. מועמדים המפרים את האילוץ הגבוה ביותר נפסלים, וכך בסדר יורד עד שנשאר מועמד יחיד. אין זה משנה אם מועמד זה מפר אילוץ כלשהו, כל עוד שאר המועמדים מפרים אילוצים גבוהים יותר. לכן הצורה האופטימלית אינה דווקא צורה מושלמת, אלא הצורה הטובה ביותר מבין הצורות האפשריות.

הגרסה הסטוכאסטית של האופטימליות (Boersma 1998, Boersma and Hayes 2001) דומה באופי שלה לזו הבסיסית. ההבדל הוא שכאן האילוצים מדורגים על גבי סקאלה הסתברותית.

במקום שנטען שאילוץ א מדורג תמיד מעל אילוץ ב, אנחנו נטען שאילוץ א מדורג מעל אילוץ ב ב-80% מן המקרים, והדקדוק עשוי להפיק פלטים שונים מהערכה אחת למשניה.

לאחר הצגת תאוריית האופטימליות, אני עובד מציג מונח מרכזי במודל שלי, *just noticeable differences* (§4.3). היות שאני מניח, בעקבות Steriade (2001a,b) שקטגוריזציה של הגאים היא על בסיס השוואה תפישתית-אודיטורית, הכרחי יהיה לבסס קטגוריזציה זו על מונחים אודיטוריים. ה-*just noticeable difference* (*jnd*) הוא השינוי המזערי שגירוי כלשהו חייב לעבור על מנת שמערכת החושים שלנו תוכל להבחין בשינוי. שינוי זה, כך נטען על ידי Weber ב-1834 הוא ביחס ישר לגודל הגירוי: ככל שהגירוי גדול יותר, כך השינוי בו צריך להיות גדול יותר כדי שנוכל להבחין בו.

2.4. מהו דמיון?

הפרק הבא (§5) עוסק במושג הדמיון בכלל, והדמיון הפונולוגי בפרט. לאחר הצגת שתי גישות קודמות (Frisch et al. 2004, Best et al. 2001), אני עובר להצגת מודל הדמיון שפיתחתי (§5.4). מודל זה מניח כי קביעת הדמיון הפונולוגי בין הגאים מבוסס בראש ובראשונה על תפישת ההגאים (Zwicky 1976, Hyman 1970, Steriade 2001a,b , Kenstowicz 2007 ועוד). מדוע? בשומענו הגה מסוים, אנחנו חשופים לאות (signal) האודיטורי בלבד והוא הקלט היחיד למערכת שלנו. הקטגוריזציה של ההגה המסוים הזה היא למעשה השוואה בין ערכי האות האודיטורי הנקלט לבין הערכים שאליהם אנחנו "רגילים". למשל, בשומענו תנועה זרה, אנחנו משווים אותה לערכים הממוצעים של התנועות בעברית, וכך עושים את הקטגוריזציה שלה.

כיצד נעשית ההשוואה? הקלט (ההגה הנכנס) עובר הערכה באמצעות מערכת אילוצים המבוססים על *jnds*. ערכי ההגה הנכנס מושווים לערכי ההגאים הקיימים בשפה. ככל שהפער התפישתי בין ההגה הנכנס לבין הגה מסוים בשפה הוא גדול יותר, כך הדמיון בין ההגאים קטן יותר ולכן הסיכוי שזו תהיה ההסגלה של ההגה קטן יותר. למשל (בגרסה מעט פשטנית), אם ההגה הנכנס הוא תנועת [u] האנגלית, התנועה מושווית לכל חמש הקטגוריות של התנועות בעברית. ההגה האנגלי הכי "מרוחק" מבחינה תפישתית מן ההגאים העבריים בסדר היורד הבא:

[u]>>[o]>>[a]>>[e]>>[i]. דהיינו, ההתאמה בין ההגה האנגלי [u] בין ה-[i] העברית היא הגרועה ביותר. אחר-כך נפסל ההגה [e] כמתאים, ושאר ההגאים בסדר יורד, עד שנשארת אופציה אחת בלבד

להסגלה – [u], לא מפני שתנועת [u] העברית זהה לתנועה האנגלית (היא אינה זהה), אלא מפני שהיא הכי פחות גרועה מבין האפשרויות הקיימות.

2.5. מקורות נתונים

המחקר אינו רק מחקר תאורטי. ניבויי התאוריה מושווים לכמה מקורות אמפיריים: (א) קורפוס; (ב) ניסוי הבחנה; (ג) ניסוי קטגוריזציה.

הקורפוס (§6.1) שנבנה לצורך מחקר זה מכיל 1383 מילים שנאספו ממגוון מקורות. חלק מן המילים נאספו מדוברי עברית ילידיים ששוחחו עמי על שלושה תחומי עיסוק (ספורט, מחשבים, קולנוע). בריאיון שהתנהל בעברית, התבקשו האינפורמנטים לספר לי על תחומי העיסוק שלהם וכל המילים השאולות מאנגלית הוקלטו ותועתקו על ידי. בנוסף למילים אלה, נאספו מילים מן התקשורת האלקטרונית, מהפקות ספונטניות ומפרסומים קודמים. שלושה עקרונות הנחו אותי באיסוף המילים כולן. כל המילים משמשות דוברי עברית בשיחה בעברית, כל המילים שאולות מאנגלית, והמילים אינן מילים ממוסדות.

בניסוי ההבחנה (§6.2.1) הצגתי ל-57 דוברי עברית 54 זוגות מילים באנגלית המדגימים 9 הבחנות שונות (לכל הבחנה 4 זוגות מינימליים ושני זוגות ללא הבדל בתנועה). המשתתפים בניסוי נדרשו לומר אם זוג המילים זהה או שונה.

בניסוי הקטגוריזציה (§6.2.2) השמעתי ל-28 דוברי עברית תנועות באנגלית בריטית ואנגלית אמריקאית. הדוברים היו צריכים לקבוע לאיזו תנועה עברית ההגה שהם שמעו הוא הקרוב ביותר. כל ההגאים הושמעו 10 פעמים בסדר אקראי.

2.6. תפקיד הדמיון בהסגלה

עם סיום הצגת המודל התאורטי להערכת דמיון (§5) ופריסת הנתונים (§6), אני עובר להצגת תפקידו של הדמיון בפונולוגיה בכלל, ובשאילה בפרט (§7).

תחילה, ישנו דיון מעמיק בדמיון בין הגאים (§7.1), שהוא הגורם העיקרי בהסגלה. הדמיון האקוסטי, כפי שמנבא המודל (§5), מוערך כנגד נתוני האמת מן הקורפוס ומן הניסויים. חלק מנתוני השוואה זו מופיעים בטבלה (2) (הטבלה המלאה מופיעה ב-§7.1.1):

(2) *הסגלה המבוססת על דמיון – ניבוי המודל מול נתונים מניסויים ומהקורפוס (ערכים הקטנים מ-5% מושמטים. ההדגשה מראה אחדות בין הניבוי למקורות האמפיריים)*

אנגלית	עברית	ניבוי מודל	ניסוי קטגוריזציה	קורפוס	דוגמאות
[i]	/i/	**95%**	**92%**	**98%**	[hip]→/hip/ 'heap'
	/e/	5%			[spid]→/spid/ 'speed'
[ɛ]	/i/	10%			[nɛt]→/net/ 'net'
	/e/	**88%**	**98%**	**98%**	[wɛb]→/web/ 'web'
[æ]	/i/	17%			[t͡ʃæt]→/t͡ʃet/ 'chat'
	/e/	**83%**	**99%**	**49%**	[pæs]→/pas/ 'pass'
	/a/			**49%**	

לאחר הדיון בדמיון האקוסטי, נדונים כמה משתנים נוספים בהגדרת דמיון בהסגלה. הרמוניה תנועתית ועקרונות אוניברסליים (§7.1.2) יכולים להשפיע על קביעת צורת המילה השאולה. למשל, התנועה השנייה בהסגלה של המילה האנגלית [ˈkæŋ.ɡə.ɹu] 'kangaroo' לעברית, [ˈkeŋ.ɡ**u**.ʁu] 'קנגורו', נקבעת בעקבות הרמוניה תנועתית בינה לבין התנועה שאחריה.

הגורם המשפיע השני בחשיבותו על ההסגלה הוא האורתוגרפיה. דיון מעמיק בהסגלה על בסיס אורתוגרפי (§7.1.4) הוא הכרחי על מנת להבין את דפוסי ההסגלה בשפה. למרות שקלט אורתוגרפי אינו קלט פונולוגי, הוא אכן יכול להשפיע על קטגוריזציה של הגאים ועל פלט המילים השאולות (Paradis 1996, Vendelin and Peperkamp 2007, Escudero et al. 2008 ועוד).

מעבר לדמיון ברמת ההגאים, גם האילוצים הפרוזודיים של השפה יכולים להשפיע על צורתה הסופית של המילה השאולה (§7.2). מבנה ההברה של המילה השאולה מ-L2 חייב להתאים למבני ההברה האפשריים בשפת היעד L1. אם אין התאמה פרוזודית כזו, אז המילים יעברו שינויים על ידי החדרה או השמטה של הגאים (Paradis and LaCharité 1997, Gouskova 2002, Shinohara 2004 ועוד). למשל, הצרור המודגש במילה האנגלית [ɜ**ɹɫ** ɡɹeɪ] 'Earl Grey' הוא בלתי אפשרי בעברית, ולכן מוחדרת תנועה ומתקבלת הצורה העברית [ˈe.**ʁel** ɡʁei] 'ארל גריי'.

כמו כן, בהסגלה של מילים שאולות, תועדה עד כה הקפדה מרשימה בשמירה על מיקום הטעם. הדבר נראה במנדרין (Silverman 1992), ב-Fon (Kenstowicz 2001), ביפנית (Shinohara 2004) ועוד. עברית אינה יוצאת דופן בהקשר זה, ומספר המקרים שבהם מיקום הטעם אינו נשמר הוא מזערי (פחות מ-2% מהמילים בקורפוס).

המרכיבים השונים בהסגלה של מילים שאולות מובאים יחדיו כמכלול במודל הדקדוק המוצג ב-§7.4. במודל זה, האינטראקציה בין מרכיבי ההסגלה (קלט אודיטורי מ-L2, קלט אורתוגרפי, אילוצי המבנה ההברתי, השפעות דקדוק אוניברסלי וכו') מפיקה את הצורה הסופית של המילה, את הפלט ב-L1.

לסיכום, מחקר זה החל בהכללה ובהבחנה. ההכללה הייתה שמילים שאולות שואפות לשמור על דמיון צורני, ככל האפשר, בינן לבין צורת המקור ב-L2, וזאת על מנת לאפשר שחזור של המידע הסמנטי על ידי אחרים. הואיל ושפות אינן מאפשרות את כל ההפקות הפונטיות, יש מצבים שבהם הדוברים נאלצים לבצע שינויים בצורת המילה השאולה, תוך שמירה על שקיפות סמנטית. שינויים אלה חייבים להיות מזעריים. דהיינו, על הפלט ב-L1 להיות דומה ככל האפשר לצורת המקור ב-L2. ואולם, רוב המחקרים משאירים את הגדרת הפרמטרים של הדמיון למחקרים עתידיים.

ההבחנה הייתה שהסגלה של מילים שאולות מפיקה תוצאות משתנות. צורות זהות ב-L2 יכולות להופיע באופנים שונים ב-L1. המודל הפורמלי שאותו אני מציע מאפשר פתרון של שתי הבעיות בו-בזמן: מחד, ישנה הגדרה כמותנית של מושג הדמיון הפונולוגי. לא עוד מושג המבוסס על תחושות ושיפוטים של דוברים, אלא מושג שניתן לכימות באופן מדויק. מאידך, התוצאות השונות של ההסגלה מוסברות על ידי המודל הסטוכאסטי המוצע, כמו גם על ידי השפעת הגורמים השונים על ההסגלה. המודל המוצע מגובה באמצעות נתונים משלושה מקורות.

למרות שהמודל המוצג מתמקד בשאלת תנועות מאנגלית לעברית, הרי שמרכיבי המודל מאפשרים מדידה והערכה של דמיון בין הגאים בכלל. מן הסתם, המאפיינים האקוסטיים של עיצורים שונים ממאפייני התנועות, אולם מושג ה-*jnd* המשמש את המודל הזה, יכול לשמש להערכה של דמיון המבוסס על קלט אודיטורי מכל סוג שהוא.

תוכן העניינים

אוניברסיטת תל-אביב
הפקולטה למדעי הרוח ע"ש לסטר וסאלי אנטין
בית הספר למדעי התרבות ע"ש שירלי ולסלי פורטר

תפקיד הדמיון בפונלוגיה:
עדויות ממילים שאולות בעברית

חיבור לשם קבלת התואר "דוקטור לפילוסופיה"

מאת

אוון-גרי כהן

הוגש לסנאט של אוניברסיטת תל-אביב

מאי, 2009

עבודה זו נעשתה בהדרכת

פרופ' אותי בת-אל