Testing the abstractness of phonological representations in Modern Hebrew weak verbs

A Dissertation Presented

by

Meghan Marie Sumner

to

The Graduate School

in Partial fulfillment of the

Requirements

for the Degree of

Doctor of Philosophy

in

Linguistics

State University of New York

at Stony Brook

May 2003

State University of New York
at Stony Brook

The Graduate School

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Abstract of the Dissertation

Testing the abstractness of phonological representations

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Doctor of Philosophy

in

Linguistics

State University of New York at Stony Brook

2002

This dissertation argues for priming as a tool to test the reality of phonological analyses. I examine alternations in two types of weak verbs (verbs that surface without one of their traditional root consonants) in Modern Hebrew. In the cases examined here, consonant loss is phonologically motivated. I show that current analytical standards allow (at least) three psychologically plausible analyses. Each analysis, while having a goal of accurately modeling the phonological component of grammar, makes vastly different predictions about the nature of this grammar.

These predictions are tested in a psycholinguistic priming experiment. The experiment is designed to provide us with direct evidence about the nature of the phonological representations for these weak verbs. The two types of weak verbs are compared to regular verbs, and two subject groups (older and

younger adults) are included to control for language change issues in Modern Hebrew.

The results support the view that younger adults have reanalyzed both types of weak verbs as vowel-final stems, providing evidence for concrete representations. For older adults, the results support an analysis proposing concrete representations for one type of weak verb, and abstract representations for the other. The ability of older adults to form abstract representations is attributed to a higher exposure to the transparent alternation than younger adults receive, as this alternation has been documented to decrease over time. The results are extended to the nominal paradigm of Modern Hebrew and I argue that we have no evidence of abstract representations for a class of segolate nouns that are traditionally analyzed as being opaque. Therefore, opacity in Modern Hebrew should not be used as motivation for modifications to Optimality Theory. Additional implications for Modern Hebrew phonology are discussed.

For phonology in general, we now have a way in which we can test predictions made by competing theories. The results raise the questions of how speakers identify surface variants as related and what types and amounts of evidence are required to motivate this abstract relationship. This research also has implications for opacity in general, casting doubt on the assumption that speakers really do acquire opaque generalizations.

for mom, dad, christian, and gram

thank you

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Acknowledgements

One thing I have learned in the past few years is that conducting research and writing a thesis is made easier by surrounding yourself with positive, supportive, and energetic people. I was lucky enough to have been in such an environment throughout my graduate career, and I have many people to thank for that. Above all, I am indebted to the members of my committee. I cannot imagine a more positive or helpful environment than the one I received from my committee as a whole, and from each member individually. First, I owe many thanks to my advisor Ellen Broselow, who was open-minded enough to support my late switch from a purely theoretical thesis to one that included experiments that, at the time, I knew nothing about. For this, I will forever be grateful. In addition, her guidance and support throughout the years helped me get through the ups and downs of research and writing. Ellen's ability to see the big picture taught me so much, and significantly improved this thesis. Without Ellen's direction, I would not have found my way to the research that I now love so much.

As the title of this thesis suggests, my research focuses on Modern Hebrew. Sadly, though, I don't speak Modern Hebrew. This is important because it will give you some idea of just how much time and effort Bob Hoberman gave me from the initial stages of my experiment to the completion of my thesis. In the beginning, I would meet Bob with a basic idea of what type of words I needed, and he would sit with me for countless hours making lists, giving me glosses, and directing me where to look for the next step. We would do this over and over again throughout the design stages. Bob's role was not only to help me in choosing the right words for the experiment. His comments and guidance greatly improved each section of this thesis. His energy and excitement would always flow over to me, giving me energy for my next task. I thank him for this, for the many emails he responded to, for always adding an extra sentence or two telling me about something else in MH that is interesting and that might be tied in with my research, and for discussions about language that always made me remember why I am here in the first place.

I can honestly say that I would not be where I am today had I not met Arty Samuel. Relatively late in my training, I met Arty when I needed help with the experimental aspects of my research. From that point on, Arty shared his knowledge and enthusiasm with me, helping me to gain a basic foundation in psycholinguistics, while nurturing my growing interest in the field. Arty has never ceased to amaze me with his breadth of expertise and his ability to clearly explain the most difficult concepts. Arty's door was always open to me, no

matter what I needed, and this not only improved my thesis, but enabled me to develop a program of research after graduate school that will allow me to receive much needed training in psycholinguistics. I am constantly impressed with Arty, his demeanor with students, his love of research, his patience, and his willingness to share what he knows and to listen to ideas – any ideas – and help shape them into sound projects. Arty had a massive impact on my academic life, and I am thankful for all of his help, support, and encouragement in my goal of crossing over to psycholinguistics.

Finally, I am grateful to Christina Bethin for her presence in my life throughout my graduate career. Sometimes I don't understand how one person could possibly give as much as Christina does in the way of lively encouragement, emotional support, and great advice for life in academia and life in general. Christina offered a shoulder to lean on when I needed one, she always made sure she knew exactly where I was in my research, she kept me on track for making deadlines, and on top of that, she offered critical comments on different versions of my thesis that improved it greatly. She has been both a friend and a mentor, and I am lucky to know her. I am indebted to my committee, for their diversity of specialties and for their unity in helping me conduct the necessary research and getting me to the point where I could write this thesis.

There are a number of people that were not on my committee that also deserve my thanks and appreciation. First, I owe so much to Mark Aronoff. I always seemed to end up in his office just when I felt like forgetting the whole thing, and I always left with a hug, a smile, and a determination to finish. His stories and positive outlook kept me laughing throughout the years. In addition, he always thought of some job that needed to be done, which kept me funded and allowed me to eat. Grad school probably wouldn't have been as much fun without food. So, Mark … thank you, thank you, thank you! I would also like to thank Marie Huffman for all of her support and efforts throughout the years. In addition, there are two people I was lucky enough to meet along the way, although only for a short time: Ram Frost and Outi Bat-El. Ram was amazing with help and suggestions while I was learning about psycholinguistics. He was generous with his time and with offers to help, and I am very thankful I was able to meet him. I am also grateful to Outi Bat-El for her generosity, excitement, and invaluable suggestions. Thank you to Jennifer Cole, who provided me with thorough and enlightening comments that made this thesis much better than it would have been without her help. In addition, I would not have been able to run any experiments without the help of two extremely important people: Donna Kat and Peter Bondy. Donna worked with me to develop the program for my experiment in the lab. I realize this took a large amount of her time, and I am thankful that she gave me all that she did. In addition, she spent hours helping me in the lab and teaching me everything I needed to know about running experiments. When I realized I would have to leave campus to get more subjects, I also realized I would need a program for my laptop. Peter Bondy

volunteered to help me (although I am still not sure he knew what he was getting into) and without his help, completing my research would have been impossible. He spent much of his free time on this project and on phone calls and emails to me, making sure things were exactly how I wanted them. I am thankful to both Donna and Peter for all of their help.

Personally, I thank my family as a whole for the moral support I received throughout graduate school. Specifically, I want to thank my mom for always asking about my research and for truly attempting to understand it when I would actually answer her. She has been both a friend and a rock of support throughout my life. And thanks for the phone calls, long conversations, and for keeping me company when I was lonely. I also want to thank her for proofreading this thesis over and over again, hopefully she didn't mis anything :o) I thank my dad for always reminding me that I am on my own adventure called life, and that I should enjoy working, but should also enjoy living. I also want to thank my dad for his long emails , for always talking politics with me, and for underlining all of the important words in every card he sent me. I want to thank both of my parents for always encouraging me to follow my heart, for supporting every decision I ever made, and for making me believe that I can do whatever I set my mind to. I thank Christian for the perfectly timed emails and phone calls that always made me laugh, for letting me ramble on when I got talkative (well, I should really thank everyone for this), for Ritters, for letting me win at tennis that one time, for teasing me even when I tell him not to, and for the big-brother-little-sister bond that I cherish. Thank you to Markie for checking up on me, and to Gram for always having time to talk about crafts, recipes, and bargain deals. Thanks to Alexis and Clio for smiles and hallway soccer games. Thanks to Lee for his never-ending enthusiasm. Thank you to Steve & Lynn for sharing their experiences with me as my graduate career was coming to a close, and for the email I got just before my defense that seemed to be the only thing that could calm my nerves. While writing my thesis wasn't as bad as I thought it would be, I still managed to hop onto the emotional roller coaster that comes along, and I have to thank three amazing friends for their support during that time (and many other times). Anke, Xochitl, and Yiya kept me above water and would always willingly step away from whatever they were doing to listen, talk, or walk around. I am thankful to Xochitl for all the times we have shared, for the many lunches and dinners we prepared at the Gnarled Hollow house, for lazy days in the garden, for game nights, Niagara Falls, and for sticking with me through everything. I want to thank Anke for the long breakfasts, yummy dinners, the bike-boat-bike, the Finger Lakes, wine tasting, and all of the fun things we have done throughout the years. And Yiya, thanks for all of the support and encouragement you gave me, especially this past year. In addition, I would like to thank the many people that made the last few years memorable: Michael & Juana, Herr und Frau Beetz, Steffi, Jörg, Jonas and Elias Craney, Oma Wilma, Thorsten, Nicole, Finn and Per Schäfer, Spencer, Martin, Annalyda, Will, Bhavani, Maribel, Stu, Pam, Dylan, Aunt Mae, Janice, Nancy, Sandra, Helen, Susan, and Mrs. Guccione.

Finally, I want to thank Tobi, my *luff* (German devoicing, even in English :o), for sharing with me an amazing four years. I have been lucky enough to receive unconditional support from someone who has been known to drive me crazy, but has also been known to do everything in his power to make sure that I am happy. Tobi has been a foundation of faith, strength, and optimism, and the time that we have spent together has changed my life forever. On the hard days, when I would doubt myself, it was Tobi's unwavering belief in me and my work that gave me hope and confidence. He pushed me when I needed to be pushed and hugged me when I needed to be hugged. Throughout the years, I was able to meet deadlines, prepare talks, and write this thesis because Tobi made my everyday life amazingly simple. Dinner was ready whenever I was hungry, my clothes were always washed and folded whenever I needed them, a car would pick me up when I didn't feel like walking home, and I never heard one complaint about anything (during those hectic times :o). While I consider myself lucky for Tobi's support throughout graduate school, it is what he brought to my everyday life that I really owe him thanks. Tobi and I learned together to appreciate every single moment we have, and in doing this, we have had a lot of smiles and laughter every single day. When I look back over the past few years, I feel like there is not a single thing in life that has passed me by. I feel as if we took hold of life, and rode it for all it was worth, whether by vacations and snowboarding trips, or by everyday things that have become second nature to us like afternoon tea and cookies, cooking gourmet meals, gardening, sunsets at West Meadow beach, or taking tons of photos and then running inside to watch the slideshow. Instead of having graduate school be a block of time that I spent studying and being too busy to enjoy life, I will always look back with a smile and a warm heart and be thankful for every minute I had here. Maybe I could have made it through grad school without Tobi, but I wouldn't have wanted to, and it would never have been this wonderful.

Chapter 1
Introduction

One issue central to phonological theory is the organization of the phonological component of grammar. Within this broad issue is a more specific concern regarding the nature of phonological representations. Phonological representations are those representations that, on a more abstract level, underlie surface forms. They tell us both about the patterning of sounds within and across languages and about the relationships among variable surface forms. More importantly, though, each proposed (or assumed) phonological representation is a hypothesis about a speaker's ability to identify surface variants of a single morpheme as being related at an underlying level of representation.

The exact nature of these mental representations has eluded phonologists for many years, resulting in disagreement over the extent of abstractness permitted within phonology. This debate about abstractness has led to the inclusion of various sorts of indirect evidence, such as data from loanwords, language acquisition, and aphasia, to support particular proposals. The inclusion of such evidence, while crucial to phonological theory, provides evidence both in favor of and against abstract representations.

One persistent issue is the presence of multiple analyses of a single set of data within phonological theory, and, other than the indirect evidence discussed above, the lack of tools available for testing the predictions made by competing analyses. This leaves us with little conclusive evidence as to the true nature of phonological representations, along with an abundance of psychologically plausible analyses that cannot be ruled out.

This thesis addresses the issue of abstractness directly by presenting a psycholinguistic priming experiment designed to test predictions made by competing, plausible analyses. One main goal of this research is to better understand the nature of phonological representations and the factors involved in the formation of these representations. The other is to promote the use of psycholinguistic experimentation in testing phonological hypotheses, to begin separating psychologically real analyses from psychologically plausible ones.

Before moving to the body of the thesis, I provide a brief background on phonological representations, and their role within phonological theory.

1.1. The motivation and purpose of phonological representations

It is well known that coronal stops in English have different surface variants depending on their environment. For example, we know that the final sound in the word *wet* is a voiceless coronal stop, and the medial sound in the word *wetter* is a voiced coronal tap. The pattern of these two manifestations of the coronal stops is predictable, and governed by the phonotactic rules of English. While these two sounds are different on the surface, the relationship between the words and the predictable nature of the alternation have been argued to motivate an underlying level of representation where these two words share a basic form with a voiceless stop.

Phonological representations allow us to represent generalizations about behavior and organization that cannot otherwise be captured. While a tap is a variant of a voiceless stop in the phonological system of Standard American English, this is not universally true. For example, speakers of Standard British English do not realize voiceless coronal stops as taps. In Spanish, the tap contrasts with voiceless coronal stops and each sound would correspond to distinct lexical representations. Therefore, phonological representations allow us to examine patterns and organization of sounds both within and across languages. If we considered only the phonetic representations, we might posit different coronal stops for both English and Spanish, for example, and miss the insight that these sounds function differently in Spanish than they do in American English.

1.2. Abstractness

One issue connected with phonological representations is the notion of *abstractness*. Abstractness refers to a difference between a phonological representation and its corresponding phonetic, or surface, representation. For example, the phonological representation for the English word *wetter*, discussed above, would normally be assumed to be /wɛt + ɚ/, while the surface representation is [wɛɾɚ]. We can say that the phonological representation is abstract because it is different from the surface representation. However, the *degree* of abstractness in this representation is very small. As we have seen, proposing a phonological representation that is different from the surface form in English allows us to account for patterns within the language, and allows us to compare and contrast patterns across languages. Phonological representations are not always minimally different from the surface representations. The degree

of abstractness that has been posited to explain the patterns and behavior of sounds across languages ranges from representations accounting for *transparent alternations* to those used to explain *opaque alternations*. A few examples of each case are provided below.

1.2.1. Transparent alternations

An alternation exists when a particular sound has two or more surface variants depending on the surrounding environment. When the environment for each variant is also present in the surface representation, the alternation is considered to be *transparent*. This means that the surface representation alone provides the evidence needed to deduce the underlying phonological representation. In English, we saw that voiceless stop phonemes have different allophonic realizations depending on their environment. This is one type of transparent alternation. Another type of transparent alternation occurs in German, where word-final consonants are devoiced.[1] This is shown in the data in (1).

(1) German word-final devoicing

	Voiceless		**Voiced**	
a.	ta:**k**	‘day’	ta:**g**ə	‘days’
b.	kö:nɪ**k**	‘king’	kö:nɪ**g**ə	‘kings’
c.	haʊ**s**	‘house’	hɔɪ**z**əʁ	‘houses’
d.	han**t**	‘hand’	hɛn**d**ə	‘hands’
e.	lo:**p**	‘praise’	lo:**b**n̩	‘to praise’
f.	hun**t**	‘dog’	hun**d**ə	‘dogs’
g.	ra:**t**	‘wheel’	rɛ:**d**ə	‘wheels’
h.	ha**p**	‘have, 1sg. (colloquial)’	ha:**b**ə	‘have, 1sg.’

The obstruents in bold in the pairs of words in (1) alternate between a surface voiceless (column 1) and surface voiced consonant (column 2). The pairs of words in (1) are generally assumed to derive from a single underlying phonological form. While the consonants in each pair differ in voicing on the surface, they are assumed to be *phonologically* the same; the forms in the left column have simply been altered to conform to the constraint, exceptionless in German, that obstruents may not be voiced in word-final position. So we can relate ‘day’ and ‘days’ by analyzing them as deriving from a single form /tag/ (or

[1] For more detailed information about devoicing in German, see Féry 1999.

/tag + ə/). The voiced consonants in example (1) are not voiced due to their (intervocalic) environment since voiceless obstruents can freely occur in this position in German, as shown in (2).

(2) Non-alternating pairs in German

a.	nʊ**s**	'nut'	nʏ**s**ə	'nuts'
b.	ta:**t**	'deed'	ta:**t**n̩	'deeds'
c.	ʃla:**f**	'sleep, imp.'	ʃla:**f**n̩	'to sleep'
d.	gu:**t**	'good'	gu:**t**ə	'good, infl.'
e.	getreɪŋ**k**	'drink, imp.'	getreɪŋ**k**ə	'drank, 1sg.'
f.	ʃtɔ**k**	'stick'	ʃtʊ**k**ə	'sticks'
g.	dʊ**k**	'duck, (imp.)'	dʊ**k**n̩	'to duck'
h.	de**p**	'idiot'	de**p**n̩	'idiots'

The alternation of word-final voiceless consonants with non-final voiced consonants in German is a transparent one. The variable segment (i.e., a voiceless obstruent) is in the environment that triggers devoicing (i.e., end of the word). From examining the surface pairs alone, a generalization can be made, and phonological theory generally proposes that speakers are able to capture these surface generalizations at the phonological level. While the phonological representation (i.e. /tag/) is abstract in the sense that it differs from its corresponding surface form (i.e., [tak]), it is abstract to a low degree, as information about the alternation and related forms is available on the surface. In this case, positing the underlying forms /tag/ and /tag-ə/ for the corresponding surface forms [tak] and [tagə] allows us to capture an underlying relationship between the two forms.

While this analysis is relatively uncontroversial, extreme versions of concrete frameworks might not allow this low degree of abstractness. For example, one possibility, similar to frequency-based analyses like that in Bybee 2001, is that the most frequently produced form of a word is the phonological form. In this case, the relationship between morphemes is not one of shared phonemes, but one of shared connections between words. In general, transparent alternations like these can be incorporated into most theoretical frameworks. The main focus of debate over the past thirty years, though, has been on analyses that posit a higher degree of abstractness.

1.2.2. Opacity

As discussed, transparent alternations require abstract representations, but the degree of abstractness involved is relatively low. There are other phenomena that involve representations with a high degree of abstractness. *Opacity* is such a phenomenon. A form is *opaque* when either a surface form does not adhere to the rules or constraints of a language, or when a change has occurred that is not explained merely by consulting the surface form since the triggering environment has been lost at some level or time (Kiparsky 1971, 1973). The phonological representations for opaque surface forms are abstract to a high degree. Opaque relationships have provided much of the motivation for serial analyses, supporting the existence of (or reference to) an intermediate level of representation.

One example of opacity, which I will return to later, is that found in segolate nouns in Modern Hebrew. Segolate nouns in Modern Hebrew have been analyzed as having an epenthetic second vowel due to the word-initial stress of these words. Modern Hebrew has traditionally been analyzed as having default word-final stress (i.e., *tiʾpes* 'to climb'). Segolate nouns, though, have stress on the initial syllable (i.e. '*delet* 'door'). This stress pattern has typically been accounted for by assuming that the underlying representation for these forms is /CeCC/, and that stress occurs before the second vowel is inserted, yielding an intermediate form like |'CeCC|, followed by epenthesis that serves to break up an illicit final consonant cluster, resulting in a bisyllabic word with initial stress ['Ce'CeC] (not the expected [Ce'CeC]).

It is the interaction of this epenthesis process and the loss of some word-final consonants that results in opacity. In Modern Hebrew, glottal stops cannot occur in coda positions. Therefore, when a segolate noun is derived from a form with an underlying final glottal stop, the resulting form is opaque. As previously discussed, segolate nouns have the underlying shape /CeCC/. So, a segolate noun with a final glottal stop can be represented as in (2).

(2) /dɛʃʔ/ 'grass, lawn'

After stress has been assigned to the only existing vowel, epenthesis occurs because the consonant cluster ʃʔ is not possible word-finally in Modern Hebrew. The resulting intermediate form is given in (3).

(3) dɛʃɛʔ

Finally, since glottal stops are prohibited from coda positions in Modern Hebrew, the final glottal stop is lost, resulting in an opaque surface form, as in (4).

(4) [dɛʃɛ]

The form in (4) is opaque because it is not apparent by looking at the form why the final vowel surfaces, especially since monosyllabic closed syllables are perfectly legitimate in Modern Hebrew. This case of opacity is one example of how abstract representations have been used to account for variable surface forms. One question that has been raised again and again over the past thirty years is: How abstract are phonological representations? Or, do speakers actually identify abstract phonological relationships among words, even if the relationships are not transparent on the surface? These questions led to a period of debate centered around the issue of abstractness and the nature of phonological representations.

1.3. The abstractness controversy

The abstractness controversy is the name given to the debate over the nature of phonological representations, and the degree to which they can vary from surface representations. The SPE framework (Chomsky & Halle 1968) permitted extreme cases of abstractness. A turning point in phonological analysis came when Kiparsky (1968) attempted to constrain the level of abstractness allowed in phonological representations. He claimed that the abstractness proposed in SPE was excessive, and that using phonological representations as purely classificatory means to differentiate forms that behave differently on the surface is unacceptable. Specifically, he proposed rules limiting absolute neutralization, which in turn constrained abstractness.

This initial attempt to constrain phonology led to a number of proposals in favor of abstract representations (such as Hyman's (1970) analysis of Nupe vowels), and to proposals that disfavor abstractness. Natural Generative Phonology (Hooper 1976) claimed that phonological representations are concrete, and proposed a number of limits on the types of rules allowed within phonological theory. Early versions of Natural Generative Phonology were not widely accepted, though, as the proposed limits basically amounted to assumptions about concreteness parallel with SPE's assumptions about abstractness (Anderson 1985). In general, restrictions placed on rules and the focus only on surface forms had the effect of rejecting phonological rules that have even a single exception. While the most conservative versions of NGP were not widely accepted, they did move the field to a more conservative approach to language. From this point on, it became more common in phonology to seek external support for arguments that favor (or disfavor) the presence of abstract phonological representations.

A well-known example is the analysis of active and passive verbs in Maori (Hohepa 1967; Hale 1968; Comrie 1980). In Maori, an abstract analysis is

supported when we consider the data set alone, but the consideration of language use and loanwords promotes a more concrete view of the data. Examples of Maori active and passive verbs are provided in (5).

(5)

	Active	**Passive**	**Gloss**
a.	hopu	hopukia	'catch'
b.	moto	motokia	'strike with fist'
c.	aru	arumia	'follow'
d.	inu	inumia	'drink'
e.	mau	mauria	'carry'
f.	mero	merohia	'stab'
g.	kimi	kimihia	'seek'
h.	patu	patua	'strike'
i.	kite	kitea	'see'

All of the active verbs end in a vowel, and the passive forms (5a-g) end in some unpredictable consonant followed by the sequence *–ia* (C*ia*). The final two examples are vowel-final stems. They surface with only the suffix *–a*. There are two plausible analyses for these data; one that posits *–Cia* as the passive morpheme, and another that posits *–ia* as the passive morpheme. A more abstract analysis would choose the latter because the consonant that surfaces before *–ia* is unpredictable, and is therefore assumed to be part of the underlying representation. The lexical forms for *hopu, inu,* and *mau* are /hopuk/, /inum/, and /maur/, respectively, but the consonants do not surface in the active form because Maori does not allow codas.

Hohepa (1967) claims that the passive morpheme is *–tia*, not *–ia*. He bases this claim on a number of facts surrounding Maori passives. First, there is considerable *within-speaker* variation. This means that a single speaker produces two variants of the passive verb 'catch', for example: *hopu**k**ia* and *hopu**t**ia*. Additionally, new passives in Maori are formed by adding *–tia* to an existing noun or adjective ending in a vowel. So, from the noun *wahine* 'woman', the passive *wahinetia* 'to be transformed into a woman' (Comrie 1980) is formed. In addition, recent loanwords from English are borrowed basically as is, even if they include codas. An abstract analysis would predict that *–ia* would surface as the passive because this allows a final consonant to be syllabified in the onset position. But even when a coda is present, the loanword takes the suffix *–tia*, violating the phonotactics of Maori.

In addition to the two approaches above, de Lacy (2000) offers a more recent account of Maori passives within Optimality Theory (OT) in which the surface patterns are due to maximal word effects, arguing for a more constrained analysis of Maori passives. In this account, constraints on the prosodic structure of a word account for the surface variation found in Maori, and

the surface forms need not rely on the abstract representations posited by Comrie.

Maori passives serve to remind us that the range of data may not converge unambiguously on a single analysis. We still have no criteria for choosing one analysis over another.

1.4. Stalemate in phonology

Currently in phonology, the degree of abstractness of representations remains a point of debate. The adaptation of loanwords has provided one possible probe into speakers' grammars, because as new words, these presumably represent effects of on-line processing. One example, and one of the most notable attempts to validate abstractness via examination of loanwords, is Hyman's (1970) treatment of Nupe palatalization and labialization. In Nupe, consonants are labialized before [o] and [u] and palatalized before [i] and [e], as shown in (6).

(6) Palatalization and labialization in Nupe

a.	eg^{w}u	'mud'	(cf., *egu, *eg^{j}u)
b.	eg^{w}o	'grass'	(cf., *ego, *eg^{j}o)
c.	eg^{j}i	'child'	(cf., *egi, *eg^{w}i)
d.	eg^{j}e	'beer'	(cf., *ege, *eg^{w}e)
e.	ega	'stranger'	

Hyman discusses the possibility of two general rules in Nupe: palatalization and labialization, as shown in (7).

(7) Palatalization: $C \rightarrow C^{j} / \_\_ \{i,e\}$

Labialization: $C \rightarrow C^{w} / \_\_ \{u,o\}$

This analysis is not sufficient when we consider the behavior of consonants before [a], in which context we find a three-way contrast between labialized, palatalized, and plain C:

(8) a. [eg^{w}a] 'hand'
b. [eg^{j}a] 'blood'
c. [ega] 'stranger'

The data can be accounted for by positing underlying /C^{w}/ and /C^{j}/. However, Hyman claims that by doing so, we do not explain the relationship between labial and palatal consonants and all following vowels except /a/. The solution he opts for is an abstract analysis, claiming that surface [a] corresponds

to three underlying phonemes. By positing the underlying contrast, we are able to treat the forms in (9) not as exceptions, but as predicted surface forms. Hyman posits the following representations for the forms in (8), along with a rule changing /ɔ/ and /ɛ/ to [a].

(9)	a. /egɔ/	→	$eg^{w}ɔ$	→	$[eg^{w}a]$
	b. /egɛ/	→	$eg^{j}ɛ$	→	$[eg^{j}a]$
	c. /ega/		→		[ega]

Labialization in (9a) is predicted as the consonant precedes a round vowel, and palatalization in (9b) is predicted because the consonant precedes a front vowel. While this solution correctly predicts the surface forms and maintains the generalizations about labialization and palatalization, this is exactly the type of absolute neutralization which Kiparsky ruled out, since there are no instances in Nupe of surface [ɔ] or [ɛ].

However, Hyman claims that loanwords borrowed into Nupe from Yoruba lend support to an analysis containing abstract underlying vowels. The examples in (10) show that Nupe speakers systematically convert surface [Cɔ] and [Cɛ] in loanwords to [$C^{w}a$] and [$C^{j}a$].

(10) Yoruba loanwords in Nupe

YORUBA	NUPE	
kɛkɛ	$k^{j}ak^{j}a$	'bicycle'
ɛgbɛ	$egb^{j}a$	'a Yoruba town'
tɔrɛ	$t^{w}ar^{j}a$	'to give a gift'
kɔbɔ	$k^{w}ab^{w}a$	'penny'

Hyman argues that this nativization process is an indicator that the rule changing /ɔ/ and /ɛ/ to [a] is real, because Yoruba [ɛ] and [ɔ] are realized as /a/ with the agreeing secondary articulation on the preceding consonant. He also offers language internal data from reduplication that show other cases where [a] acts as a round vowel and a low vowel. He therefore concludes that the facts support the analysis involving absolute neutralization.

Hyman makes a strong case for abstract underlying vowels in a rule-based framework. Unfortunately, though, it is the nature of rule-based phonology that promotes abstractness in this case, and an analysis within Optimality Theory does not rely on abstract vowels. In rule-based phonology, the only way to maintain the palatalized/labialized consonant generalization is to posit abstract underlying representations. In Optimality Theory, though, generalizations are stated on the surface. Therefore, the underlying representation does not matter because the surface constraints will ensure that

only legal Nupe forms will surface. So, while it might be true that the loanwords from Yoruba support the claim for abstract underlying vowels in a rule-based framework, this claim is not necessarily supported in the current framework.

Within OT, though, issues of abstractness remain for surface variants of morphologically related forms. Current standards of phonological analysis allow both abstract and concrete representations. While external evidence bearing on the issues provides us with indirect evidence as to the nature of particular phenomena, we find support for all types of representations. The debate about abstractness brings us to a stalemate in that both types of representations have been supported with external evidence ranging from loanword data to language acquisition data. One possible conclusion we can draw is that both types of representations exist, but the circumstances surrounding each alternation promote or inhibit the formation of abstract representations.

1.5. The real problem

The main problem surrounding the abstractness debate, simply put, is that we know relatively little about the organization and nature of phonological representations. We have many analytical tools with which we can test the validity of some proposed representations, but even these tools are unable to help us choose among competing analyses that fall within the bounds of phonological analysis. The abstractness debate is central to phonology because the abstractness or concreteness of representations is representative of the kinds of relationships speakers are able to identify. Knowing whether a surface generalization is internalized by a speaker and to what extent this occurs will help us model a part of phonology that has received relatively little attention: the move from initial constrained representations posited by learners to a more abstract representation. A widely-held assumption in language acquisition is that learners of a language begin with constrained representations that match outputs, but form more abstract representations when information (i.e., surface alternations) becomes available. However, we have relatively little direct information supporting this assumption.

1.5.1. Addressing the issues

To address the issues surrounding both the debate about abstractness and the little direct evidence available regarding the nature of phonological representations, I will test hypotheses concerning the phonological representations for Modern Hebrew verbs via psycholinguistic experimentation. Two alternations are compared, one phonologically transparent, and one more abstract. The decision to examine less controversial forms instead of testing

opaque forms allows us to focus our attention on asking *why* particular representations are abstract or not, instead of *whether* or not particular representations are abstract.

The results of the experiment add to our understanding of what types of surface variations speakers are able to relate on the phonological level. This research is relevant to phonology for two main reasons. First, as I show, we can use psycholinguistic experiments to test the assumptions that underlie phonological theory. This allows us to better understand relatedness from a speaker's perspective and will hopefully serve as an additional means of providing us with more direct evidence in favor of (or against) particular theories or analyses. Second, this thesis serves as a starting point in asking: What types of evidence do speakers use in forming phonological representations? There is no question that phonology-independent factors influence phonology, but we do not know all of the factors involved, the extent to which each is involved, or the thresholds at which they become beneficial (or detrimental). In sum, the debate about abstractness led us to question the nature of representations, but in order to resolve the debate we must test the predictions of each theory.

Chapter 2
Modern Hebrew weak verbs

One goal of phonological theory is to posit psychologically plausible representations for any given set of data. This goal can be satisfied in a number of ways and can result in (at least) two competing analyses, one abstract and one concrete. The ultimate choice of analysis generally depends on the existence of independent evidence combined with a particular theoretical stance. For the most part, current tools in phonology are too weak to choose among the competing analyses. Therefore, a number of equally plausible competing analyses may exist for a single set of data. I show this to be true for weak verbs in Modern Hebrew.

There are two main goals of this chapter. First, I show that surface alternations in Modern Hebrew weak verbs may be analyzed in three different ways, each equally acceptable and none psychologically implausible. Second, I discuss the predictions made by each analysis so we can attempt to test these predictions in an experiment presented in Chapter 3. While the focus of this chapter is on weak verbs in Modern Hebrew, I provide some basic information about the phonology and morphology of Modern Hebrew below.

2.1. Background

Modern Hebrew is a Semitic language spoken mainly in Israel. It has about 5 million native speakers living in Israel (Schwarzwald 2001), and about 500,000 more living abroad (Glinert 1989). Modern Hebrew is typical of most Semitic languages in displaying root-and-pattern morphology. This means that there is a specific arrangement of consonants and vowels (a pattern) typical of some grammatical class of morphemes, and that the root consonants which carry the lexical meaning, appear in the arrangement specified by each pattern. There are seven themes of verbs, or *binyanim* in Modern Hebrew.[2] The seven binyanim of Modern Hebrew are provided in (1).

[2] I use the traditional term *binyan* (*binyanim*, (pl.)) here and throughout.

(1) Modern Hebrew Verbal Patterns

Binyan Name	**Abstract Pattern**	**Example**	**Gloss**
pa'al	CaCaC	katav	'he read'
nif'al	niCCaC	nixnas	'entered'
hif'il	hiCCiC	hitxil	'began'
huf'al	huCCaC	huzkar	'was mentioned'
pi'el	CiCeC	tipes	'he climbed'
pu'al	CuCaC	ʃudar	'it was broadcasted'
hitpa'el	hitCaCeC	hitlabeʃ	'got dressed'

In the example above, the name of each binyan is given in the leftmost column. The binyan names are composed of the root p-ʔ-l, and these three root consonants are combined with the abstract pattern in the second column to arrive at the pattern name. Examples of each binyan are provided in the third column, followed by their gloss. Within each binyan there may be more than one pattern, as in the case of the nif'al binyan, shown in (2).

(2) Nifʔal

a. niCCaC: Pattern for past and present
b. iCaCeC: Pattern for future
c. hiCaCeC: Pattern for infinitive and imperative

Traditionally, some generalizations can be made about the binyanim, although the meaning is not always predictable. For example, the pa'al and pi'el patterns are the active patterns, hif'il may signal a transitive verb, and nif'al may be a change of state verb, an intransitive verb, and may also have a passive meaning. However, as mentioned above, there are many exceptions.[3]

While the verbal system has only seven binyanim, the nominal system has over one hundred nominal patterns, or mishkalim. In addition, new nouns need not conform to any specific mishkal, but every new verb must conform to one of the seven binyanim. Many have used this to argue that patterns no longer exist in the nominal system (Ussishkin 2000), although Aronoff (1994) shows that the distinction is one only of obligation, and that it is not a signal of extinction of the root and pattern in the nominal system of Modern Hebrew.

[3] In addition, two binyanim, huf'al and pu'al, are the passive forms of the hif'il and pi'el binyanim. This has caused some to analyze the verbal system as having only five patterns, but this distinction is not relevant here.

Nonetheless, the notion of a root and pattern is likely to be more productive in the verbal system.

2.2. Phonology

The consonant phonemes of Modern Hebrew are given in Table 1. In addition to these consonants, there are four additional sounds that are limited to loanwords (ʒ, dʒ, tʃ, and w) (Schwarzwald 2001).

	bi-labial	**alveo-lar**	**alveo-palatal**	**palatal**	**velar**	**uvular**	**glottal**
stop	p b	t d			k g		ʔ
fricative	f v	s z	ʃ		x	R	h
affricate		ts					
nasal	m	n					
lateral		l					
approx.				j			

Table 1. Modern Hebrew consonants

While the voiceless glottal fricative /h/ is listed in the table, it is not part of the phoneme system for many speakers of Hebrew. Additionally, the historical voiced pharyngeal fricative (ʕ, written letter *ayin* (ע)) has merged with the glottal stop (ʔ, written letter *alef* (א)) and they are both pronounced as [ʔ] when they are produced (Rosén 1977). In addition to this merger, the voiceless pharyngeal fricative [ħ] has merged with the voiceless velar fricative [x], and they are both pronounced as [x] in Modern Hebrew.

The vowel system of Modern Hebrew is a typical five-vowel system, as shown in Table 2.

	[-back]	**[back]**
High	i	u
Mid	e	o
Low	a	

Table 2: Modern Hebrew vowels

The non-low vowels in Modern Hebrew are realized as their lax counterparts in closed syllables or unstressed positions (Schwarzwald 2001).

2.3. Regular Verbs

All regular verbs in Modern Hebrew are formed via the combination of roots and patterns, discussed in section 2.1. The focus throughout the dissertation will be on verbs in the pi'el binyan. This binyan has both a large number of regular verbs and a sufficient number of weak verbs with which we can test the abstractness of phonological representations.[4] Verbs in Modern Hebrew are inflected for person, number, and gender, as shown in the following table. Table 3 shows that the tense of the verb is designated by the abstract pattern, while person, number, and gender marking are accomplished through affixation.

(P)GN	SURFACE FORM	ABSTRACT PATTERN	ROOT	GLOSS
2FS	tipas-t	CiCaC-t	TPS	'you (F.SG) climbed'
2FS	dibar-t	CiCaC-t	DBR	'you (F.SG) spoke'
2MP	tipas-tem	CiCaC-tem	TPS	'you (M.PL) climbed'
2MP	dibar-tem	CiCaC-tem	DBR	'you (M.PL) spoke'
FS	me-tapes-et	me-CaCeC-et	TPS	'(F.) climbs'
FS	me-daber-et	me-CaCeC-et	DBR	'(F.) speaks'
MS	me-tapes	me-CaCeC	TPS	'(M.) climbs'
MS	me-daber	me-CaCeC	DBR	'(M.) speaks'
2FS	te-taps-i	te-CaCC-i	TPS	'you (F.SG) will climb'
2FS	te-dabr-i	te-CaCC-i	DBR	'you (F.SG) will speak'
2MP	te-taps-u	te-CaCC-u	TPS	'you (M.PL) will climb'
2MP	te-dabr-u	te-CaCC-u	DBR	'you (M.PL) will speak'

Table 3. Some inflectional patterns for the verbs *tipes* 'he climbed' and *diber* 'he spoke'

[4] Since our goal is to provide experimental evidence relating to the abstractness of phonological representations, we need an outlet for testing this. A natural choice might be opaque nouns that are widely discussed in the literature (i.e., (McCarthy 1998); however, there are too few of these nouns to provide significant results in an experimental paradigm. Weak verbs in Modern Hebrew address the same issues and offer more tokens.

A sample paradigm of a regular verb is provided in (3). For each paradigm throughout this thesis, I provide the verb in the citation form (3ms), followed by the conventional root, and the gloss.

(3) Verbal paradigm for *tipes*, t-p-s, 'he climbed'

PAST

1s	tipás-ti	1p	tipás-nu
2ms	tipás-ta	2mp	tipás-tem
2fs	tipast	2fp	tipás-ten
3ms	tipes	3p[5]	tips-u
3fs	tips-a		

PRESENT

ms	metapes
fs	metapéset
mp	metapsim
fp	metapsot

FUTURE

1s	ʔatapes	1p	netapes
2ms	tetapes	2mp	tetapsu
2fs	tetapsi	2fp	tetapésna
3ms	jetapes	3mp	jetapsu
3fs	tetapes	3fp	tetapésna

INFINITIVE

letapes

In the past and future tenses, verbs are inflected for person, gender, and number. Present tense verbs are inflected only for gender and number. All three root consonants (i.e., t-p-s) occur in every form within the verbal paradigm for regular verbs. This is the main difference between regular verbs and weak verbs. Weak verbs behave differently, as we see in Section 2.4.

2.4. Weak Verbs

In some inflections, a number of verbs in Hebrew surface without one of their root consonants. These verbs are generally regarded as having weak

[5] Gender for 3p forms comes from a preceding pronoun (cf., *hen tipsu* 'they (f) filled' vs. *hem tipsu* 'they (m) filled').

roots, or a root that does not behave like that of regular verbs. According to Schwarzwald (2001), there are roughly seven different types of weak roots in Modern Hebrew, which fall into two main categories: mute roots and defective roots. *Defective root* is the traditional term given to the class of verbs which surfaces (in some inflections) without one of its root consonants *for no apparent reason*. In other words, the phonology does not motivate the consonant loss for defective roots. Many /n/-initial roots in Modern Hebrew fall into this category. For example, the root n-p-l surfaces without the initial root consonant in the form *yipol* (*yinpol) 'he will fall' (cf. k-t-b, yixtov 'he will write'). There is no constraint against the structure of the word (CVnpVC), as there are words in Modern Hebrew that have this form (i.e., *jinpots* 'scatter, smash', *linpóa* 'blow').

The second category of weak verbs is the class of verbs with *mute roots.* This term is traditionally used to classify verbs which surface (in some inflections) without a root consonant for phonological reasons. The missing root consonant in this group of verbs is motivated by the phonotactics of Modern Hebrew (Berman 1981a; Bolozky 1999; Frost et al. 2000, among others). Because glottal stops are prohibited from surfacing in codas, roots that contain final glottal stops will surface without final glottal stops anytime the pattern calls for the final root consonant to appear in coda position (i.e., pi'el 3ms CV.CV**C**), a glottal stop will not appear. So, for the root m-l-ʔ, the third person singular form is [mile], not *[mileʔ]; the loss is motivated by the phonotactics of the language. Therefore, glottal loss in Modern Hebrew is phonologically conditioned, while *n* loss in the defective root is not. Throughout this thesis, we will refer to verbs that surface without one of their root consonants as *weak verbs*. We will be concerned mainly with weak verbs that are mute, or *phonologically conditioned* weak verbs, for the remainder of this thesis.[6]

2.5. Phonologically-conditioned weak verbs in Modern Hebrew

In Chapter 1, it was suggested that a number of comparable analyses can be proposed for many phonological phenomena. Phonologically-conditioned weak verbs in Modern Hebrew serve as an illustration of this point, as there are two types of phonologically-conditioned weak verbs that may be analyzed differently depending on the theoretical perspective: ʔ-final and j-final weak verbs.[7] In this section, I construct three plausible analyses for these two types of

[6] I use the term *phonologically-conditioned weak verbs* for clarity. It refers to the group of verbs that are traditionally classified as having defective roots, or roots that surface without one consonant due to phonology (whether for synchronic or historical reasons).

[7] I use the terms ʔ-*final* and j-*final* weak verbs to refer to those verbs *traditionally* considered to have ʔ as the final root consonant and j as the final root consonant, respectively. These terms

verbs and show that none can be ruled out. This leaves us with three perfectly plausible analyses. By examining the weak verbs in detail, we can identify the predictions made by each analysis, and test them in the experiment presented in the following chapter.

Of the two types of verbs, the ʔ-final verbs have the more productive alternation. Verbs with final glottal stops are generally assumed to have a final underlying glottal stop that surfaces only when the pattern has an onset position available for the final consonant of the root. As we saw above, an example of this type of verb is the word *mile* (traditional lexical representation /mileʔ/). This alternation, ʔ~Ø, is governed by the phonotactics of Modern Hebrew (which prohibit coda glottal stops) and is considered predictable by most accounts of phonology. An example paradigm of a ʔ-final weak verb in the pi'el binyan is provided in (4).[8]

(4) Verbal paradigm for *mile*, m-l-ʔ, 'he filled'

PAST

1s	milé-ti	1p	milé-nu
2ms	milé-ta	2mp	milé-tem
2fs	mile-t	2fp	milé-ten
3ms	mile	3p	milʔu
3fs	milʔ-a		

PRESENT

ms	me-male
fs	me-male-t
mp	me-malʔ-im
fp	me-malʔ-ot

are for clarity only, and do not represent claims I am making about the representational nature of these verbs.

[8] For the majority of the thesis, I focus on weak verbs in the pi'el binyan because there exist many ambiguities in other binyanim. For example, in the pa'al binyan, the form [kara] has a three-way ambiguity between 'he read' (k-r-ʔ), 'he dug, mined' (k-r-j), and 'he bowed, kneeled' (k-r-*ʕ).

FUTURE

1s	ʔa-male	1p	ne-male
2ms	te-male	2mp	te-malʔ-u
2fs	te-malʔ-i	2fp	te-malé-na
3ms	je-male	3mp	je-malʔ-u
3fs	te-male	3fp	te-malé-na

INFINITIVE

le-male

In the paradigm above, a glottal stop surfaces any time the pattern contains the third root consonant in an onset position (i.e., CiC**C**u *milʔu* (3p past), meCaCCim *memalʔim* (mp present), teCaCCi *temalʔi* (2fs future)).

The second type of phonologically-conditioned weak verb is the class of verbs that ends in /j/.[9] An example of this type of verb is *nika* 'he cleaned' (traditional root n-k-j), whose final consonant /j/ never surfaces with the final root consonant in the verbal paradigm (although it does surface in related nouns). The analyses for this group of verbs are not as uniform as those for glottal-final verbs, as they range from those that claim that this is a vowel-final verb to those that claim that the final consonant is very real (although very abstract). An example paradigm of a j-final weak verb is provided in (5).

(5) *nika*, n-k-j 'he cleaned'

PAST

1s	nikí-ti	1p	nikí-nu
2ms	nikí-ta	2mp	nikí-tem
2fs	niki-t	2fp	nikí-ten
3ms	nika	3p	nik-u
3fs	nikt-a		

PRESENT

ms	me-nake	fs	me-naka
mp	me-nak-im	fp	me-nak-ot

[9] This group of verbs is traditionally analyzed as being in the same category as glottal-final weak verbs, however, the loss of /j/ is no longer motivated by phonology. The final consonant, though, is still analyzed as being part of the root, although this is not the only view (Schwarzwald 2001, Ravid 1995, among others, would not posit an underlying /j/ for these forms).

FUTURE

1s	ʔa-nake	1p	ne-nake
2ms	te-nake	2mp	te-nak-u
2fs	te-naki	2fp	te-naké-na
3ms	je-nake	3mp	je-nak-u
3fs	te-nake	3fp	te-naké-na

INFINITIVE

le-nakot

In this set of weak verbs, the final root consonant *j* does not surface in any form of the verb. Having presented the two types of weak verbs that we consider for the remainder of the thesis, I now present three possible (and plausible) analyses of the phonological representations for these verbs.

2.5.1. Analysis 1: Abstract and concrete representations

The generalizations that can be drawn from the paradigms presented in (2)-(4) are:

- All root consonants surface in every inflected form for regular verbs.
- Glottal stops surface only in the onset position.
- Historical final *j* never surfaces in verbal paradigm.

A small data set that represents these generalizations is given in (6).

(6)

a.	tipes	‘he climbed’
b.	tipsu	‘they climbed’
c.	diber	‘he spoke’
d.	dibru	‘they spoke’
e.	mile	‘he filled’
f.	milʔu	‘they filled’
g.	vide	‘he verified’
h.	vidʔu	‘they verified’
i.	nika	‘he cleaned’
j.	niku	‘they cleaned’
k.	gila	‘he discovered’
l.	gilu	‘they discovered’

The forms in (6a-d) show the general pattern of regular verbs. All three root consonants surface in both the 3ms and the 3p forms. When we move to the glottal-final forms in (6e-h), we might initially propose that there are only two consonants in the underlying form for these two cases. But, the forms in (6f,h) tell us otherwise. If we compare these verbs with the regular verbs, we see that a third consonant surfaces in the onset (6f,h), but not in the coda position (6e,g). So, we are able to predict the occurrence of the final consonant and we have a phonological explanation for its absence (i.e., syllable structure constraints). An opponent of this analysis may claim that too few of these verbs exist to support the glottal stop/zero alternation (there are only fifteen verbs of this type). This alternation, though, is productive throughout Modern Hebrew and appears in many other words. One example is the set of words that have the historical pharyngeal as a final root consonant. As discussed above, the pharyngeal has merged with the glottal stop. Therefore, verbs that end with a final historical pharyngeal also exhibit the glottal stop/zero alternation we find in ʔ-final weak verbs. An example paradigm for this set of verbs is given in (7) (stress is on the final syllable unless otherwise indicated).

(7) Verbal paradigm for *ʃigéa*, ʃ-g-*ʕ 'drive crazy'

PAST

1s	ʃigá-ti	1p	ʃigá-nu
2ms	ʃigá-ta	2mp	ʃigá-tem
2fs	ʃigá-t	2fp	ʃigá-ten
3ms	ʃigéa	3p	ʃigʔ-u
3fs	ʃigʔ-a		

PRESENT

ms	me-ʃagéa
fs	me-ʃagáʔ-at
mp	me-ʃagʔ-im
fp	me-ʃagʔ-ot

FUTURE[10]

1s	ʔa-ʃagéa	1p	ne-ʃagéa
2ms	te-ʃagéa	2mp	te-ʃagʔ-u
2fs	te-ʃagʔ-i	2fp	te-ʃagá-na
3ms	je-ʃagéa	3mp	je-ʃagʔ-u
3fs	te-ʃagéa	3fp	te-ʃagá-na

[10] The 2fp and 3fp forms in the future tense are purely literary.

INFINITIVE
le-ʃagéa

In addition to the alternation found for ʔ-final weak verbs, the same alternation exists in a separate set of verbs (as shown in (7)), and across Modern Hebrew phonology. This alternation, then, is transparent, productive, and predictable.

The same is not true for j-final weak verbs (6i-l). We see that these verbs are different from regular verbs in two ways: (1) they have only two consonants and (2) the final vowel is different in the 3ms forms. Therefore, when we consider the verbal paradigm alone, we have no reason to assume that there is a final underlying /j/ in the representations of these verbs. We do have sufficient motivation to posit an underlying final glottal stop for the glottal-final verbs. This leads us to propose the representations in (8).

(8) Representations for ʔ-final and j-final weak verbs
(Plausible analysis #1: Abstract and concrete representations)

a.	/mileʔ/	⟶	mile	'he filled'
b.	/mileʔ-u/	⟶	milʔu	'they filled'
c.	/nika/	⟶	nika	'he cleaned'
d.	/niku/	⟶	niku	'they cleaned'

The analysis in (8) claims that we have no evidence to posit an underlying final consonant in the /j/-final forms. The ʔ~Ø alternation, though, is predictable. The forms in (8a,b) derive from a single underlying representation (/mileʔ/), with (8b) being inflected for the third person plural (*-u*). A glottal stop is present in the underlying form for both words, even though it does not surface in (8a). The analysis is quite different for j-final verbs. The representations here support the claim that there is no evidence available that supports an analysis with an underlying /j/.[11]

Overall, this analysis is based on the information from the paradigms, and the small data set in (6). This type of analysis is consistent with the general view that the evidence supplied by surface generalizations and phonotactics

[11] The representations in (8) posit two separate stems for these verbs. This is not the only option, as we will see later. For now, though, the main point is that we have evidence within the paradigm of an underlying /ʔ/, but not of an underlying /j/.

motivates the formation of abstract representations. In the ʔ-final weak verbs, evidence of the pattern exists within the data set; however, this information is missing in the data for /j/-final verbs. This analysis allows for a difference between the two types of alternations, arguing that transparent, phonologically motivated consonant loss is recognized by speakers, and posited as part of the phonological representations. However, there is no evidence, other than the history of Modern Hebrew, to suggest that there is an underlying final consonant in the representations of j-final weak verbs. Bolozky (1999) takes this view, arguing that the surface patterns speakers are exposed to for the /j/-final forms are patterns of vowel-final verbs, and that is the generalization speakers are learning. Therefore, while some argue that there is a final underlying /j/ in these cases, this claim is not substantiated in this analysis.

2.5.2. Analysis 2: Abstract representations

The question of what constitutes evidence for a particular analysis is central to the second analysis, which supports underlying final consonants for both sets of weak verbs. If we consider the past tense forms for j-final weak verbs, we see that there is in fact evidence of an underlying /j/. A difference in the final vowel of regular verbs and weak verbs in the past tense forms can be attributed to an underlying /j/. Compare the data sets in (9) and (10).

(9) Past tense forms for the regular verb *tipes*, t-p-s 'he climbed'

1s	tipás-ti	1p	tipás-nu
2ms	tipás-ta	2mp	tipás-tem
2fs	tipas-t	2fp	tipás-tem
3ms	tipes	3p	tips-u
3fs	tips-a		

(10) Past tense forms for the j-final weak verb *nika*, n-k-j 'he cleaned'

1s	nikí-ti	1p	nikí-nu
2ms	nikí-ta	2mp	nikí-tem
2fs	niki-t	2fp	nikí-ten
3ms	nika	3p	nik-u
3fs	nikt-a		

The second vowel in the pattern for regular verbs is [a] in all but three forms (the third person forms: 3ms, 3fs, and 3p). The second vowel for the corresponding forms in the j-final weak verbs is not [a], but [i]. This surface [i] can be accounted for if there is an underlying /j/ that surfaces as a vowel. When

a j-final weak verb surfaces with a consonant-initial suffix, then the underlying /j/ surfaces as a vowel ([i]).

The surface [i] alone may not be sufficient evidence for positing an underlying /j/ for these verbs. Supporting evidence can be found once we consider related nouns. Two j-final verbs, along with related nouns that contain a surface [j], are provided in (11).

(11)	a.	kana	'he bought'	(root k-n-j)
	b.	kone	'customer'	
	c.	kinjan	'property'	
	d.	kanjan	'buyer'	
	e.	kenjon	'shopping mall'	
	f.	nika	'he cleaned'	(root n-k-j)
	g.	nikuj	'cleaning'	
	h.	nikajon	'cleanliness'	

When we move away from the verbal system and look across all forms in Modern Hebrew, we see that there is evidence of a final consonant for the traditional /j/-final forms. In examples (11c-e) and (11g,h) the final root consonant [j] does indeed surface. The problem, though, is that it does not surface in a large number of forms. The addition of this data lends support to the analysis mentioned above, that a final /j/ is part of the phonological representation of j-final weak verbs. The presence of the nouns and the surface [i] in the past tense forms of the verbs is motivation for an abstract /j/ in all related forms. The claim, then, would be that the occurrence of [j] is predictable, that the relationship between *kana* 'he bought' and *kanjan* 'buyer', for example, is transparent, and that an underlying /j/ should be posited in the phonological representation of the verbs as well as the nouns. This argument would result in the representations in (12). [12]

(12) Representations for ʔ-final and j-final weak verbs
(Plausible analysis #2: Abstract representations)

a.	/mileʔ/	→	mile	'he filled'
b.	/mileʔ-a/	→	milʔa	'she filled'
c.	/nikaj-on/	→	nikajon	'cleanliness'
d.	/nikaj-ti/	→	niki-ti	'I cleaned'

[12] Here and throughout I do not focus on the final vowel of the 3ms form for j-final verbs, or on the 3fs epenthetic *t*. If you compare the paradigms of regular verbs to j-final verbs, you will see that the 3ms form always has a second vowel that is different than that in the rest of the inflections (cf. *tip**a**s-ti* 'I climbed', *tip**e**s* 'he climbed'). The epenthetic *t* in the 3fs form is historical, and this form is considered to have its own representation.

The main difference in the first two analyses lies in what constitutes enough surface evidence to enable speakers to form a generalization and posit an abstract representation. In the example in (12), the existence of a surface [j], the surfacing high vowel in the verbal paradigm, and the preference in Modern Hebrew for tri-consonantal roots combine to motivate the underlying relatedness of the surface forms.

Thus far, we have two possible analyses for weak verbs in Modern Hebrew. The first analysis involves a transparent relationship for the ʔ~ Ø alternation, supporting the claim that an underlying glottal stop for traditional ʔ-final weak verbs is included in the phonological representation. For traditional j-final verbs, this analysis is consistent with the claim that there is not enough evidence to support an underlying /j/, therefore no underlying final consonant is represented for this set of weak verbs. The other analysis, more abstract in nature, claims that the existence of a final consonant in related forms and within paradigm variation enable the move from the constrained representation that speakers initially posit to a more general representation, linking the variable surface forms with a single, underlying representation.[13] Both analyses are acceptable, and we currently have no tools with which we can choose one over the other. These are not the only possible analyses, and I provide one final analysis below.

2.5.3. Analysis 3: Concrete representations

If we base our phonological analyses purely on data sets like those in (6) and (10), we might only arrive at the two analyses already presented. However, consideration of independent data might support a different analysis. Here I consider the usage patterns and phonology-independent factors and argue for a concrete analysis for both types of weak verbs.

This type of approach supports the analysis presented in (7) in which the underlying /j/ in j-final weak verbs is purely historical. An additional argument is that it is not clear whether the relationship between nouns and verbs is strong enough for speakers to make this abstract generalization. Furthermore, since surface [i] never alternates in the verbal paradigm, speakers would never posit anything other than underlying /i/. In sum, a concrete analysis questions the "evidence" used in forming abstract representations and claims that speakers cannot internalize this generalization because:

- [j] never surfaces in the verbal paradigm,

[13] For arguments in favor of abstract representations in Modern Hebrew, see Barkai 1972.

- while a few nouns and verbs may have a related meaning, this does not prove that they share a phonological representation, and

- the fact that the verbs are not variable themselves provides no evidence to a speaker that an alternation is present.

Therefore, this third analysis is similar to the first analysis in the representation of j-final verbs as having no underlying /j/. However, there is a difference between the two analyses, and that difference manifests itself in the representation of ʔ-final weak verbs.

The difference between this analysis and that presented in (12) falls not on the j-final weak verbs, but on the ʔ-final weak verbs. We have seen that there is a transparent relationship between the glottal stops that surface in onset positions in Modern Hebrew (i.e., *milʔa* 'she filled') and the loss of glottal stops in coda positions (i.e., *mile_* 'he filled'). The paradigm in (4), while serving as a complete data set from which we can make generalizations, does not provide us with the information we need to make an informed analysis. For example, there are a number of factors other than the simple ʔ~Ø alternation that affect the ways in which speakers form underlying representations and identify variable surface forms as stemming from a single, abstract form. These factors, presented below, are used to support the following representations that constitute the third, and final, analysis of weak verbs in Modern Hebrew.

(13) Representations for ʔ-final and j-final weak verbs
(Plausible analysis #3: Concrete representations)

a.	/mile/	⟶	mile	'he filled'
b.	/milʔ-a/	⟶	milʔa	'she filled'
c.	/nikaj-on/	⟶	nikajon	'cleanliness'
d.	/niki-ti/	⟶	niki-ti	'I cleaned'

This analysis supports the view that there are no consonants in the phonological representations that are not present in the surface forms. Basically, each phonological representation is identical to its corresponding surface form exactly. There is no proposed underlying relationship between j-final verbs and nouns, and no proposed underlying glottal stop for ʔ-final verbs (unless the glottal stop is in the onset (13d)). While we have discussed why the representations are concrete for j-final weak verbs, the arguments for concrete ʔ-final weak verbs (13c) require a detailed discussion.

2.5.3.1. External factors blocking final abstract glottal stops

As we know, glottal stops are banned from coda positions, and therefore, whenever the final consonant of this group of verbs would occur in the coda, it does not surface. This is illustrated in (14).

(14) Glottal-final weak verbs
mile m-l-ʔ 'he filled'

1s	mile-ti	1p	mile-nu
2ms	mile-ta	2mp	mile-tem
2fs	mile-t	2fp	mile-ten
3ms	mile	3p	milʔ-u
3fs	milʔ-a		

The final root consonant, ʔ, only occurs in two forms in (14) (and a total of seven forms in the entire paradigm provided in (4)), whereas the final root consonant surfaces in every form of a regular verb. This alternation, though, is assumed to be transparent by most accounts of phonology, since the surface pattern of glottal stops is predictable throughout Modern Hebrew, not only in the domain of weak verbs. However, this assumption may be unwarranted when we consider additional facts about glottal stops in Modern Hebrew.

(15) Glottal stops in Modern Hebrew

1. Glottal stops are guided by the phonotactics of MH, as they may surface only in the onset position. When in coda position, they do not surface (Rosén 1977).

2. Onset glottal stops are produced *optionally* (Berman 1981a; Schwarzwald 2001).

3. Onset glottal stops are *usually* omitted (Berman 1981b).

4. Glottal stops are present in less than five percent of new roots (Schwarzwald 1984).

5. Glottal stops, even while deleted, are always written as a letter of the alphabet.

6. Glottal-final weak verbs total 15 in the pi'el pattern in Modern Hebrew (equivalent to 3% of the pi'el verbs).[14]

The first point raised in (15) is one that has served as motivation for the abstract analysis of opacity in the nominal system of Hebrew. In Modern Hebrew, there is a class of nouns that is traditionally analyzed as having an epenthetic second vowel that is signaled by the initial stress, as opposed to the default initial stress.[15] These nouns are typically called segolate nouns, after the second vowel, called a seghol. For example, the word *délet* 'door' has initial stress. An analysis of this form stems from the underlying form /delt/ which first takes stress on the first vowel and then epenthesizes a vowel to break up an illicit final consonant cluster.[16] This analysis leads to opacity when we consider segolate nouns that have a final underlying glottal stop. An example of a segolate noun that is typically analyzed as having an underlying glottal stop is the form [déʃe] 'lawn, grass'.

As the first point in (15) states, and as previously discussed, glottal stops cannot surface in coda positions. The existence of the underlying glottal stop is crucial for an abstract analysis of segolate nouns in MH, as there is no reason for epenthesis of [e] unless there is an illegal consonant cluster at some level. While this case is more extreme than the case of weak verbs (as the alternation in the verbal system is transparent), the question of whether there is an underlying glottal stop in both cases is pertinent to our understanding of phonology in general, and the extent to which speakers can identify surface variants as stemming from a single underlying form. For this reason, we cannot take the first point in isolation. The nature of glottal stops in Modern Hebrew is more complicated than indicated by many existing analyses of Modern Hebrew opacity, and the analysis of transparent weak verbs that is our ultimate goal.

When considering the next two points together the picture becomes much different. First, the production of glottal stops in onset positions is optional (Berman 1981a; Schwarzwald 1984; Glinert 1989; Schwarzwald 2001). This is not a trivial observation. In MH, glottal stops do not only occur as root final consonants, but in the root-initial and root-medial positions as well. The fact that onset production is optional is complicated when we look at the latter forms, forms with medial glottal stops. Consider the examples in (16).

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[14] This number includes only those verbs written with the letter representing a glottal stop (*alef*). The number goes up to 49 when we add verbs that end in the historical pharyngeal (that are now pronounced as glottal stops).

[15] But see (Ussishkin 2000) and Graf (2001) who offer different views about the stress patterns of Modern Hebrew.

[16] For ease of explication I discuss this in terms of a rule-ordered analysis, however these forms are handled quite efficiently in a constraint-based framework with the use of a constraint prohibiting stress on epenthetic vowels, and a coda constraint.

(16) a. baʔar ~ baar ‘he burned’
b. raʔad ~ raad ‘he shook’
c. zoʔem ~ zoem ‘angry’
d. reʔut ~ reut ‘friendship’
e. teʔom ~ teom 'twin'
f. maʔus ~ maus ‘disgusting’
g. taʔer ~ taer ‘describe’

The optionality of the production of glottal stops is important because of forms like those in (16). In these words, the deletion of an abstract glottal stop results in a highly marked structure, namely vowel hiatus. One solution to vowel hiatus across languages is epenthesis. In isolation, these words may reasonably be analyzed as having epenthetic elements to break up a less preferable VV structure. However, epenthesis would not be expected in forms like those in (17).

(17) a. karʔa ~ kara ‘she read’
b. kafʔa ~ kafa ‘she froze’
c. milʔa ~ mila ‘she filled’

If glottal stops are optionally deleted in these forms, they should not be analyzed as a result of epenthesis since their presence creates a more marked structure (i.e., the creation of a closed syllable, CVC.CV, rather than the maintenance of an open syllable, CV.CV). However, we do not know whether speakers handle both types of glottal loss in the same manner, especially since the forms in (16) may motivate a less abstract analysis which includes glottal insertion.

The next point, and one that is related to the previous discussion, is that glottal stops are *usually* deleted. This is pointed out by Berman (1981a), among others. The percent of time glottal stops are deleted is extremely important in understanding what type of evidence must be present in the speech signal to motivate an abstract form (or maintain a concrete one). In the case of weak verbs, we may ask how much exposure speakers have to the “transparent” alternation. Consider the weak verb paradigm given below (18).

(18) *mile* m-l-ʔ ‘he filled’

PAST

1s	mile-ti	1p	mile-nu
2ms	mile-ta	2mp	mile-tem
2fs	mile-t	2fp	mile-ten
3ms	mile	3p	milʔ-u
3fs	milʔ-a		

PRESENT

ms	me-male
fs	me-male-t
mp	me-malʔ-im
fp	me-malʔ-ot

FUTURE

1s	ʔa-male	1p	ne-male
2ms	te-male	2mp	te-malʔ-u
2fs	te-malʔ-i	2fp	te-malé-na
3ms	je-male	3mp	je-malʔ-u
3fs	te-male	3fp	te-malé-na

INFINITIVE

le-male

Of the twenty-four forms in the paradigm, only seven forms, or 29.17%, have glottal stops in a position where they *could* be produced. In the remaining 70.83% of the forms, the pattern calls for the third root consonant to surface in a coda position, which immediately rules out glottal stops.

Including the *optionality* of glottal stop production, the number of instances in which glottal stops are produced significantly decreases. While Berman (1981a) argues that the trend of glottal stop deletion began in particular socioeconomic groups, she also shows that this is no longer the case and glottal stops are produced less and less as time goes by, independent of socioeconomic status. At this point, without a linguistic corpus of Modern Hebrew productions, we do not know the exact numbers, but we can make a conservative estimate of the situation. We are concerned about three generations of speakers; young adults, older adults (parents of younger adults), and those who provided input in the early stages of the older adults’ lives: their

parents' generation. I refer to these as G3 (young adults), G2 (parents), and G1 (grandparents), respectively.

If we assume that glottal stops are deleted optionally half of the time, and that deletion increases over time, we can estimate the production of glottal stops throughout time. Presumably, G1 speakers produced every possible onset glottal stop, G2 speakers produced fewer glottal stops, deleting them, for example, a quarter of the time, and G3 speakers produce the fewest glottal stops, deleting them half of the time. The importance of considering the production of glottal stops enables us to understand the exact situation of younger adult speakers of Modern Hebrew, and to understand at what point a generalization is identified as such by language learners. One estimate of glottal stop production is represented in Table 3.

	Percent of glottal stops produced	**Percent of verbs that are produced with glottal stops**
G1 (grandparents)	100.00	29.16
G2 (parents)	75.00	21.87
G3 (young adults)	50.00	14.58

Table 3. Conservative estimate of production of and exposure to glottal stops in weak verbs

In Table 3, *glottal stop production* is an estimate of the percent of the time a speaker of each generation may produce glottal stops, considering that they are optional. As discussed above, glottal deletion increases over time. This means that the production of glottal stops decreases for each generation. *Percent of verbs that are produced with glottal stops* is the estimated amount of glottal stops within a paradigm to which a speaker is exposed. Within the ʔ-final weak verb paradigm, we saw that only 29% of the verbs have patterns that contain onset glottal stops. So if a speaker of generation G1 produces glottal stops in every single onset, approximately thirty percent of the inflected ʔ-final weak verbs would be produced with glottal stops. Additionally, if we follow the decline in the production of glottal stops documented in the literature, each successive generation will produce fewer instances of onset glottal stops, leading to less and less *access* to that consonant within the verbal paradigm.

Table 3 gives us a conservative estimate of how much exposure G3 speakers might have to the final root consonant in transparent ʔ-final weak

verbs. Of course, this is extremely simplified, because the percent of access to a particular sound or alternation would presumably decrease as exposure from speakers from the same generation increased. Additionally, Berman (in 1981) claimed that in colloquial speech, glottal stops are *usually* deleted. If we take *usually* to mean the form that is commonly used, our numbers are too high. Consider the difference when we lower the production rate of G2 speakers.

	Percent of glottal stops produced	**% of verbs that are produced with glottal stops**
G1 (grandparents)	100.00	29.16
G2 (parents)	50.00	14.58
G3 (young adults)	25.00	7.29

Table 4. Realistic estimate of production of and exposure to glottal stops in weak verbs

This set of numbers appears to be in accord with literature on the topic of glottal deletion in Modern Hebrew. Here, I can only suggest that the production of (and therefore exposure to) glottal stops resembles something like that in Table 4. Younger adult speakers of Hebrew, then, are exposed to glottal stops in ʔ-final weak verbs about 7.29% of the time. Is this number large enough to maintain the tri-consonantal root in these words? The concrete analysis presented here claims that it is not. At the very least, the incorporation of the issues thus far suggests that the alternation of glottal stops in Modern Hebrew is by no means simple. Therefore, any analysis that posits abstract glottal stops in Modern Hebrew should be reconsidered, or considered with caution.

The next points raised are also important to the understanding of abstractness and the limits on phonological representations. These issues involve orthography and the overall presence of glottal stops in Modern Hebrew. Glottal stops are always written, even when deleted. The relationship between phonology and orthography is particularly important in Modern Hebrew since the writing system is riddled with history.

It is also important to note that the number of weak verbs that have final glottal stops is small. Based on numbers alone, we have to consider which is more reasonable, developing an abstract representation for fifteen words, or storing them as identical to the outputs.

Finally, a brief comment on the overall presence of glottal stops in Modern Hebrew concludes our investigation into the nature of glottal stops and their interaction with weak verbs in MH. As shown by Schwarzwald (1984), fewer than 5% of new roots of Modern Hebrew contain glottal stops. This suggests that the glottal stop may be a marginal phoneme of Modern Hebrew, a topic that is addressed in Chapter 5.

In this section, we have seen little evidence to support underlying glottal stops in the majority of weak verb inflections. The data in (5) exhibit an apparent transparent alternation; however, the consideration of independent factors might lead us to the conclusion that this alternation is not part of speakers' grammars. The additional factors discussed indicate that speakers are not exposed to enough evidence to move from a constrained representation (i.e. /mile/) to an abstract one (i.e., /mileʔ/). While independent supporting evidence is sought for this claim in Chapter 3, it is clear that, at the very least, the incorporation of phonology-independent issues into a phonological analysis provides insight into the phonology of weak verbs in Modern Hebrew, and offers a different picture than the one drawn by the examination of the data set alone.

2.5.4. The three analyses of weak verbs

So far in this chapter, we have seen three completely plausible analyses of weak verbs in Modern Hebrew, each with its own claims as to the types and amounts of evidence speakers use to form a phonological representation, whether abstract and differing from the surface form, or concrete and identical to the surface form. The first analysis proposes that underlying glottal stops do exist for all ʔ-final weak verbs, but that there is no evidence of underlying /j/ in any j-final weak verbs. The glottal stop alternation is claimed to be transparent and predictable, as it has been suggested that the phonotactics of languages are learned at an early stage of acquisition (Hayes 1999). However, the lack of surface [j] in the verbal paradigm makes an underlying /j/ questionable.

The second analysis shares the view about glottal stops with the first analysis, but argues that there is in fact evidence of an underlying /j/. Many verbs in the j-final weak verb paradigm surface with [i] instead of [a], which appears in regular verbs. This vowel difference is attributed to the underlying status of /j/, which may merge with the pattern vowel [a] and surface as [i], or simply surface in its place. In addition to the surface [i], there are a number of related nouns that appear with [j]. The abstract analysis claims that speakers relate the verbs and nouns at the phonological level and the surfacing [j] in nouns cues speakers to this relationship.

In contrast to the abstract analysis, I presented a concrete analysis which claims that the phonological representations look exactly like the surface forms.

This analysis sides with the first analysis in terms of the historical nature of /j/, and proposes that underlying /j/ is not present in the phonological representation of any j-final verb. This analysis differs from the others in that it proposes the same type of concrete relationship for ʔ-final verbs. Once we consider external factors such as deletion, and the exposure speakers have to an alternation, the assumption that the ʔ ~ Ø alternation is transparent becomes questionable. Therefore, the third analysis also posits concrete representations for ʔ-final weak verbs and claims that glottal stops are only in the underlying representation of forms that surface with glottal stops.

Without biases, all three analyses adhere equally to standards of phonological analysis. While other areas such as loanword phonology and aphasic data (as discussed in Chapter 1) help expand upon our understanding of the nature of phonological representations, we may also find experimental support in psycholinguistics. Each analysis presented here makes specific claims about the nature of representations in the grammars of speakers, and about the kinds of evidence that are used in forming these representations.

2.6. Predictions

In this section, I briefly introduce the basic predictions of each analysis presented above.[17] The predictions are discussed more thoroughly in Chapter 3, along with a priming experiment designed to test these predictions.

2.6.1. Predictions of Analysis 1: Concrete and abstract representations

This analysis proposes that there is no final consonant for any j-final weak verb, and there is an underlying glottal stop for all ʔ-final weak verbs. In an experiment that tests the nature of representations of these two types of verbs, then, we would expect to find a difference in the way speakers handle each type of verb. In general, we expect to find some type of support for abstract representations for ʔ-final weak verbs, but none for j-final weak verbs. If a difference between the two verbs is found, then the presence of an alternation within the verbal paradigm is an effective source of evidence that enables speakers to form an abstract representation. In contrast, the presence of an alternating sound in related nouns is not sufficient evidence for speakers to identify the forms as related at the phonological level.

[17] I only supply the basic predictions here since the precise predictions are dependent on the experiment, and they are discussed in the following chapter.

2.6.2. Predictions of Analysis 2: Abstract representations

The second proposed analysis is consistent with claims that final underlying consonants are present in all j-final and ʔ-final weak verbs. If this proposal is supported, we expect the experimental results to provide us with evidence that there is a final consonant in the underlying representations. Both types of weak verbs are similar to regular verbs at the phonological level in this analysis. If evidence of underlying consonants is found, then, in addition to the glottal stop alternation being internalized, an underlying /j/ is motivated by surface [i] in the verbal paradigm, and/or related nouns that surface with [j].

2.6.3. Predictions of Analysis 3: Concrete representations

The third analysis presented in this chapter claims that all representations for j-final and ʔ-final weak verbs are concrete and they are identical to their surface forms. This analysis focuses mainly on external factors and raises questions about what types of external factors influence phonological representations. We would expect both types of weak verbs to be handled the same by speakers, but different from regular verbs, as they do not share a pattern with regular verbs at the phonological level. If this type of evidence is found, then the pure existence of a phonological alternation (that is both predictable and transparent by current standards of phonology) does not enable a speaker to posit an abstract representation if the speaker does not have enough access to this alternation. The optional deletion of glottal stops would play a role in blocking the formation of an abstract representation in this case.

The concrete analysis makes one additional prediction. One possibility is that we find a difference between the way older and younger adults represent ʔ-final weak verbs. If each generation's exposure to the glottal/zero alternation was different, it is reasonable to expect that the older generation, with more exposure to the final consonant, formed an abstract representation, while the younger generation, with less exposure to glottal stops, never moved from an initially-posited concrete representation. This prediction, along with the others, is tested in Chapter 3.

2.7. Conclusion

Two types of weak verbs in Modern Hebrew were presented in this chapter: one with an abstract representation compliant with the phonotactics of

Modern Hebrew, and one with a historical final /j/ that may surface as the vowel [i] in some forms of the verbal paradigm. Three plausible analyses were proposed in an attempt to account for the surface alternations found within the verbal paradigms. At this point, the choice among analyses is dependent on which types of evidence one deems sufficient to posit particular representations. Do related forms (like nouns) provide evidence that a speaker can use to identify relatedness at the phonological level? Or, does there have to be an alternation motivated by the phonotactics of a language within the verbal paradigm? Is the presence of a predictable alternation all a speaker needs to identify surface variants as deriving from a single underlying form, or can this identification process be blocked by external factors? All of these questions were raised here and are answered in the following two chapters.

At this point in time, we have no means to tease apart psychologically plausible analyses and psychologically real ones, as can be seen from the analyses provided ranging from abstract to concrete. There are a number of factors weighing on weak verbs in MH, and it is possible (according to Analysis #3) that we cannot rely purely on phonology, as it is intertwined with a number of phonology-independent factors. While this chapter has highlighted a number of issues that may prove influential in analyzing weak verbs in Modern Hebrew, the following chapter attempts to understand the effects of these factors, in order to establish a set of criteria that govern the formation of abstract representations. But, more importantly, the experiment presented in Chapter 3 is designed to provide us with direct evidence as to the nature of representations, serving as a tool that can help us choose the analysis that best accounts for weak verbs in Modern Hebrew.

Chapter 3
Morphological priming in Modern Hebrew

Phonological theory lacks established criteria for choosing between multiple plausible analyses for the same set of data. In Chapter 2, I illustrated this by proposing three equally plausible analyses to account for alternations found in two types of weak verbs in Modern Hebrew. The choice of a particular analysis is dependent on the types of supporting data that one accepts as evidence. While the goal of each analysis is to accurately model the phonological component of grammar, each makes vastly different predictions about the nature of representation, the organization of grammar, and the types of evidence speakers use to identify two surface variants as related.

The goal of this chapter is to explore the representations and processing of weak verbs from a psycholinguistic perspective. Here, I present the results of a morphological priming experiment in Modern Hebrew designed to clarify the nature of underlying representations of weak verbs. The main question on which the experiment is based is whether we have psycholinguistic evidence for abstract final consonants, as discussed in the previous chapter. To explore this issue, I designed a morphological priming experiment, which is presented in Section 3.3. Before discussing the experiment, though, a brief background on priming and on psycholinguistic research in Modern Hebrew is provided below.

3.1. Priming

Priming refers to the effect whereby a target word is recognized faster when preceded by a related word or probe than when it is preceded by an unrelated one. For example, the target word in a stimuli pair of two semantically-related words (e.g., light-PLUG)[18], will be recognized faster than the target word in a stimuli pair containing two semantically unrelated words (e.g., dog-PLUG). Priming, or the speeded up recognition of a related target, has been found for semantically, syntactically, morphologically, and phonologically related pairs. Each examination into the types of forms that

[18] Here and throughout, a prime target pair is represented as prime-TARGET.

exhibit a priming effect allows us to better understand the nature of lexical forms, relationships among words, and the factors involved in lexical activation and word recognition.

While we are interested in the phonological representation of verbs, the experiment presented in this chapter is not a phonological priming experiment, but a morphological priming experiment. A phonological priming experiment was not designed for two reasons: (1) the phonotactics of Modern Hebrew make it impossible to compare underlying glottal stops with surface glottal stops in coda positions, and (2) the only possible design comparing surface and underlying glottal stops is likely to have ambiguous results. More specifically, we know that phonological priming occurs between two phonologically similar forms (i.e., Marslen-Wilson 1987). Furthermore, much research on phonological priming has shown the rime of a syllable to produce the most robust priming effects (Slowiaczek & Hamburger 1992; Radeau et al. 1995, Slowiaczek et al. 2000, among others). Therefore, for ʔ-final weak verbs, the most effective way to design the experiment would be to have a weak verb prime, like *mil**e***, that is hypothesized to have /mileʔ/ as the corresponding phonological form, and a target that has the surface structure *CiCeʔ*. The desired target structure in this case is impossible in Modern Hebrew since glottal stops are banned from coda positions.

One solution to this problem is to find a word that shares the sequence *eʔ* on the surface with the underlying *eʔ* sequence in /mileʔ/. One option is to include pairs like *mile-TEʔER* (or, /mil**e**ʔ/-T**E**ʔER) into the design. In this pair, the proposed underlying sequence matches the surface sequence. One problem, though, is that this design tests the priming ability of a final underlying glottal stop with a surface medial glottal stop in the onset position. To my knowledge, there is no experiment that shows priming can occur in this situation. Therefore, the lack of a priming effect would be ambiguous between the inability of the prime to facilitate recognition and the inability of the design to allow priming. This complication compels us to consider a different way of examining the issue. We can then consider a more general focus: a design which allows us to examine whether we have evidence for a final consonant at all, not specifically /ʔ/ or /j/. Morphological priming allows us to examine weak verbs from a more general perspective.

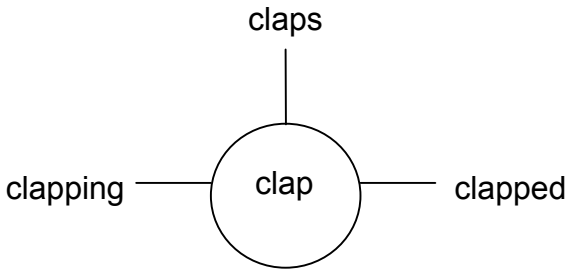
3.1.1. Morphological priming

Morphological priming, like semantic or phonological priming, occurs when target recognition is facilitated by a related preceding prime. The morphological priming effect is well documented in the literature (i.e., Emmorey (1989) and Marslen-Wilson & Zhou (1995), Clahsen et al. 2001, among others).

The foci of research in many morphological priming experiments include the relationships among morphologically related words (i.e., clap, claps, clapped), whether morphologically complex words are broken down or stored as separated morphemes (e.g., clapped = clap + PAST), and whether irregularly inflected words are broken down or stored as whole units in the lexicon.

There are two general views on the role and organization of morphology in psycholinguistics: one claims that morphology does not play a role in processing, and the other claims that the morphology of a word does in fact play a role in word recognition and production. The former view underlies most connectionist models (e.g., (Rumelhart & McLelland 1986) that view relationships as a set of connections among words. An example of a common representation of this view is the satellite model where a stem is the central form, and it is connected to other forms, as in (1).[19]

(1)



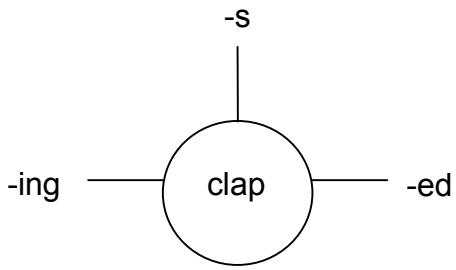
In this view, the center of the satellite is typically a stem, and it is connected to other related word forms, not morphological units, but whole words. Other models may differ in that they do not have one center stem. But in most such models, it is the entire word that is stored, along with its inflections. This word is not parsed into smaller morphological units by speakers.

In a morphologically-based model, which assumes that morphology does in fact play a role in word recognition, a word can be decomposed into separate morphemes which affect processing and recognition. There is a large body of research that supports this view. For example, Marslen-Wilson and colleagues (1994) conducted priming experiments to examine the relationship between a stem and its derived forms, as well as the relationship between derived forms. They designed a priming experiment to test stimuli pairs such as *government-GOVERN*, *governor-GOVERN*, *government-GOVERNOR*. Priming was found in the first two cases, but not in the latter case. This was explained by suggesting that the stem is stored and related not to whole words, but to morphemes. Basically, the word *government* activates both the stem *govern* and the suffix *–ment.* Marslen-Wilson et al. propose that even though the stem is activated, access to the derivational suffix inhibits access to another derived word.

[19] This is a simplified view of the model, and there are more complicated variants that make similar claims about morphology (see, for example (Bybee 1995; Elman et al. 1996)).

Morphological priming has also been found among inflected forms (e.g., (Fowler et al. 1985)). The relationships assumed in some models accounting for these results are as in (2).

(2)



In this example, where the stem is related to individual morphemes, not whole words, the implication is that a word is parsed into smaller morphological units during processing. With this brief introduction on morphological priming and related issues, we turn now to the more specific topic of morphological priming in Modern Hebrew.

3.2. Morphological priming in Modern Hebrew

The examination of Modern Hebrew, and Semitic languages in general, is important in understanding lexical representations and word recognition since the morphology is composed of roots and patterns, as discussed in Chapter 2. In English, to form the past tense of the word *climb*, we simply add –*ed*. The morphological composition of verbs is quite different in Modern Hebrew, and Semitic languages in general. In Modern Hebrew, verbs are inflected for person, number, and gender by the combination of an abstract pattern (generally, a phonological shape minus the root consonants) and affixes. Some examples for the regular verbs *tipes* and *diber* are provided in (3).

(3) Sample inflectional patterns for the verbs *tipes* 'he climbed' and *diber* 'he spoke'

	(P)GN	SURFACE FORM	ABSTRACT PATTERN	ROOT	GLOSS
a.	2FS	tipas-t	CiCaC-t	TPS	'you (F.SG) climbed'
b.	2FS	dibar-t	CiCaC-t	DBR	'you (F.SG) spoke'
c.	2MP	tipas-tem	CiCaC-tem	TPS	'you (M.PL) climbed'
d.	2MP	dibar-tem	CiCaC-tem	DBR	'you (M.PL) spoke'
e.	FS	me-tapes-et	me-CaCeC-et	TPS	'(F.) climbs'
f.	FS	me-daber-et	me-CaCeC-et	DBR	'(F.) speaks'
g.	MS	me-tapes	me-CaCeC	TPS	'(M.) climbs'
h.	MS	me-daber	me-CaCeC	DBR	'(M.) speaks'
i.	2FS	te-taps-i	te-CaCC-i	TPS	'you (F.SG) will climb'
j.	2FS	te-dabr-i	te-CaCC-i	DBR	'you (F.SG) will speak'
k.	2MP	te-taps-u	te-CaCC-u	TPS	'you (M.PL) will climb'
l.	2MP	te-dabr-u	te-CaCC-u	DBR	'you (M.PL) will speak'

The examples in (3) show that a surface form is composed of an abstract pattern or shape, plus the three consonants that compose the root. The examples in (3a-d) all share the abstract pattern CiCaC plus a suffix. The root consonants surface in the positions specified by the abstract pattern, interleaved with the vowels for each pattern. Examples (3a) and (3b) show that a different root changes the meaning of the word, but the person, gender, and number for a particular pattern remain constant across roots. Examples of the present tense patterns for the two roots TPS and DBR are provided in (3e-h), and the future tense patterns are given in (3i-l). Each group of words is morphologically complex, consisting of a root, a pattern, and affixes.

One important question is whether speakers are able to decompose these complex surface forms into a root (i.e., TPS) and an abstract pattern (i.e., CiCeC, where C = root consonants). Frost and colleagues (Deutsch et al. 1998; Frost et al. 2000a; Frost et al. 2000b) have argued that decomposition in Modern Hebrew does indeed occur during word recognition.

3.2.1. Verbal pattern priming

In a series of experiments examining verbal patterns in Modern Hebrew, Frost and colleagues (Deutsch et al. 1998; Frost et al. 2000a; Frost et al. 2000b) argue that morphologically complex words are stored as individual morphemes, and that the nonlinear morphology of Modern Hebrew is decomposable into a root and a word-pattern morpheme.[20] Originally, in a masked priming experiment (Deutsch et al. 1998; results reduplicated in cross-modal presentation in Frost et al. 2000[21]), Frost and colleagues examined the effect on word recognition of a target preceded by a prime sharing the same word-pattern. The stimuli consisted of target verbs preceded by four conditions: identity, related-complete, related-weak, and a control, or unrelated condition. The identity condition consisted of primes and targets that were identical, with the intention of showing the maximum priming effect that can occur. The related-complete condition consisted of regular verb primes (verbs in which all root consonants surface) that share the pattern of the target word. The related-weak condition consisted of weak verb primes (primes that surface without a root consonant) that share the pattern of the target word. Finally, the unrelated condition consisted of a verb from a different pattern that was matched for phonological relatedness similar to the other primes. Examples of the stimuli are provided in Table 1.

Condition	**Identity**	**Related-complete**	**Related-weak**	**Control**
Primes				
Gloss	'he managed'	'he filmed'	'he overthrew'	'fell apart'
Pronunciation	[hispik]	[hisrit]	[hipil]	[hitparek]
Root	s-p-k	s-r-t	n-p-l	p-r-k
Target				
Written form (Same for all conditions)	הספיק <hspyk>	הספיק	הספיק	הספיק

Table 1. Examples of stimuli from Deutsch et al. 1998

[20] The experiments discussed here focus only on Modern Hebrew verbs, as Deutsch et al. 1998 showed that nouns do not exhibit pattern priming.

[21] While the results were reduplicated for regular verbal patterns, the weak verb condition was not included in the cross-modally presented experiments.

Frost et al. (1998) found that the identity condition exhibited the largest priming effect (targets in the identity condition were recognized 54 milliseconds (ms) faster than targets preceded by a control prime), as expected. There was also significant priming in the related-complete condition (17ms), but no significant priming in the related-weak condition (6ms). According to Frost and colleagues, these results support an analysis in which verbs are decomposed into two morphological units, a root and an abstract pattern. The lack of priming in the related-weak condition signals the inability of the word recognition system to parse a word that is missing a root consonant (but see the following section for issues related to this claim). Additional experiments were designed to factor out semantic and phonological factors in the results (Deutsch et al. 1998, Frost et al. 2000b).

3.2.2. Unresolved issues

There are a number of issues that remain to be addressed, once we consider the linguistic aspects of weak verbs in Modern Hebrew discussed in Chapter 2. First, it is important to note that while the morphological priming experiments presented in Deutsch et al. 1998, Frost et al. 2000a did include weak verb primes, the design of the experiment masks the possibility of a weak verb effect.

As discussed, there are two types of weak verbs in Modern Hebrew: those with phonologically-motivated consonant loss, and those with unmotivated consonant loss. Both types of weak verbs were included in a single condition in the experiments. Weak verbs like those mainly used in the experiment (n-initial weak verbs) are the type which exhibit unmotivated consonant loss. Therefore, it is not necessarily true that these verbs have an underlying initial consonant. While some phonologically-motivated weak verbs may have been included in the design, lumping these two types together has two undesired results: any priming effect of one group could be masked by the presence of other groups within the same condition, and even weak verbs traditionally analyzed as phonologically motivated (/j/-final verbs) present little evidence for a final consonant. The design of the experiment thus offers little chance to see an effect of weak verbs. Additional design issues contribute to the lack of effect in weak verbs, as only twelve weak verb trials were used. This low number limits the possibility of an effect surfacing, since an effect may be specific to a particular type of weak verb.

An additional relevant factor is that, as is typical of many experiments, all of the subjects were college-age students. While this may not be an issue for every language, it should not be considered irrelevant for Modern Hebrew since we have linguistic evidence that might suggest a difference in age groups (if

exposure to phonological alternations is important). The inclusion of two age groups is the only way in which we can address language change.

One final issue is that the experiments discussed were all presented cross-modally. This means that either (1) the prime was presented visually and the target was presented auditorily, or (2) the prime was presented auditorily and the target was presented visually. So, for example, in the experiment, subjects would hear the prime [hisrit], and then see the target הספיק (spelling of the target word *hispik* 'he managed'). This means that the entire root is available to the subject at once, which also means that the influence of orthography is greater than in an experiment with auditory presentation of both prime and target. Therefore, while the cross-modal paradigm has been generally used in both morphological and phonological priming experiments, for Hebrew it is problematic because the nature of the Modern Hebrew writing system makes the root available for the subjects, as the writing system contains only consonants with vowels either omitted or represented by dots and lines above or below the consonants.[22] With this in mind, we can now turn to our morphological priming experiment.

3.3. Experiment

In the experiment, the priming effects of regular verbs (verbs with all three root consonants) in the pi'el pattern of Modern Hebrew were compared with the effects of phonologically-motivated weak verbs (those that have or may have had an underlying final root consonant, but in which this consonant surfaces rarely (ʔ) or not at all (j) in the verbal paradigm) in the same pattern. The experiment contained four conditions: regular-same pattern, ʔ-final weak, j-final weak, and control-different pattern. All targets were regular verbs in the pi'el pattern.

The regular-same pattern consisted of regular pi'el verb primes followed by regular pi'el verb targets (e.g., niked-SHILEM). This condition was included to ensure that a priming effect was found. The ʔ-final weak verb condition consisted of ʔ-final weak verb primes in the pi'el pattern followed by pi'el regular verb targets (e.g., mile-DIBER). The j-final weak verb condition included j-final weak verb primes in the pi'el pattern followed by pi'el regular verb targets (e.g., nika-DIBER). Finally, the control included pa'al regular verb primes, followed by pi'el regular verb targets (e.g., katav-SHILEM). This is the condition in which Frost and colleagues have never found a priming effect (Deutsch et al. 1998, Deutsch et al. 1998, Frost et al. 2000a). The purpose of separating the two

[22] Vowels were not written in these experiments, though, as all forms chosen can be read unambiguously without the vowels.

types of weak verbs was to provide a contrast between verbs that have all three root consonants in some forms in the verbal paradigm, and those that never have the third root consonant in the verbal paradigm.

To determine whether a priming effect is found, we examine the reaction times of the related conditions relative to the control condition, where the morphological patterns of the primes and targets are different, but the primes have the same number of sounds as primes in the regular-related condition. Also, unlike in the work of Frost and colleagues, there was no phonological overlap among primes and targets other than the vowels specified for each verbal pattern in our stimuli pairs. For example, Frost and colleagues examined the patterns hif'il, huf'al, and nif'al, which all begin with prefixes. Therefore, all primes and targets of the same pattern share the prefix. Since this experiment examines only pi'el targets, there is no prefix available to possibly signal a particular pattern.

3.3.1. Method

3.3.1.1. Participants

Twenty-four older adult and sixteen younger adult native speakers of Modern Hebrew participated in this experiment. The native language of all subjects is Modern Hebrew, although all participants speak English fluently as a second language. All subjects are currently living in the United States (New York State or New Jersey) and speak Hebrew daily either as the language used at home or the language used at work or school. The majority of younger adults are here while going to college, whereas the majority of older adults live permanently in the United States. The older adult group has a mean age of 49.5, compared to a mean age of 20.5 for the younger adult group. The purpose of including two age groups in this experiment was to identify whether there exists a difference in effects between the two age groups, as the analysis in Chapter 2 that incorporates phonology-independent factors predicts.

3.3.1.2. Stimuli and design

The stimuli were produced by a native speaker of Modern Hebrew and recorded directly into the computer through a microphone in a soundproof booth. The stimuli were recorded in groups of ten and later edited into individual files using Goldwave software. The stimuli consisted of 192 prime-target pairs, broken into two sets of 96 trials. The trials included 12 regular-same pattern

pairs, 12 ʔ-final weak pairs, 12 j-final weak pairs and 12 unrelated condition pairs. Examples of the stimuli are provided in Table 2.

	Condition	Prime	Gloss	Target	Gloss
1	**Control (different pattern)**	katav	'he read'	ʃilem	'he paid'
2	**Regular-same pattern**	niked	'he dotted'	ʃilem	'he paid'
3	**ʔ-final weak verbs**	mile	'he filled'	diber	'he spoke'
4	**j-final weak verbs**	nika	'he cleaned'	diber	'he spoke'

Table 2. Examples of the stimuli used in Exp. 1 in the Control, Regular-same pattern, ʔ-final weak verb, and j-final weak verb conditions

In addition to the critical stimuli, 48 real word filler trials and 96 nonword filler trials were used. The nonwords were matched to the targets used in the real words and were formed with a nonexistent root. One potential problem with this design, as shown in Table 1, is that not all conditions were able to have the same target, as there are too few ʔ-final weak verbs (only 12 common ʔ-final weak verbs) to make more than one stimuli list containing these verbs. This means that if all conditions shared the same target, subjects would have to hear the target words four times. Targets were judged to be commonly occurring words by native speakers of Hebrew (on a four point scale: very common, common, not that common, rare), and all words rated below "common" were excluded from the experiment.

The experiment was an auditory-auditory lexical decision task, which means that the participants would hear both the prime and the target and receive no visual stimuli on the computer screen. The auditory lexical decision task has been found to be highly replicable for some effects, such as word frequency (Luce 1986; Marslen-Wilson 1990), and has had mixed results for other effects like neighborhood density (shown in Luce 1986, but not replicated in Marslen-Wilson 1990). While the results of the auditory lexical decision task may at times be difficult to interpret, the reduced influence of orthography and the desire to understand how spoken words are accessed make it a better choice than any visual presentation of the stimuli.

3.3.1.3. Procedure

The participants were presented with auditory stimuli through headphones. Each trial consisted of the presentation of the prime, a 500ms interstimulus interval, followed by the presentation of the target. There was a three second break between trials. Each subject heard all targets two times. Half of the participants received the first block of 96 trials (Block A) followed by the second block of 96 trials (Block B), and the other half received the order Block B followed by Block A.

Participants were instructed to make lexical decisions about the targets by pressing a “WORD” button or a “NONWORD” button on the keyboard of a computer. After the initial block of 96 trials, the subjects took a short break and then continued with the second block. The presentation of each block was randomized, so the targets would be presented in a different order in each block. The experiment lasted approximately twenty minutes per subject.

3.4. Predictions

3.4.1. Overall predictions

Based on psycholinguistic research, we predict that we should find a priming effect for the regular verb-same pattern condition across all subjects. Previous research in both masked priming and cross-modal experiments found that target word recognition is facilitated when the target is preceded by a verb sharing the same morphological pattern. Therefore, we expect faster response times for this condition than for reaction times to targets preceded by a verb of a different morphological pattern.

3.4.2. Weak verb conditions

There are two weak verb conditions in this experiment. Considering the possibilities purely from the perspective of research conducted in psycholinguistics, we have one distinct prediction. The inclusion of linguistic factors, however, leads us to different predictions, as outlined below.

3.4.2.1. Psycholinguistic versus linguistic predictions

Psycholinguistic evidence (e.g., studies by Frost and colleagues discussed above) predicts that weak verb primes will not result in the facilitation of a related regular verb target since a surface consonant is missing. However, as discussed in Section 3.2, the previous experiments in this area did not focus on phonologically motivated weak verbs or the possibility of an effect dependent on age groups.

Within linguistics, we have three possible analyses of weak verbs in Modern Hebrew, as well as a possible difference between age groups. In Chapter 2, we saw that the three analyses include a concrete analysis of both types of weak verbs, an abstract analysis for both types of weak verbs, and a mix of the two analyses, where the more productive glottal stop/zero alternation enables an abstract representation, contrary to the non-productive j~Ø alternation. Different results are predicted for each possible analysis.

A concrete analysis is consistent with past psycholinguistic research and we would expect no effect for younger adults in the weak verb conditions. An abstract analysis would predict that the weak verbs examined share an abstract pattern with regular verbs (CiCeC), and we therefore expect to find priming between weak verbs and regular verbs that share a pattern. The third possible analysis we considered focuses on the difference between the two types of weak verbs, suggesting that the glottal stop/zero alternation is transparent and predictable to speakers, while the same is not true for j-final weak verbs. In this case, we expect to find facilitation in the ʔ-final weak verb condition, but not in the j-final weak verb condition.

One additional prediction is specific to the linguistic situation of each age group and to ʔ-final weak verbs. We have seen that the production of glottal stops has decreased over time. As a result, older adults have been exposed to more evidence of a final root consonant in ʔ-final weak verbs than younger adults have. If the amount of exposure to an alternation plays a role in the formation of abstract representations, we expect to find an effect in the ʔ-final weak verb condition, but not the j-final weak verb condition.

In addition, if the existence of an alternation is sufficient evidence to motivate the movement from an initially-posited concrete representation to a more abstract underlying representation, then age should not play a role in the results, as there does exist a ʔ~Ø alternation in Modern Hebrew, however marginal it may be. If this is the case, then we expect that ʔ-final weak verbs should prime related targets across subjects.

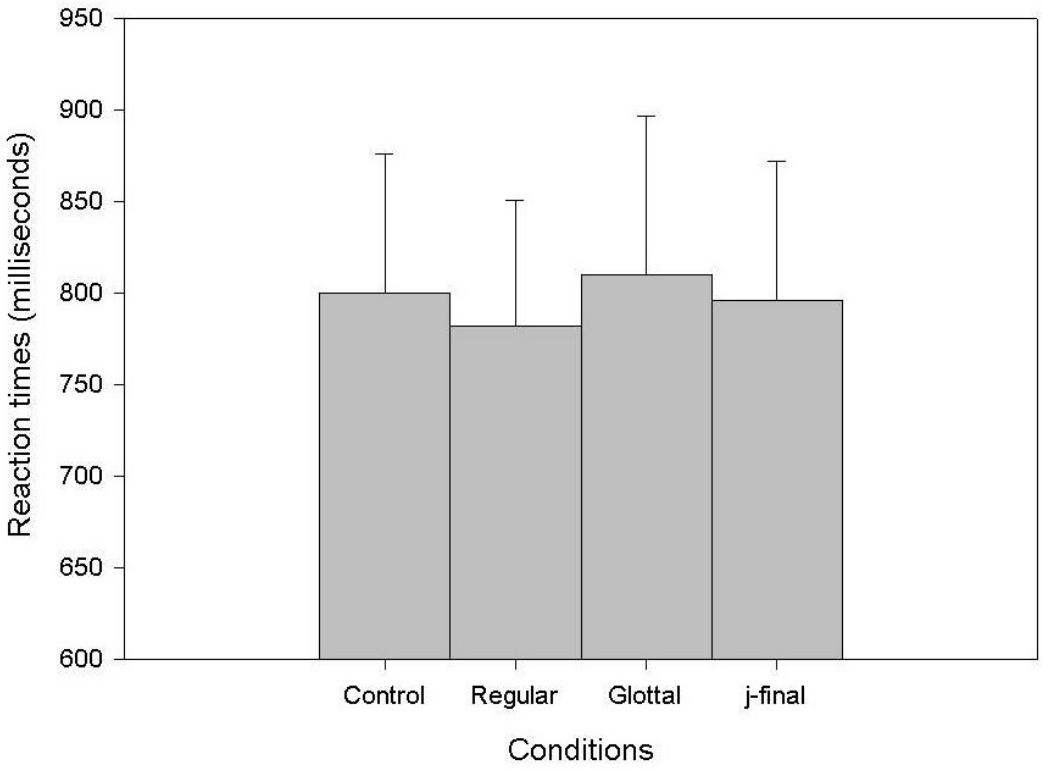
3.5. Results

Reaction times for correct responses were averaged across all participants. Trials with incorrect responses were discarded. The effects of the related-same, ʔ-final weak, and j-final weak conditions were assessed in relation to the control, which served as a baseline. The results across age groups are presented in Table 3 and Figure 1.

Related-same		**ʔ-final weak**		**j-final weak**		**Control**	
RT	% error	RT	% error	RT	% error	RT	% error
767 (-20)	7.1	795 (+8)	6.1	783 (-4)	5.6	787 --	6.7 (effect)

Table 3. Reaction times (ms) and percentage of incorrect responses for lexical decisions to target words in Experiment 1

Figure 1. Mean Response Times (RTs in Milliseconds) and Error Rates for All Subjects for Each Condition in the Morphological Priming Experiment



Significant facilitation in the related-same condition was found across subjects. An analysis of variance (ANOVA) was conducted to compare the results of each condition with the control. The prime-condition was significant across all subjects for the related-same condition ($F(1,40) = 13.99$, $p<.01$, SD = 69.0), but not for the two weak verb conditions (ʔ-final weak verbs: $F(1,40) = 3.88$, $p =.049$, SD = 86.3; j-final weak verbs: $F(1,40) = 0.56$, $p = 0.45$, SD = 75.7). These results replicate earlier findings of verbal pattern priming in Modern Hebrew.

The ANOVA also found an interaction between age and condition for the ʔ-final weak verbs, and a significant effect was found for older adults (but not younger adults) for this condition (older adults: $F(1,24) = 20.51$, $p<.01$, SD = 34.6; younger adults: $F(1,16) = 0.56$, $p = 0.46$, SD = 53.4). Tables 4 and 5 provide the results by age group.

Condition	Regular-same	ʔ-final weak verbs	j-final weak verbs
Older Adults	828	867	847
Control	850	850	850
Effect	-22	+17	-3

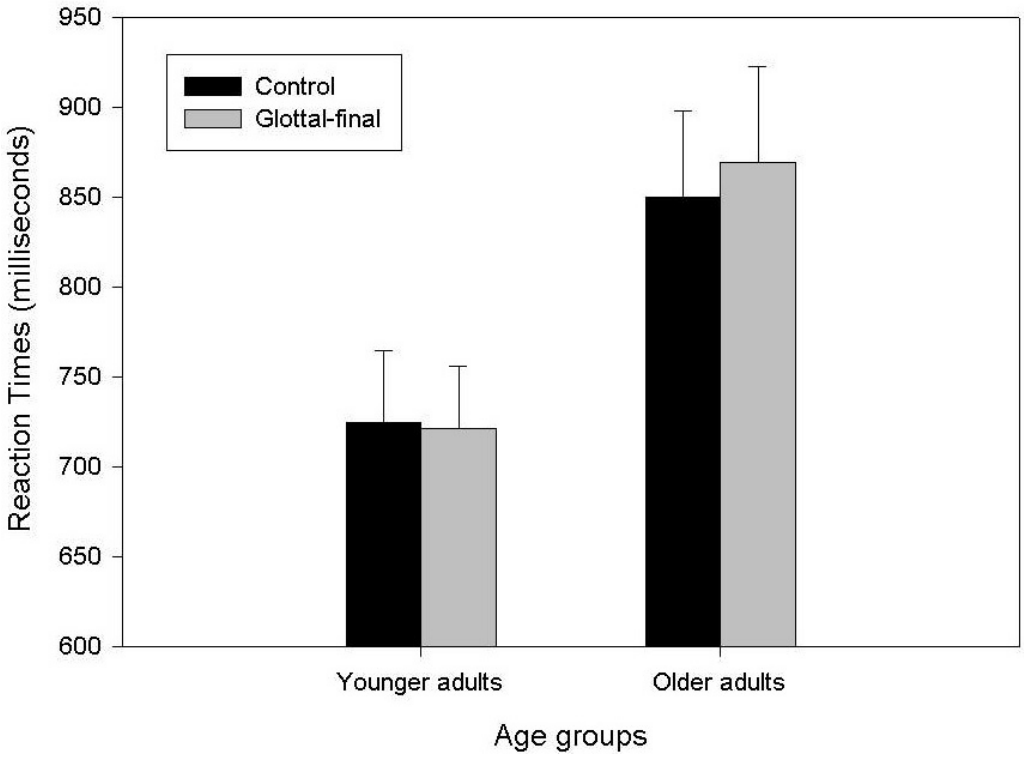
Table 4. Reaction times (ms) for older adults

Condition	Regular-same	ʔ-final weak verbs	j-final weak verbs
Older Adults	706	721	719
Control	724	724	724
Effect	-18	-3	-5

Table 5. Reaction times (ms) for younger adults

As shown above, the results are the same across age groups, except for the ʔ-final weak verb condition. In this condition, younger adults show no effect. The response times of older adults, however, are significantly slowed for targets preceded by ʔ-final weak verbs than for those preceded by regular verbs from a different morphological pattern. A comparison of the ʔ-final condition is provided in Figure 2.

Figure 2. Mean Response Times (RTs in Milliseconds) and Error Rates for Younger and Older Adults for the ʔ-final Weak Verb and Control Conditions in the Morphological Priming Experiment



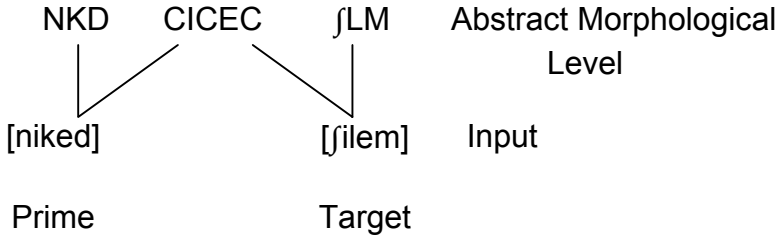
3.6. Discussion

In general, there are two results that hold over both age groups. First, the results support the regular verbal pattern priming that has been previously reported in the literature. Second, the data show that the j-final weak verbs are not able to facilitate recognition of regular verbs. In addition to these two observations, the two age groups diverge in reaction times to the third condition: older adults exhibit latent response times when regular verbs are preceded by transparent weak verbs like *mile*, whereas younger adults exhibit no significant effect. I discuss the results for each condition separately, including age groups where relevant.

3.6.1 Related-same condition: Priming

Both younger and older adults have faster reaction times for regular verbs when they are preceded by verbs of the same pattern than when they are preceded by verbs of a different pattern. This result replicates findings by Frost et al. that the sharing of a verbal pattern has a priming effect in Modern Hebrew. Therefore it is clear that verbs of the same pattern are recognized as similar for speakers at some level and it is this similarity that facilitates priming. Frost et al. use this evidence (and the lack of effect for weak verbs, although see discussion in Section 3.2.2) to argue that speakers are able to parse Hebrew verbs into a root and a morphological pattern, and it is the sharing of this morphological pattern that facilitates recognition. Under this analysis, an example trial in this condition would resemble that in (4), where the prime and the target share an abstract morphological level.

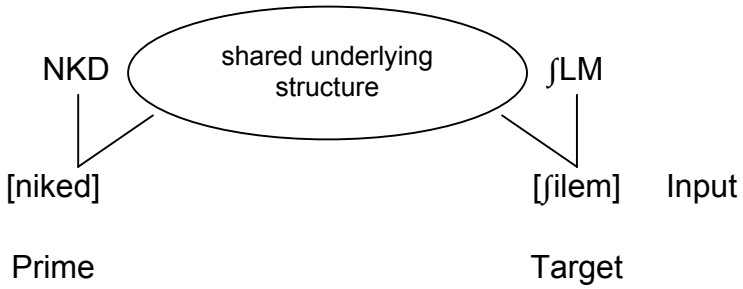
(4)



These results as suggest that the facilitation found in the previous experiments was not due to the sharing of a prefix, but to a general result of sharing abstract morphological patterns. In Modern Hebrew, though, it is not clear whether this priming effect necessarily implies that the abstract morphological template is shared, or that some overall sharing of phonological shape results in priming. This is due to the fact that in Modern Hebrew almost all words that have the

same phonological shape (either hiCCiC (e.g., Frost and colleagues) or CiCeC (present study)) are morphologically related. Therefore, these two dimensions of relatedness (phonological shape and morphological relatedness) cannot be teased apart with these data. Therefore, a more conservative proposal is that the facilitation is due to the sharing of either a morphological template, or word shape, as in (4').

(4')



The main difference between (4) and (4') is that the latter does not commit to an explicit encoding of the abstract CV structure. One possibility is that the syllable structure may be encoded as an integral part of the phonetic-phonological component, and can contribute to the emergence of the template. In other words, the template need not be independent of the words that contribute to its definition. This more general approach is consistent with the predictions we have made so far, and also concludes that priming may not be due to the sharing of a specific template, but to an underlying shape that words may share.

3.6.2. j-final weak verbs: No effect

In this condition, historical j-final weak verbs (e.g., *nika* 'he cleaned') preceded regular verb primes of the same pattern (*diber* 'he spoke'). There are two issues that should be clarified before discussing the results. First, there may be a question as to whether these verbs really are pi'el verbs. For all morphological purposes, they pattern exactly like the forms in the pi'el pattern, even though they have a different second vowel (see Aronoff 1994 for a discussion about specified vowels in different pattern). Focusing on the second vowel, it may also be suggested that no priming effect is found because the second vowel is different and it is this similarity that results in facilitation. If this were the case, we would then expect ʔ-final weak verbs to facilitate the recognition of target verbs similar to the facilitation found in the regular-same condition. As we can see from Table 3, this is not the case, as no facilitation is found in the ʔ-final weak verb condition.

The lack of effect in this condition can be interpreted to mean either that there is no underlying final root consonant for this set of verbs, or that the missing surface consonant prohibits decomposition from occurring. While Deutsch et al. 1998 claim that it is the lack of the surface root consonant that blocks decomposition, the former position is taken here, and will be discussed further in the linguistic analysis in Chapter 4. Briefly, though, the main difference between regular verbs and j-final weak verbs in this analysis is that the j-final forms are stored as concrete forms and have no abstract pattern. Thus, the primes have no underlying relationship with the targets and their presence does not facilitate target word recognition.

3.6.3. ʔ-final weak verbs: Mixed results

Transparent weak verb primes are the only primes in the experiment that affect regular verbs differently depending on the age group. While we see no effect in the younger age group, we see a negative effect in the older group. The results for each group are discussed below.

3.6.3.1. Younger adults: No effect

The lack of effect in transparent weak verbs also replicates earlier findings on weak verbs in general. In younger adults, the missing consonant makes decomposition impossible because the form cannot be parsed into smaller units, similar to j-final forms discussed above. Therefore, like j-final verbs, we find no evidence of an abstract pattern similar to regular verbs for younger adults. This issue is addressed more fully in the following chapter.

3.6.3.2. Older adults: Inhibition

Perhaps the most surprising result is that found for the ʔ-final condition in the older adult age group. The results show a negative effect, or inhibition: rather than facilitating access to a related target, the ʔ-final weak verb prime actually slowed down processing significantly. This section deals with possible analyses of these results.

There are two analyses of the inhibitory effect of transparent weak verb primes that are worth investigating: the influence of neighborhoods and the mismatch between the phonetic form and the phonological form. In the literature, both have been shown to cause a processing delay (Connine et al.

1993; Connine 1994; Luce & Pisoni 1998). While this degree of mismatch has never been examined, and Hebrew neighborhoods are not completely mapped, both accounts have something to offer, and I go through each below.

3.7. Phonological mismatch

Mismatch is the term used to describe the situation that arises when a phonetic form diverges from the intended lexical item. Research in this area is divided between studies of phonologically regular variation, such as assimilation (as in the pronunciation *greem beans* for *green beans*, cf. Lahiri & Marslen-Wilson 1991, Gaskell & Marslen-Wilson 1996; Coenen et al. 2001; Gow 2001; Gow 2002), and investigations of arbitrary variation caused by mispronunciations (as in the pronunciation *tervice* for *service,* cf. Connine et al. 1993; Frauenfelder et al. 2001). For both types of variation, a critical theoretical question is how current models of word recognition are able to cope with such variation.

3.7.1. Mispronunciations

Research on mispronunciation explicitly looks for the conditions that do disrupt word recognition. A typical approach is to manipulate one or more features in a base word in order to determine if this change affects access to the intended lexical representation. It has been shown that although mismatch by a single feature does not prevent access, word recognition is slowed down significantly (Coenen et al., 2001; Deelman & Connine, 2001; Marslen-Wilson et al., 1996).

For example, Marslen-Wilson et al. (1996) examine the effects of phonological distance on the access to lexical representations. In an auditory-auditory priming experiment, they examined the effectiveness of a mispronounced word (i.e., *pomato*) in activating the intended lexical item (i.e., *tomato*). They found that there is an effect of phonological distance on word recognition. In other words, the more different a surface form is from the intended lexical item, the slower the processing of that word. (Connine et al. 1993) conducted similar auditory word recognition studies, and examined both medial and final conditions and concluded that the effects are the same independent of position. These studies, though, focus on arbitrary variation (i.e., mispronunciations differing by one or two features), not phonologically regular variation, which may not slow processing at all since it is predictable.

3.7.2. Phonologically regular variation

The second main focus of mismatch research centers on phonologically predictable variation, although there is much less work done in this area. The main work that has been done focuses on assimilation in English, and how the word recognition system adapts to predictable, legal phonetic variations such as assimilation (Gow 2001, 2002; Gaskell & Marslen-Wilson 1995). Gow (2001) conducted a series of experiments aimed at understanding the nature of assimilation. For example, in the phrase *green beans* the [n] in the word *green* assimilates its place of articulation to match that of the following consonant, making the final consonant more similar to the initial consonant of the following word, yielding *greem beans* (Gow 2001). There is a large body of evidence suggesting that such assimilation does not disrupt word recognition (Gaskell & Marslen-Wilson, 1996; Gow, 2001; Marslen-Wilson et al., 1995).

This result illustrates a critical distinction between illegal, mispronounced featural mismatch, as in the pronunciation of *pomato* for *tomato*, and legal, phonologically regular featural mismatch, as in *greem beans* for *green beans*. In the former case, there is a significant cost; in the latter, there is not. Recently, however, it has been argued that assimilation does not result in a complete feature change (Gow 2002). Gow has presented evidence that in assimilation, a segment does not change to a completely new segment, and that listeners are able to use these subphonemic acoustic cues in word recognition. Natural assimilation consists of coarticulated segments that form an intermediate production, somewhere between the target segment (e.g., /n/ *bean*) and the theoretically assimilated segment (e.g., /m/ *bean*). These cues are sufficient to eliminate possible ambiguity between assimilated phrases like *right berries* (pronounced as *ripe berries*) and phrases that do not undergo assimilation like *ripe berries* (with *ripe* as the intended word). If Gow is correct, this is a good example of a situation in which variation (i.e., change from a phoneme's ideal form) can actually improve word recognition by eliminating ambiguity at the phonemic level.

3.7.3. Mismatch analysis

The research discussed above draws a distinction between phonologically legal mismatch and mispronunciations. We may expect, similar to work on assimilation, that phonological variation of the type we find in Modern Hebrew improves word recognition. This, however, is not the case, as we see that older adults in Modern Hebrew have longer response times to ʔ-final weak verbs (which are governed by a phonological alternation). One possibility is that there are two distinct types of phonological variation: one that, like assimilation,

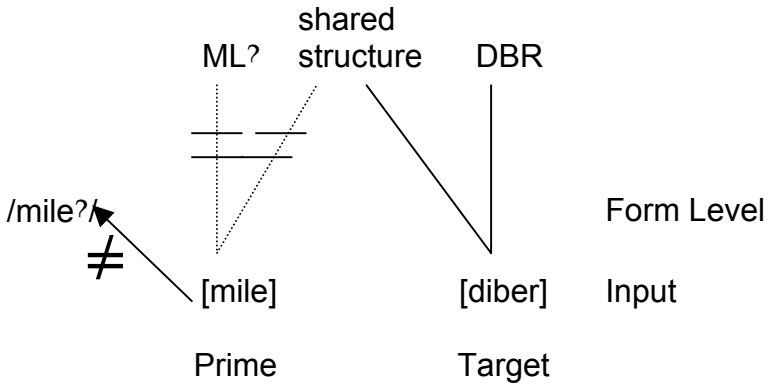
supplies us with additional and beneficial cues, and another type that has a processing cost associated with the loss of information. Support for a distinction between types of phonological variation comes from a series of priming and phoneme monitoring experiments by Deelman and Connine (2001) who find slower processing for unreleased voiceless stops than for released voiceless stops.

The release of a stop provides acoustic information about the preceding consonant. The loss of this release, while phonologically regular, involves a loss of information. A mismatch analysis of weak verbs in Modern Hebrew, then, would suggest that as the amount of information lost increases, processing speed decreases.

In order to analyze the results as an effect of phonological mismatch, two things must be claimed; the lexical form contains a glottal stop (the absence of which *is* the mismatch) and mismatch to this degree causes inhibition. In other words, the difference between the lexical item and the surface form is great enough to cause a delay in accessing the intended lexical item. This in turn slows the processing of a regular verb of the same pattern. This is not to say that every time a speaker encounters a deletion, processing fails. Rather, in this particular task, morphological decomposition was not possible because the items needed for decomposition were not readily available on the surface, and accessing the stored lexical form was costly.

One way to think of this is that a regular verb prime does not need to access the stored form for additional information, as all of the information is carried within the speech signal (see example (4)). In the case of ʔ-final weak verbs, though, the lexical form and the speech signal do not match, and therefore the lexical form must be consulted. Based on past research, we can conclude that access to the lexical item is slowed because mismatch delays access. And, since decomposition cannot occur when all of the underlying components do not surface (Deutsch et al. 1998), it is blocked. In this case phonological mismatch causes a delay, and since the information lost is an entire consonant, the pattern needed for decomposition cannot be abstracted from the surface form. One possible representation of this is given in (5).

(5)



Basically, all of the information for a word is available, the word can be decomposed. Additionally, in the case of ?-final weak verbs, access to the lexical item is significantly delayed because the surface form is missing information due to phonological variation. This type of analysis is consistent with research on spoken word recognition, as discussed for unreleased voiceless stops.

Additional support comes from research by Luce et al. (2001). They conducted a series of repetition priming experiments using variation to understand the nature of form-based representations. English words that surface with a tap (e.g., *writer, rider*) were examined. Typically in repetition priming experiments, identical words prime each other. It would be expected, then, that a carefully articulated presentation of *writer* [t] would prime itself better than a casually articulated presentation with a tap [ɾ]. Their results show that both primes (i.e., [ɹʌɪtəˠ] and [ɹʌɪɾəˠ]) facilitate the recognition of carefully articulated *writer* equally: [ɹʌɪɾəˠ] is as successful in activating /ɹʌɪtəˠ/ as is the identical form [ɹʌɪtəˠ]. Luce et al. argue that a form with a tap activates corresponding representations with both /t/ and /d/. From this, they conclude that both underlying and surface forms are activated in variation.

This is important because it provides us with additional evidence that abstract representations are accessed when surface forms deviate from the intended lexical items. We have various types of evidence that suggest that delays are associated with phonologically regular variation. The processing delays we have seen thus far are associated with featural changes between the surface form and the intended lexical representation. A phonological mismatch analysis for the glottal stop/zero alternation in Modern Hebrew is consistent with the claim that the delay in processing is due to a segmental difference between the acoustic form and the phonological form. Therefore, the delay in processing in the ?-final weak verb condition is longer than that found in past mismatch

studies because the degree of mismatch is greater in this study than in past studies.

There are two main benefits to this analysis. First, unlike a neighborhood analysis, this analysis makes no reference to the root, the status of which is currently under debate. The only claim is that there is a difference between surface form and the lexical item, and this difference causes a delay in accessing the appropriate item. It can account for the difference in results between older and younger adults, consistent with the linguistic evidence supporting concrete representations for younger adults.

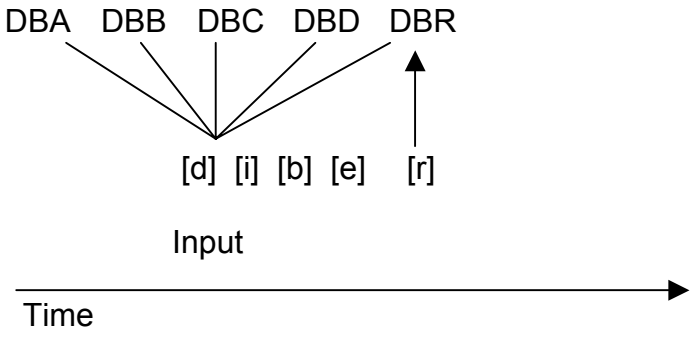
On the other hand, this analysis is not without problems. First, we have little foundation on which to base this claim, as research in this area is slim. For example, the variation found in assimilated forms and tapped coronal stops is vastly different from the alternation we are considering here. While we have seen that the loss of information in unreleased variants of voiceless stops does result in a delay, it is a big jump to claim that the loss of a segment is inhibitory. The main problem is that too little research has been conducted in the area of phonologically regular variation. There are a number of possible experiments that should be conducted. The examination of phonologically regular variation of all types is necessary, including examination of optional feature change, like glottalization of final coronal stops in English (t~ʔt~ʔ), deletion of "spelled pronunciations" (e.g., sandwich [sæ̃wɪtʃ]), optional stop deletion as in the form *winter* (e.g., [wɪntəɹ] ~ [wɪNəɹ]), and dialectal deletions (e.g., deletion of [r] in Long Island dialects of English). Understanding how the processing system copes with different types and degrees of variation and mismatch will enable us to better evaluate phonological mismatch as an explanation of the data.

3.8. Neighborhood effects

Spoken word recognition has been shown to be dependent on word frequency (Marslen-Wilson 1990) and on the number of phonologically similar words in the lexicon (Luce & Pisoni 1998). The set of words or morphemes that are phonologically similar is called a neighborhood. In this definition, *phonologically similar* refers to words or morphemes that differ in one sound. For example, in English, *cake, Kate, case,* etc. are all in the same neighborhood as they differ only in the word-final sound. The relationship among words or morphemes in a particular neighborhood has been shown to cause processing delays, and inhibitory effects (Goldinger et al. 1992). Luce et al. (1996) have shown that during spoken word recognition, similar words compete for recognition, and that words are processed less efficiently in high-density neighborhoods.

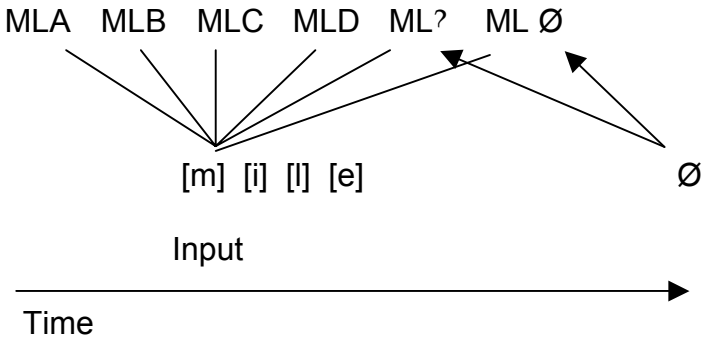
If we consider neighborhoods in Modern Hebrew to be organized by roots, the latent response times we find in older adults for the ʔ-final prime condition might then be caused by competition and access of unintended forms. For example, upon hearing the form [mile], all m-l-C roots are activated. This is particularly relevant for this group of forms, as they have no final consonant, and competition continues until a uniqueness point is reached. However, without a final consonant cueing the uniqueness point of the word, the competition lingers on, until the silence signals the intended lexical form. Compare the representation in (6) of a regular verb to that of a ʔ-final weak verb in (6).

(6) a.



In the above example, as the acoustic signal is heard by the speaker, decomposition is occurring. By the time the second consonant is presented, there is a neighborhood of roots all with DB as the first two consonants. As the final consonant [r] is provided, the intended lexical candidate is identified successfully. This is not the case for ʔ-final weak verbs, as the only signal to the intended word is the absence of a consonant, or silence, and until this is recognized as a signal, the competitors stay active for a longer period of time. It is not until a later point that the silence is interpreted as a cue.

(7) a.



In the example in (7), there are two possible roots for the surface form *mile*; a triconsonantal root (ML?) and a biconsonantal root (ML). This analysis does not distinguish between the two possible roots. In this analysis, all MLX roots are

competing for recognition. In the case of ʔ-final weak verbs, the competition between roots causes the processing delay. This is because the final consonant identifying the intended lexical item is not present in the acoustic signal. In the case of regular verbs, all of the information is available (three root consonants), and the intended root is recognized as soon as the final consonant is pronounced, reducing the effect of competitors. In the case of ʔ-final weak verbs, though, the final consonant is never pronounced, so the competitors stay active until silence is recognized as a cue for two possible roots (ML and MLʔ). One benefit of this analysis is that competition effects can easily account for the 17ms delay we find in this condition, whereas we are unsure whether such long delays are possible in the situation of phonological mismatch.

The main problem associated with this analysis is one of possible circularity. We would expect a similar pattern in the younger adult group, unless weak verbs in younger adults are not organized by roots. However, we cannot make the claim that weak verbs in young adults are not organized by roots on the basis of these results alone. It is important to note, though, that there is little evidence from the linguistic data that Hebrew speakers posit a root in weak verbs, especially for younger generations of Hebrew speakers. In addition, the circularity may remain independent of linguistic evidence because the results here might actually argue against the notion that Modern Hebrew neighborhoods are organized by roots. In Modern Hebrew, the neighborhood of roots beginning with DB (i.e., *DBR*) is much denser than the neighborhood of *words* beginning with *DIBE* (i.e., *diber*). Therefore, we might expect to find evidence of competition if neighborhoods are organized by roots and not by words, but we find priming between regular verbs instead. Further research into the organization of neighborhoods in Modern Hebrew and the effects associated with dense and sparse neighborhoods is necessary to effectively evaluate this account.

3.9. Summary

Both the phonological mismatch analysis and the neighborhood competition analysis can be combined with current research examining the nature of irregular and regular verbal morphology. Allen and Badecker (2002) examine both irregular and regular verbs and show that irregular verbs have not only a distinct form level entry, but also an entry at the abstract morphological level. The difference between the two analyses is shown in (8) and (9).

(8) **Phonological Mismatch**

Older Adults	**Younger Adults**	
ML[ʔ]	n/a	Abstract Morphological Level
/mile[ʔ]/	/mile/	Form Level
[mile]	[mile]	
Input	**Input**	

In the phonological mismatch account, the difference between generations lies in the presence or absence of an abstract underlying glottal stop. In the older adults, it is the access to the underlying form (needed because information is missing on the surface) that delays or prohibits the decomposition of the verb, resulting in latent response times for related targets. The younger adults do not have an abstract morphological level for these forms, as the form cannot be broken down. And the surface form matches the underlying form (which is why we cannot tell in the adult case whether it is access to the underlying form that causes the delay and then allows decomposition, or whether decomposition is prohibited). The neighborhood analysis makes different predictions about the nature of the representations for the two age groups.

(9) **Neighborhood analysis**

Older Adults	**Younger Adults**	
ML?, ML	Ø	Abstract Morphological Level
/mile?/, /mile/	/mile/	Form Level
[mile]	[mile]	
Input	**Input**	

In this analysis, the difference lies mainly at the abstract morphological level, where the competition takes place. The younger adults do not have roots associated with these forms (which is consistent with a linguistic analysis suggesting that these verbs have been reanalyzed as vowel final stems), whereas the older adults have two candidates for possible roots at the abstract morphological level (ML? and ML). In this analysis, the response latency is easily accounted for; however, it is unclear what the nature of the adult phonological representations are, as the delay is not caused by mismatch, but by competition among roots. Therefore, the difference between age groups is attributed to the organization of weak verbs into roots in older adults (but not in younger adults) and the competition among competitors with similar roots. The claim that a final abstract consonant exists is not necessary for this analysis (contrary to the mismatch analysis).

3.10. Conclusion

This chapter explored the effects of weak verbs on the recognition of regular verbs in Modern Hebrew. Using morphological priming experiments with auditory-auditory presentation, we saw the effect of verbal pattern priming in Modern Hebrew among regular verbs. There is no effect associated with j-final weak verbs, and they are treated as different from regular verbs of the same pattern, similar to the control condition.

Finally, we saw a predicted split in the treatment of ?-final weak verbs by younger adults and older adults. The lack of effect in younger adults can be attributed to either the lack of an abstract representation, resulting in no mismatch, or the lack of competition, as weak verbs are not associated with

abstract roots. Older adults have longer response times in the ʔ-final weak verb condition, and this can be explained under a phonological mismatch analysis or as an effect of neighborhood competition due to the lack of acoustic cues. Inhibitory effects in psycholinguistics have been accounted for via mismatch and neighborhood effects. Although each effectively accounts for the data, more research is needed in both phonological mismatch in general and neighborhood organization in Modern Hebrew to better evaluate the proposed analyses.

Chapter 4
Linguistic analysis and implications

The priming experiment in Chapter 3 provided us with evidence that j-final and ʔ-final weak verbs are treated as different from each other by older adults, and ʔ-final weak verbs are treated as different across age groups. The two types of weak verbs, one having a historical underlying /j/ (j-final weak verbs) and the other subject to phonologically transparent alternation (ʔ-final weak verbs), are both treated as unrelated to regular verbs by younger adult speakers of Modern Hebrew. The older adults also treat j-final weak verbs similar to a control, but the results differ for ʔ-final weak verbs. Older adults treat ʔ-final weak verbs as different from both related regular verbs and unrelated regular verbs.

Earlier, different predictions were made about how weak verbs would be handled by speakers depending on our criteria for positing theoretically abstract representations. Here, I review the predictions for each verb type, along with the results from the experiment, and provide a linguistic analysis of these two types of weak verbs in Modern Hebrew. Specifically, I make the following claims: [23]

- j-final weak verbs have been reanalyzed by older and younger adults as vowel-final stems.
- Younger adults have reanalyzed glottal-final weak verbs as vowel-final stems on analogy with j-final weak verbs.
- Glottal-final weak verbs are represented differently in the grammars of older and younger adults.
- A low amount of exposure to an alternation blocks the formation of abstract phonological representations, even for predictable, transparent alternations.

[23] It is possible to provide two analyses throughout this chapter, one that has a root and one that does not, but in which all forms stem from a single phonological form, and vowel variations are derived. I do not focus on this distinction in this chapter because the issue here is not one of whether a root exists, but whether an underlying final consonant is present.

- Extending this analysis to opaque segolate nouns in Modern Hebrew, the assumption that speakers posit opaque representations for these nouns is unfounded.

The remainder of this chapter focuses on supporting the claims made above. The first four claims concern weak verbs in Modern Hebrew, and are discussed below, along with a review of the experimental results.

4.1. Experimental findings

We saw in Chapter 3 that the reaction times of older and younger adults are similar for regular verb targets preceded by j-final weak verb primes, and divergent for the same targets preceded by /ʔ/-final weak verb primes. For j-final weak verbs, no effect (no statistical difference in reaction times to control stimuli and j-final stimuli) was found for either age group. The results split for the /ʔ/-final condition, as a negative effect was found in the older adult group (reaction times to /ʔ/-final stimuli were significant compared to control stimuli), while no effect was found in the young adult age group. For clarity, the results from the experiment are summarized in Table 1.

CONDITION	TARGETS	OLDER ADULTS	YOUNGER ADULTS
Regular verb **CaCaC:** ganav	Regular verb different pattern CiCeC: **tipes**	---	---
Regular verb CiCeC: **niked**	Regular verb same pattern CiCeC: **tipes**	priming	priming
ʔ-final weak verb CiCe: **mile** (/mileʔ/)	Regular verb same pattern CiCeC: **diber**	longer response times	---
j-final weak verb CiCa: **nika**	Regular verb same pattern CiCeC: **diber**	---	---

Table 1. Effects from priming experiment presented in Chapter 3

4.2. Linguistic analysis of weak verbs in Modern Hebrew

In this section, I consider the experimental results along with linguistic evidence. I provide an analysis of weak verbs in Modern Hebrew that is consistent with both types of evidence. First, I consider j-final weak verbs and propose that for both older and younger adults, they have been reanalyzed as vowel-final stems.

4.2.1. j-final weak verbs

One condition of the experiment included third person masculine singular weak verbs that historically come from the root C-C-j, such as the word *nika* 'he cleaned'. While it is generally assumed that these verbs have been reanalyzed as having vowel-final stems, there are analyses that posit an underlying /j/. Two questions regarding analyses of weak verbs in general are: What evidence do we have to support an abstract or a concrete analysis, and what factors play a role in forming the representation? For j-final weak verbs, there are two main arguments in support of positing abstract underlying /j/. First, there is a preference in Modern Hebrew for triconsonantal roots, making a C-C-j root more desirable than a C-C (-∅) root.[24] Second, there are semantically-related words in the language that surface with [j] (i.e., *nukuj* 'cleaning', *nikajon* 'cleanliness'). An abstract analysis would include the presence of these forms as sufficient support for positing an underlying /j/ for the verbs.

On the other hand, there is also strong evidence motivating a concrete analysis. First, the final consonant never surfaces in the inflectional paradigm. In contrast to the glottal stop, [j] is not prohibited from the onset or coda position. As the related forms show, the lack of surface [j] is unmotivated. This is especially true in the case of the third person plural forms. These forms, like the form *niku* 'they cleaned' (cf., *tipsu* 'they climbed', pattern CiCCu), surface without a third consonant. While this does not directly support a concrete analysis, it does discredit an abstract one. The majority of past tense forms for these verbs has the form CiC**i** + suffix (as opposed to the regular verb pattern CiCaC + suffix or CiCeC for the third person masculine singular). One argument in favor of an underlying /j/ would be that the final [i] is in fact the vocalization of the underlying /j/, and it surfaces instead of the specified vowel for the pattern. If this were true, then we would have no explanation for why the third person plural forms are always CiCu (i.e, *niku*), and not **nikju*, or simply *niki*. Especially since the

[24] While Modern Hebrew does have roots composed of two and four consonants, these are rare compared to triconsonantal roots.

surface structure [ju] is possible in Modern Hebrew (cf., *juval* (a proper name); *sijum* 'conclusion'; *djunot* 'dunes'; *tjuta* 'rough draft').[25]

Finally, the related forms used in support of an abstract analysis can also support a concrete representation, as the number of related forms is low, and it has not been shown that a few forms in the nominal paradigm with a surface [j] are more influential in identifying related forms than the entire verbal paradigm in which we find no examples of surface [j].

The priming experiment in Chapter 3 did not provide us with any evidence that there is an abstract relationship between j-final weak verbs and regular verbs of the same pattern. As discussed, reaction times to targets preceded by j-final weak verbs do not differ significantly from reaction times to targets preceded by a verb of a different pattern (control condition). We expected to find priming only if the primes and targets shared an underlying pattern. The lack of effect does not prove that j-final weak verbs have concrete representations, nor does it disprove an abstract analysis. But, it does provide evidence against an analysis that posits an abstract underlying /j/.

It may be argued that the reason there is no priming effect is because the primes and targets are too different on the surface. For example, the weak verb primes have the vowel [a] where the regular verb targets have the vowel [e] (i.e., nik**a** –DIB**E**R). One possibility is that the lack of priming is due to this surface variation between prime and target. This possibility is easily discarded. If it were true, we would expect glottal-final weak verbs that share the same surface vowels as the targets to facilitate the recognition of regular verb targets (i.e., mil**e** – DIB**E**R). This is not the case for either age group, as these forms inhibit target word recognition for older adults and have no effect (facilitatory or inhibitory) on the recognition of target words for young adults.

Considering that an abstract representation containing /j/ is not supported experimentally, and we have strong internal evidence supporting concrete representations, I claim that these verbs are not decomposable, and have no final underlying consonant for either age group. Representations for the first person singular forms are provided in (1):

[25] See Broselow 1976 for similar facts in Arabic dialects.

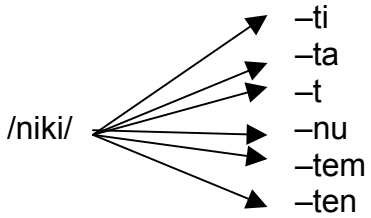
(1) Proposed older and younger adult representations for j-final weak verbs

a. /niki + ti/	→	[nikiti]	'I cleaned'
b. /nika/	→	[nika]	'he cleaned'
c. /dimi + ti/	→	[dimiti]	'I compared, likened'
d. /dima/	→	[dima]	'he compared, likened'
e. /bili + ti/	→	[biliti]	'I frightened'
f. /bila/	→	[bila]	'he frightened'
g. /kili + ti/	→	[kiliti]	'I finished'
h. /kila/	→	[kila]	'he finished'
i. /jipi + ti/	→	[jipiti]	'I embellished'
j. /jipa/	→	[jipa]	'he embellished'

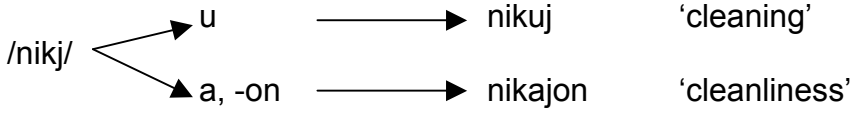
Related words such as *nikuj* 'cleaning' thus differ from the verbs in that they do have an underlying final consonant; however, it is not clear whether this consonant is analyzed by speakers as a final root consonant or not. So, contrary to an analysis that associates the related nouns and verbs at the phonological level, the representations are distinct, as shown in (2).

(2) Representations for j-final verbs and related forms

a.



b. nikuj, nikajon



In (2a), the underlying form is a vowel-final stem that is associated with the inflections within the verbal paradigm. (Here, though, only the past tense inflections are represented.) While it is possible to propose a biconsonantal root

for this form, this analysis is unlikely as j-final forms do not behave like other biconsonantal roots in Modern Hebrew that double the final consonant to fill the abstract pattern.

The semantically related nouns for 'cleaning' and 'cleanliness' are not derived from the same underlying phonological representation (2b), since we have no evidence of an underlying final consonant in the weak verbs. The representation in (2b) shows that nouns with a surface [j] contain an underlying final consonant in the phonological representation. [26]

The main distinction between (2a) and (2b) is that the first representation is vowel final, with no underlying final consonant, and the latter is consonant final, retaining historical /j/. There is variation within the paradigm where the final vowel does not surface (i.e., *nika*, *nikta*, and *niku*). Here, there are two possibilities for analysis: we can either posit representations that match the surface forms, having three possible stems for [clean, V] (/niki, nik, nika/), or derive the related forms. The first possibility seems more likely, especially when considering all tenses and the behavior of 3ms forms across Modern Hebrew; however, I do not provide an analysis here, since the main point is that no verbs have an underlying /j/.

As discussed in Chapter 2, the verbal paradigm for j-final weak verbs contains no tokens of [j], the historical final root consonant. This is a constant for both generations, as the consonant in this case is not subject to the surface variations found in ʔ-final weak verbs. As we have seen, experimental evidence supports a less abstract approach to phonology consistent with concrete representations for these verbs, such as that of Hooper (1976). In Natural Phonology, Hooper proposes a True Generalization Condition which limits the theoretical abstracting ability attributed to speakers. In other words, speakers are only able to identify surface generalizations by the transparent surface data available to them. In a Natural Phonology approach, since the verbal paradigm for j-final weak verbs does not contain any instances of surface [j], speakers base their representations on the available forms. Thus, concrete representations are supported since there is no evidence of an alternation. The same generalization is incorporated into OT as Lexicon Optimization, which states that the input that most closely resembles the output should be chosen when there is no empirical evidence for choosing one input over another (Prince & Smolensky 1993). In sum, if a form is not variable, then its phonological form matches the surface form.

[26] The representation in (2b) does not claim that n-k-j is analyzed as a root; however, this option is not opposed though, and the point here is only that the nouns stem from a different representation than the verbs. For an analysis of Modern Hebrew that does not rely on roots, see Ussishkin 2000.

One question remains: How do we define the term *variable*? Surely, *nika* and *nikuj* are related, and this should count as surface variation. While it is true that they are phonologically similar and semantically related, we do not want to make the claim that they stem from a single abstract representation, given the experimental results and the limited nature of the surface variation. Therefore, the simplex existence of a surface variation does not constitute enough evidence to motivate a speaker to move to a more abstract representation (from an initially posited concrete representation). The surface variation in this case is not sufficient to enable speakers to form an underlying abstract generalization.

The underlying relationship between *nika* and *nikuj* may have been present in Hebrew historically, and should be captured as part of a diachronic account. But, other than the existence of [j] in a few semantically-related forms, there is no reason to believe that these two forms stem from a single phonological form synchronically. This is a plausible claim once we accept that the kind and nature of surface variation plays a role in forming phonological representations. The evidence presented here leads us to claim that derivationally related alternations are not sufficient to justify an abstract representation for Modern Hebrew j-final weak verbs.

4.3. ʔ-final weak verbs

The second weak verb condition of the experiment included third person masculine singular weak verbs that have been argued to derive from the root C-C-ʔ, for example *mile* 'he filled'. As discussed in Chapter 2, the behavior of glottal stops is governed by the phonotactics of Modern Hebrew (glottal stops may not surface in the coda). In contrast to j-final weak verbs, now analyzed as vowel-final weak verbs, the distribution of the final consonant (glottal stop) is phonologically predictable and transparent. Glottal-final weak verbs also differ from vowel-final weak verbs, as the consonant in question does surface in the verbal paradigm (i.e., *milʔa* 'she filled'). An analysis proposing an abstract representation (one containing a root-final glottal stop) is supported by the predictable and transparent distribution of glottal stops (which obeys the phonotactics) and the presence of the alternation within the verbal paradigm.

When we consider outside factors such as language use and the exposure speakers have to the surface alternation, an underlying glottal stop becomes questionable. Since speakers optionally delete onset glottal stops regularly, the transparent nature of the glottal stop/zero alternation may become more opaque because speakers are not exposed to the alternating consonant. The more commonly produced form for *milʔa* 'she filled' is *mila* 'she filled'. The same is true for the third person plural form *milʔu* 'they filled', which is more

commonly produced as *milu* 'they filled'. This is true across the language in general.

Onset glottal stops provide critical evidence to speakers that an alternation exists. If these cues are frequently deleted, then it may prove difficult for a speaker to identify an alternation, even a transparent one. Also, within the verbal paradigm, only eight out of twenty-three forms have onset glottal stops (all of which are usually deleted). So an analysis with concrete representations focuses on the amount of evidence available to speakers, and whether or not this evidence enables speakers to internalize a (diminishing) surface generalization. The result is that in this case the underlying representation matches the surface form exactly.

In the j-final weak verbs, we did not expect to see a priming effect, since there is little support for underlying /j/. In the case of the glottal-final weak verbs, though, we have a predictable and transparent alternation on the one hand, and a slow loss of this alternation on the other. Therefore, we have two possible predictions. If predictability and transparency are the only factors involved in motivating abstractness, we would expect to find a priming effect across subjects, independent of age. If a speaker's exposure to a specific alternation influences the phonological representation, we expect that older and younger adults will treat glottal-final weak verbs differently, as older adults have had more exposure to the alternation than younger adults.

The results for this condition (ʔ-final weak verb prime followed by a regular verb target) are more complicated than those for the j-final weak verb condition, as older and younger adults show different patterns. Younger adults treat these forms as they treat j-final forms (different from related regular verbs but the same as unrelated regular verbs), whereas older adults have a significant negative effect, or latent response times to targets in this condition. While the negative effect was not necessarily predicted, different results for each age group were predicted only if the exposure to an alternation affects the formation of phonological representations. This is because all other factors (i.e., frequency of word and type, orthography, etc.) are constant across age groups.[27]

4.3.1. Younger adults and ʔ-final weak verbs

In the experiment, young adults reacted to targets following ʔ-final weak verbs and those following j-final weak verbs in the same manner. Specifically,

[27] Two factors that were not controlled are the influence of orthography and normative pronunciations on older adults, and the effect length of stay in the United States may have on L1.

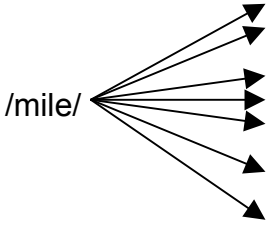
there was no effect for either condition. In other words, ʔ-final weak verbs (and j-final weak verbs) were treated as different from regular weak verbs. This may be due to the fact that a surface consonant is missing. Frost and colleagues (1999, 2000) claimed that the missing consonant blocks decomposition. If this were true, though, we would not expect age to be a factor in the results, and it clearly is.

When arguing for an underlying glottal stop, the predictable and transparent glottal/zero alternation is generally assumed to support an abstract analysis. A case has been made in Chapter 2 that this assumption may not be supported when we factor within speaker variation into the equation. Here, the lack of effect in ʔ-final and j-final weak verb conditions in the young adult age group, along with significant latent response times to targets in the ʔ-final condition for older adults, suggest that the glottal/zero alternation is neither predictable nor transparent for young adult speakers of Modern Hebrew. This is interesting, as most grammars consider the glottal/zero alternation to be productive, and posit an underlying glottal stop in the representations for these verbs.

Considering the reduction in the production of glottal stops and the lack of experimental support, we have no motivation to support the claim that the weak verbs examined here have underlying glottal stops. Rather, the evidence suggests that this alternation is not transparent to younger adult speakers of Modern Hebrew. Therefore, I propose the representations in (3) for ʔ-final weak verbs in Modern Hebrew.

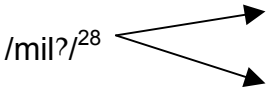
(3) Representations for ʔ-final weak verbs

a.



–ti	‘I filled’
–ta	‘you (2ms) filled’
–t	‘you (2fs) filled’
–Ø	‘he filled’
–nu	‘we filled’
–tem	‘you (2mp) filled’
–ten	‘you (2fp) filled’

b.



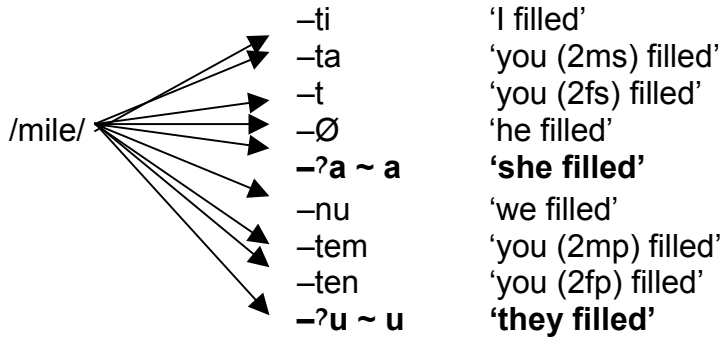
–a	‘she filled’
–u	‘they filled’

[28] The alternation of glottal stop in the onset position is addressed in detail in Chapter 5.

The analysis proposed here is that there are two distinct representations for this set of weak verbs in Modern Hebrew. The majority of the forms within the verbal paradigm are suffixes added to a vowel-final stem (3a), and there are a few forms (if we include all tenses) that derive from a phonological representation that has an underlying glottal stop (3b). The main generalization is that if a glottal stop does not surface, it is not part of the phonological representation. The forms in (3a) are invariable and glottal stops are never produced on the surface. In the forms in (3b), glottal stops may surface optionally. The generalization that glottal stops are prohibited from the coda position is not one that is internalized by young adult speakers of Modern Hebrew.

In addition to the bi-representational analysis above, one possibility is to propose that the glottal stops that surface in the 3fs and 3p forms are contained in allomorphs of –a and –u, respectively. In this case, the representations in (4) would account for ʔ-final weak verbs and the optional glottal stops in the 3fs and 3p forms.

(4) Representations for ʔ-final weak verbs and ʔ-initial allomorphs



The proposal in (4) attributes the onset variation in the glottal stop to an allomorphic variant of the suffixes. This is one possibility that cannot be ruled out and is supported by the fact that these are the only vowel-initial suffixes in the past tense paradigm and the fact that in regular verbs, the ʔ-initial allomorph would be disfavored as it would create either a complex coda or a complex onset. For example, the regular verb *dibra* ‘she spoke’ would not surface with the variant –*ʔa* because this would create a complex onset that is not possible in Modern Hebrew (i.e. **dib.rʔa*). This is analogous to *a ~ an* allomorphy in English. This analysis allows us to account for the experimental results for younger adults since the glottal stops are not contained within the root, and it

has the added benefit of maintaining a single underlying stem for all inflected forms.

Both proposals (3) and (4) claim that a reanalysis has taken place, as these forms are no longer treated as consonant-final, but vowel-final. If this is the case, we expect to find evidence of this reanalysis elsewhere within Modern Hebrew. This is exactly what we do find, as glottal-final weak verbs in the pi'el pattern are regularly produced on analogy with vowel-final weak verbs, as shown in (5).

(5) Variation within glottal-final weak verbs

Normative		Colloquial	Vowel-final weak verbs
mil**e**-ti	~	mil**i**-ti	nik**i**-ti
mil**e**-ta	~	mil**i**-ta	nik**i**-ta
mil**e**	~	mil**a**	nik**a**

In (5), the final vowel in the normative pronunciation of glottal-final weak verbs differs from that of vowel-final stems. In addition, colloquial pronunciations of glottal-final weak verbs (which are more commonly produced than the normative forms) are produced on analogy to vowel-final stems. In this case, ʔ-final weak verbs behave like vowel-final verbs. Analogical changes like this signal a restructuring of the phonological representation.

In addition, it is important to realize that the alternation in ʔ-final weak verbs is of the type X~Ø, not X~Y. The difference is that in the X~Ø alternation, an alternation exists between a sound and the absence of a sound, and in the second case (X~Y), an alternation exists between two sounds. While it was not tested in this thesis, one possibility to explore is whether different types of cues have particular costs or benefits associated with them. That is: Is a sound-sound alternation (X~Y) easier to detect than a sound-no sound alternation (X ~ Ø)?[29]

In Modern Hebrew, when a glottal stop is optionally deleted, no sound surfaces, and the speaker has no cue to signal a surface alternation. Whereas, if the alternation were between [t] and [ʔ], for example, and one was produced more often than the other, there would always be an acoustic cue present in production and this might help speakers identify patterns and relatedness across variable forms. The proposed representations in (3) and (4) stem from the inability of speakers to identify the ʔ~Ø alternation because they have not been exposed to sufficient evidence to motivate the formation of an abstract representation, even if it is a linguistically transparent one.

[29] For related discussion see Steriade 2001.

Additional factors that may play a role in the phonological makeup of weak verbs are orthography, word type (or shape) frequency, and exposure to the surface alternation. The first two are constant across age groups, and would not predict a split in the treatment of the forms. The last factor, though, is specific to age, as the amount of exposure to the ʔ~Ø decreases as optional deletion becomes more common generation after generation.

4.3.2. Older adults and ʔ-final weak verbs

The older adult age group exhibited significantly longer response times to targets preceded by ʔ-final weak verbs than to those preceded by unrelated regular verbs. One possible explanation of these results is that the presence of an underlying glottal stop causes a delay in processing. However, another possible explanation is considered in the next section.

4.3.2.1. Neighborhood effects

Neighborhood effects offer one explanation of the latent response times found for older adults for ʔ-final weak verbs. As discussed in Chapter 3, a phonological neighborhood consists of a group of words or morphemes that differ in one sound. During spoken word recognition, similar words compete against each other for recognition. Therefore, morphemes or words may be processed more slowly, or less efficiently, in a neighborhood that has a lot of competitors. The manipulation of neighborhood density as an experimental factor is consistent with this idea (Goldinger et al. 1989).

An inhibitory neighborhood effect can be related to the results found for older adults in the ʔ-final weak verb condition. Competition in this case may stem from the lack of a surface final consonant. With no final consonant, there is no cue to signal the appropriate lexical item, and therefore competitors remain active. As explained in Chapter 3, spoken word recognition differs from visual word recognition, as the stimuli are presented in real time, as opposed to visual stimuli that provide a subject with all of the information at once. In this case, competition among roots having the same first two root consonants as the glottal-final stimuli causes a delay. So, it is the competition among common roots that results in longer response times. More specifically, the indecisiveness caused by a missing surface consonant results in longer processing times. Therefore, the glottal-final root is chosen by default (as discussed in Chapter 3), as ultimately the lack of an acoustic cue signals the appropriate root, but only after a significant processing delay.

However, we have no evidence of this claim outside of the results of this experiment. Without this information the analysis would ascribe the lack of effect in younger adults to the absence of a final underlying glottal stop in ʔ-final roots. But we do not have independent evidence that young adults' neighborhoods are not organized into roots. After further investigation, the neighborhood effect analysis may prove to be more reasonable, but at this point, it is unwarranted. Additionally, little is known about the status of neighborhoods in Modern Hebrew.

4.3.2.2. Mismatch and underlying glottal stops

The second interpretation of the data is that the latent response times are the result of mismatch between the surface form [mile] and an underlying form /mileʔ/. In other words, even while phonologically legal, the deviation by a segment (ʔ~∅) between the two forms has a processing cost. One issue faced by this interpretation is that past research generally concentrates on mismatch by one or two features (in both phonologically legal variation and illegal variation (like mispronunciations)) and deletion has yet to be examined. Research on legal variation has focused mainly on assimilation, with a few stray articles on other types of variation such as tapping (Luce et al. 2001) and released versus non-released stops in English (Deelman & Connine 2001). Coenen et al. (2001) show that assimilation, while legal, is associated with a processing cost, as changed forms are recognized more slowly than unchanged forms.

As discussed in Chapter 3, Deelman & Connine (2001) examined the effect of missing information associated with unreleased stops in English (compared to released stops, which contain more acoustic information). They found that while the unreleased variant of a stop is predictable, the information lost in unreleased stops is significant enough to slow processing. It is likely, then, that a higher processing cost is associated with a larger degree of variation (1 feature versus 1 segment), even in phonologically governed variation.

A mismatch analysis claims that there is an underlying glottal stop in the phonological representation, and the difference between surface forms and underlying forms causes processing difficulties.[30] This analysis supports the phonological representation in (6).

[30] This does not imply that this is true in conversation. Words are presented in isolation in the experiments, thus, free of context.

(6) Phonological representations for ʔ-final weak verbs in older adults based on a mismatch analysis

a. /mileʔ/ ⟶ /mileʔ/ ⟶ [mile] 'he filled'
b. /mileʔ-a/ ⟶ /milʔa/ ⟶ [milʔa] 'she filled'

In the representations in (6), the underlying representations for all forms in the verbal paradigm are related in that they share an underlying glottal stop. In this analysis, the behavior of glottal stops is transparent, as they are manifested in the phonological form. The delay in processing in a mismatch analysis signals a difference between the surface form and the underlying form. Furthermore, the delay is long (17ms) because the mismatch is more than just featural mismatch, involving the presence or absence of a segment. This explanation of latent response times accounts for both the difference between ʔ-final verbs and regular verbs in older adults and the difference between older and younger adult representations of ʔ-final weak verbs.

Both surface forms and underlying representations for regular verbs are identical. This enables decomposition to occur, and the shared abstract properties of the two facilitate the recognition of the target word. In the ʔ-final weak verbs, though, the two levels of representation, surface and phonological, are not identical. Consistent with past research, this difference between levels slows processing. The difference between older and younger adults, then, lies in the nature of the ʔ-final weak verb representation. Older adults identified the surface generalization and posited an abstract final glottal stop in the phonological representation, whereas younger adults were not able to do so.

One point of interest is that while the concreteness of representation for young adults was attributed to the lack of exposure to the relevant alternation, we may conclude that older adults were able to form abstract representations. Therefore, the exposure they had to the alternation is sufficient for them to internalize a surface pattern.

Interestingly, the older adults were also exposed to a low number of glottal stops, since the verbal paradigm has surface glottal stops *at most* about 30% of the time. If further research into mismatch supports this interpretation of the data, we have evidence that a speaker must be exposed to a sound in a sound-no sound alternation only 30% of the time to incorporate it into the phonological representation. This does not imply, though, that the transparency is based purely on phonological grounds.

While abstract representations may be supported for ʔ-final weak verbs for older adults, I do not claim that this is due only to phonology. Both

orthography and the older adults' strong affiliation with normative pronunciations (Bentur 1978) aid in recognizing the surface pattern. While I was not able to control for these factors in the experiment, I do not rule them out here, as it is likely that these factors have contributed to the presence of an underlying glottal stop in older adult representations of ʔ-final weak verbs.

In an analysis that supports underlying glottal stops for all glottal final weak verbs, the representations are not based only on phonological relations. The attention to normative pronunciations by older adults may enhance the surface alternation. A research plan that aims to isolate such factors and examine their influence on phonological representations separately will allow us to better understand the thresholds beyond which abstract representations are not possible.

4.3.3. Conclusion

So far, we have seen that even traditional transparent alternations may not be transparent to speakers under certain conditions. Specifically, the representation of verbs like *mile, mile-ti,* and *mile-nu* are /mile/, /mile-ti/, and /mile-nu/, respectively (not */mileʔ/, */mileʔ-ti/, and */mileʔ-nu/ for younger adult speakers of Modern Hebrew). This can be attributed to the lack of exposure to the surface alternation, which prohibits the formation of an abstract representation. Therefore, representations for ʔ-final weak verbs for younger adults are concrete.

Older adults treat ʔ-final weak verbs differently than younger adults, and this can be attributed to either neighborhood competition or mismatch, the latter appearing more likely at this time. This suggests that older adults identify the surface variation as stemming from a single underlying representation and that the exposure they have to the alternation counts as sufficient evidence (although we must not forget the influence of orthography and affiliation with normative pronunciations). It was claimed that, in accord with most grammars, j-final weak verbs have been reanalyzed as vowel-final stems and an analysis containing an underlying /j/ most likely does not represent the synchronic grammar for any speakers.

4.4. Opacity

One area of study that is directly affected by this research is opacity in Modern Hebrew. This section challenges the assumption that speakers are able to internalize opaque surface generalizations. Opacity has been the subject of

much discussion in linguistics for the past thirty years, but has been especially important since the onset of Optimality Theory (Prince & Smolensky 1993) due to the difficulty of capturing opaque relations in a bi-level framework.

Opacity has also been claimed to be one of the most critical issues in phonology (Idsardi 2000), opacity has sparked the generation of modifications to bi-level OT (i.e., Sympathy Theory (McCarthy 1999), Enriched-Input Theory (Sprouse 1998), Turbidity (Goldrick 2000)). Opacity has been used as support for stratal OT (Booij 1996; Bermúdez-Otero 1999), and has been analyzed by way of additional mechanisms incorporated into bi-level OT (Sumner 1999). All of these approaches have paid little attention to issues of psychological reality surrounding opacity, such as those raised in Chapter 2 of this thesis.

Surface opacity can be either non-surface apparent or non-surface true (Prince & Smolensky 1993; Kager 1999; McCarthy 1999). This means either that a surface form does not adhere to the rules or constraints of a language, or that a change has occurred that is not explained merely by consulting the surface form since the triggering environment has been lost at some level or time. An example of the first type is the opacity of vowel epenthesis in Turkish (Kenstowicz & Kisseberth 1979; Kager 1999). In Turkish, when the suffix *–m* is added to consonant final stems, a vowel is inserted to break up illicit final consonant clusters, as in (7).

(7) /jel-m/ → [jel**i**m] ‘my head’

And, [k] cannot surface intervocalically. Therefore, a stem final /k/ does not surface before a vowel initial suffix, as in (8).

(8) /inek-i/ → [ine.i] ‘his foot’

Additionally, the two processes interact in stems ending in /k/ that also have the first person possessive suffix. The result is an opaque surface form, as in (9).

(9)

UR:	/inek + m/	
Epenthesis:	inekim	
k-deletion:	ineim	
SF:	[i.ne.**i**m]	‘my foot’

The form above is non-surface apparent because the surface form does not make it obvious why a vowel is epenthesized, since the triggering environment no longer exists on the surface. The second type of opacity exists when it appears from the surface form that a rule of a language has not been applied, although its environment has been met. In Isthmus Nahuat (Kenstowicz & Kisseberth 1979; Kager 1999), approximates are devoiced word finally (/tájoːl/ → [tájoːl̥] ‘shelled corn’). In addition, vowels are deleted word finally (/tami/ → [tam] ‘it ends’). The ordering of devoicing before vowel deletion results in a form that

has a final voiced approximate on the surface ([ʃikakil] < /ʃikakili/ → devoicing not applicable → apocope ʃikakil → [ʃikakil]). Thus, the devoicing rule is not surface true. In Modern Hebrew, we are concerned with the first type of opacity.

4.4.1. Opacity in Modern Hebrew

In Modern Hebrew, the opacity of segolate nouns has been claimed to support modifications to bi-level OT (McCarthy 1998). In the following discussion, I claim that Modern Hebrew segolate nouns do not provide a case of opacity and do not support previously proposed theoretical modifications.

A basic assumption of phonology is that speakers can identify and internalize generalizations about surface forms. Segolate nouns in Modern Hebrew constitute a group of words about which a phonological generalization can be made. Examples of MH segolate nouns are given in (10).

(10) Segolate nouns in Modern Hebrew

a. délet	'door'
b. bérex	'knee'
c. léxem	'bread'
d. kéves	'sheep'
e. téʃer	'gift, present'
f. néxed	'grandson'

Segolate nouns in Modern Hebrew differ from other nouns because they have initial stress. Traditional analyses of MH consider final stress to be the unmarked stress in MH (Glinert 1989; Schwarzwald 2001).[31] A derivational analysis of these nouns includes stress assignment and epenthesis, as shown below.

(11)

UR:	/delt/	'door'
Stress Assignment:	délt	
Vowel Epenthesis:	délet	
SF:	[délet]	

[31] There are a number of recent analyses, however, that argue this point and suggest either that penultimate stress is the default (Graf 2001) or that stress is fixed (Ussishkin 2000). For the purpose of a clear discussion of opacity in segolate nouns, I use the traditional analyses.

An OT analysis would presumably include a constraint prohibiting stress on epenthetic vowels. The issue of segolate nouns becomes more complicated when we consider forms with glottal stops as the final root consonant, as shown in (12).

(12) Opaque segolate nouns in Modern Hebrew

a. déʃe	‘grass, lawn’
b. péle	‘wonder’
c. téne	‘basket’
d. pére	‘wild one’
e. kéle	‘jail’

The forms given in (12) are similar to the regular segolate nouns because they have epenthetic stress and the epenthesized [e]. The only difference is that this group of nouns presents a case of opacity because the triggering environment for epenthesis (an illicit coda cluster) is not present on the surface. The opacity in segolate can be explained derivationally as a result of rule ordering. A typical ordered rule derivation for (12a) is provided in (13).

(13)

UR:	/deʃʔ/
Stress Assignment:	déʃʔ
Vowel Epenthesis:	déʃeʔ
Glottal deletion:	déʃe
SF:	[déʃe]

These forms are easily accounted for in a rule-based framework. It is the move toward bi-level OT, and the elimination of intermediate levels, that makes an analysis of such opacity difficult. Since the constraints look at the surface form, in this case [deʃe], there is no need for an epenthetic vowel, as there is no *surface cluster* to break up (cf., [de**l**e**t**] < /delt/). This comparison is made in the following two tables (simplified to focus only on the final consonant cluster and epenthetic vowel), using the constraint set in (14).

(14) Constraints for segolate nouns in Modern Hebrew

*CC]: Word-final consonant clusters are prohibited

MAX: Do not delete a segment

DEP: Do not insert a segment

(15) Transparent segolate nouns in MH

/delt/	*CC]	MAX	DEP
a. del		*!	
b. delt	*!		
c. dele		*!	*
☞d. delet			*

The ranking *CC],MAX >> DEP predicts vowel epenthesis, arriving at the optimal output in (15d).[32] The problem is that the constraint ranking in (15) that is needed to arrive at the form (15d), along with a new constraint prohibiting coda glottal stops, predicts a non-surfacing form in (16) below. In fact, no ranking of the constraints will choose the desired candidate (16c). An example tableau along with the constraint ranking in (15) is provided. The additional constraint (*ʔ]σ) prohibits glottal stops from surfacing in the coda position.

(16) Opaque segolate nouns in MH

/deʃʔ/	*ʔ]σ	*CC]	Max	Dep
☞a. deʃ			*	
b. deʃʔ	*!	*		
☹c. deʃe			*	*!
d. deʃeʔ	*!			*

The established ranking *CC],MAX>>DEP rules out both (16b) and (16d), as they have coda glottal stops, which are prohibited because of the constraint *ʔ]σ. The ranking needed for segolate nouns also rules out the desired form (16c), which violates both MAX (deleting a consonant) and DEP (inserting a vowel). Given the input /deʃʔ/ the optimal candidate with this ranking would

[32] Of course, a complete analysis would include stress and an explanation of the insertion of [e] as opposed to another vowel. These are not relevant to the current discussion.

simply be [deʃ] (16a), since surface motivation for an epenthetic vowel does not exist.[33] This issue of how to account for opacity within Optimality Theory has received much attention in recent literature, and has motivated a number of theoretical proposals. These are briefly discussed below.

4.4.1.1. Multi-level theories

In an attempt to maintain a restricted constraint inventory, and to capture the relationship between stratification and morphological and prosodic constituency, a number of models incorporating intermediate levels into OT have been adopted. All of these models are able to account for opacity, as they incorporate an intermediate form to which constraints can refer.[34] Three such examples are Stratal or Interleaved OT (Bermúdez-Otero 1999), Derivational Optimality Theory (Rubach 2000) and Enriched Input Theory (Sprouse 1998).

The benefits of using such models when dealing with opacity are that opacity is easily accounted for along the lines of a derivational framework. Multiple levels allow for an intermediate level at which the epenthesis trigger (an unwanted word-final consonant cluster) exists, and the importance of surface forms is maintained. In derivational OT, an initial computation takes place, resulting in an output that serves as the input to the next level of analysis. An account of opacity in Modern Hebrew in a serial derivational OT framework is provided in the following tableau.

(17) Stage 1: Epenthesis in Modern Hebrew segolate nouns

/deʃʔ/	*CC]	Max	Dep
a. deʃ		*!	
b. deʃʔ	*!		
c. deʃe		*!	*
☞d. deʃeʔ			*

The first stage of a derivational analysis deals only with epenthesis. The candidate identical to the input (17b) does not surface because the final consonant cluster is ruled out by a high-ranking constraint *CC]. The forms in (17a,c) that surface without an input consonant cause a violation of Max. This

[33] Although an analysis forcing bisyllabicity has been proposed (Bruening 1999), this solution accounts only for opaque nouns, and causes problems for other words, as there are many words in Hebrew that are monosyllabic (e.g., [baθ] 'daughter').

[34] A detailed discussion of opacity and cyclicity with reference to stratal paradigms can be found in (Kiparsky 2001).

makes the remaining form, the one with an epenthetic consonant (17d), the winner. In a derivational approach, the winning candidate of the first stage or level then serves as the input to the next one, as shown in example (18).[35]

(18) Stage 2: Modern Hebrew

/deʃeʔ/	*ʔ]	*CC]	Max	Dep
a. deʃ			**!	
b. deʃʔ	*!	*		
☞c. deʃe			*	
d. deʃeʔ	*!			

At this level, the constraint banning coda glottal stops is introduced. This, and the fact that the output forms are being compared with an input from a prior level of analysis, combine to predict that the opaque form will surface (18c). The inclusion of a step that allows additional constraints also claims that the epenthetic vowel and the glottal coexist at some point, and this allows the desired form (18c) to be chosen.

Multi-step accounts have faced criticism because they establish an intermediate form that never surfaces in the language, an issue faced by derivational analyses in general. This analysis is a translation of a rule-based analysis into OT, and nothing new is gained or explained by it. A response to this issue, and opacity in general, is an adaptation to bi-level OT called Sympathy Theory.

4.4.1.2. Sympathy Theory

An additional modification to bi-level OT is Sympathy Theory proposed by McCarthy in 1998. Sympathy introduces a new correspondence relation in addition to the input-output mapping of pure OT. The new correspondence relationship compares output candidates to a sympathetic candidate, which is basically a candidate that would be the preferred form, given a different ranking of constraints, but fails to surface. Central to Sympathy Theory is the notion of a selector constraint which chooses the sympathetic candidate. Other candidates must resemble this sympathetic candidate and failing to do so results in a

[35] I do not go through an Enriched Input analysis here, as it is similar to Derivational OT. The main difference is that instead of separate stages (as in DOT), both input and intermediate representations are included in a single tableau with a set of constraints that specifically refer to the intermediate, or enriched, form. This is similar to Sympathy in that a special constraint set is necessary, and similar to stratal OT since the enriched form is the output of the form chosen from constraints on the input.

constraint violation. A simplified analysis adapted from McCarthy 1998 is provided in (19).[36]

(19) Sympathy account of segolate nouns in MH

/deʃʔ/	*ʔ]σ	֍Max-V	Dep-V
a. deʃ		*!	
b. deʃʔ	*!	*	
☞c. deʃe			*
֍d. deʃeʔ	*!		*

In the above table, ֍Max-V represents the sympathetic constraint. This is a constraint that compares candidates with the sympathetic candidate [deʃeʔ]. Both (19a) and (19b) violate ֍Max-V because they surface without a vowel that is present in the sympathetic candidate, namely, [e]. The sympathetic candidate itself violates the coda constraint *ʔ]σ. The only remaining choice is the opaque form that has an epenthetic vowel and no surface motivation for that vowel.

In essence, Sympathy does not avoid the criticisms faced by serial analyses. It too gives weight to an intermediate form and allows that form to be consulted by other candidates. Unlike output-output correspondence (Benua 1997), the additional relation is not between two real words of a language, but a non-existent word and a surface form. While Sympathy accounts for the opacity data, the main motivation for the framework lies in incorporating traditional abstract analyses, like opacity in Modern Hebrew, into OT, while maintaining the parallelism intended by bi-level OT.

4.4.1.3. The abstractness assumption

While it is clear that the types of analyses discussed account for the data and allow reference to intermediate forms, there is a bigger issue at hand. That is, all of the analyses take as a basic assumption that the input to these forms is /deʃʔ/. Consistent with a traditional approach to phonology, this abstract representation is assumed to be recoverable from surface data that include related forms in the language. Examples of opaque nouns and related forms are provided in (20).

[36] In this case, the selector constraint is Max-V, which is fulfilled by only the faithful candidate (19b) and one other candidate (19d).

(20)	Opaque Noun:	déʃe	‘grass, lawn’
	Related forms:	deʃaʔim	‘lawns’
		diʃʔo	‘his lawns’

Traditionally, this data set has been considered sufficient evidence to posit abstract representations in phonology. However, the basic assumption that glottal stops are present in the underlying representation is unsupported, and the presence of a handful of related words with optionally produced glottal stops is not sufficient motivation for positing an abstract representation.

First, glottal-final segolate nouns in Modern Hebrew number only six. Second, we have little evidence for underlying glottal stops in ʔ-final weak verbs for younger adults, as discussed earlier in this chapter. Therefore, one possibility to consider is the extension of this analysis to ʔ-final segolate nouns. Support for this idea comes both from the lack of evidence supporting abstract final glottal stops in younger adult representations and previous experimental evidence examining the nominal paradigm in Modern Hebrew. It has been shown that while regular verbs are decomposable into a root and an abstract morphological pattern, this is not true for nouns (Deutsch et al. 1998). One strong argument for underlying glottal stops in opaque nouns is that the root is psychologically real. The experiments presented by Deutsch et al. (1998) suggest that, at least for nouns, the root and pattern is not psychologically real.

Therefore, I argue that the analysis for weak verbs proposed for ʔ-final weak verbs in Modern Hebrew should be extended to ʔ-final nouns, as well. This means that traditional glottal final roots in Modern Hebrew (CCʔ) have been reanalyzed and do not include an underlying glottal stop. Without support for underlying glottal stops in ʔ-final segolate nouns, we have no reason to assume that opacity in Modern Hebrew is manifested in the synchronic system of the language. Therefore, I argue that the representations for ʔ-final segolate nouns do not contain underlying glottal stops. THe motivation for deriving these nouns and verbs from a single glottal-final root is historical, and does not support theoretical modifications to Optimality Theory.

One argument against this proposal is that related forms with surfacing glottal stops do exist. As we have already seen, the mere existence of an alternation is not the only criterion in motivating abstract representations. Supporting this notion is the fact that the majority of the related forms are literary words, not used in everyday speech. For example, the word *diʃʔo* ‘his grass’ is formal and not used in speech (limiting the access a speaker has to evidence of an alternation). The phrase *ha déʃe ʃelo* ‘the grass of him’ is used more commonly.

Furthermore, as I have discussed in detail in Chapter 2, glottal stops are commonly deleted even in onset position, and younger generation speakers do not show evidence of underlying glottal stops in transparent forms. The same applies here where the related forms, when pronounced, are most likely to be pronounced without the glottal stop, eliminating evidence of a glottal stop. Additionally, in all of the words related to opaque segolate nouns in MH, the glottal stop occurs intervocalically, where it could easily be perceived as a hiatus resolution rather than an abstract phoneme.

Therefore, it is more accurate to claim that these forms have been reanalyzed as words (not roots) without glottal stops, and that the generalization about opacity is historical in nature. Opacity in segolate nouns in Modern Hebrew does not require a phonological explanation, and these forms should not be used to support additional machinery or mechanisms in theory.

This claim made about segolate nouns in Modern Hebrew can and should be extended to other examples of opacity, as well. At least in Modern Hebrew, the sorts of relationships that have been called opaque do not derive from abstract representations.

4.5. Phonology and opacity

Focusing on opacity in Modern Hebrew, I argued that the apparent opacity of glottal-final segolate nouns is a remnant of a serial way of thinking associated with older rule-based theories. It is neither an issue nor a problem for current phonology, as this degree of abstractness is not reflected in the grammars of speakers. This proposal is relevant for phonological theory as well.

The main goal of phonology is to model a speaker's competence. Various accounts of opaque phenomena serve to capture an opaque relationship while maintaining the input-output mapping of bi-level OT (as does Sympathy Theory), or to provide us with insight as to the relationship between processing levels and prosodic constituency (as in Stratal or Interleaved OT). However, it has been shown here that perhaps we are focusing our attention on solving the wrong problem. The focus here is not on the best way to account for opacity, but on whether opaque relationships are identified by speakers.

Consistent with our goal of understanding the nature of the phonological component of grammar, it is at least as likely that a few uncommon, exceptional words have been internalized, as it is that they have a representation vastly different from their surface forms. While there are cases of opaque relationships that appear to be common and productive in some languages (i.e., vowel

harmony in Pulaar (Archangeli & Pulleyblank 1995)), a number of these cases seem to be historical in nature (i.e., Modern Hebrew segolate nouns), or simply idiosyncrasies of particular languages.

Opacity in many cases is simply a remnant of years of examining the data serially, as an old-fashioned rule-based analysis is still the easiest way of *illustrating* opacity. This has translated into the assumption of derivational and non-derivational theories that the underlying representations in these forms are abstract. However, using a serial analysis as a tool for illustrating extreme cases of abstractness does not necessarily mean that we should accept this abstractness as the true nature of these forms. For all cases of apparent opacity, we must seek experimental support for abstract representations before assuming a speaker has internalized the opaque generalizations in the grammar.

A close look at opacity in Modern Hebrew shows that all of the analyses, whether cast in Sympathy Theory, Enriched Input Theory, or Derivational Optimality Theory, assume a high degree of abstractness. In this thesis, I have argued that even transparent alternations are not identified as such by speakers. I have also claimed that the amount of exposure speakers have to particular alternations affects their ability to form abstract representations (where abstract only means differing from the surface, not necessarily opaque). Taking this into account with the facts that (1) there are only six opaque segolate nouns in Modern Hebrew, (2) there are few forms in each language that serve as a cue to an alternation, and (3) there is experimental support that nouns in Hebrew are not stored as roots, I can only come to the conclusion that opacity is not representative of a speaker's competence in Modern Hebrew and does not constitute a psychologically real phenomenon.

4.6. Conclusion

This chapter is centered around two main themes: the organization of weak verbs in the grammar of young and older adults and the reanalysis of opaque segolate nouns in Modern Hebrew as deriving from concrete representations, not abstract ones.

In the first part of the chapter, I claimed that weak verbs traditionally analyzed by linguists as having a final underlying /j/ have been reanalyzed as vowel final stems. I proposed that the same is true for younger adults of Modern Hebrew, as the available evidence is insufficient to support the formation of an abstract representation. The main factor inhibiting abstraction is the low exposure to the surface alternation, as the optional deletion of glottal stops has become the norm rather than the exception, and deletion has increased with time, leaving little surface evidence with which young adults can form a

generalization. Because adults showed delayed response times in the ʔ-final weak verb condition, their representations are quite likely different from younger adults. I discussed two possible analyses for ʔ-final weak verbs in older adults, neighborhood competition and phonological mismatch, with the latter seeming more plausible. This would support an underlying glottal stop in the phonological representations of older adults. However, it is not clear that the representation is based on purely phonological evidence, as a strong association with orthography and normative pronunciations in older adults was not controlled.

Next, I addressed the issue of opacity in Modern Hebrew, focusing on a class of ʔ-final segolate nouns. I argued that we have no motivation to posit abstract representations for these forms, thus rendering the representations concrete and transparent. I challenged the basic assumption that abstract phonological representations underlie these forms, and claimed that it is inaccurate. While there is a group of words in Modern Hebrew that pattern together, factors such as the small number of forms, the weak evidence from related forms, and the lack of experimental support for underlying glottal stops, promote a more concrete analysis.

In conclusion, we have little support for abstract representations for younger adults in Modern Hebrew. Considering the basic assumption that learners posit concrete representations and move to more abstract representations as information becomes available, I claim that this move was not possible because younger adults do not receive enough information. Older adults, however, are exposed to a sufficient amount of evidence of an alternation and are able to posit underlying glottal stops. This abstracting ability, though, is not only due to phonology, but may also be due to uncontrolled factors such as orthography and prescriptivism as well.

Chapter 5
The two glottal stops of Modern Hebrew

In this thesis, I have focused on weak verbs that have been traditionally analyzed as deriving from a phonological form with an underlying glottal stop. I discussed the slow decline of the use and productivity of glottal stops in Modern Hebrew and showed that their presence in the language is diminishing, so much so that even formerly transparent alternations are not transparent to younger adult speakers of Modern Hebrew. Consequently, it has been argued that glottal stops in Modern Hebrew are not present in stem-final position, even in what are traditionally considered transparent alternations: forms like *mile* 'he filled' correspond to lexical /mile/ not */mileʔ/. The general assumption then is that glottal final forms have been reanalyzed as vowel-final stems in Modern Hebrew. In this chapter, I consider the distribution of glottal stops throughout Modern Hebrew, and show that the decrease in the production of glottal stops has resulted in a change in status for glottal stops in Modern Hebrew overall, not just in the closed class of glottal-final weak verbs. Additionally, I claim that a thorough analysis of glottal stops in Modern Hebrew is one that includes two glottal stops: one a marginal phoneme and the other a phonetic onset.

5.1. Distribution of glottal stops

First, I examine the distribution of glottal stops throughout the language in detail. Remember from Chapter 2 that glottal stops are optional, and they are deleted more often than they are pronounced. In Modern Hebrew, glottal stops occur word initially, as shown in (1).[37]

(1) Word-initial glottal stops in Modern Hebrew

a.	ʔibed	'lose (tr.)'
b.	ʔaxal	'eat'
c.	ʔérets	'land, country'
d.	ʔagem	'sad, mournful, melancholic'

[37] Thanks to Bob Hoberman for providing the data for this section.

The forms above have a glottal stop in the word-initial position, or as the first root consonant. Of the three root positions, the initial position is the position with the greatest number of glottal stops. Glottal stops also occur intervocalically, as the second root consonant. Examples of intervocalic glottal stops are given in (2).

(2) Intervocalic glottal stops in Modern Hebrew

a.	daʔag	'he cared'
b.	kaʔav	'he ached'
c.	zoʔem	'angry'
d.	jáʔar	'forest'
e.	reʔut	'friendship'

Finally, glottal stops occur post-consonantally in some verbal inflections (as discussed in Chapter 2), and in many nouns and adjectives. Surface glottal stops appear post-consonantally in all positions: initially, after a consonant-final prefix (3a-b); in second position when the pattern consists of the first consonant in the coda position immediately followed by the second consonant in onset position (3c-g); and in final position when the second consonant is in the coda position and the third consonant surfaces in the onset (3h-l).

(3) Post-consonantal glottal stops

a.	hitʔamlut	'physical exercise'
b.	hitʔabed	'he committed suicide'
c.	misʔada	'restaurant'
d.	mifʔal	'factory, project'
e.	matʔim	'suitable'
f.	mitʔan	'load'
g.	milʔel	'penultimate stress'
h.	givʔa	'hill'
i.	marʔa	'mirror'
j.	mirʔe	'pasture'
k.	milʔa	'she filled'
l.	karʔa	'she read'

This final group of forms differs from the first two groups, in that the glottal stop in each form follows a consonant. In addition, as noted before, it is more common for glottal stops to be deleted than retained. This variation results in

more productions of (1) – (3) without glottal stops than with glottal stops. This is relevant in forming representations, and may be crucial depending on the given theory of phonology. For example, Bybee (2001) lays out a grammar in which all instances of forms are stored. In such an framework, the form in (3a) would have two representations: /hitʔamlut/ and /hitamlut/. Each time a token is produced, it is stored, and the form with the higher number of tokens (the most frequent of the two) is the most easily accessed.

A token-based framework, leads us to question the influence of the sound change in progress in Modern Hebrew (glottal stop loss) on the phonological system as a whole. If the least common production is one with glottal stops, then it is possible that the phonological form reflects this, and contains no underlying glottal stop. This, plus the facts that final underlying glottal stops are unsupported, and glottal stops are cross-linguistically a common epenthetic onset, question the assumption that underlying glottal stops exist in Modern Hebrew. These facts, in turn, support the claim that glottal stops have lost their phonological status in Modern Hebrew. In order for this claim to be made, though, an account of surface glottal stops is necessary. In the following, I provide arguments supporting an insertion analysis of glottal stops in Modern Hebrew.[38]

5.2. Status of glottal stops in Modern Hebrew

Based on the evidence presented so far, we have found no support for final underlying glottal stops in Modern Hebrew. More specifically, the results suggest that stems with underlying final glottal stops do not exist. For example, I have argued that the forms [mile] and [deʃe] which are traditionally analyzed as deriving from the inputs /mileʔ/ and /deʃʔ/ have been reanalyzed as /mile/ and /déʃe/, respectively, as there is insufficient evidence to prompt a speaker to move from a concrete to a more abstract representation.

As discussed in the first section, though, there are a number of words in Modern Hebrew in which glottal stops freely occur, although they are generally deleted. We have seen that glottal stops surface word-initially, intervocalically, and post-consonantally depending on the pattern and root position. I argue below that in the first two cases, these are not optionally deleted glottal stops, but optionally inserted glottal stops, inserted to serve as a phonetic onset. The glottal stop/zero post-consonantal alternation, however, is not governed by a

[38] One question not addressed in this chapter is *why* the sound change is occurring. One explanation may involve perception, along the lines of Mielke's (2001, 2002) explanation of [h] loss in Turkish. There is insufficient evidence to make this claim at this time, though, so I can only suggest the possible link between perception and glottal stop loss.

need for an onset, and must therefore be part of the phonological system, if only a peripheral one.

The use of epenthetic consonants to satisfy an onset constraint is not uncommon across languages, as Axininca Campa exhibits the epenthesis of [t] to break up vowel hiatus (Levin 1985), and German, for example, has regular glottal epenthesis before vowel-initial morphemes (Fox 1990). In the next section, I argue that Modern Hebrew has two glottal stops. One is a marginal phoneme that occurs only in a definite set of words, and the other is a phonetic onset, similar to glottal stops in German.

5.2.1. Epenthetic glottal stops in Modern Hebrew

The decline in production of glottal stops in Modern Hebrew over the years (Berman 1980, Glinert 1994, Schwarzwald 2001) is indicative of a shift in the phonology of Modern Hebrew. Let us consider again the distribution of glottal stops in detail, and the implications for phonology. We have seen that glottal stops occur word-initially (1), and that these are optional. This gives us the data set in (4).

(4) Word-initial glottal stops in Modern Hebrew

a.	ʔibed ~ ibed	'lose (tr.)'
b.	ʔaxal ~ axal	'eat'
c.	ʔérets ~ érets	'land, country'
d.	ʔagem ~ agem	'sad, mournful, melancholic'

In this set, the missing glottal stops are traditionally analyzed as part of the phonological form, thus they are deleted. To a speaker without access to the historical forms in which glottal stops were consistently produced, these forms may also be analyzed as having epenthetic glottal stops, satisfying the preference for syllables with onsets. Considering the history of Modern Hebrew, deletion may seem to be the most plausible analysis, while considering the synchronic data alone leads to an insertion analysis. Glottal stop production is optional, and both insertion and deletion are plausible, but the question here is which analysis best reflects a speaker's representation. The consideration of the data in (4) alone supports an insertion analysis, as glottal stops are common epenthetic elements at word boundaries, and the loss of a glottal stop creates a marked onsetless syllable. Glottal stops are optional in every position, though, not just word initially, as shown in (5).

(5) Intervocalic glottal stops in Modern Hebrew

a. daʔag ~ daag	‘he cared’
b. kaʔav ~ kaav	‘he ached’
c. zoʔem ~ zoem	‘angry’
d. jáʔar ~ jáar	‘forest’
e. reʔut ~ reut	‘friendship’

The forms in (5) vary between the more common production without glottal stops (vowel hiatus) and the less common production with glottal stops. Both intervocalic consonant loss and insertion are common across languages. To analyze the forms in (5) as undergoing consonant loss, an underlying glottal stop must be present. We saw in Chapters 3 and 4 that we have no evidence to support final underlying glottal stops in Modern Hebrew. What evidence do we have to posit underlying glottal stops in the forms in (4) and (5)? The deletion of glottal stops in the forms in (5) results in the formation of a hiatus context. According to Casali (1997), the sequence V.V is a highly marked form that languages generally tend to avoid. Additionally, glottal-stop insertion is common across languages, especially at word edges and before stressed syllables (Uffman 2002). Therefore, we might plausibly assume that the alternations in (5) result from the insertion of glottal stops in order to break up a marked sequence, rather than the deletion of a glottal stop between two vowels. The data presented thus far lead us to two possible analyses, each discussed below.

5.2.1.1. Underlying glottal stops

The first possible analysis is consistent with the diachronic developments in Modern Hebrew and includes glottal stops in the underlying forms for all words in examples (4) and (5). Our goal is to arrive at two possible outputs for each form, as glottal stops are optional. Constraints used in this analysis include those in (6).

(6)

ONSET:	Syllables must have onsets
MAX C:	Do not delete consonants
*ʔ:	Glottal stops should not surface

Incorporating these constraints into the analysis, we arrive at one variant: the form that surfaces with a glottal stop.

(7) Underlying glottal stops that surface

/re?ut/	ONSET	MAX C	*?
☞a. re.?ut			*
b. re.ut	*!	*	

In this case, form (7a) is both faithful to the input and unmarked. Each syllable has an onset, unlike its counterpart (7b), which violates both faithfulness and onset constraints. The constraints in (7) choose the least marked and most faithful candidate. However, the majority of the time, the form that surfaces does not have a glottal stop. To account for this, we must have a ranking like that in (8).

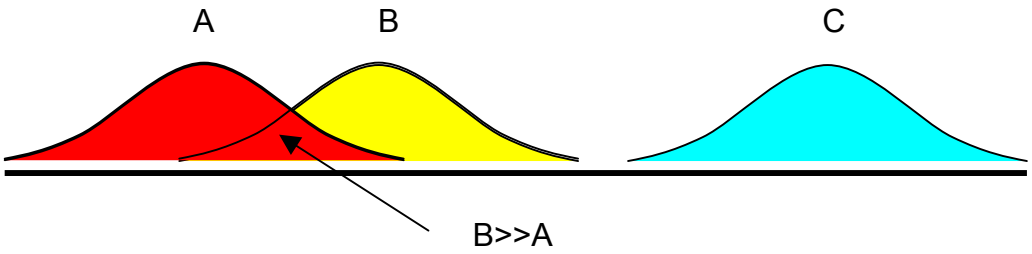
(8) Underlying glottal stops that do not surface

/re?ut/	*?	ONSET	MAX C
a. re.?ut	*!		
☞b. re.ut		*	*

In the analysis presented here, the markedness constraint prohibiting surface glottal stops outranks ONSET and MAX C in order to arrive at the desired output. One analysis of variation would simply argue that the constraints are optionally reranked, allowing for the surface form in (7) sometimes, and the form in (8) other times. This analysis, though, is more descriptive than explanatory, as it does not capture the fact that *most* of the time, glottal stops do not surface. An analysis consisting only of reranking would predict each form 50% of the time.

As discussed earlier, one way to handle variation is to adopt a token-based model in which each production has its own representation, and the most frequent production is the one that is basic for that word. Another possibility, though, is to treat the variation as an effect of partially overlapping constraints, along the lines of that proposed in Boersma 1997 and Boersma & Hayes 1999. Boersma and Hayes introduce the Gradual Learning Algorithm, which is an algorithm designed to model the learning of optimality-theoretic grammars. In this model, constraint ranking is probabilistic. Therefore, each constraint is not a single point on a continuum, but a gradient ranking along a continuum, as in (9).

(9) Gradual learning algorithm



In the grammar represented in (9), the ranking of A>>C is absolute, as the constraints are distantly ranked and there is no interaction between them. Constraints A and B, on the other hand, are ranked close together, so close in fact that the probabilities of each constraint overlap. The overlapping of two constraints (i.e., constraints A and B above) make the ranking B>>A probable a certain percentage of time. In other words, the lower ranked constraint (i.e., constraint B) can dominate the higher ranking constraint (i.e., constraint A). So, if constraint ranking is probabilistic, and two constraints are closely ranked, we would expect to arrive at the ranking B>>A a small percentage of the time, even though the majority of the time the ranking A>>B will hold. The idea of overlapping constraints is able to model free variation like that found in Modern Hebrew, as shown in (10).

(10) Optional glottal stop deletion in Modern Hebrew

/re?ut/	*? ↓				
		↓ ONSET			MAX C
☞a. re.ut		*!			*
b. re?ut			*		

The table in (10) provides us with a plausible analysis for the variation of glottal stops in Modern Hebrew. The overlapping constraints show that in the majority of cases *? will be obeyed, but in a small number of cases, either ONSET or MAX C (in this case ONSET) will outrank *?, resulting in a surfacing glottal stop. Incorporating a Gradual Learning Algorithm-type account allows us to predict that glottal stops will surface less often than they are omitted. While the variation is accounted for, this type of analysis is by no means limited to those cases that contain an underlying glottal stop.

The main question that remains is: what evidence do we have to posit an underlying glottal stop? It is clear that the data in (1) and (2) are ambiguous. Below, I provide a new account for glottal stops in Modern Hebrew, and provide additional data that support the claim that many glottal stops in Modern Hebrew are phonetic.

5.2.1.2. Epenthesis of glottal stops

The analysis promoted in this section is that the phonological system of Modern Hebrew has been reorganized so that glottal stops are no longer underlying in the forms in (4) and (5). Instead, they are inserted to satisfy ONSET. The use of the faithfulness constraint DEP C (11) is crucial to this analysis.

(11) DEP C: Do not insert a consonant

(12) Optional insertion of glottal stops

/reut/	ONSET	DEP C
a. re.ut	*!	
☞b. re.ʔut		*

The difference between the analysis in (12) and that in (7) is that the underlying form no longer contains a glottal stop. This in turn makes the optimal form a result of the interaction of general markedness and faithfulness constraints. In (7) and (8), the input contains a glottal stop, so both ONSET and MAX C favor preservation of the glottal stop (which is not what usually occurs). In (12), the opposition is between the need for an onset (ONSET) and a ban on insertion (DEP C). Ranking the faithfulness constraint above the markedness constraint results in no insertion, as in (13).

(13) No insertion of glottal stop

/reut/	DEP C	ONSET
☞a. re.ut		*
b. re.ʔut	*!	

Here again, we have a situation in which we can use overlapping constraints to more fully explain the distribution of glottal stops in Modern Hebrew. The table is provided in (14).

(14) Optional insertion of glottal stops in Modern Hebrew

/reut/	DEP C		
			ONSET
☞a. re.ut			*
b. reʔut	*!		

In example (14), DEP C is ranked above ONSET while they are ranked closely enough to overlap. As discussed above, faithfulness plays a role in this case and not in the glottal stop deletion analysis because in the latter, the form [re.ut] violates both markedness and faithfulness constraints. Here, the input comes without a glottal stop. This analysis is consistent with the fact that the majority of the time, [reut] will surface, maintaining identity with the input, whereas [reʔut] will surface when ONSET outranks DEP. The overlap is small here to reflect actual usage in which the common surface form is the one without the glottal stop. Both can surface, however, as the example in (15) shows.

(15) Optional insertion of glottal stops in Modern Hebrew

/reut/	DEP C ↓	↓ ONSET	
a. re.ut		*!	
☞b. reʔut			*

While [reʔut] is the less common form, it is possible for it to surface. In (15), we see that the natural overlap of two closely related constraints allows for the casual production of glottal stops to break up hiatus contexts (or serve as onsets in word-initial positions (4)).

While the underlying glottal stop analysis is motivated on historical grounds, we should ask whether we have evidence for the insertion analysis beyond the data in (4) and (5). We can find evidence both within Hebrew and in other languages. First, as previously mentioned, epenthesis is a common solution to unwanted onsetless syllables. In German, for example, glottal stops are regularly inserted to serve as onsets before vowel-initial morphemes, as in (16).[39]

(16) Epenthesis of glottal stops in German (Fox 1990)

a. er-innern	[ʔɛʁ-ʔɪnəʁn]	'to remind, recall'
b. ver-eisen	[fɛʁ-ʔaɪzn̩]	'to freeze up'
c. ent-ehren	[ʔɛnt-ʔe:ʁən]	'to dishonor'
d. überall	[ybəʁ-ʔal]	'everywhere'
e. Augenarzt	[ʔaʊgənʔaʁts]	'eye doctor'

[39] Here, we see glottal stops inserted to serve as onsets, even when a consonant is available, (16a-e), as long as the morpheme begins with a vowel. A strong analysis of MH would be that it follows German in this respect and that all glottal stops are phonetic onsets.

The examples in (16) show that German prefers glottal stop onsets both word-initially and –internally before vowel initial morphemes. While this is one case of consonant epenthesis, there are many more, one additional example coming from Axininca Campa, where [t] is inserted to break up V + V sequences (Levin 1985).

(17) Epenthesis of [t] in Axininca Campa

a. /noN-pisi-i/	nompisi**t**i	'I will sweep'
b. /noN-piyo-i/	nompiyo**t**i	'I will heap'
(cf. /noN-kim-i/	no$_{\eta}$kimi	'I will hear')

Cross-linguistically, it is common to find consonants inserted to serve as onsets, and Modern Hebrew can be considered as one language of many that exemplifies this phenomenon. In addition to cross-linguistic preferences, language-internal evidence supporting an insertion analysis exists, as well.

5.2.1.3. Internal evidence[40]

Within Hebrew, there is also evidence that glottal stops are not warranted in the underlying representation. First, we can focus on glottal-initial words. Some words act as if an underlying glottal stop is present in the phonological form, as in (18).

(18) a. /l + ʔabed/ leʔabed ~ leabed 'to lose'

In (18), the form [ʔabed] receives the prefix *le-* as opposed to *l-* because *le-* is the prefix variant that surfaces with consonant-initial words. If the glottal stop were not present, we would expect the form *[labed] (from /l + abed/), which does not occur (Bat-El 1994). This is not a generalization that can be made throughout Hebrew, though, as there are forms that behave the way an insertion analysis would predict. Consider the forms in (19).

(19)

a.	ʔalaxson	lixsen	(*leʔixsen)
	'diagonal'	'to make diagonal'	
b.	ʔamerikani	hitmarken	(*hitʔamarken)
	'american'	'to americanize'	

but initially,

[40] I am grateful to Outi Bat-El for pointing out many examples in this section and for helpful comments and suggestions.

c.	ʔabstrakti	ʔibstrekt
	‘abstract’	‘to make abstract’

In the cases in (19a, b), the glottal stop is ignored, and surfaces only word-initially before a vowel. The form in (19c) shows that the glottal stop surfaces before an initial vowel independent of the pattern. Forms like this in (19) lend support to the argument that glottal stops are not present in the underlying representation, but surface only to satisfy the need for an onset.

Two types of forms within Modern Hebrew are crucial to this analysis. One type consists of words like *dialekt* [di.ja.lɛkt] ‘dialect’[41]. While *dialekt* is written with the letter representing the glottal stop (א, alef), a glottal stop is never produced naturally in this form, or others like it. *Dialekt* may be pronounced with a glottal stop only when each syllable is pronounced separately as [di] [ʔa] [lɛkt], but this is comparable to word-initial glottal stop epenthesis. Glottal stop deletion is counterintuitive in this case. The surface form [di.ʔa.lɛkt] is the most faithful output, satisfying both ONSET and MAX (for an input containing a glottal stop). In order for [di.ja…] to surface, the faithful glottal stops onset is deleted and replaced by a glide. In an insertion analysis, no glottal stop is predicted, MAX is not violated, and ONSET is satisfied. In a UR that does not contain a glottal stop, surface [j] is the best way to satisfy both DEP and ONSET, as in (20).

(20) [i] as an onset in Modern Hebrew

/dialɛkt/	DEP ↓	↓ ONSET
☞a. σ σ d i a		
b. σ σ d i ʔ a	*!	
c. σ σ d i a		*!

[41] The pronunciation of *dialekt* and related forms were provided from 3 native speakers of Modern Hebrew.

In the example above, we would not predict an output with a glottal stop at any time because the winning form does not violate DEP or ONSET (as long as constraints preventing multiple associations are ranked below ONSET). Therefore, this should not be a variable form, as it does not matter whether DEP or ONSET is higher because (20a) will always be the most optimal candidate when compared with its competitors.

The second group of words important to an insertion analysis are borrowings that come with a V.V sequence, but surface with a V.ʔV sequence. Many of these words surface with optional glottal stops, even though the lending language does not have glottal stops in these forms.[42] Consider the forms in (21).

(21) Words produced in Modern Hebrew with inserted glottal stops

a.	te.ʔorja	'theory'
b.	te.ʔatron	'theater'
c.	po.ʔema	'poem'
d.	Kle.ʔopatra	'Cleopatra'

The forms in (21) are all borrowed with vowel-vowel sequences and are adapted into Modern Hebrew with onset glottal stops. Forms like these provide us with evidence that glottal stop is in fact the consonant of choice for phonetic onsets, and show that epenthesis does indeed occur in Modern Hebrew. The question, then, how far should we extend the analysis?

Taking the external and internal evidence presented, I claim that glottal stops in the forms discussed so far in this section, namely word-initial and post-vocalic, are epenthetic phonetic onsets. Furthermore, a traditional analysis that is guided by the writing system is diachronic in nature and not necessarily the most accurate explanation of the organization of the synchronic grammar of present-day Modern Hebrew. Speakers are able to form representations based on the data available. The decrease in the production of glottal stops has led to the reorganization of the phonology of Hebrew. However, there are words in Modern Hebrew in which the optional glottal stop surfaces post-consonantally. Glottal stops in this position are (potentially) contrastive, and must therefore be considered as part of the phonology. I consider these glottal stops to be the second glottal stop of Modern Hebrew: the marginal phoneme.

[42] Thanks to Bob Hoberman for pointing this out to me.

5.2.2. Phonological glottal stops in Modern Hebrew

While the analysis presented here supports the analysis of glottal stops as inserted onsets, it does not assume that the glottal stop is no longer a phoneme of Modern Hebrew. Post-consonantal glottal stops are contrastive, and thus must be represented in the phonological representation. Consider the forms with post-consonantal glottal stops in (22).

(22) Post-consonantal glottal stops

a. hitʔamlut	'physical exercise'
b. hitʔabed	'he committed suicide'
c. misʔada	'restaurant'
d. mifʔal	'factory, project'
e. matʔim	'suitable'
f. mitʔan	'load'
g. milʔel	'penultimate stress'
h. givʔa	'hill'
i. marʔa	'mirror'
j. mirʔe	'pasture'
k. milʔa	'she filled'
l. karʔa	'she read'

As mentioned, when glottal stop occurs in this position, it is contrastive, as shown in (23).

(23) Contrastive glottal stops

a.	jiʃ(ʔ)al	'he will ask'
b.	jiʃal	'it/he will drop off'
c.	bar(ʔ)a	'she created'
d.	bara	'he created'
e.	jig(ʔ)aʃ	'it will quake'
f.	jigaʃ	'he will approach'

While glottal stops are optional in all forms, they are nonetheless potentially contrastive. This does not entail that glottal stops are full-fledged members of the phonological inventory of Modern Hebrew, though. In German, glottal stops are also the epenthetic consonant of choice, and they are inserted

post-consonantally before stressed vowels (Fox 1990). This epenthesis may also be contrastive (c.f. *ver-reisen* [fɛʁ-ʁaɪzn̩] 'to go away (on business)' vs. *ver-eisen* [fɛʁ-ʔaɪzn̩] 'to freeze up'), however, glottal stops are typically not included in the inventory of German (i.e., Fox, 1990, Hawkins 1987, Wiese 1996). So, the finite set of contrastive glottal stops may be representative of a marginal phoneme.

One relevant issue is whether each form of this type has one or two underlying representations. For example, Bybee (2001) would posit two underlying representations for the forms in (23a,c,e). She outlines a model that tracks each token of a word and sets up a representation for all varieties of a form. By doing so, abstractness is limited as there is an identical representation for every surface form. Eventually, as tokens are saved in memory, the form with the greatest number of tokens is the one that is accessed and serves as the basic form. A grammar of this type is provided in (24).

(24) Token-based representations
bar^{ʔ}a 'she created'

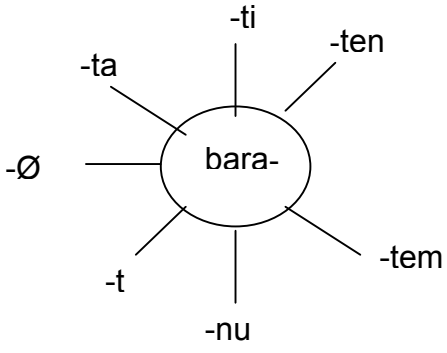
[bara] ⟶ /bara/

[bar^{ʔ}a] ⟶ /bar^{ʔ}a/

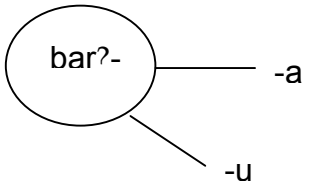
In this analysis, there exists an underlying glottal stop, but it is only activated when the surface form itself has a glottal stop. A model consistent with this analysis would have related words linked together with no reference to the morphology. So each inflected form would be associated with a different underlying representation. An alternative to this view is to say that there are two forms associated with glottal-final forms, for example, and that one is bare with no glottal stop (25a), while the other has an underlying glottal stop that can optionally be lost (25b).

(25) Representations for *bara* 'he created'

a.



b.



The representation in (25b) maintains the phonemic status of the glottal stop. However, as has long been recognized, in different languages, some phonemes or contrasts are more important than others. For example, Lyons (1968) discusses the distinction between the English pairs p/b and ʃ/ʒ. While there are an extremely high number of words in which mistaking [p] for [b] will result in a misunderstanding (i.e., saying *cap* for *cab* or *pin* for *bin*), this is not the case with the ʃ/ʒ pair, as there are very few words in English in which these two sounds contrast. Therefore, the former contrast carries a higher functional load than the latter contrast. The simple point here is that the glottal stop, while contrastive in a small set of words, is not functionally important, as not acquiring it will cause virtually no comprehension problems, if any.

5.3. Conclusion

Considering the distribution of glottal stops in Modern Hebrew, we arrive at two possible ways to analyze the data. One analysis, corresponding to the historical nature of the writing system, is that all written glottal stops are phonological. In Chapters 3 and 4, this has been shown to be inaccurate for weak verbs. This argument was extended to word-initial and intervocalic glottal stops. While underlying glottal stops are supported by tradition and the importance of the root system, we have significant evidence supporting two glottal stops in Modern Hebrew: phonetic onsets and marginal phonemes.

The main implication of this proposal is that the status of glottal stops as phonological in Modern Hebrew is marginal. Additionally, we have little evidence to posit underlying glottal stops in Modern Hebrew, and the majority of forms containing glottal stops as a root consonant must be stored as whole units. This appears to be complementary with the alternations in which glottal initial words pattern with words lacking an initial root consonant. While the analysis here maintains two distinct glottal stops, it is not incongruous with an analysis that assumes the reanalysis of all glottal stops as phonetic (similar to German) in the future.

Chapter 6
Concluding remarks

In this section, I would like to briefly discuss three issues stemming from this study that I see as important to future research in phonology: the identification of relatedness, its theoretical implications, and the importance of underlying representations in phonological theory.

6.1 Residual issues

6.1.1. Identifying relatedness

The arguments presented in this thesis have a more general implication for phonology. That is, we must begin to address how speakers identify related forms and abstract a generalization from a surface pattern before we can fully understand the nature of phonological representations and the degree of abstractness that is tolerated in a system. At the very least, the data presented here lead us to support a view that generalizations made by some linguists are not necessarily the same as those internalized by non-linguist speakers of a language. From this point, I see two options for future research: establishing the types of evidence that motivate abstractness, and incorporating phonology-independent factors into output-oriented frameworks.

One agenda for future research stems from current research in language acquisition. It is generally accepted that speakers begin with a concrete representation and then move towards a more abstract representation as they have access to more information and more surface forms. The access to this information enables learners to make generalizations about surface patterns and extract predictable information. However, little research has been conducted on identifying what constitutes “enough evidence” to motivate a speaker to posit a more abstract representation. Simply having the alternation occur is not sufficient, as shown in Chapters 3 and 4 of this thesis. What we want to know is, once a speaker posits a concrete form:

- What types of information motivate or inhibit the move to a more abstract representation?

- What are the thresholds beyond which abstraction is not possible?

From the current data, we know that the amount of access a speaker has to a particular pattern will affect the identification of a general relationship. However, we do not know the upper and lower boundaries for this factor. Previous research has shown that orthography (Bentur 1978) and word frequency ((Bybee 2001), among others) factor into the nature of the phonological component of grammar. While we are moving towards a better understanding of the role of external factors, and their interaction with phonology, we have by no means identified all relevant factors or clearly identified their role or effect. Possible ways to address these issues include additional psycholinguistic experiments isolating phonology-independent factors, further investigation into legal types of variation and the processing effects associated with different degrees of variation, and threshold-based experiments aimed at establishing boundaries (upper and lower) beyond which type and token frequency help or hinder processing of related forms.

6.1.2. Do we need phonological representations?

More research focusing on the importance of phonological representations is also necessary. Recently, there has been a surge in phonology research placing more emphasis on outputs and relations among surface forms (Benua 1995, 1997; McCarthy 2001; Albright 2002, among others). This research, along with research explaining what factors are involved in phonology and the extent of their influence, leads us to question whether we need underlying representations at all. The function of underlying representations has been to reflect speakers' awareness of alternations. However, once we introduce mechanisms for describing word-word correspondences into the grammar, it may be possible to dispense with underlying representations altogether (see proposals by Burzio 1998, Bybee 2001).

6.2 Conclusion

This dissertation focused on three issues central to phonological theory: (1) the allowance of multiple plausible analyses of the same set of data (and the inability to choose among them); (2) the use of psycholinguistic experimentation as a means of testing these competing analyses; and (3) the (in)ability of

speakers to internalize surface generalizations depending on the amount of exposure they have to a particular sound alternation.

I proposed three analyses for alternations in two types of Modern Hebrew weak verbs. Different views on what types of evidence are used by speakers in identifying surface patterns result in equivalent support for all three proposals. This, along with the fact that there are no established criteria in the theory for ruling out competing analyses, compels us to look elsewhere for an explanation.

In Chapter 3, I presented a psycholinguistic priming experiment that directly addresses issues of relatedness in Modern Hebrew weak verbs. The results of the experiment do not support abstract representations in younger adult Modern Hebrew speakers, even for what linguists consider to be transparent alternations. There is support, though, for abstract representations for older adults for traditional transparent alternations. I do not attribute the abstractness to phonology alone, though, as other factors such as older adults' affiliation with the normative pronunciations and the influence of orthography were not controlled in this experiment.

In Chapter 4, I provided a linguistic analysis of the experimental results and extended the claim that younger adults do not posit abstract glottal stops in the class of ʔ-final segolate nouns traditionally analyzed as opaque. I proposed that there is little evidence in favor of abstract underlying glottal stops in these nouns, and argued that these phonology-independent factors should be given more weight, especially in analyses of apparently opaque data. The general assumption that learners are able to identify opaque surface relations, at least in Modern Hebrew, is not supported, and it is probable that this claim can be extended to other cases of opacity. The main implication of this claim is that theoretical modifications to Optimality Theory based on opacity (in this case in Modern Hebrew) are unjustified.

Building on the discussion of glottal stops in Modern Hebrew, I examined the distribution of glottal stops in Modern Hebrew more thoroughly in Chapter 5. Here, I claimed that there are two glottal stops in Modern Hebrew: one an epenthetic onset, and the other a quasi-phoneme. The gradual loss of glottal stops provides progressively less evidence to speakers of the phonological status of this consonant. This makes the status of glottal stops potentially ambiguous to a speaker. To resolve this ambiguity, both a disfavoring of marked forms and language internal evidence enable speakers to interpret the glottal stops as epenthetic. Of course, there remain a number of post-consonantal glottal stops. These are candidates for quasi-phoneme status in Modern Hebrew (similar to proposals for glottal stops in German (Fox 1990)).

The experiment presented in this thesis was designed to address the linguistic issues of abstractness and relatedness. While this type of research is necessary, there is a gap between experimental research from a linguistic

perspective and that from a psychological perspective. This is made clear by the lack of experimental evidence available to help explain the results found for older adult speakers of Modern Hebrew. Further pursuit of psycholinguistic exploration of linguistic phenomena will close this gap and allow more productive and collaborative research between the two fields.

In conclusion, the psycholinguistic experiment presented in this thesis served to test phonological hypotheses regarding the nature of phonological representations. Based on the results, both abstract and concrete representations were proposed for Modern Hebrew weak verbs. In general, experiments sensitive to linguistic issues allow us to distinguish psychologically plausible hypotheses from psychologically real ones. More importantly, though, they move us closer to our goal of accurately modeling the phonological component of grammar.

References

Albright, Adam. 2002. The acquisition of basehood in morphological paradigms. Doctoral dissertation, University of California, Los Angeles.

Allen, Mark and Badecker, William. 2002. Inflectional regularity: Probing the nature of lexical representations in a cross-modal priming task. Journal of Memory and Language, 46.705-22.

Anderson, Stephen. 1985. Phonology in the Twentieth Century: Theories of rules and theories of representations. Chicago: University of Chicago Press.

Archangeli, Diana, and D. Pulleyblank. 1995. Grounded phonology. Cambridge: MIT Press.

Aronoff, Mark. 1994. Morphology by itself: Stems and inflectional classes, vol. 22: Linguistic Inquiry Monograph. Cambridge: The MIT Press.

Barkai, M. 1972. Problems in the phonology of Israeli Hebrew. Doctoral dissertation, University of Illinois.

Bat-El, Outi. 1994. Stem modification and cluster transfer in Modern Hebrew. Natural Language and Linguistic Theory, 12.571-93.

Bentur, Esther. 1978. Orthography and the formulation of phonological rules. Studies in the Linguistic Sciences, 1.1-25.

Benua, Laura. 1997. Transderivational identity: Phonological relations between words. Doctoral dissertation, University of Massachusetts, Amherst.

Benua, Laura. 1995. Identity effects in Morphological truncation. In J. Beckman, L. Dickey, and S. Urbanczyk (eds.), Papers in Optimality Theory. University of Massachusetts, Amherst, GLSA, 77-136.

Berman, Ruth. 1981a. Regularity vs. anomaly: The acquisition of Hebrew inflectional morphology. Journal of Child Language 8.265-82.

Berman, Ruth. 1981b. Language development and language knowledge: Evidence from the acquisition of Hebrew morphophonology. Journal of Child Language 8.609-26.

Bermúdez-Otero, Ricardo. 1999. Constraint interaction in language change: Quantity in English and Germanic. Doctoral dissertation, University of Manchester.

Boersma, Paul. 1997. How we learn variation, optionality, and probability. In R. van Son (ed.), The Proceedings of the Institute of Phonetic Sciences, 21. Amsterdam: The Instute of Phonetic Sciences, 43-58.

Boersma, Paul, and B. Hayes. 2001. Empirical tests of the gradual learning algorithm. Linguistic Inquiry 32.45-86.

Bolozky, Shmuel. 1999. Measuring productivity in word formation: The case of Israeli Hebrew. Leiden: Brill.

Booij, Geert. 1996. Non-derivational phonology meets Lexical Phonology. In I. Roca (ed.), Derivations and constraints in the lexicon. Oxford: Clarendon Press, 261-88.

Broselow, Ellen. The phonology of Egyptian Arabic. Doctoral dissertation, University of Massachusetts, Amherst.

Bruening, Benjamin. 1999. Morphological templates and phonological opacity. Handout of paper presented at the Second International Meeting on Morphology, University of Malta, September 1999.

Burzio, Luigi. 1998. Multiple Correspondence. Lingua 104.79-109.

Bybee, Joan. 2001. Phonology and Language Use. Cambridge: Cambridge University Press.

Bybee, Joan. 1995. Regular morphology and the lexicon. Language and Cognitive Processes, 10.425-55.

Casali, Roderic. 1997. Vowel elision in hiatus contexts: Which vowel goes. Language 73.493-533.

Chomsky, Noam, and M. Halle. 1968. The Sound Pattern of English. New York: Harper and Row.

Clahsen, Harald; S. Eisenbeiss; M. Hadler; and I. Sonnenstuhl. 2001. The mental representation of inflected words: An experimental study of adjectives and verbs in German. Language 77.510-43.

Coenen, E.; P. Zwitserlood; and J. Bölte. 2001. Variation and assimilation in German: Consequences for lexical access and representation. Language and Cognitive Processes 16.535-64.

Comrie, Bernard. 1980. Diachronic arguments for the psychological reality of abstract phonology: A critical review. In B. Butterworth (ed.), Language Production: Speech and Talk. London & New York: Academic Press, 271-96.

Connine, Cynthia. 1994. Vertical and horizontal similarity in spoken-word recognition. In C. Clifton and L. Frazier (eds.), Perspectives on sentence processing. Hillsdale: Lawrence Erlbaum Associates, 107-20.

Connine, Cynthia, D. Blasko, and D. Titone. 1993. Do the beginnings of spoken words have a special status in auditory word recognition? Journal of Memory and Language 32.193-210.

de Lacy, Paul. 2000. Maximal word effects and the Maori passive. MIT working papers in linguistics.

Deelman, T., and C. Connine. 2001. Missing information in spoken word recognition: Nonreleased stop consonants. Journal of Experimental Psychology: Human Perception and Performance 27.656-63.

Deutsch, Avital; R. Frost; and K. Forster. 1998. Verbs and nouns are organized and access differently in the mental lexicon: Evidence from Hebrew. Journal of Experimental Psychology: Learning, Memory, and Cognition 24.1238-55.

Dupoux, Emmanuel, and S. Peperkamp. 2002. The phonetic filter hypotheses: How phonology impacts speech perception (and vice versa). Paper presented at the 2nd International Contrast in Phonology Conference, Toronto, Canada, May 3-5, 2002.

Elman, J. L.; E. A. Bates; M. H. Johnson; A. Karmiloff-Smith; D. Parisi; and K. Plunkett. 1996. Rethinking innateness: A connectionist perspective on development. Cambridge, MA: MIT Press.

Emmorey, Karen D. 1989. Auditory morphological priming in the lexicon. Language and Cognitive Processes 4.73-92.

Féry, Caroline. 1999. Final devoicing and the stratification of the lexicon in German. ROA 274-0798.

Fowler, Carol A.; S. E. Napps; and L. B. Feldman. 1985. Relations among regular and irregular morphologically related words in the lexicon as revealed by repetition priming. Memory & Cognition 13.241-55.

Fox, Anthony. 1990. The Structure of German. Oxford: Clarendon Press.

Frauenfelder, Ulrich H.; M. Scholten; and A. Content. 2001. Bottom-up inhibition in lexical selection: Phonological mismatch effects in spoken word recognition. Language and Cognitive Processes 16.583-607.

Frost, Ram; A. Deutsch; and K. Forster. 2000a. Decomposing morphologically complex words in a nonlinear morphology. Journal of Experimental Psychology: Learning, Memory, and Cognition 26.751-65.

Frost, Ram; A. Deutsch; O. Gilboa; M. Tannenbaum; and W. D. Marslen-Wilson. 2000b. Morphological priming: Dissociation of phonological, semantic, and morphological factors. Memory & Cognition 1277-88.

Gaskell, M. Gareth, and W. D. Marslen-Wilson. 1996. Phonological variation and inference in lexical access. Journal of Experimental Psychology: Human Perception and Performance 22.144-58.

Glinert, Lewis. 1989. The grammar of Modern Hebrew. Cambridge: Cambridge University Press.

Goldinger, Stephen A., P. A. Luce, D. B. Pisoni, and J. K. Marcario. 1992. Form-based priming in spoken word recognition: The roles of competition and bias. Journal of Experimental Psychology: Learning, Memory, and Cognition 18.1211-38.

Goldinger, Stephen. 1989. Echoes of echoes? An episodic theory of lexical access. Psychological Review 105.251-79.

Goldrick, Matthew. 2000. Turbid output representations and the unity of opacity. Proceedings of the Northeast Linguistics Society, 231-45.

Gow, David W., Jr. 2001. Assimilation and anticipation in continuous spoken word recognition. Journal of Memory and Language 45.133-59.

Gow, David W., Jr. 2002. Does English coronal place assimilation create lexical ambiguity? Journal of Experimental Psychology: Human Perception and Performance 28.163-79.

Graf, Dafna. 2001. Stress assignment in the nominal system of Modern Hebrew. ROA 443-0701.

Hale, Ken. 1968. Review of Patrick W. Hohepa, A profile Generative Grammar of Maori. Journal of the Polynesian Society 77.83-99.

Hawkins, John A. 1987. German. In B. Comrie (ed.), The world's major languages. Oxford: Oxford University Press, 110-38.

Hayes, Bruce. 1999. Phonological acquisition in Optimality Theory: The early stages. ROA 327-0699.

Hohepa, Patrick W. 1967. A Profile Generative Grammar of Maori: International Journal of Linguistics, Memoir 20. Bloomington: Indiana University Press.

Hooper, Joan. 1976. An introduction to Natural Generative Phonology. New York: Academic Press.

Hyman, Larry. 1970. How concrete is phonology? Language, 46.58-76.

Idsardi, William. 2000. Clarifying opacity. The Linguistic Review, 17.337-50.

Kager, Rene. 1999. Optimality Theory: Cambridge Textbooks in Linguistics. Cambridge: Cambridge University Press.

Kenstowicz, Michael, and C. Kisseberth. 1979. Generative phonology: Description and theory. New York: Academic Press.

Kiparsky, Paul. 1968. How abstract is phonology? Bloomington: Indiana Linguistics Club.

Kiparsky, Paul. 1971. Linguistic universals and linguistic change. In Emmon Bach and Robert T. Harms (eds.), Universals in linguistic theory. New York: Holt. 171-202.

Kiparsky, Paul. 2001. Paradigmatic effects. Cambridge: Cambridge University Press.

Lahiri, Aditi, and W. D. Marslen-Wilson. 1991. The mental representation of lexical form: A phonological approach to the recognition lexicon. Cognition 38.245-94.

Levin, Juliette. 1985. A metrical theory of syllabicity. Doctoral dissertation, Massachusetts Institute of Technology.

Luce, Paul A. 1986. A computational analysis of uniqueness points in auditory word recognition. Perception & Psychophysics 39.155-58.

Luce, Paul A.; C. McLennan; and J. Charles-Luce. 2001. Abstractness and specificity in spoken word recognition: Indexical and allophonic variability in long-term repetition priming. In Bowers and Marsolek (eds.), Rethinking implicit memory. Oxford: Oxford University Press.

Luce, Paul A., and E. A. Lyons. 1998. Specificity of memory representations for spoken words. Memory & Cognition 26.708-15.

Lyons, John. 1968. Introduction to Theoretical Linguistics. Cambridge: Cambridge University Press.

Marslen-Wilson, William D. 1987. Functional parallelism in spoken-word recognition. Cognition, 25.71-102.

Marslen-Wilson, William D. 1990. Activation, competition, and frequency in lexical access. In G. Altmann (ed.), Cognitive models of speech processing: Psycholinguistic and computational perspectives. Cambridge, MA: MIT Press, 148-72.

Marslen-Wilson, William D.; A. Nix; and M. G. Gaskell. 1995. Phonological variation in lexical access: Abstractness, inference and English place assimilation. Cognitive Processes 10.285-308.

Marslen-Wilson, William D., L. K. Tyler, R. Waksler, and L. Older. 1994. Morphology and meaning in the English mental lexicon. Psychological Review 101.3-33.

McCarthy, John J. 1998. Sympathy and phonologicl opacity. Ms., University of Massachusetts, Amherst. ROA 252-0398.

McCarthy, John J. 2001. Optimal paradigms. Ms., University of Massachusetts, Amherst. ROA 485-1201.

Mielke, Jeff. 2001a. Turkish /h/ deletion: Evidence for the interplay of speech perception and phonology. Paper presented at Northeast Linguistics Society, NYU/CUNY.

Mielke, Jeff. 2001b. Perception in phonology: The case of Turkish /h/ deletion. Paper presented at Chicago Linguistic Society, Chicago, IL.

Prince, Alan, and P. Smolensky. 1993. Optimality Theory: Constraint interaction in generative grammar. Ms., Rutgers University and University of Boulder.

Radeau, Monique; J. Morais; and J. Segui. 1995. Phonological priming between spoken words. Journal of Experimental Psychology: Human Perception & Performance 21.1297-311.

Ravid, Dorit. 1995. Language change in child and adult Hebrew: A psycholinguistic perspective. New York: Oxford Press.

Rosén, Haiim B. 1977. Contemporary Hebrew. The Hague: Mouton.

Rubach, Jerzy. 2000. Glide and glottal stop insertion in Slavic: A DOT analysis. Linguistic Inquiry 31.271-317.

Rumelhart, D. E., and J. L. McLelland. 1986. On learning the past tenses of English verbs. In D. Rumelhart and J. McLelland (eds.), Parallel Distributed Processing: Explorations in the microstructure of cognition. Cambridge, MA: MIT Press, 216-71.

Schachter, D. L., and B. A. Church. 1992. Auditory priming: Implicit and explicit memory for words and voices. Journal of Experimental Psychology: Learning, Memory, and Cognition 18.915-30.

Schwarzwald, Ora R. 1984. Analogy and regularization in morphophonemic change: The case of the weak verbs in Post-Biblical Hebrew and Colloquial Modern Hebrew. AfroAsiatic Linguistics 9.87-100.

Schwarzwald, Ora R. 2001. Modern Hebrew.vol. 127: Languages of the World/Materials. Munich: LINCOM Europa.

Slowiaczek, Louisa M., J. M. McQueen, E. G. Soltano, and M. Lynch. 2000. Phonological representations in prelexical speech processing: Evidence from form-based priming. Journal of Memory and Language 43.530-60.

Slowiaczek, Louisa M., and M. Hamburger. 1992. Prelexical facilitation and lexical interference in auditory word recognition. Journal of Experimental Psychology: Learning, Memory, and Cognition 18.1239-50.

Sprouse, Ronald. 1998. The case for enriched inputs. Paper presented at the Annual Meeting of the Linguistic Society of America, New York, NY.

Sumner, Meghan. 1999. Compensatory lengthening as coalescence: Analysis and implications. In S. Bird, A. Carnie, J. Haugen, and P. Norquest (eds.), The Proceedings of the 18th West Coast Conference on Formal Linguistics. Somerville: Cascadilla Press, 532-44.

Uffman, Christian. 2002. Intrusive [r] and optimal epenthetic consonants. Paper presented at the Toulouse Conference on English Phonology, Toulouse, France, June 26, 2002.

Ussishkin, Adam Panter. 2000. The emergence of fixed prosody. Doctoral dissertation, University of California, Santa Cruz.

Wiese, Richard. 1996. *The phonology of German*. Oxford: Oxford University Press.