Optimal Underlying Representations

Martin Krämer

Universitetet i Tromsø / CASTL*

1. Introduction

In Optimality Theory (OT), all non-alternating structure is assumed to be fully specified in the lexicon (Prince & Smolensky 1993, Inkelas 1994, Burzio1996, 1999, 2000, Kager 1999, Beckman and Ringen 2004):

> "...if no alternations occur in a morpheme's shape, the learner will never postulate an input deviating from the actual observable output form. Due to *Lexicon Optimization*, the input simply equals the output unless there is reason to deviate."
>
> (Kager 1999: 414)

Lexicon Optimization (LO) is a mechanism in OT that uses the EVAL function to choose an optimal underlying representation from a set of potential inputs for a form once the constraint ranking for the relevant aspect of a language's grammar has been set up. In rule-based generative phonology, underlying representations have usually been chosen according to general principles of economy rather than through an automated mechanism. Yip (1996) identifies four economy principles, referring to economy of individual lexical entries, economy of phoneme inventories, economy of phonotactic combinations and economy of paradigms, which determine the choice of underlying representations. This mismatch between OT and previous approaches to lexical storage, however, emerged in OT as a consequence of the Richness of the Base Hypothesis (RotB), a cornerstone of OT, which states that all differences between languages emerge as a side effect of the interaction of constraints on surface representations, rather than of diverging underlying representations. Hence, a grammar set up by a linguist has to generate the forms optimal in a language regardless of the assumed input. Thus, unlike in Lexical Phonology (Kiparsky 1982, 1985) or SPE (Chomsky and Halle 1968), there are no constraints on the lexicon of a language.

As far as the automatic determination of underlying representations out of a set of possible inputs is concerned, Prince and Smolensky (1993) and Inkelas (1994) note that any candidate for an underlying form that is different from the output will incur violations of faithfulness constraints which a candidate lexical representation identical to the output lacks. Hence, the latter is chosen as optimal. This observation has been used by Burzio as one of the core arguments to reject underlying representations per se.

> "It is easy to see that (...) the actual input *equals* the actual output. The reason is that any input different from the output (...) would only add violations of IO-F without ever avoiding any other violation in return. (...) Now the claim illustrated for P&S (...) appears to be non-distinct from the (...) claim that there is only surface representation and no UR." (Burzio 2000: 55)

---

* Center for Advanced Study in Theoretical Linguistics.

This issue aside, the OT predictions for underlying forms stand in sharp contrast to theories of underspecification such as Archangeli's (1988) Radical Underspecification, since, according to LO, all features should be specified in the underlying representation, even fully predictable ones in non-alternating structure.

Inkelas (1994) extends LO to determine the underlying representation of morphemes that alternate in different phonological contexts. Her results are summarised in (1).

(1) OT/LO view on lexical representation:

	Predictable	Unpredictable
Alternating	underspecified	specified
Nonalternating	*specified*	specified

In this paper, I will discuss the following three questions arising in this context.

1. Does OT, after the introduction of Correspondence Theory (McCarthy and Prince 1995), predict full specification for non-alternating predictable structure after all?
2. Is there a way to determine underlying representations for the above structures?
3. Is there any evidence for the Richness of the Base or might there as well be constraints on underlying representations?

The empirical focus in this paper is on tensing/laxing of the low front vowel in Belfast English. In this variety of English, the tenseness of the low front vowel /æ/ is fully predictable from the quality of the following consonant (Harris 1990). A similar pattern was reported as well for American accents such as New York and Philadelphia English (Ferguson 1972, Kahn 1976, Payne 1980, Labov 1981, Dunlap 1987, Benua 1995). The general assumption is that the tense and the lax front low vowel are allophones of the same underlying phoneme. The question that arises is whether this is specified for the predictable feature or not, and if it is specified, what is the basic form – tense or lax? In OT, according to the authors cited above, there should be two distinct underlying representations, i.e., one for each allophone.

In section 2, I will introduce Benua's (1995) OT analysis of New York/Philadelphia tensing, and apply it to the Belfast case. On the basis of this analysis I will show that OT does not unambiguously predict full specification for the two allophones in question, but rather the results depend on two factors, the formulation of faithfulness constraints and the nature of the assumed feature as either binary or unary. In section 3, I will present the results of a study on the realisation of forms which violate the phonotactic restrictions of Belfast English. For this purpose, students from Belfast were tested on their realisation of German words which contain a long low vowel in the laxing environment and German words which contain a short low vowel in the tensing environment. Preempting the results, I conclude from the data in section 3 that, on the one hand, the underlying form(s) of low front vowels in Belfast English cannot be determined. On the other hand, this study shows that these speakers have lexical access to forms violating the phonotactics of their language, and, hence, the shape of underlying forms does not seem to be restricted by constraints on lexical representations. This can be interpreted as support for the RotB.

2. English low vowel tensing in OT

As said in the introduction, the tenseness/laxness of the front low vowel is fully predictable in Belfast English. Tense vowels occur in syllables closed by fricatives, voiced stops and nasals (2a), while the lax vowel surfaces in syllables closed by a voiceless stop (2b) and in open syllables (2c). In (2), I have indicated tenseness with a length mark rather than with a capital E, as is the usual practice in the literature, since length is the phonetic

cue for tenseness here, rather than raising and/or diphthongisation, unlike in other varieties (see Morén's 2004 study of Staten Island English on the unreliability of length as a phonetic cue to tenseness in American English).

(2) æ-tensing in Belfast English (e.g., Harris 1990: 91)

a.	Tense:	bad, pass, path, laugh, man, Sam	[baːd, paːs, paːθ, laːf, maːn, saːm]
b.	Lax:	tap, bat, match, back	[tap, bat, matʃ, bak]
c.	Lax:	panel, ladder, wagon	[panl, ladɪ, wagn]

The same pattern is found in New York/Philadelphia English. Tensing and laxing interact with morphology in that the lax and the tense vowel is found as well in tensing and in the laxing environments, respectively, in morphologically complex forms and in truncations. This is illustrated in (3) and (4).

(3) Underapplication of tensing in Belfast and New York/Philadelphia

pass	[pæːs]	passive	[pæ.sɪv]	passing	[pæː.sɪn]
mass	[mæːs]	massive	[mæ.sɪv]		

(4) Underapplication of laxing in New York/Philadelphia truncations (Benua 1995)

Pamela	[pæ.mə.lə]	Pam	[pæm]
Janice	[dʒæ.nɪs]	Jan	[dʒæn]
cafeteria	[kæ.fə.ti.ria]	caf	[kæf]
Massachusetts	[mæ.sə.tʃu.səts]	Mass	[mæs]
pathology	[pæ.θɑ.lə.dʒi]	path	[pæθ]

Belfast English differs slightly from this pattern in that tensing applies in truncated forms as in the examples below.

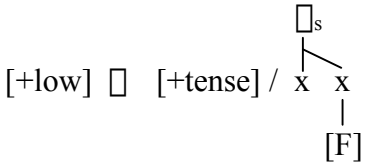
(5) Truncations in Belfast English

a.	b.
m[a]gazine	m[aː]g
tr[a]ditional jazz	tr[aː]d jazz
undergr[a]duate	undergr[aː]d

This results in a slight difference in the ranking of constraints for Belfast English compared to New York/Philadelphia, as will be developed below.

In rule-based phonological theory, the unmarked feature specification is singled out and/or the allophone with the wider distribution is taken as basic or underlying. As a result we get the lax vowel as basic and accordingly have to explain the occurrence of the tense allophone by a rule, as given in (6).

(6) Tensing rule (see e.g., Harris 1990)



Thus, in Lexical phonology, one would either assume a constraint on underlying representations that restricts the set of inputs to the phonology or take the underspecified vowel as the input in all cases and fill in the default value of the feature [tense] at a late stage of the derivation, where the feature filling rule affects only those items that have not received [+tense] through the earlier tensing rule (see, e.g., Kiparsky 1988, Harris 1989, 1990 for Lexical Phonology analyses of tensing). In OT, this is not a choice, since there are no constraints on underlying representations, as formulated in the RotB hypothesis.

(7) Richness of the Base Hypothesis (Smolensky 1996:3)
The source of all systematic cross-linguistic variation is constraint reranking. In particular, the set of *inputs* to the grammars of all languages is the same. The grammatical inventories of a language are the *outputs* which emerge from the grammar when it is fed the universal set of all possible inputs.

Hence, an OT analysis has to cover both environments, to exclude the mapping of a hypothetical input /baːt/ to surface *[baːt]. The question is whether OT gives us an underspecified lexical representation automatically or not. Benua proposes the set of constraints in (8) to account for the pattern.

(8) Constraints (Benua 1995):
a. *æ*-TENSING : *æC]$_{\sigma}$. where |C| > [-cont, -vc]
('No *æ* in syllables closed by fricatives or voiced consonants.')

b. *TENSE-low: 'Low vowels are lax.'

c. IDENTIO(tense): Let α be a segment in the input, and β be a correspondent of α in the output. If α is [γtense] then β is [γtense].

The specific markedness constraint (8a) has to outrank the more general markedness constraint (8b) in order to have any surface effect at all, and both markedness constraints outrank the faithfulness constraint (8c). This grammar is illustrated in tableaux (9) and (10).

(9) Example tableau for the tense vowel

	æ -TENSING	*TENSE-low	IDENT IO
a. pas	*!		
☞ b. paːs		*	

(10) Example tableau for the lax vowel

	æ -TENSING	*TENSE-low	IDENT IO
☞ a. a.sɪd			
b. aː.sɪd		*!	

To account for the underapplication in truncations and level 2 affixes, Benua introduces a transderivational faithfulness constraint, which guards correspondence relations between a simplex base and the truncated form or affixed form, IDENTBT(tense). For New York/ Philadelphia, this is ranked on top of the hierarchy, yielding underapplication of tensing in truncated forms. For the Belfast variety, the constraint has to be inserted between the two markedness constraints. As a result we find overapplication of tensing with level 2 affixes and regular application of tensing with truncated forms.

(11) Overapplication of tensing in Belfast

	æ-TENSING	IDENT BT	*TENSE-low	IDENT IO
a. pa.sɪn		*!		
☞ b. paː.sɪn			*	
base: (9b)				

(12) Tensing of truncated forms in Belfast

	æ-TENSING	IDENTBT	*TENSE-low	IDENT IO
a. trad	*!			
☞ b. traːd		*	*	
base: [tra.dɪ.ʃə.nl]				

The transderivational correspondence effects are rather marginal to the issue at stake in this paper. The important question here is which of the two vowels is determined as the underlying form via LO. In the tableaux below we will consider three possibilities, a lax input, a tense input and an underspecified input (represented as A), since, according to Inkelas (1994) ternarity (i.e., binary features that can be underspecified as a third possibility) is an option. I will first illustrate the predictions of a theory of faithfulness that assumes Identity constraints on features. Then, I will look at the possibility of a MAX/DEP model of feature faithfulness. I assume, in line with most authors, that Identity constraints check feature values. That is, if a feature is set to value *x* in the input it has to have value *x* in the output, if it is set to □*x* at one level of representation it should be the same at the other. If there is no value set in one level of representation or the feature is missing altogether at one level there is nothing to check for the constraint and it is vacuously satisfied (for a diverging interpretation of these constraints see, e.g., Noske 2000).

(13) LO with ternary feature

i.	æ-TENSING	*TENSE-low	IO-IDENT
☞ a. /asɪd/, [asɪd]			
b. /asɪd/, [aːsɪd]		*!	*
c. /aːsɪd/, [asɪd]			*!
d. /aːsɪd/, [aːsɪd]		*!	
☞ e. /Asɪd/, [asɪd]			
f. /Asɪd/, [aːsɪd]		*!	

ii.	æ-TENSING	*TENSE-low	IO-IDENT
a. /pas/, [paːs]		*	*!
b. /pas/, [pas]	*!		
☞ c. /paːs/, [paːs]		*	
d. /paːs/, [pas]	*!		*
☞ e. /pAs/, [paːs]		*	
f. /pAs/, [pas]	*!		

Since the analysis is in line with the Richness of the Base, any input leads to the correct optimal output. Complementary distribution is reflected in the grammar. As we can see from the tableaux in (13), it could additionally be reflected in the lexicon, since LO does not make a choice between the fully faithful, i.e., diverging, inputs (i.a and ii.c, respectively) and the underspecified ones (i.e and ii.e). If LO does not decide we have to refer back to some general principle of economy, which would prefer underspecification over divergent underlying representations. Hence, the claim that LO chooses representations with specified features for predictable nonalternating structure is not born out.

However, Inkelas made this claim before the introduction of Correspondence Theory, in the PARSE/FILL model of faithfulness, and the reason for this prediction was actually her assumption of a *INSERTION constraint, which bans the introduction of structure or information in output candidates that is not present in the input. In Correspondence Theory, the equivalent to an anti-insertion constraint is DEPIO. Hence, we might as well assume DEPIO(F) and, consequently, MAXIO(F) constraints, as some authors propose (see, e.g., Butska 1998, Lombardi 1998). In a theory with binary features, we need individual in-

stantiations of these constraints for each feature specification. As shown in (14), the prediction made by LO under these assumptions is diverging fully specified lexical entries.

(14) LO with [±tense] and MAX/DEP(F)

	æ-TENSING	*TENSE-low	DEP (+tnse)	MAX (+tnse)	DEP (-tnse)	MAX (-tnse)
a. /pas/, [paːs]		*	*!			*
☞ b. /paːs/, [paːs]		*				
c. /pAs/, [paːs]		*	*!			
d. /aːsɪd/, [asɪd]				*!	*	
☞ e. /asɪd/, [asɪd]						
f. /Asɪd/, [asɪd]					*!	

A unary feature [tense] combined with MAX and DEP constraints yields divergent lexical representations for the two allophones (15) as well.

(15) LO with monovalent [tense] and MAX/DEP(F)

ii.	æ-TENSING	*TENSE-low	DEP(tense)	MAX(tense)
☞ a. /paːs/, [paːs]		*		
b. /pAs/, [paːs]		*	*!	
c. /aːsɪd/, [asɪd]				*!
☞ d. /Asɪd/, [asɪd]				

With MAX/DEP constraints on features, the result is essentially the same regardless of the nature of the feature (unary or binary/equipolent), LO picks two distinct lexical entries for the two allophones.

So far, we can conclude that OT/LO as such do not make any predictions for underlying representations. Everything hinges on the formulation of faithfulness constraints and the choice of feature. If we consider economy of lexical inventories and economy of individual representations, the favourable approach, then, is the one that predicts lexical underspecification for both allophones, rather than two different underlying forms. This view is supported by the evidence given by Harrison and Kaun (2000, 2001) who found patterns in word games in Turkic and Finno-Ugric languages that suggest that, in vowel harmony systems, vowels which are predictable by the overall harmony pattern, but which never alternate, are stored as underspecified, a phenomenon, which they label 'pattern-responsive lexicon optimization.'[1]

Considering a case of complementary distribution in Hungarian, Szentgyörgyi (2004) arrives at similar results as those shown above. As consequences, he considers the options to either abandon underlying representations or the Richness of the Base. Burzio (2000 and elsewhere; see quote in section 1 here) already concluded from the alleged OT prediction of full specification that we can eliminate the underlying level of representation altogether. Can either result be regarded as support for such a move? The answer, I think, is no. The burden of proof actually lies with those who assume underlying

[1] In the case at hand, i.e., vowel lengthening and shortening in Belfast English, the fact that the whole vowel system is affected by restrictions on length driven by the postvocalic tautosyllabic consonant, might also be regarded as support for an underspecification analysis. However, the consonants triggering length and shortness, respectively, are not the same for all vowels. High tense vowels are long before voiced fricatives and the retroflex approximant as well as in open syllables only and short elsewhere, while lax high vowels are always short. Other vowels are subject to the same restrictions as the low front vowel. Compare [ɹɛːd] *red* with [bɛt] *bet*. The difference in length and shortness triggers for the different groups of vowels is also an argument against the claim that this is a purely phonetic effect.

representations: If one does so there must be a reason, and the only reason can be that underlying representations sometimes crucially diverge from surface representations. This has been shown time and again in the discussion of opaque interactions of phonological processes. For a recent argument for abstract underlying representations see Krämer (2003) for example. The same reasoning holds for the question whether we should commit ourselves to the RotB or not: the RotB might be an assessment criterion for linguistic analyses or a part of linguistic reality. If we believe the latter, we have to find evidence. Therefore, in the next section, I set out to find out what the underlying representations of complementary allophones are and whether this can tell us anything about the RotB.

3. Learning German in Belfast

The basic question in this survey was what speakers with strict phonotactic restrictions would do with inputs that violate these restrictions. If the grammatical mechanism underlying the low vowel tensing pattern is, as the label suggests, a grammatical mechanism that introduces tensing in the respective context, rather than a grammar that determines the specification of the feature in both environments, one might expect that tense vowels in laxing environments might occur once a speaker encounters inputs to that extent. A non-trivial question arising here is whether adult speakers actually perceive such phonotactically illformed structures.

The acquisition of a phonematic contrast in a second language that involves two sounds which are in complementary distribution in the learners native language is generally thought to be one of the major challenges in the acquisition of the sound system of a second language (Eckman, Elreyes and Iverson 2003). In this study, two natives of Belfast who had learned German in school, up to their A-levels, and two subjects without prior contact with German read out a list of German words containing long low front vowels in phonological environments that cause laxing in English as well as German words with short low front vowels in tensing environments.

All subjects were in their twenties and first had to read out a list of English words, containing some fillers and items to be used to determine the major phonetic cue of the lax/tense difference as well as their phonotactic restrictions on tense and lax low front vowels. The German word list was read out once by a native speaker of German (the author) to the proficient German speakers (henceforth P1 and P2). The 'naïve' speakers (henceforth N1 and N2) could listen to the list or individual items as often as they wished. There was a short break for each subject before the actual production task. The subjects' productions were digitally recorded.

The low front vowel in Belfast English is very low, close to cardinal vowel 4. An exception is the realisation before voiced dorsals, where the vowel is raised to [ɛ]. Otherwise, there is no audible difference in quality between the tense and the lax vowel, at least not for the speakers who took part in this study. In German, the cue for tenseness in the low vowel is duration, as in minimal pairs such as *Schlaf* [ʃlaːf] 'sleep' and *schlaff* [ʃlaf] 'slack, loose'. Furthermore, we find both long as well as short vowels in environments where we don't find them in Belfast English, respectively.

Table (16) shows vowel lengths of English test words. The left-hand column shows expected tenseness/laxness according to the literature on Belfast English (Wells 1982, Hughes and Trudgill 1987, Harris 1985, 1989, 1990, and others) in the lexical item listed in the next column. The following columns show the vowel length of each vowel respectively by speaker. The final column shows average length across speakers. The three lines at the bottom show averages of all vowels, lax vowels and tense vowels, respectively by speaker. The boxes at the bottom in the right hand corner show averages of all, lax and tense vowels, respectively, across speakers.

(16) Participants' lengths of tense and lax low vowels in English

expected		item	P1	P2	N1	N2	average
lax	a.	'hat'	0.112	0.099	0.120	0.114	0.111
tense	b.	'mass'	0.266	0.252	0.250	0.250	0.255
lax	c.	'massive'	0.103	0.102	0.100	0.084	0.097
tense	d.	'passing'	0.145	0.177	0.180	0.115	0.154
lax	e.	'magazine'	0.104	0.094	0.115	0.112	0.106
lax	f.	'student**mag**'	0.171	0.252	0.310	0.285	0.255
average			0.150	0.162	0.179	0.160	0.163
average		lax	0.106	0.098	0.111	0.106	0.105
average		tense	0.194	0.227	0.247	0.266	0.234

We can see from this table that the average tense vowel in this variety of English is about twice the length of a lax vowel in monosyllabic words. Furthermore, we see that three out of the four speakers have a tense vowel in a laxing environment in forms with the progressive suffix (*passing*). In these bisyllabic forms the tense vowel is shorter than the average tense vowel in monosyllables (around 0.05 seconds shorter), but still considerably longer than the average lax vowel in monosyllables. This might be due to a phonetic 'squeezing effect' that results in shorter segment durations in longer words. Hence, vowel length is not an absolute value, but rather a relational factor. Moreover, we can assume that the progressive is formed with the unaffixed form as a base (in Lexical Phonology terms, progressive formation is postlexical and tensing is lexical). Adjectivized nouns do not show overapplication of tensing (as in *mass* ~ *massive*). This corresponds to the findings in the literature. However, the truncated form (f) shows a low vowel in a tensing environment with a base with a lax vowel. All four speakers exhibit tensing here, hence, Benua's claim of underapplication of tensing in such forms does not hold for this variety. This was already reflected in the OT analysis sketched above. More importantly, these measurements substantiate the claim that in Belfast English, length is a reliable and predictable cue.

We can now look at the subjects' realizations of the German forms which violate the phonotactics of Belfast English. Table (17) shows a summary of the results.

(17) Summarised results of German task

	German	Target pronunciation	Realisation		Gloss
a.	Schlaf	[ʃlaːf]	[ʃlaːf]	correct	'sleep' (N)
	Spaß	[ʃpaːs]	[ʃpaːs]	correct	'fun'
b.	Hans	[hans]	[haːns]	tensing	proper name
	rasch	[ʀaʃ]	[ɹaːʃ]	tensing	'quick'
	schlaff	[ʃlaf]	[ʃlaːf]	tensing	'slack'
	nass	[nas]	[naːs]	tensing	'wet'
c.	Rat	[ʀaːt]	[ɹat]	*laxing*	'advice'
	Stab	[ʃtaːp]	[ʃtaːb]	correct	'bar, pole'

Tense vowels in environments corresponding to the tensing environment in English were overwhelmingly produced correctly by all participants (17a). As the results in (17b) indicate, lax vowels in the tensing environment were generally tensed, while tense vowels in the laxing environment displayed laxing. One could conclude that none of the participants perceived the actual length of the German vowels and simply followed the English pattern. However, the picture is slightly more complex and more revealing, as a breakdown by speakers and a look at the actual lengths of individual vowels reveals.

(18) Measurements of two high proficiency speakers of German

	Target	P1	v length	P2	v length
a.	hans	hans	*0.095*	haːns	*0.235*
b.	ʀaʃ	ɹaːʃ	0.209	ɹaɪʃ	0.172
c.	ʀaːt	ɹat	**0.105**	ɹat	**0.114**
d.	ʃlaːf	ʃlaːf	0.195	ʃlaˑf	0.163
e.	ʃpaːs	ʃpaːs	0.278	ʃpaːs	0.195
f.	ʃlaf	ʃlaːf	*0.202*	ʃlaf	*0.133*
g.	nas	naːs	0.243	naːs	0.210
h.	ʃtaːp	staːb	0.213	gɹaːb	0.249

Both participants with comparably high proficiency in German produced a lax vowel in the token with a tense vowel in the laxing environment (18c). However, both speakers must have had access to the correct input, since P1 produced (18a) correctly, where we would have expected tensing, while P2 had a faithful mapping for (18f) where we would have expected tensing as well. P2's realization of (18b) is interesting as well. She produces a vowel of less than the expected length for a tense vowel, but articulates it still significantly longer than a lax vowel should be. Here we observe some tension between faithful mapping and phonotactic restrictions. This issue becomes even more apparent when we look at the 'naïve' speakers.

(19) Speakers with no prior knowledge of German

	Target	N1	v length	N2	v length
a.	hans	haˑns	**0.156**	haːns	0.230
b.	ʀaʃ	ɹaˑʃ	**0.168**	ɹaːʃ	0.231
c.	ʀaːt	ɹaˑt	**0.168**	ɹaˑt	**0.164**
d.	ʃlaːf	ʃlaːːf	0.285	ʃlaːf	0.228
e.	ʃpaːs	ʃpaːːs	0.313	(no	response)
f.	ʃlaf	ʃlaːf	0.203	ʃlaːf	0.237
g.	nas	naˑs	**0.173**	naːs	0.244
h.	ʃtaːp	staːːb	0.286	gɹaːb	0.208

The subjects with no prior knowledge of German show intermediate length in both lax vowels in tensing environments (19a,b,g) and tense vowels in laxing environments (19c). In no case have the two test persons succeeded to fully reproduce the offending structures. However, N2 definitely applies tensing in originally lax items (19f,g) according to the requirements of her native phonology. Remarkably, N1 realises almost all vowels which are in the environment where we would find their counterpart with intermediate length, regardless of their length in the input by the German native speaker. The intermediate realisations provide us with the following insight: like the two proficient speakers, these two subjects obviously perceive the length in the inputs and they are able to store them accurately. In the reproduction, however, two factors seem to stand in conflict. On the one hand there is the drive to faithfully imitate the target and on the other there are the requirements of their native phonology that militate against this. Hence, in the forms with intermediate length we see the result of a conflict between an extralinguistic force, imitation, and the linguistic system, i.e., grammatical wellformedness.

There are two important conclusions to be drawn from these data. On the one hand, all speakers have access to linguistic structures that violate high ranking constraints of their grammar and these forms can be stored in their lexicon. On the other hand we see that improvements to offending structures are made by tensing as well as laxing. Hence, the label 'vowel tensing' captures only one side of the coin. Thus, an analysis that accounts for the distributional facts by a rule or constraint on tensing in tensing environments only

has to be regarded as insufficient. Moreover, the fact that all speakers can access tense vowels in laxing environments and lax vowels in tensing environments shows that there is no filter holding directly over inputs. This is strong support for the claim that linguistic patterns emerge from interaction of constraints on surface structures only rather than through restrictions on inputs.

4. Conclusion

In this paper, I have investigated the question whether OT predicts underlying representations for nonalternating predictable phonological structure through LO as claimed in the literature (going back to Prince & Smolensky 1993 and Inkelas 1994) and whether we can determine underlying representations of such structures with a simple experiment. The motivation for this study lies in the discrepancy between the alleged OT prediction and hitherto held views on the economy of the lexicon. If we look at lexical representations from an economic point of view, two complementary allophones are traced back to one abstract representation, which is underspecified for the feature that is determined according to the two mutually exclusive contexts. This saves the lexicon from discriminating two distinct units where it can do with one and it reduces memory load of individual lexical items since one feature value does not have to be stored. In OT, such considerations are largely ignored and LO emphasizes the need to reduce computational friction, as represented by constraint violations.

The answer to both the above questions is negative so far. In particular, the nature of underlying representations depends in such cases crucially on the definitions of constraints on the input-output mapping and on the theory of features we subscribe to (unary or binary/ternary). For two allophones in complementary distribution (such as the lax and the tense low front vowel in Belfast English) whose allophonic relation can only be detected through phonetic similarity, the mutual exclusiveness of the two contexts and knowledge on the history of the language we get diverging predictions according to which theory of faithfulness and which theory of features we apply. However, the Identity approach to faithfulness combined with binary features gives us a choice between distinct representations for the two allophones and uniform underspecification of both. Here, the analyst can fall back on general principles of economy to make a choice. Hence, we might replace Inkelas' (1994) and Harrison & Kaun's (2000, 2001) schematic tables by the following.

(20) Underlying representations:

	Predictable	Unpredictable
Alternating	underspecified	specified
Nonalternating	*indeterminable*	specified

The same technical argument can be applied to predictable alternating structure: The RotB forces the analyst to postulate a grammar that is restrictive enough to cope with any input. Different assumptions about faithfulness constraints and about feature values lead to different predictions, which means to no prediction at all, i.e., these underlying representations are indeterminable. The door is still open, though, for the use of crucial underspecification as advocated for by Inkelas (1994, 2000), Inkelas, Orgun & Zoll (1997).

Since LO, as it is understood today, focuses on the minimization of constraint violations one could ask whether this is the right tool in the quest for underlying representations or whether LO is completely irrelevant toying around with a theory's possibilities.

The experiment with native speakers of a variety of English that displays vowel tensing showed that when speakers are confronted with a contrast between sounds that are in complementary distribution in their native language, they make changes that cater

for both environments (i.e., tensing and laxing in this case), which gives further support to the above view that underlying representations of predictable nonalternating structures are indeterminable. Furthermore, the study showed that these speakers can distinguish such inputs, which was interpreted here as the freedom of competent language users to store bases that are not conform to the surface patterns of the language. In conclusion, the lexicon is not limited by restrictions or constraints holding directly over underlying representations. This is the answer to the third and last question asked at the beginning of this paper.

Acknowledgements

I am particularly grateful to Alison, Jacinta, Martina and Michele, who served as patient subjects in this study. A big thank you goes to Emanuela Canclini, Chris Golston and John McCarthy for suggestions on an earlier version of a completely different paper and to Patrik Bye, Dafna Graf and Bruce Morén for their input. The ideas presented here have also been presented at the workshop on 'The Lexicon in Optimality Theory', Leiden University, June 2004 and at the CASTL Colloquium in Tromsø, October 2004. I owe these groups for their input as well. Needless to say that none of the above is responsible for any errors and inaccuracies in this paper.

References

Archangeli, Diana 1988. Aspects of underspecification theory. Phonology 5: 183-207.

Beckman, Jill N., and Catherine O. Ringen 2004. Contrast and Redundancy in OT. In Proceedings of the West Coast Conference on Formal Linguistics 23, 101-114. Somerville, MA: Cascadilla Press.

Benua, Laura 1995. Identity effects in morphological truncation. In UMOP 18, 77-136. University of Massachusetts, Amherst.

Burzio, Luigi 1996. Surface constraints versus underlying representations. In Current trends in phonology: Models and methods, ed. Jacques Durand and Bernard Laks, 123-141. Salford: University of Salford Publications.

Burzio, Luigi 1999. Surface-to-surface morphology: When your representations turn into constraints. Ms. Johns Hopkins University, Baltimore.

Burzio, Luigi 2000. Cycles, Non-Derived-Environment Blocking, and Correspondence. In Optimality Theory. Phonology, Syntax, and Acquisition, ed. Joost Dekkers, Frank van der Leeuw and Jeroen van de Weijer, 47-87. Oxford: Oxford University Press.

Butska, Luba 1998. Faithfulness to [voice] in Ukrainian: An analysis of voicing alternations within Optimality Theory. RuLing Papers 1:59-73. Rutgers University.

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

Eckman, Fred R., Abdullah Elreyes, and Gregory K. Iverson 2003. Some principles of second language phonology. Second Language Research 19: 169-208.

Harris, John 1985. Phonological variation and change: studies in Hiberno-English. Cambridge: Cambridge University Press.

Harris, John 1989. Towards a lexical analysis of sound change in progress. Journal of Linguistics 25: 35-56.

Harris, John 1990. Derived phonological contrasts. In *Studies in the pronunciation of English. A Commemorative Volume in Honour of A. C. Gimson*, ed. Susan Ramsaran, 87-105. London: Routledge.

Harrison, K. David, and Abigail Kaun 2000. Pattern-Responsive Lexicon Optimization. In Proceedings of NELS 30, 327-340. GLSA, University of Massachusetts, Amherst.

Harrison, K. David, and Abigail Kaun 2001. Patterns, pervasive patterns and feature specification. In Distinctive Feature Theory, ed. T. Alan Hall, 211-236. Berlin: Mouton de Gruyter.
Hughes, Arthur, and Peter Trudgill 1987. English Accents and Dialects. London: Arnold.
Inkelas, Sharon 1994. The Consequences of Optimization for Underspecification. In Proceedings of NELS 25, 287-302. GLSA, University of Massachusetts, Amherst.
Inkelas, Sharon 2000. Phonotactic blocking through structural immunity. In Lexicon in Focus, ed. Barbara Stiebels and Dieter Wunderlich, 7-40. Berlin: Akademie Verlag.
Inkelas, Sharon, Cemil Orhan Orgun, and Cheryl Zoll 1997. Implications of lexical exceptions for the nature of grammar. In Constraints and derivations in Phonology, ed. Iggy Roca, 393-418. Oxford: Clarendon Press.
Kager, René 1999. Optimality Theory. Cambridge: Cambridge University Press.
Kiparsky, Paul 1982. From Cyclic Phonology to Lexical Phonology. In The Structure of Phonological Representations I, ed. Harry van der Hulst and Norval Smith, 131-175. Dordrecht: Foris.
Kiparsky, Paul 1985. Some Consequences of Lexical Phonology. In Phonology Yearbook 2, 85-135.
Kiparsky, Paul 1988. Phonological change. In Linguistics: The Cambridge Survey. vol. I: Linguistic Theory: Foundations, ed. F. W. Newmeyer, 363-415. Cambridge: Cambridge University Press.
Krämer, Martin 2003. Intervocalic *s*-voicing, geminates, and the Richness of the Base in Veneto Italian. Rivista di Grammatica Generativa 28, 71-85.
Lombardi, Linda 1998. Evidence for Max feature constraints from Japanese. University of Maryland Working Papers in Linguistics 7, 41-62.
McCarthy, John, and Alan Prince 1995. Faithfulness and Reduplicative Identity. *UMOP* 18, 249-384. University of Massachusetts, Amherst.
Morén, Bruce 2004. The Phonetics and Phonology of front vowels in Staten Island English: When the traditional descriptions and the facts do not agree. Poster presented at LabPhon9, June 2004.
Noske, Manuela 2000. [ATR] Harmony in Turkana: A Case of Faith Suffix >> Faith Root. Natural Language & Linguistic Theory 18: 771-812.
Prince, Alan, and Paul Smolensky 1993. Optimality Theory: Constraint Interaction in Generative Grammar. Ms., Rutgers University and University of Colorado.
Smolensky, Paul 1996. The initial state and 'Richness of the Base' in Optimality Theory. Technical Report, Johns Hopkins University, Baltimore.
Szentgyörgyi, Szilárd 2004. Richness of the Base, Lexicon Optimization and Underlying Representations in OT. Paper presented at the 12th Manchester Phonology Meeting, 20 – 22 May 2004, Manchester.
Wells, John C. 1982. Accents of English 2. The British Isles. Cambridge: Cambridge University Press.
Yip, Moira 1996. Lexicon Optimization in Languages without Alternations. In Current trends in phonology: Models and methods Vol. 2, ed. Jacques Durand and Bernard Laks, 757-788. ESRI, University of Salford Publications, Salford.

Institutt for Språkvitenskap / CASTL
Universitetet i Tromsø
9037 Tromsø
Norway

martin.kraemer@hum.uit.no