A Psycholinguistic Approach to Abstractness: The Case of Hebrew*

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1 Introduction

One goal of phonological theory is to explain the systematic patterns that exist among languages. Another is to create a model that is psychologically plausible. The intent of this article is to present ongoing research and to show that while a number of analyses exist to account for phonological phenomena, we are currently lacking tools to help us choose among these proposed analyses. The incorporation of psycholinguistic experimentation allows us to test the theories that have been developed and to draw an important distinction between psychologically plausible theories and psychologically real ones.

One issue that lends itself to this type of research is that of abstractness within phonological theory. *Abstractness* refers to the postulation of inputs that differ from pronounced forms. Opacity, in which the relationship between the input and output appears to require intermediate levels of representation, has received much attention recently, and has even been referred to as "the single most important issue in current phonological theory" (Idsardi 2000: 337). Opacity has led to various proposals within Optimality Theory (Prince & Smolensky 1993), such as Sympathy Theory (McCarthy 1998), Output-output correspondence (Benua 1997), Enriched-input theory (Sprouse 1998), Turbid output representations (Goldrick 2000), and Interleaved OT (Kiparsky 1998). However, when considering what the nature of phonological representations is, transparent alternations are just as crucial to this understanding as opaque ones. Abstractness in general, and the debate about how abstract or concrete phonological representations are, is crucial to competing theories, including Generative Phonology (Chomsky & Halle 1968) and Natural Phonology (Hooper 1976).

Using Modern Hebrew as an example, I illustrate the issues discussed above. I also show how we can use psycholinguistic experiments as a tool to help us understand the nature of phonological representations, and to help us

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choose among theories and analyses in order to arrive at analyses that mirror native speaker competence.

2 Assumptions and Abstractness

2.1 Opacity in Hebrew

Hebrew has faced a number of diachronic changes that have rendered much of the language's phonology opaque. While there is general agreement that historical changes have been the cause of opaque forms, whether by rules or serial OT computations, it is not clear how the data should be analyzed synchronically. Consider a typically cited example from Hebrew.

(1) UR: /deʃʔ/ 'lawn'
Epenthesis: deʃeʔ
Deletion: deʃe
SF: *deʃe*

(*diʃʔo* 'his lawn'; *deʃaʔim* 'lawns')

In example (1), an epenthetic vowel appears to break up an illicit consonant cluster at the end of a word, either by rule or constraint. Later, though, the final consonant that triggered this epenthesis is deleted, resulting in an opaque surface form. Words in Hebrew like that in (1), generally referred to as segholate nouns, are infrequent, as are related forms. While this fact may not appear to be important, it is a factor that provides argumentation both for theories that support abstract representations, and those that do not, at the same time.

For example, the sheer existence of related forms such as *diʃʔo* 'his lawn' is considered by many to be strong enough evidence to argue in favor of and abstract underlying representation of /deʃʔ/ for *deʃe*. This is because the triconsonantal system in Hebrew consistently has the same three consonants for all related forms of a word. Therefore, supporters of this type of abstract representation use the existence of other related words that have the three consonants, d-ʃ-ʔ, as an argument that speakers posit these three consonants in the underlying representation for any word relating to 'lawn'. While proponents of this analysis agree on the shape of the underlying form, the explanations of this alternation vary. Balcaen and Hall (1999) propose that an underlying glottal stop changes to a vowel, Goldrick and Smolensky

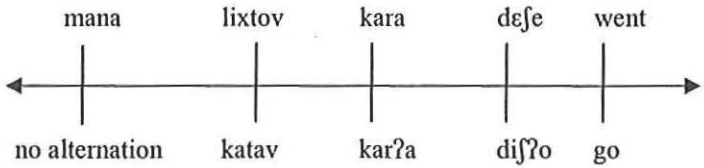
(1999) propose that allows a segment to be projected, but not pronounced so the triggering environment is never destroyed, and Sympathy Theory also provides an account of the data.

On the other side, those who do not support such abstract representations, use the infrequency and small number of related words to argue that there simply is not enough evidence to support a phonological representation that is so far removed from the spoken form, related words or not. In addition, the facts that only a small number of words exhibit this phenomenon and these words, while listed in Hebrew dictionaries, are rarely used, also support more concrete analyses.

2.2 Abstractness

The issues discussed above lead to numerous proposals about how to handle opaque data within phonology. One question that has not received as much attention, though, is what are speakers doing with abstract representations in general. Through psycholinguistic methodology, I show that we can better understand what evidence is "evidence enough" for speakers to posit abstract representations. The experiments discussed also help us decide whether all surface alternations are the same for a speaker, or whether some patterns are more discernable to speakers than others. More specifically, where do we draw the line on the continuum in (2)?

(2) Continuum of relatedness



In (2), I differentiate between a number of types of surface alternations. In Hebrew, k~x (lixtov/katav), ʔ~∅ (kara/karʔa), and epenthetic *e* appears in C-C-ʔ nouns. This is because at this point in time, the psychological reality of abstract representations is not clear. The three alternations, C~C, C~∅, and opaque alternations, may all be treated in the same manner, for example, all could have abstract representations that surface with the appropriate alternating forms, or a speaker may treat all forms differently, as there may be varying levels of association among the forms. This distinction raises the question of whether an underlying consonant alternating with a surface consonant

is the same to a speaker as an underlying consonant that alternates with nothing on the surface. Is a speaker able to do what phonologists do, which is realize a pattern and posit an abstract representation? There is little psycholinguistic research, if any, aimed directly at understanding this, or understanding the relationship between a form like *kara*, that is a transparent form stemming from the root k-r-ʔ and an opaque form like dɛʃe. Understanding the way forms that differ in relatedness are treated will help us map out what the nature of phonological representations is in a synchronic grammar. For this reason, I concentrate both on opaque forms in Hebrew, and transparent alternations.

3 Glottal stops in Hebrew

The status of glottal stops in Hebrew is an interesting one. The glottal stop is a consonant written in the orthography of Hebrew, but its presence as a spoken consonant is diminishing. According to Berman 1997, glottal stops are never pronounced in coda position, as discussed throughout the phonology literature, but it is also optional elsewhere, and its usage in the onset position is deteriorating. Therefore, it is not entirely clear that even within a productive verbal system that contains numerous glottal stops by description, that these glottal stops are actually part of the grammar.

3.1 C-C-ʔ verbs

In Hebrew, verbs are inflected for person, number, and gender in the past and future forms, and only for number and gender in the present and imperative forms. Looking just at the past and future forms, a paradigm for a typical triconsonantal root with no glottal stops is given in (3).

(3)

	Past	Future
1s	gamarti	egmor
2ms	gamarta	tigmor
2fs	gamart	tigmeri
3ms	gamar	yigmor
3fs	gamra	tigmor
1p	gamarnu	nigmor
2mp	gmartem	tigmeru
3fp	gamru	yigmeru

Table 1. Past and future forms for the root g-m-r, 'finish'.

The three consonants of the root are always pronounced and always written for the forms in (3). In contrast, Hebrew has some triconsonantal verbs with a root shape C-C-ʔ. Some of these forms are given in (4).

(4) Non-opaque forms with underlying glottal stop

a.	bara	'created, 3msg'	e.	bite	'pronounced, 3msg'
b.	matsa	'found, 3msg'	f.	ripe	'healed, 3msg'
c.	nasa	'carried, 3msg'	g.	kine	'envied, 3msg'
d.	kara	'read, 3msg'	h.	mile	'filled, 3msg'

In these forms, the glottal stop is always written in the orthography, however it is not always pronounced. In fact, in the majority of the forms it is not pronounced, and in the few that have pronounced glottal stops, that pronunciation is optional, as shown in (5).

(5) Sample paradigm, ***kara*** 'read'

	Past	Future
1s	karati	ekra
2ms	karata	tikra
2fs	karat	**tikreʔi ~ tikrei**
3ms	kara	yikra
3fs	**karʔa ~ kara**	tikra
1p	karanu	nikra
2ms	karatem	**tikreʔu ~ tikreu**
3fs	**karʔu ~ karu**	**yikreʔu ~ yikreu**

Table 2. Past and future forms for the root k-r-ʔ, 'read'.

Any inflection that would cause a glottal stop to be in the coda position results in a surface form without a glottal stop, as in both 1s forms. When glottal stops are in onset positions they are pronounced, but they, too, can be deleted even when the onset occurs intervocalically, as in the 3fs future form.

In sum, then, the verbal system in Hebrew has a large number of inflected forms. This large number may provide strong evidence for positing underlying glottal stops in verbs, in which the situation is different from that of segholate nouns ending in glottal stops. Also important is the fact that they are never produced in coda position and they are entirely optional, and on the verge of becoming distinct, in onset position.

3.2 Some opaque forms

In addition to the transparent alternations that include final glottal stops, Hebrew also has a few nouns, like that in (1), that are opaque because of the loss of glottal stop in final position. Additional examples are given in (6).

(6) Some opaque forms

a. deʃe	'lawn'	(cf. *deʃaʔim* 'lawns'; *diʃʔo* 'his lawn')
b. kele	'jail'	
c. pele	'wonder'	(cf. *plaʔim* 'wonders'; *pilʔi* 'wondrous')
d. pere	'wild (one)'	
e. tene	'basket'	

The forms in (6) have a few related forms that can surface with glottal stop (optionally), but while these forms are listed in most Hebrew dictionaries, they are not commonly used in the language, or in everyday writing. With this, and the fact that glottal stops are produced less and less, it is possible that a particular speaker might never have access to the final glottal stop in these forms at all.

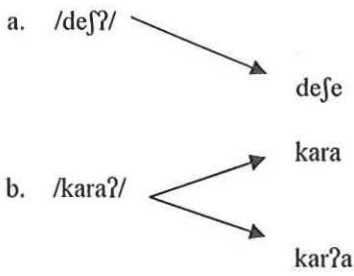
4 Possible analyses of glottal stops in Hebrew

Here, I go through three possible ways theoretical phonology can analyze glottal stops in transparent and opaque alternations in Hebrew. While I choose only three, there are many possible analyses in between, and this is the entire problem. One goal of phonology is to understand how speakers are treating such forms, and we are unable to do that solely with theoretical analyses.

4.1 Abstract analysis

An abstract analysis would argue in favor of glottal stops being included in the underlying representations of both transparent and opaque surface forms, as shown below.

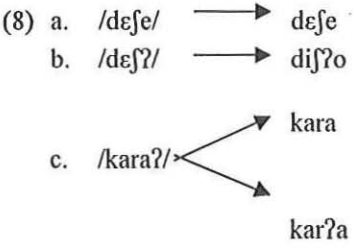
(7) Abstract analysis



Support for this analysis includes the presence of glottal stops in related forms, the phonotactics of the language, and a strong preference in Hebrew for a triconsonantal root. According to Hayes (1999), we would not predict that the absence of glottal stops finally would deter a speaker from positing a glottal stop in the underlying representation because the phonotactics of a language are learned by speakers early on.

4.2 More concrete analysis

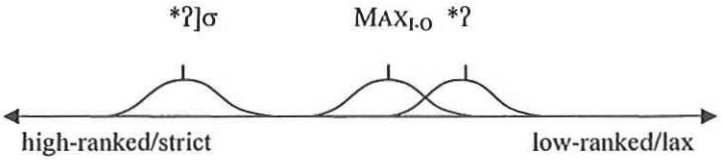
Another possible analysis, moving toward a more concrete input, or an input that more closely resembles the output, is one in which the opaque nouns and their related surface forms derive from a single underlying representation. Instead, as Bolozky (1999) argues, the surface generalizations are memorized. As for the transparent alternations, these still stem from the same underlying representation.



The small number of opaque nouns and related forms, along with their uncommon usage make this analysis favorable. Also, the idea that surface generalizations are easier to learn than deciphering abstract forms from opaque surface forms provide further support for an analysis that argues in favor of lexicalization of opaque forms. An analysis like this would still need to explain why it is that the glottal stop in the form in (8b) is optional. One possi-

ble explanation for this variation that occurs within speakers follows from the Gradual Learning Algorithm proposed by Boersma & Hayes (2001). This type of analysis would argue that since constraints are represented as bell curves, the variation is due to the fact that in a particular grammar, the constraints are not ranked far enough away from each other to ensure one consistent ranking all the time, as shown below.

(9) Possible analysis for variation within individuals



This analysis allows for a difference between the two types of alternations, arguing that the verb paradigm is productive and powerful enough to cause speakers to capture the phonological relationship among words is an argument that the transparent alternations need not be lexicalized.

4.3 Concrete inputs

Considering productivity, variation, and limited access to surface glottal stops, a third analysis would argue that there is simply not enough evidence in Hebrew to support underlying glottal stops. They could be considered orthographic remnants, and the underlying representations for all forms with glottal stops look like the surface forms. The representation of this analysis is laid out in (10).

(10)
a. /deʃe/ → deʃe
b. / deʃʔ/ → diʃʔo
c. /kara/ → kara
d. /karaʔ/ → karʔa

I have provided three completely plausible analyses of how to treat glottal stops in Hebrew. Currently, we have no tools for choosing among analyses except the assumptions each camp of phonology hold to be the most important and psychological plausible. In my opinion, a strong argument can be made for all three analyses and we must turn to other sources of evidence to

help us choose among the analyses, because after all, we are interested in what is really happening in the phonological component of grammar.

5 Psycholinguistic experimentation and predictions

Through psycholinguistic experimentation, we are able to test how speakers treat non-alternating, forms simple transparent alternations, and opaque alternations. This information helps us choose among the number of analyses available, helps us establish limits that exist for abstractness, if any, and allow us to better understand the effect orthography has on phonological representations. This is of particular importance in Hebrew, since it is the literate, educated speakers that are more likely to produce glottal stops, and the non-literate speakers that are least likely to use them, with a large amount of variation in between groups.

5.1 Auditory lexical decision task

In the proposed experiments, subjects are expected to perform an auditory lexical decision task. There are two main reasons for the choice of task. First, Hebrew, as discussed above, is heavily influenced by orthography. Any type of written word recognition task cannot separate orthographic influences from phonological ones. Additionally, the focus of this task is phonological priming, which has seen an increasing amount of evidence of support, and these results are especially reliable in rime priming, as shown in Radeau et al. 1995.

5.2 Experimental predictions

In this section, I consider again the three possible analyses of glottal stops in Hebrew previously discussed and outline the experimental predictions made by each analysis.

5.2.1 Abstract analysis

In an auditory lexical decision task, phonologically similar words have been shown to prime each other (Slowiaczek et al. 1987). Therefore, we can test whether words that are proposed to have underlying glottal stops, as *kaʔa* and *deʃe* in the abstract analysis discussed above, prime spoken words that contain glottal stops.

The abstract analysis in which all forms contain underlying glottal stops because of a preference for triconsonantal roots and the existence of related

words with glottal stops would predict that phonological priming occurs when both the opaque and non-opaque forms precede a target with a pronounced glottal stop.

5.2.2 More concrete analysis

The analysis that moves in the direction of more concrete inputs, recall, makes a distinction between the opaque *defe* cases, and the non-opaque alternating forms like *kara*. The theoretical analysis holds that the rare, opaque forms are stored, or memorized, while the transparent, more productive verb forms are abstract and contain underlying glottal stops.

Therefore, experimentally, we predict that priming should occur with the transparent Hebrew words, and that speakers posit a triconsonantal root for these forms. We should not see priming, though, in the opaque forms, as they are argued to be too infrequent, rare, and removed from related words to force a speaker to posit abstract representations for these forms.

5.2.3 Concrete analysis

The concrete analysis explained earlier holds that there is not enough motivation in either case for a speaker to posit abstract representations. The declining use of glottal stops and the low access speakers have to related words support the presence of concrete representations, not abstract ones.

This type of analysis predicts that no facilitation will be found among the opaque and non-opaque forms and a target that contains a glottal stop. The rationale is that these forms are not phonologically similar, and therefore, should not prime each other.

6 The experiment

This experiment is an auditory lexical decision task. Subjects are presented with a prime, followed by a 500ms interstimulus interval (ISI), and then a target. According to Goldinger (1989), a long ISI brings target perception back to a baseline where we are more likely to witness phonological priming. The task is to decide whether the target is a real word of Hebrew. Each subject responds to 150 trials, has a ten minute break, and then responds to the same 150 trails in a different order. The subjects are bilingual Hebrew-English speakers, consisting of 20 adults and 20 teenagers, and 10 non-literate speakers of Hebrew. The reason for the difference in age is to try to examine what role orthography plays in phonological development. The adult speakers and the non-literate speakers serve as two boundaries, and the

experiment allows us to examine whether the teenagers pattern like one group or the other, or whether they have their own distinct pattern. Then, we can begin to understand whether orthographic effects are more likely in adults than in teenagers due to exposure, familiarity, and use of the writing system.

6.1 Materials

The first experiment is designed to test whether facilitation occurs when a transparent alternating form like *kara* 'read' is a prime and precedes a surface form like *da?ag* 'worried'. The stimuli consist of 20 critical targets, 55 non-critical targets, and 75 non-word targets, each with 2 real word primes. The high number of non-critical and non-word targets makes it unlikely that any kind of learning strategy will be used during the experiment.

6.2 Prime/target pairs

In this experiment, there are three crucial prime/target pairs. First, primes and targets that are phonologically similar are used in order to test whether priming occurs in the desired environment.

(11)		Target		Prime	
	a.	garam	'caused'	zaxar	'remembered'
	b.	serev	'refused'	biker	'visited'

These pairs ensure that facilitation of word recognition occurs between the rime of the prime and the initial VC sequence of the target. The time it takes a subject to make a lexical decision for the target when preceded by the primes above is compared to the time it takes a subject to make a lexical decision for the target when preceded by an unrelated prime, like *silev* 'linnked' for (11a), or *gidel* 'grew' for (11b).

It is important notice that the vowels remain the same for all of the primes. This is to avoid any type of morphological priming. By controlling for any morphological differences, we are able to see whether the phonology is facilitating word recognition independent of other variables.

The second set prime/target pairs that is crucial to the experiment are the pairs that have a prime with a debatable final glottal stop and are not opaque. These primes are paired with targets that have a pronounced glottal stop, as shown in (12).

(12)		Targets		Primes	
	a.	da?ag	'worried'	matsa (/?/)	'found'

b.	na?am	'made a speech'	kafa (/ʔ/)	'froze'
c.	ʃa?al	'asked'	kara (/ʔ/)	'read'

If the glottal stop is in fact part of the phonological representation, then we would expect facilitation to occur. The presence of a final glottal stop makes these prime/target pairs phonologically similar and subject to phonological priming. We can see whether these forms are related, by speakers, to other words in the verb paradigm since it has been shown by Slowiaczek et al. (1987) that perception involves activation of all phonologically related words.

The reaction times of these prime target pairs are compared to the reaction times of CVCV primes that have no underlying glottal stop and the same targets. Some sample unrelated primes are *bana* 'built', *zaxa* 'won', and *tala* 'hung'.

The final set of prime/target pairs contains the opaque forms, as shown in (13).

(13)		Targets		Primes	
	a.	peʔer	'glorified'	deʃe (/ʔ/)	'lawn'
	b.	teʔem	'suited'	kele (/ʔ/)	'jail'
	c.	beʔer	'explained'	tene (/ʔ/)	'basket'

The most widely accepted analysis of the primes is one that posits underlying glottal stops. Therefore, experimentally, if this analysis is upheld, we should see facilitation effects between the prime/target pairs above. This means that both the primes in (12) and in (13) should result in faster reaction times when the target contains a surface glottal stop.

If more concrete representations exist, then the primes and targets would not be phonologically similar, and no motivation for facilitation would be present.

6.3 What we want to know

There are three main questions this experiment is aimed at answering in order to help us decide among theories. First, is there a difference in reaction times of a target when it is preceded by a CVCV prime as opposed to a CVCV(C) prime where the final consonant is a possible glottal stop? More specifically, are reaction times faster for *da?ag* when preceded by *matsa/ʔ/*, than when preceded by *ratsa*?

Second, is there a difference between opaque and non-opaque primes and targets? More specifically, are reaction times faster for a form like *teʔer* when preceded by *mile/ʔ/* (non-opaque), rather than *pele/ʔ/* (opaque)?

Finally, if facilitation is found, is the effect as pronounced for C-C-G roots as for C-C-C roots? Or, could there be some kind of hierarchy of priming based on abstractness?

7 Future research

This paper is meant to be a starting point, showing where phonological theory may benefit from psycholinguistic experimentation. While the experiments discussed are designed to answer the questions outlined in the paper, there are still a number of questions that need to be pursued and can be pursued through the incorporation of psycholinguistic experimentation. First, how do we separate orthography from phonology? While I have controlled for orthography in my experiments by running three subject groups, we will only gain a little insight about the role orthography plays in phonology.

Additionally, future research should question the amount of evidence necessary to support abstract representations. Is the existence of semantically related words enough motivation, or must the forms have a certain amount of phonological overlap? One outlet for such research is in languages such as Hebrew where there are various types of alternations, but also where the alternations only occur in a subset of words so that they can be compared with words that are phonetically similar that stem from non-alternating phonological representations.

Finally, is there a difference between X~Y alternations and X~∅ alternations? This question leads back to understanding what evidence is strong enough to force a speaker to posit an abstract phonological representation. Finding an answer to this question will enable us to understand where speakers draw the line to relatedness and how the arrive at abstract forms.

8 Conclusion

The main goal of this paper was to propose avenues of research that enable us to search for evidence that supports one theory, or one analysis, over another, and helps us better understand the psychological reality of phonological representations. The experiment proposed here examines abstractness, both opaque and non-opaque, and uses this concept as a tool for understanding the nature of representations. Furthermore, I hope to have shown that while the extreme cases of abstractness, or opaque forms, are one of the

main issues in phonological theory today, abstractness in general is an issue that is not fully understood. Our concept of abstractness both within theories and across theories can benefit from psycholinguistic experimentation aimed at examining how speakers treat phonologically abstract forms.

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