

## Rethinking the ‘duplication problem’

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### Abstract

This paper reviews arguments regarding the ‘duplication problem’ (DP) in phonology, which is the observation that in many languages a productive alternation coexists with a related static generalization about underlying forms. The DP has been of particular relevance to phonological theory in the era of Optimality Theory (OT) because it has been claimed that derivational models of phonology suffer from the DP while OT with Richness of the Base (OT-ROTB) does not. In this paper, it is argued that there is no DP. An understanding of the diachronic origins of alternations and lexical patterns explains the frequent cooccurrence of the two types of patterns, such that the relation between the two does not necessarily have to be formally captured in the synchronic grammar. A model in which alternations and generalizations about roots are not driven by a single constraint in the grammar is argued to make more accurate empirical predictions than OT-ROTB.

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### 1. Introduction

In this paper, I review arguments regarding the ‘duplication problem’ (henceforth DP), which is ‘the observation that rules of grammar often duplicate in their dynamic mappings the restrictions that are imposed statically by lexical redundancy rules’ (McCarthy, 2002:71). The DP, having been pointed out at least as early as Chomsky and Halle (1968) (henceforth SPE), has been of particular relevance to phonological theory in the era of Optimality Theory (OT)<sup>1</sup> because it has been claimed that derivational models of phonology suffer from the DP while OT does not (see, e.g., Kager, 1999:55–56). I will argue in this paper that there is not really a duplication problem because cases of parallel static and dynamic patterns originate in a sound change, and that sound change is the single source of the explanation for the dual patterns. As I discuss, the argument for the DP relies on some assumptions that are at the very least debatable, and the commonly accepted solution to the DP (OT with Richness of the Base) makes some problematic historical/empirical predictions.

A commonly cited type of duplication is that exhibited by a language where a phonological generalization that holds within morphemes also applies across morpheme boundaries, giving rise to alternations. An example can be found in Buchan Scots, which exhibits vowel height harmony (Dieth, 1932; Fitzgerald, 2002; Paster, 2004). Buchan is a dialect of Lowland (i.e., non-Gaelic) Scots spoken in north-east Scotland. In Buchan Scots, unstressed underlyingly high vowels surface as mid when preceded by a stressed non-high vowel (this ignores a blocking effect exhibited by intervening voiced obstruents and certain clusters; see Paster, 2004 for details). As seen in (1)a, the vowel of the diminutive and adjective-forming suffixes (both underlyingly /-i/) surface as [i] when the stem vowel is high. (1)b shows that when the stem vowel is non-high, the suffix

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<sup>1</sup> Henceforth, unless specified, ‘OT’ should be read as ‘classic OT’ (Prince and Smolensky, 1993) as opposed, e.g., to Stratal OT, which I discuss in section 4.3.



vowel harmony process were reducible to a single rule; he argued that '[t]he attempt to unify a rule and a constraint (or two rules) is not, properly speaking, a job for phonological descriptions. . . Explaining *why* a language has such and such a property, and not such and such another property, is in principle distinct from the business of describing just what properties it has, and the two projects must be kept separate. There is absolutely no a priori reason to imagine that the descriptively correct analysis of a given set of facts from natural language will also be the simplest formally. . . ' (1974:293). Thus Anderson's solution to the DP rejects the notion that rules and MSCs need to be stated only once in the grammar – essentially denying that duplication is a 'problem'. I will pursue this approach further in section 4.

As was made clear in later work, it is not always possible to reduce a productive rule and the related generalization about lexical items to a single rule that applies to both monomorphemic and complex words, even if the rule is permitted to be ordered in the derivation just like any other rule. Kenstowicz and Kisseberth (1979) showed that the 'ordering' solution is untenable as a general solution to the DP because there are languages in which a regular phonological rule is blocked when the output of the rule would violate an MSC. Therefore, they argued, MSCs cannot simply be regular rules that happen to apply to lexically stored forms as well as producing alternations in complex words, because MSCs have the ability to affect the application of regular phonological rules in a way that cannot be accounted for via ordering. The key example comes from Tonkawa (Kenstowicz and Kisseberth, 1979:431–433). In Tonkawa, CCC sequences do not occur within morphemes; this can be accounted for via the MSC in (5).

$$(5) \quad [ \quad ] \rightarrow [+syll] / \_ \text{CC} \\ \text{CC} \_$$

Tonkawa also has an elision rule that deletes the first vowel of a verb stem if there is a CV- prefix, as shown in (6a) (Kenstowicz and Kisseberth, 1979:431). In words with no CV- prefix, as in (6b) (Gouskova, 2007:373, adapted from Hoijer, 1933, 1946, 1949), the second vowel of the stem is deleted (note that the vowels undergoing elision are shown in bold in the underlying form here and in later examples).

- (6) a. /netale/ we-ntale-n-oʔ 'he is licking it/them'  
       /picena/ we-pcena-n-oʔ 'he is cutting it/them'  
       b. /notoxo/ notxo-ʔ 'he hoes it'  
       /jamaxa/ jamxa-ʔ 'I paint his face'

This elision rule fails to apply in cases where its application would result in a CCC sequence (Kenstowicz and Kisseberth, 1979:432). An example is given in (7), where the /a/ of the underlying form resists elision because the result of applying elision would be a word with an illegal CCC cluster.

- (7) /nepaxke/ nepaxke-n-oʔ 'he is smoking'  
       \*nepxke-n-oʔ

If elision applied in (7), the MSC as stated in (5) would incorrectly 'fix' the /pxk/ sequence by changing either the /p/ or the /k/ into a vowel rather than leaving all three consonants intact and restoring the elided /a/, which would be the repair needed to produce the correct surface form. So in this case the MSC needs to be able not just to repair an ill-formed structure derived at an earlier stage in the grammar, but to prevent the ill-formed structure from being derived at all. To solve this problem, Kenstowicz & Kisseberth proposed a single constraint that both prohibits CCC in underlying forms and blocks the application of elision when it would create a CCC sequence – foreshadowing the OT approach to the DP.

Two general approaches to the DP have been discussed so far. The first is to attempt to reduce rules and MSCs to a single statement in the grammar, whether an ordered rule as in the SPE approach, or a constraint as in Kenstowicz & Kisseberth's proposal (see also Kisseberth, 1970a,b for earlier discussion of 'derivational constraints'). The second is to assume, following Anderson, that the grammar tolerates redundancy between rules and MSCs. A third possibility is to deny the existence of MSCs, an approach that was taken by Clayton: 'MSC's are merely artifacts of the grammar, and thus play no part in the phonological component of a language' (1976:302).

Other solutions to the DP have been proposed in the literature, though they generally fall into the categories identified above. One of these is 'persistent rules' (Chafe, 1968:131; Halle and Vergnaud, 1987:135; Myers, 1991; see also Stanley, 1967), which can apply at multiple times throughout a derivation in order to repair the output of rules that create ill-formed structures. Persistent rules are thus a hybrid of the ordering and constraint-based solutions. Underspecification (see, e.g., Archangeli, 1984) is another approach, or set of approaches, to the DP that is part of the 'ordering' strategy. There are many different types of underspecification (see Steriade, 1995 for one overview), but in general their relationship to the DP is that underlying forms are unspecified for (some) (contextually) predictable feature values, so that the same phonological rules that produce alternations in complex words also fill in the features in monomorphemic words. I will not

go in depth into underspecification here, but instead I refer the reader to McCarthy (2002) for discussion and for criticism of underspecification and some other proposed solutions to the DP.

By the 1990s there was no generally accepted solution to the DP. It was in part as a response to this, and building on Kenstowicz & Kisseberth’s earlier proposals, that OT emerged along with Richness of the Base (ROTB; Prince and Smolensky, 1993; Smolensky, 1996). ROTB is ‘[t]he assumption that no grammatical restrictions are stated at the level of lexical representation’ (Kager et al., 2004:22) – in essence, an explicit rejection of MSCs. In OT with ROTB, both lexical patterns and productive alternations result from a single set of markedness constraints on surface forms. This is argued to be a major advantage of OT-ROTB over derivational (rule-based) models of phonology; Vaux (2005) describes the DP as ‘perhaps the most invoked OT argument against [derivational phonology]’. Kager et al. (2004:22) assert that OT-ROTB ‘offers a radical and principled solution to the duplication problem’. Similarly, McCarthy describes the duplication problem as ‘a powerful empirical reason’ for assuming OT-ROTB (2002:71) and states that ‘[the] formal similarity and functional redundancy between MSC’s and rules is a significant liability of the classic theory’ (1998:125). Kager (1999:57) argues that OT’s solution to the duplication problem makes it ‘a much simpler theory’ than rule-based theory because the latter requires both rules and constraints (MSCs) while OT has only constraints.<sup>3</sup>

In an OT-ROTB analysis of the Buchan Scots example described in section 1, the generalization that roots exhibit partial vowel height harmony, as well as the alternation in suffix vowels, would be driven by a single surface constraint. I give a sample analysis below using the constraint ALIGN-R[-hi] to drive the harmony pattern.<sup>4</sup> The basic constraints needed for the analysis are given in (8).

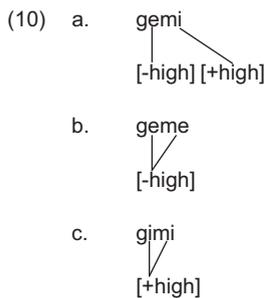
- (8) ALIGN-R[-hi]: Any [-high] must be aligned to the right edge of a word.
- IDENT[±hi]-V̇: The value of [±high] in a stressed vowel must be identical to the value in the corresponding input vowel.
- IDENT[±hi]: An input [±high] must have an identical output correspondent.

As seen in (9), the ranking of the alignment constraint below the faithfulness constraint referring to stressed vowels but above the more general faithfulness constraint ensures that the candidate exhibiting lowering of the suffix vowel (b) will win out over the fully faithful candidate (a) as well as one in which the [-high] feature is deleted altogether (vacuously satisfying the alignment constraint) (c).

(9)

[gɛmɛ] ‘gamie’			
/gɛm-i/	IDENT[±hi]-V̇	ALIGN-R[-hi]	IDENT[±hi]
a. gɛmi		*!	
b. gɛmɛ			*
c. gimi	*!		*

The diagrams in (10a–c) show the output configurations of the [±high] feature for candidates (9a–c), respectively.



<sup>3</sup> Vaux (2010) makes the opposite argument, pointing out that multiple constraints are generally needed to do the work of a single rule. The argument is meant to counter a classic critique of rule-based phonology based on ‘conspiracies’ (cases where multiple rules yield a single type of surface structure) rather than the DP, but Vaux extends the argument to make a case against the DP as well, taking a somewhat different angle from the one pursued in this paper.

<sup>4</sup> Because this analysis is given for illustrative purposes only, the choice of an ALIGN constraint as opposed to ANCHOR (McCarthy and Prince, 1995, 1999), NO-INTERVENING (Zoll, 1996), AGREE (Bakovic, 2000), or any other constraint or mechanism proposed to handle vowel harmony in OT is immaterial to the argument. The point here is merely to show what one workable OT-ROTB account would look like; I do not intend to argue for this particular analysis over a different OT-ROTB analysis nor to compare its merits with those of any other type of analysis (e.g., the rule-based analysis given earlier).

(11) confirms that the same ranking correctly predicts the static pattern in monomorphemic words.

(11) [vere] 'very'

/vere/	IDENT[±hi]-V̄	ALIGN-R[-hi]	IDENT[±hi]
a. veri		*!	*
b. vere			
c. viri	*!		**

Note that the same surface form is selected even if the underlying form of 'very' has a word-final /i/ rather than /e/, as shown in (12).<sup>5</sup>

(12) [vere] 'very'

/veri/	IDENT[±hi]-V̄	ALIGN-R[-hi]	IDENT[±hi]
a. veri		*!	
b. vere			*
c. viri	*!		*

Crucially in ROTB, the language learner's choice of /vere/ is not guided by a prohibition against underlying forms with disharmonic vowels, since no such prohibitions exist in the grammar. Instead, under Lexicon Optimization (Prince and Smolensky, 1993:192), it is assumed that the learner will arrive at /vere/ rather than /veri/ as the underlying form because the mapping /vere/ → [vere] is optimal. Thus, apparent constraints on underlying forms simply emerge from the constraint ranking rather than being stated as MSCs, and therefore OT-ROTB solves the DP.

### 3. Assumptions behind the DP

The existence of a 'duplication problem' hinges on the assumption that the explanation for all phonological patterns should be captured in the formal characterization of the synchronic grammar. This view leads to two specific assumptions relevant to the DP. The first is that generalizations about static patterns in the lexicon are psychologically real and must be accounted for in the phonological grammar. The alternative to this would be the state of affairs described by Hale and Reiss: '[MSCs] serve merely to state descriptive generalizations about the memorized content of the lexicon of a particular language. Even if we, as linguists, find some generalizations in our description of the lexicon, there is no reason to posit these generalizations as part of the speaker's knowledge of their language, since they are computationally inert and thus irrelevant to the input-output mappings that the grammar is responsible for' (2008:17–18).

A second assumption underlying the DP is that the functional unity of two or more phenomena observed in a language should correspond to unity of formal explanation for the phenomena – i.e., the grammar does not tolerate redundancy and there are no 'coincidences'. Without both of these assumptions, the DP disappears entirely. There is no 'duplication' if knowledge of static patterns in the lexicon is not part of the mental grammar – regardless of whether a productive rule generates a surface pattern that mimics the static pattern. And there is no 'problem' if grammars tolerate redundancy and/or if not every discernible similarity between patterns in a language has to be captured and explained in the grammar.

Regarding the first assumption, the matter cannot be said to be settled completely, and so in this paper I will not argue for or against MSCs. There are multiple arguments in favor of the view that static patterns in the lexicon are encoded in the grammar; one is the fact that loanwords are sometimes adapted to conform to patterns in the native lexicon. However, loanword adaptation in itself does not prove the existence of MSCs, since it is possible that the borrower perceives the word in a way that is already influenced by the phonology/phonetics of his/her native language, such that the input may have already been adapted perceptually before it has a chance to interact with the grammar (as hypothesized by, e.g., Peperkamp and Dupoux, 2003). It must therefore be demonstrated that the input contains a structure that the grammar disallows and repairs via adaptation – an intricate point to argue. A further problem is that there are some cases where loanword adaptation is contradicted by patterns in the native lexicon. Peperkamp (2005) discusses several cases where loanword adaptation differs from the regular phonology of the borrowing language, as well as cases where loanwords undergo unnecessary adaptations that 'repair' structures that are not ill-formed in the borrowing language, suggesting that loanword adaptation is not purely a byproduct of constraints on the native lexicon (whether MSCs, or surface constraints in the ROTB model).

<sup>5</sup> A harmonic monomorphemic form like [piti] 'pity' will not surface as \**pīte* in this analysis because ALIGN-R[-high] does not compel insertion of [-high] at the right edge. ALIGN constraints quantify universally over the element being aligned and existentially over the edge to which they align (McCarthy and Prince, 1993), so ALIGN-R[-high] (which can also be stated as ALIGN ([-high], R, PWd, R)) dictates only that any [-high] (if present) should be aligned to the right edge of the word.

Other arguments for MSCs have been made based on well-formedness judgments. For example, Frisch and Zawaydeh (2001) present results of a study showing that Arabic speakers make judgments about the well-formedness of novel words that are consistent with an OCP-PLACE MSC. They argue that since the judgments differ from what would be expected if they were based on pure statistical generalizations, the constraint must be part of the grammar rather than simply reflecting statistical knowledge external to the grammar. Coetzee (2008) reports parallel findings in a study of English speakers' reactions to nonce-word stimuli of shapes [spVp], [stVt], and [skVk], arguing that their performance on phoneme identification, word-likeness, and lexical decision tasks goes beyond merely reflecting their statistical knowledge of the frequency of patterns in the lexicon. See Vaux (2005) for references to several other studies showing that speakers use knowledge of statistical patterns in the lexicon in order to decide on underlying forms.

The upshot of this discussion is that there does exist a body of evidence in favor of MSCs, but some of the arguments are controversial. In fact, though, the existence of MSCs is not crucial to the logic of the argument in this paper. As I will continually point out, the arguments do not depend on the existence or non-existence of MSCs. Therefore, for the remainder of the paper, I will focus on the second assumption at issue – that grammars must encode all generalizations about the sound patterns of a language with no redundancy and no generalization left uncaptured or unexplained.

There are a number of arguments against this second assumption. One of these is Anderson's argument that the grammar is not responsible for unifying rules and MSCs; I discuss this argument further in section 4.1 below. Another reason to believe that grammars may tolerate duplication between rules and MSCs is that a similar kind of redundancy is found elsewhere in phonetic/phonological systems. For example, Robinson (1976) discusses a case from the Schaffhausen dialect of Swiss German where a single rule appears to apply twice in a single derivation. One rule lowering *o* to *ɔ* before *r* must precede umlaut, but a more general rule lowering *o* to *ɔ* before coronal obstruents must follow umlaut; were it not for the interaction with umlaut, the two lowering rules could be collapsed. Robinson argues that in cases like this, as long as the grammar can recognize the second application as a 'generalization' of the first rule, then the grammar will not be unduly complex.<sup>6</sup> Bermúdez-Otero (2010) makes a similar point regarding phonetic phenomena that are phonologized as categorical rules/constraints but remain in the language as gradient phonetic processes as well.

To the extent that Roberts' and Bermúdez-Otero's arguments go through, grammars must already be allowed to permit redundancy (whether between multiple applications of a single rule or between phonetic and phonological processes), suggesting that 'duplication' between an alternation and a static pattern should also be tolerated (if indeed MSCs do exist in the grammar). In section 4.2 I will present some empirical findings suggesting that what some would call 'duplication' is not only tolerable but unavoidable in the analysis of certain phonological systems if static patterns are to be encoded in the grammar.

#### 4. Against the DP

It was argued in the previous section that the existence of the DP rests on two assumptions: that grammars must account for generalizations about underlying forms, and that the mechanism for doing so should not be functionally redundant with any regular phonological rules/constraints in the grammar. If either (or both) of the assumptions is successfully argued to be incorrect, then there is not a DP. I discussed some arguments above regarding first assumption. In the remainder of the paper, I focus on the second assumption, arguing that an approach in which static and dynamic generalizations are not necessarily unified in the grammar makes superior empirical predictions to those made by OT-ROTB in terms of the types of languages that exist and the ways in which languages change historically. I begin in section 4.1 by advocating a diachronic approach to 'explanation' in phonology, including an explanation for the common co-occurrence of functionally similar static and dynamic generalizations in the phonologies of the world's languages.

##### 4.1. A diachronic approach

Anderson (1974:393) observed that in languages exhibiting 'duplication' between alternations and static patterns, '[b]oth the constraint and the rule... have the same explanation, where an explanation in phonological terms is often provided by our substantive empirical knowledge of the physics and physiology (and perhaps eventually, neurology) of speech' (see also Vaux, 2008:58–59 on this point). It should not be surprising that a language exhibits vowel harmony, for example, both within the lexicon as well as in the form of a productive rule, since vowel harmony is a natural result of common and well-understood coarticulatory phonetic effects. Where Anderson departed from other theorists was in taking the position that the failure to formally unify the constraint with the rule does not constitute a failure to explain the relationship between the phenomena, since the grammar is not the sole locus of explanation in phonology. Kiparsky (1972:219) makes a similar point in arguing that '[t]he existence of [cases of a productive rule and a corresponding MSC] is

<sup>6</sup> See also Mohanan (2000) on multiple different OT constraints needed to handle nasal place assimilation in English.

simply a consequence of how languages change, and does not pose a problem for linguistic theory.<sup>7</sup> In Kiparsky's view, such cases arise when a sound change that results in a productive phonological rule undergoes restructuring so as to be manifested in multiple places in the grammar. Later work has taken up this idea and produced a significant body of evidence in favor of the view that many patterns in phonology can be explained diachronically (see, e.g., Blevins, 2004 and other research under the 'Evolutionary Phonology' heading). A diachronic explanation does not preclude the possibility that the motivation for a phonological pattern may also be encoded in the synchronic grammar, but it does mean that an analysis that does not posit such encoding can still be said to be an explanatory account.

Anderson's view of the nature of explanation in phonology goes a long way towards solving the DP, especially in light of the fact that the years following his (1974) remarks on phonetic explanations for phonological patterns have seen great advances in the development of our knowledge of the phonetic underpinnings of phonology. But Anderson's and Kiparsky's arguments can be pushed a step further: Not only are dynamic and static patterns influenced by the same factors, but in fact it is likely that they arise at the very same moment in history, *due to a single historical sound change*.<sup>7</sup> To my knowledge, this point has not been stated explicitly in the literature, nor have these ideas been discussed in recent literature in connection with the DP as an argument for OT.

Buchan Scots provides an illustrative example. To account for the development of vowel harmony in Buchan Scots, Paster (2004) proposed a sound change in pre-modern Buchan Scots, where co-articulatory phonetic lowering of an unstressed high vowel after a non-high vowel results in a categorical change of the final vowel to [-high]. This sound change, being fully regular (*modulo* the consonant blocking effect mentioned earlier) and blind to morphological boundaries, would have affected both monomorphemic and complex words. (13) shows Buchan Scots at two hypothesized stages with respect to vowel harmony. At Stage I, there is no categorical vowel harmony, but the final /i/ is produced as a slightly lowered variant, [i̯], in words with a non-high stressed vowel, due to coarticulation (both in monomorphemic words like 'very' and in complex words like 'lassie'). This is indicated by the hypothetical transcriptions in (13a–c). At Stage II, the phonetic coarticulation effect becomes part of the regular phonology of the language, transforming [i̯] into a [-high] vowel, /e/. This may have occurred due to listener error of the type characterized as 'hypocorrection' by Ohala (1981, 1993), where the listener perceives a phonetic feature of a sound and attributes it to a categorical phonological feature rather than an accidental coarticulatory effect.

(13)	Stage I	a. *veri 'very'	b. *las-i 'lassie'	c. *bik-i 'beakie'
		[ver̩]	[las-i̯]	[bik-i̯]
	Stage II	vere 'very'	las-e 'lassie'	bik-i 'beakie'

The important point about the development of vowel harmony in Buchan Scots is that, in this scenario, the same sound change simultaneously gave rise to a productive rule and a static pattern. The rule emerged as a direct consequence of the sound change because of the newly created alternation in the suffix vowel, and the static pattern in morphemes emerged because no word in the lexicon failed to undergo the sound change. Hence, the rule and the generalization about morphemes are explained by a single mechanism.

The view taken here (which I will henceforth refer to as the diachronic approach) presupposes that the explanation for a phonological pattern (or for a convergence between two or more phonological patterns in a language) may lie outside the realm of a speaker's mental grammar. However, there is evidence in favor of the diachronic approach beyond *a priori* theorizing about the nature of explanation in phonology. In fact, as I discuss below, OT-ROTB and the diachronic approach make different predictions for language change, allowing us to distinguish the two approaches empirically.

<sup>7</sup> The complete passage from Kiparsky (1972:216) may suggest a model where a sound change results in a rule, which in turn results in the creation of an MSC. Referring to 'cases in which some phonological rule mirrors a morpheme structure condition in its content,' Kiparsky writes: 'The most common type of case here is that of a sound change which both remains as a productive rule in the phonology and causes a corresponding change in the morpheme structure conditions. What synchronically is overlap between a phonological rule and a morpheme structure condition is historically a single phonological process which is reflected, through restructuring, in several places in the grammar. The existence of such cases is simply a consequence of how languages change, and does not pose a problem for linguistic theory.' In this paper I am making the somewhat different claim that the alternations and the static pattern holding within morphemes (whether formalized as an MSC or not) arise simultaneously at the moment when the sound change is 'phonologized', to use Hyman's (1976) term – when some aspect of a sound's pronunciation that is due, e.g., to accidental coarticulation, and does not reflect a phonetic target dictated by a phonological feature/representation, is exaggerated beyond the original phonetic effect and comes to be represented as a categorical phonological featural/representational change in the mental grammar of a speaker. On this assumption, the sound change can be said to give rise to alternations and a static pattern simultaneously; this is different from Kiparsky's scenario where the pattern starts as a rule and ends up spreading to the lexicon. A third possible way of viewing the relationship between sound change and phonological rules is Hayes' view that 'rules are the seeds of sound change [emphasis in original]' (2009:224). In Hayes' model, the way that (many) sound changes happen is that '1 A new phonological rule is introduced into a language. 2 The new rule is applied with increasing frequency. 3 A new generation restructures the system: they acquire no rule, but a different set of underlying representations' (2009:226).

#### 4.2. Predictions for language change

The standard characterization of language change in OT is that it involves constraint reranking (see, e.g., Archangeli, 1997:31). This means that static generalizations and the related alternations in a language should undergo changes in tandem. For example, if an alternation is lost, then the static generalization may be lost as well, since the markedness constraint responsible for both patterns would be demoted below the relevant faithfulness constraint, allowing new words violating the markedness constraint to enter the lexicon. Similarly, if a static generalization is lost, then the related alternation should immediately disappear from the language. Kiparsky (1972:219) makes a parallel point regarding ‘conspiracies’, asking ‘Are there cases where [the rules in a conspiracy] are subject to parallel historical changes at some point in the development of a language?’ and claiming not to have found any such examples.

Under the view I am advocating, static and active patterns are not driven by a single constraint as in OT-ROTB. Therefore, rules and static generalizations are free to undergo changes independently of each other. For example, a rule might be lost (e.g., via leveling of an alternating affix), but the related static generalization could remain. Alternatively, the static generalization could be lost (e.g., due to borrowing), but the rule could remain. There could also be slight changes to, e.g., the target or trigger of the rule, with no concomitant change to the static generalization. As we will see below, all three of these predicted developments are attested in the world’s languages, strongly supporting the view I am advocating here. We begin with languages that exhibit a phonological rule/phenomenon that creates alternations but does not hold within roots.

##### 4.2.1. Loss of a static generalization

Consider a hypothetical example from Buchan Scots. Suppose that through borrowing from English or via some other mechanism, Buchan Scots acquired some CV[-hi]CV[+hi] roots.<sup>8</sup> If enough disharmonic words entered the Buchan Scots lexicon, eventually there would be no justification for positing an MSC requiring vowel harmony. However, there would still be sufficient evidence via alternations for the synchronic rule changing *i* to *e*. In a rule-based approach, we could say simply that roots were no longer harmonic, but the active vowel harmony rule was retained; the non-application of vowel harmony within roots could be handled by designating the rule as applying only in derived environments or by writing a morpheme boundary into the rule. The OT approach predicts that language change will proceed according to constraint reranking, so Buchan Scots ALIGN-R[-hi] >> IDENT[±hi] would be reversed in order to allow the newly borrowed disharmonic roots to surface as disharmonic. This would result in the loss of the suffix alternation simultaneously with the loss of harmony in roots.

Since there are not enough disharmonic words in Buchan Scots for us to confidently declare the static vowel harmony pattern to be lost, this should not be counted as a counterexample to the OT prediction. However, there are other languages that do exhibit alternations with no corresponding static generalization. Examples of derived environment effects (also known as ‘non-derived environment blocking’) provide ample attestation of this state of affairs<sup>9</sup>; a classic case comes from Finnish (see, e.g., Kiparsky, 1993:283), where /t/ changes to [s] before /i/ across a morpheme boundary, but tautomorphemic /ti/ sequences are unaffected. An example from the vowel harmony domain comes from Turkish, which exhibits productive vowel harmony in suffixes but has many disharmonic roots (see, e.g., Clements and Sezer, 1982).<sup>10</sup> Thus, roots can be disharmonic for [±back], as in (14a), while suffix vowels harmonize, thus exhibiting alternations, as in (14b) (data are from Clements and Sezer, 1982:216, 222–223, using the adapted transcriptions from Archangeli and Pulleyblank, 2007).<sup>11</sup>

- (14) a. takvim ‘calendar’ adet ‘item, piece’  
       bobin ‘spool’ peron ‘railway platform’  
       kubbe ‘dome’ muzip ‘mischievous’

<sup>8</sup> In fact, there is evidence that such roots have already entered the Buchan Scots lexicon. Fitzgerald (2002) cites the following examples from Wölcck (1965) (page numbers are from Fitzgerald, 2002): *lajlr* ‘lawyer’ (68), *kæčī* ‘kitchen’ (71), *krɫni* ~ *krani* ‘crannie’ (66, 72), *spɛrɟi* ‘spainyie’ (72), *krani* ‘crow’ (72). To this can be added the example ‘grannie’ from Paster (2004), which was initially transcribed as *grane*, but whose F1 measurement for the final vowel turned out to be significantly lower than for other tokens of [e], putting it into the F1 range for [i]. Youssef (2010) argues that these exceptions result from special properties of the medial consonants, claiming that the medial palatal consonants of *lajlr* and *kæčī* have a raising effect on the following vowel, that /ŋ/ is underlyingly specified as [Lowered Larynx] ([LL]), and that some instances of /n/ in the language also have [LL], while others do not. However, another way of interpreting these examples is that they are simply lexical exceptions (whose medial consonants may historically have had some hand in causing them to be disharmonic).

<sup>9</sup> Thanks to an anonymous reviewer for pointing this out.

<sup>10</sup> Harrison and Kaun’s (2001) study mentioned earlier suggests based on a language game experiment that vowel harmony can apply to roots in Turkish. Their analysis would not be consistent with an MSC, but it does not entail that Turkish roots are not subject to vowel harmony, either. I take Harrison & Kaun’s claims about Turkish to be somewhat tentative since they are based on ‘preliminary results’ of a pilot study involving only two speakers.

<sup>11</sup> A reviewer points out that the Turkish lexicon is stratified rather than uniform, and the native stratum does seem to require roots to be harmonic. With disharmonic stems, suffixes harmonize with the last vowel of the stem: cf. *kitap* ‘book’, *kitap-lar* ‘books’; *eşya* ‘collection of items’, *eşya-lar* ‘collections of items’; *şeftali* ‘peach’, *şeftali-ler-in* ‘peaches (gpl.)’ (Anderson, 1974:212).

b.	nom.sg.	gen.sg.	nom.pl.	gloss
	ip	ip-in	ip-ler	'rope'
	jyz	jyz-yn	jyz-ler	'face'
	sap	sap-in	sap-lar	'stalk'
	kiz	kiz-in	kiz-lar	'girl'

There is a possible account of this situation in OT-ROTB, which relies on Positional Faithfulness (Beckman, 1998). Positional Faithfulness was devised to account for the observation that certain positions or categories are less likely than others to undergo phonological rules (e.g., affixes vs. roots, unstressed vs. stressed syllables, etc.). Under Positional Faithfulness, assuming that constraints are universal (McCarthy, 2002), then every IDENT constraint has a 'root' version that universally outranks the 'affix' version (McCarthy and Prince, 1995). So the hypothetical change to roots in Buchan Scots could result not in the ranking IDENT[±hi] >> ALIGN-R[-hi] (which would completely eliminate vowel harmony), but rather IDENT[±hi]-root >> ALIGN-R[-hi] >> IDENT[±hi]-affix. This would allow a disharmonic word such as *krani* 'crow'<sup>12</sup> to retain its final /i/, assuming the word is analyzed as monomorphemic, as I do in (15a). Complex words with a non-high root vowel would still undergo lowering of the suffix vowel, as in (15b).

(15)a. [krani] 'crow'

/krani/	IDENT[±hi]-root	ALIGN-R[-hi]	IDENT[±hi]-affix
☞ a. krani		*	
b. krane	*!		

b. [mane] 'mannie'

/man-i/	IDENT[±hi]-root	ALIGN-R[-hi]	IDENT[±hi]-affix
a. mani		*!	
☞ b. mane			*

In general, the ranking schema Faithfulness(root) >> Markedness >> Faithfulness(affix) should account for cases like this (and like Turkish) where there are alternations but where the same pattern does not hold within morphemes. However, there are other problems for the Positional Faithfulness solution. One is that, as I discuss in section 4.2.2, there are also languages showing the reverse state of affairs – where a static generalization is retained but the active rule has been lost.

#### 4.2.2. Loss of an active process

In the Marash dialect of Armenian, roots are harmonic for [back] and [round] but there are no alternations in affix vowels (Vaux, 1998:151, 2005). The roots shown in (16a) are representative of roots in the language: vowels that are contrastively specified for [back] and [round] never co-occur with vowels having the opposite specification for the same feature. Given this, the root types in (16b) are disallowed, and they are not attested. However, as shown in (16c), affixed words can be disharmonic, showing that the harmony pattern in roots does not correspond to a productive alternation. Notice also in (16c) that affixes themselves, such as the suffix *-umi*, can exhibit disharmony, showing that we cannot explain the pattern within roots by claiming that harmony applies 'morpheme internally'.<sup>13</sup>

(16) a. Harmonic roots in Marash Armenian (Vaux, 1998:157)

k <sup>h</sup> ana	'how many/much'	əsər	'today'
ærin	'blood'	ybyr	'when'
hik <sup>h</sup> æ	'soul'	urnog	'example'

b. Disallowed root types (Vaux, 1998:157)

*CuCy	*CuCø	*CeCy	*CiCy
*CyCu	*CyCo	*CeCø	*CiCø
*CoCø	*CoCy	*CøCe	*CøCi
*CøCo	*CøCu	*CyCe	*CyCi

<sup>12</sup> See note 8.

<sup>13</sup> Thanks to an anonymous reviewer for pointing this out.

- c. Disharmonic words (Bert Vaux, p.c.; # marks exx. from Adjarian, 1954:398)
- |                            |                             |
|----------------------------|-----------------------------|
| as-i-m                     | 'say-theme.V-1SG'           |
| g-os-æ-Ø                   | 'IMF.-say-THEME.V-3SG'      |
| bart <sup>h</sup> agon-i-s | 'owing-be-2SG'              |
| yr-iri                     | 'interrog.pron-PL.NOM'#     |
| yr-ur-un                   | 'interrog.pron-PL-GEN/DAT'# |
| yr-ur-umi                  | 'interrog.pron-PL-INSTR'#   |

Another similar example comes from Ngbaka (Archangeli and Pulleyblank, 2007:365), where root vowels agree in [ATR] (in addition to showing strong distributional skewing towards completely identical vowels), but affix vowels do not alternate. A Positional Faithfulness approach does not help with cases like this, since if the 'root' version of any faithfulness constraint is universally ranked above the 'affix' version (see, e.g., McCarthy and Prince's (1995) metaconstraint FAITH(STEM) >> FAITH(AFFIX)), there is no good way to account for cases where affix vowels exhibit greater faithfulness than root vowels using Positional Faithfulness.<sup>14</sup> Anderson (1974:288) briefly discusses a related but slightly different type of example from early Germanic, where umlaut was still a productive phonological process. There would have been no front round vowels in underlying forms – a fact which would be encoded by an MSC in a theory that includes them. However, the active phonological grammar could have no such restriction, since umlaut would regularly produce front round vowels in surface forms. Though preferential root vs. affix faithfulness is not at issue here, this constitutes another example of a language having a static pattern (no front round vowels) without a corresponding active pattern (a rule eliminating front round vowels).

#### 4.2.3. Changes in an active or static generalization

Another challenge for the OT-ROTB approach comes from languages where there are static generalizations and alternations that are clearly related but are different enough that they cannot be reduced to a single statement in the grammar. This is predicted in an approach such as the one advocated here, where patterns in the lexicon are free to change independently of phonological rules; it is problematic for an approach in which both patterns are governed by a single markedness constraint. English (Chomsky and Halle, 1968:172; Anderson, 1974:288–289), for example, disallows tense vowels before most consonant clusters. This can be analyzed as Closed Syllable Shortening (CSS; Myers, 1987). Under this rule, tense vowels change to lax when followed by CC sequences that are formed across certain morpheme boundaries, as seen in (17a). Within morphemes, tense vowels are allowed before clusters of coronal consonants, as seen in (17b). However, the productive rule of CSS does apply before clusters of coronal consonants across a morpheme boundary, as shown in (17c).<sup>15</sup>

- |      |    |                      |    |              |    |                  |
|------|----|----------------------|----|--------------|----|------------------|
| (17) | a. | convene convention   | b. | wild *wilm   | c. | retain retentive |
|      |    | describe descriptive |    | saint *saimp |    | mean meant       |
|      |    | lose lost            |    | toast *toask |    | wide width       |

Hence, the constraint responsible for CSS cannot also be responsible for the within-root generalization since the patterns are slightly different.<sup>16</sup>

Another example comes from Kikuria (Bantu), which has a rule raising mid vowels to high before a high vowel. This can be seen in (18), where the infinitive prefix and the pre-prefix (or 'augment') surface with the vowel [u] when the stem has a high vowel; otherwise they surface with [o] (the *k* ~ *ɣ* alternation in the infinitive prefix triggered by the following consonant is unrelated). Data are from my field notes.

<sup>14</sup> Two solutions are technically possible. One is to allow root and affix faithfulness to be freely rankable (contrary to McCarthy & Prince's metaconstraint). Another is to introduce a positional markedness constraint that holds over roots but not over other domains. Either of these possible solutions would constitute a significant weakening of the theory of Positional Faithfulness and its purported empirical/typological advantages.

<sup>15</sup> A complication to English CSS is that there are a number of lexical exceptions, in sufficient numbers that some may question whether the class of roots ending in coronal clusters is a legitimate class of exceptions or one that accidentally emerges from the more general set of exceptional forms. It would be interesting to determine what percentage of exceptions involves roots ending in final coronal clusters; I leave this question open for future investigation. Thanks to Ricardo Bermúdez-Otero for raising this issue.

<sup>16</sup> Myers' (1987) rule-based analysis may have a solution to this problem for the OT account, in that it contains a rule making root-final coronal clusters extrametrical (elsewhere, only root-final single consonants, but not clusters, are extrametrical). If extrametricality – including this special case of coronal cluster extrametricality – is permitted in the OT analysis, then a single constraint against long vowels within a closed syllable could still account for the data in (17).

- (18) u-γu-tun-a 'to want'      o-ko-gor-a 'to buy'  
 u-ku-bin-a 'to sing'      o-γo-sɛk-a 'to laugh'  
 u-ku-biim-a 'to measure'      o-γo-saamb-a 'to burn'

There is a related generalization within roots: mid vowels do not precede high vowels. So far these patterns seem to be identical and could be unified via a constraint aligning the feature [-high] to the left edge of the word. However, there is a difference between the static pattern and the alternating pattern that complicates this picture. As pointed out by Fischer (2010:24), raising is triggered by the palatal consonants /tʃ/ and /ɲ/ across a morpheme boundary, but not within morphemes. (19a) shows raising triggered by palatal consonants in the derived context; (19b) shows that mid vowels do not raise to high when followed by a tautomorphemic palatal consonant. (19c) shows a root simultaneously triggering raising in the prefixes due to its initial palatal consonant, while failing to undergo raising triggered by its final palatal consonant (examples from Fischer, 2010:23, 25; 'PRE' indicates the pre-prefix, 'FV' indicates the default 'final vowel', and 'INTR' indicates an intransitive suffix).

- (19) a. /o- ko- ɲa:r      -a/ /o- ko- tʃem -ok -a/  
 [u- ku- ɲa:r      -a] [u- γu- tʃem -ok -a]  
 PRE- INF- wither      -FV PRE- INF- boil -INTR -FV  
 'to wither'      'to boil'
- b. /o- ko- βɛtʃ      -a/ /o- ko- keɲ -a/  
 [o- ko- βɛtʃ      -a] [o- γo- keɲ -a]  
 PRE- INF- bustle.about -FV PRE- INF- run -FV  
 'to bustle about'      'to run'
- c. /o- ko- tʃetʃ      -ok -a/  
 [u- γu- tʃetʃ      -ok -a]  
 PRE- INF- fade -INTR -FV  
 'to fade'

Thus, the static harmony pattern in roots differs from the alternating pattern in whether palatal consonants condition raising, posing a challenge for a model where both patterns would need to be driven by a single constraint. If a single constraint drives both patterns, we do not expect historical changes to the conditioning environment for one of the patterns without the same change applying to the other pattern.

#### 4.2.4. Summary of empirical findings

In this section we have discussed a number of examples of phenomena predicted by an approach that does not seek to account for active and static generalizations with a single constraint. This approach predicts three different possible developments, each of which is attested: languages that lose a static pattern but retain the related alternation (section 4.2.1), languages that lose an active pattern but retain the related static pattern in roots (section 4.2.2), and languages where either the active or static pattern undergoes some change that does not affect the other pattern (section 4.2.3). Of these patterns, only the first is readily compatible with the OT-ROTB approach, and then only if we adopt Positional Faithfulness. The other two types of developments, as discussed above, are not predicted by the OT-ROTB approach. This is problematic for proponents of the DP argument, because the advantage of OT-ROTB with respect to the DP is supposed to be that it unifies generalizations about roots with related alternating patterns. If, as I have argued in this section, this unification results in incorrect historical/typological predictions, then this suggests that such unification is not a property of phonological grammars.

Before concluding the paper, in section 4.3 I consider whether the DP argument can be salvaged under alternative versions of OT-ROTB. As we shall see, these alternative approaches are capable of modeling the relevant facts, but only in such a way that undermines the DP argument.

#### 4.3. Alternative approaches

In this paper I have focused on a particular version of OT, namely classic OT (Prince and Smolensky, 1993) with ROTB, arguing that the duplication problem that it purports to solve is not a problem to begin with. I argued further in section 4.2 that OT-ROTB makes inaccurate predictions for the types of phonological systems and historical phonological changes that should be attested or not attested in the world's languages. However, a number of different versions of OT have been proposed since 1993, and those that take into account morphological constituency, namely Stratal OT (SOT; Kiparsky,

2000; Bermúdez-Otero, *forthcoming*) and cophology theory (Inkelas, 1998), are exempt from some of these arguments. Therefore, I wish to make some brief remarks specifically on these two versions of the theory before concluding the paper in section 5.<sup>17</sup>

Recall the three problems for OT-ROTB identified in section 4.2. The first was that some languages have productive rules/constraints that are not mirrored by static patterns in the lexicon. In SOT, because of its ‘interleaved’ architecture adapted from Lexical Phonology (Kiparsky, 1982a,b), constraints can be ranked differently at different levels such as the stem, word, and phrase. SOT thereby avoids the first problem, in that a markedness constraint can be low-ranked at the stem level but high-ranked at higher levels.<sup>18</sup> This ranking strategy can be used to model cases like Turkish where roots can be disharmonic but affixes must harmonize. Similarly, in OT with cophologies, different morphological constructions can be associated with different constraint rankings. Like in the SOT solution, stems may have a cophology where the markedness constraint is low-ranked, but the constructions formed with affixes that undergo vowel harmony may have a different cophology where the markedness constraint is high-ranked.

The second problem for OT-ROTB discussed earlier is that some languages have the opposite situation – generalizations about the lexicon that do not correspond to productive alternations in morphologically complex words. SOT and cophology theory can also handle this problem, since a markedness constraint can be high-ranked in the stem level/cophology but low-ranked in other levels/cophologies. This would yield a system like the Marash dialect of Armenian, where roots are harmonic but affixes do not alternate.

The third problem for OT-ROTB identified earlier was that there are cases in which a static and dynamic generalization appear to be related historically but cannot reduce to a single rule/constraint in the grammar because the triggering environment differs slightly between the two. The SOT and cophology-based OT solutions to this third problem are less clear than the solutions to the first two. For a language in which related static and dynamic generalizations are not analyzable as being driven by a single markedness constraint, if we still want to assume ROTB and capture the static pattern in the grammar, then both SOT and OT analyses with cophologies would presumably have to assume two distinct and differently formulated constraints – one holding over stems and a slightly different one holding over the set of affixed forms that exhibit alternations – with each of the two versions of the constraint being the active (high-ranked) one in different strata/cophologies. This would allow for an OT analysis of this type of language, but notice this scenario brings us back to a duplication problem according to the logic of the DP argument: we would need two separate markedness constraints, rather than just one, to drive the lexical pattern and the alternations. Therefore, the ability to model this type of situation in SOT or with cophologies does not really ‘save’ the OT-ROTB account. If we adopt the type of account described here, we have duplication, which is precisely the ‘problem’ that OT-ROTB was supposed to solve. We could avoid the duplication by leaving the lexical generalization out of the grammar (just as we could do in a rule-based account without MSCs) – but as I have continually pointed out here, if lexical patterns do not have to be encoded in the synchronic grammar then there is no DP to begin with (and hence we lose the argument for OT-ROTB).

Thus, SOT and cophology-based OT approaches fare better than classic OT in terms of their empirical predictions for the phenomena under discussion here. However, for the class of cases just described, an SOT or cophology-based approach – while technically possible – undermines the DP and its use as an argument for OT-ROTB. This suggests that no type of OT account has an advantage over a rule-based account with respect to the DP, contradicting the claims cited earlier that the DP favors OT over rule-based phonology.

## 5. Conclusion

I have argued in this paper that the claimed existence of a duplication problem is not supported by an examination of the full range of empirical facts, and is based on theoretical assumptions whose validity is, at the very least, debatable. The first assumption concerns the existence of MSCs and, more generally, generalizations about underlying forms. As I discussed, there are a number of arguments in favor of MSCs, but not all linguists agree that they exist in synchronic grammars. If they do not, then there is no ‘duplication’.

Even if there is duplication, I have argued that it is not a ‘problem’. Duplication is problematic only if the synchronic grammar is considered to be the sole valid locus for the explanation of phonological patterns and why certain patterns co-occur. When diachrony is taken into account, as in the approach advocated here, the DP is no longer a problem, since a single sound change may be identified as the source of both a static and a dynamic phonological pattern in a language –

<sup>17</sup> Many thanks to Ricardo Bermúdez-Otero for elucidating discussion of these issues.

<sup>18</sup> Stratal Optimality Theory lacks a ‘root’ level phonology (see, e.g., Bermúdez-Otero, *forthcoming*), so all generalizations about roots emerge from stem-level constraints. SOT thus makes the interesting prediction that all generalizations about roots should be explainable via constraints on stems. Cophology theory, on the other hand, does allow a ‘root cophology’ (Inkelas, 1999; in fact, Inkelas and Orgun, 1994 argue that a root-level cophology is necessary for Turkish).

regardless of whether they can be unified within the formal analysis of the synchronic grammar – and therefore the explanation for both patterns is unified. A consideration of the pathways of phonological changes and some systems that result from them (discussed in section 4.2), suggests that the diachronic approach better matches the full range of empirical data relative to the predictions made by OT-ROTB. Thus, taking diachrony into account as a legitimate locus for explanation in phonology not only allows us to eliminate the DP, a long-standing problem in phonology, but also improves our ability to model the ways in which alternations vs. generalizations about roots may independently change over time in a language.

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## References

- Adjarian, H., 1954. Complete Grammar of the Armenian Language, vol. 2. Haykakan SSH GA Hratarakchutyun, Erevan.
- Anderson, S., 1974. The Organization of Phonology. Academic Press, New York.
- Archangeli, D., 1984. Underspecification in Yawelmani Phonology and Morphology. Ph.D. Dissertation, MIT.
- Archangeli, D., 1997. Optimality theory: an introduction to linguistics in the 1990s. In: Archangeli, D., Langendoen, T. (Eds.), *Optimality Theory: An Overview*. Blackwell, Oxford, pp. 1–32.
- Archangeli, D., Pulleyblank, D., 2007. Harmony. In: de Lacy, P. (Ed.), *The Handbook of Phonology*. Cambridge University Press, Cambridge, pp. 353–377.
- Baković, E., 2000. Harmony, Dominance, and Control. Ph.D. Dissertation, Rutgers University.
- Beckman, J., 1998. Positional Faithfulness. Ph.D. Dissertation, UMass Amherst.
- Bermúdez-Otero, R., 2010. Currently available data on English *t/d* deletion fail to refute the classical modular feedforward architecture of phonology. In: Paper Presented at the 18th Manchester Phonology Meeting, University of Manchester.
- Bermúdez-Otero, R. *Stratal Optimality Theory*. Oxford University Press, Oxford, forthcoming.
- Blevins, J., 2004. *Evolutionary Phonology*. Cambridge University Press, Cambridge.
- Chafe, W., 1968. The ordering of phonological rules. *International Journal of American Linguistics* 24, 115–136.
- Chomsky, N., Halle, M., 1968. *The Sound Pattern of English*. Harper and Row, New York.
- Clayton, M., 1976. The redundancy of underlying morpheme-structure conditions. *Language* 52, 295–313.
- Clements, G., Sezer, E., 1982. Vowel and consonant disharmony in Turkish. In: van der Hulst, H., Smith, N. (Eds.), *The Structure of Phonological Representations II*. Foris, Dordrecht, pp. 213–255.
- Coetzee, A., 2008. Grammaticality and ungrammaticality in phonology. *Language* 84 (2), 218–257.
- Dieth, E., 1932. *A Grammar of the Buchan dialect (Aberdeenshire): Descriptive and Historical*. Vol. 1: Phonology – Accidence. Heffer, Cambridge.
- Fischer, J., 2010. *Vowel-Height Harmony in Kuria*. MA Thesis, UCLA.
- Fitzgerald, C., 2002. Vowel harmony in Buchan Scots English. *English Language and Linguistics* 6, 61–79.
- Frisch, S., Zawaydeh, B., 2001. The psychological reality of OCP-place in Arabic. *Language* 77, 91–106.
- Gouskova, M., 2007. The reduplicative template in Tonkawa. *Phonology* 24 (3), 367–396.
- Hale, M., Reiss, C., 2008. *The Phonological Enterprise*. Oxford University Press, Oxford.
- Halle, M., Vergnaud, J.-R., 1987. *An Essay on Stress*. MIT Press, Cambridge, MA.
- Harrison, K., Kaun, A., 2001. Patterns, pervasive patterns, and feature specification. In: Hall, T. (Ed.), *Distinctive Feature Theory*. Mouton de Gruyter, Berlin, pp. 211–236.
- Hayes, B., 2009. *Introductory Phonology*. Wiley-Blackwell, Malden, MA.
- Hojjer, H., 1933. Tonkawa: an Indian language of Texas. In: Boas, F., Hojjer, H. (Eds.), *Handbook of American Indian Languages* 3. J.J. Augustin, New York, pp. 1–148.
- Hojjer, H., 1946. Tonkawa. In: Hojjer, H., Bloomfield, L., Haas, M., Halpern, A., Li, F., Newman, S., Swadesh, M., Trager, G., Voegelin, C., Whorf, B. (Eds.), *Linguistic Structures of Native America*. Viking Fund, New York, pp. 289–311.
- Hojjer, H., 1949. *An Analytical Dictionary of the Tonkawa Language*. University of California Press, Berkeley and Los Angeles, CA.
- Hyman, L., 1976. Phonologization. In: Juilland, A. (Ed.), *Linguistic Studies Presented to Joseph H. Greenberg*. Anma Libri, Saratoga, pp. 407–418.
- Inkelas, S., 1998. The theoretical status of morphologically conditioned phonology: a case study of dominance effects. *Yearbook of Morphology* 1997, 121–155.
- Inkelas, S., 1999. Exceptional stress-attracting suffixes in Turkish: representations vs. the grammar. In: van der Hulst, H., Kager, R., Zonneveld, W. (Eds.), *The Prosody–Morphology Interface*. Cambridge University Press, Cambridge, pp. 134–187.
- Inkelas, S., Orgun, C., 1994. Level economy, derived environment effects and the treatment of exceptions. In: Wiese, R. (Ed.), *Proceedings of a Workshop on Recent Developments in Lexical Phonology*, Heinrich-Heine Universität, Düsseldorf, pp. 63–90.
- Kager, R., 1999. *Optimality Theory*. Cambridge University Press, Cambridge.
- Kager, R., Pater, J., Zonneveld, W., 2004. Introduction: constraints in phonological acquisition. In: Kager, R., Pater, J., Zonneveld, J. (Eds.), *Constraints in Phonological Acquisition*. Cambridge University Press, Cambridge, pp. 1–53.
- Kenstowicz, M., 1994. *Phonology in Generative Grammar*. Blackwell, Oxford.

- Kenstowicz, M., Kisseberth, C., 1979. *Generative Phonology: Description and Theory*. Academic Press, New York.
- Kiparsky, P., 1972. Explanation in phonology. In: Peters, S. (Ed.), *Goals of Linguistic Theory*. Prentice-Hall, Inc., Englewood Cliffs, NJ, pp. 189–225.
- Kiparsky, P., 1982a. Lexical Morphology and Phonology. In: Yange, I.-S. (Ed.), *Linguistics in the Morning Calm*. Hanshin, Seoul, pp. 3–91.
- Kiparsky, P., 1982b. Word-formation and the lexicon. In: Ingemann, F. (Ed.), *1982 Mid-America Linguistics Conference Papers*, Department of Linguistics, University of Kansas, Lawrence, KS, pp. 1–29.
- Kiparsky, P., 1993. Blocking in non-derived environments. In: Hargus, S., Kaisse, E. (Eds.), *Studies in Lexical Phonology*. Academic Press, San Diego, CA, pp. 277–313.
- Kiparsky, P., 2000. Opacity and cyclicity. *The Linguistic Review* 17 (2-4), 351–367.
- Kisseberth, C., 1970a. On the functional unity of phonological rules. *Linguistic Inquiry* 1, 291–306.
- Kisseberth, C., 1970b. Vowel elision in Tonkawa and derivational constraints. In: Sadock, J., Vanek, A. (Eds.), *Studies Presented to Robert B. Lees by His Students*. Linguistic Research, Edmonton, Alberta, pp. 109–137.
- McCarthy, J., 1998. Morpheme structure constraints and paradigm occultation. In: Gruber, M., Higgins, D., Olson, K., Wysocki, T. (Eds.), *CLS 32.2: The Panels*. Chicago Linguistic Society, Chicago, IL, pp. 123–150.
- McCarthy, J., 2002. *A Thematic Guide to Optimality Theory*. Cambridge University Press, Cambridge.
- McCarthy, J., Prince, A., 1993. Generalized alignment. In: Booij, G., van Marle, J. (Eds.), *Yearbook of Morphology*. Kluwer, Dordrecht, pp. 79–153.
- McCarthy, J., Prince, A., 1995. Faithfulness and reduplicative identity. In: Beckman, J., Walsh Dickey, L., Urbanczyk, S. (Eds.), *Papers in Optimality Theory*. GLSA, Amherst, MA, pp. 249–384.
- McCarthy, J., Prince, A., 1999. Faithfulness and identity in Prosodic Morphology. In: van der Hulst, H., Kager, R., Zonneveld, W. (Eds.), *The Prosody–Morphology Interface*. Cambridge University Press, Cambridge, pp. 218–309.
- Mohanan, K., 2000. The theoretical substance of the optimality formalism. *The Linguistic Review* 17 (2-4), 143–166.
- Myers, S., 1987. Vowel shortening in English. *Natural Language and Linguistic Theory* 5, 485–518.
- Myers, S., 1991. Persistent rules. *Linguistic Inquiry* 22, 315–344.
- Ohala, J., 1981. The listener as a source of sound change. In: Masek, C., Hendrick, R., Miller, M. (Eds.), *Papers from the Parasession on Language and Behavior*. Chicago Linguistic Society, Chicago, IL, pp. 178–203.
- Ohala, J., 1993. The phonetics of sound change. In: Jones, C. (Ed.), *Historical Linguistics: Problems and Perspectives*. Longman, London, pp. 237–278.
- Paster, M., 2004. Vowel height harmony and blocking in Buchan Scots. *Phonology* 21 (3), 359–407.
- Pater, J., Tessier, A.-M., 2005. Phonotactics and alternations: testing the connection with artificial language learning. In: Flack, K., Kawahara, S. (Eds.), *University of Massachusetts Occasional Papers in Linguistics*, vol. 31. Graduate Linguistics Students' Association, Amherst, MA, pp. 1–16.
- Peperkamp, S., 2005. A psycholinguistic theory of loanword adaptations. In: Ettliger, M., Fleisher, N., Park-Doob, M. (Eds.), *Proceedings of the 30th Annual Meeting of the Berkeley Linguistics Society*. Berkeley Linguistics Society, Berkeley, CA, pp. 341–352.
- Peperkamp, S., Dupoux, E., 2003. Reinterpreting loanword adaptations: the role of perception. In: Solé, M., Recasens, D., Romero, J. (Eds.), *Proceedings of the 15th International Congress of Phonetic Sciences*. Causal Productions, Adelaide, pp. 367–370.
- Prince, A., Smolensky, P., 1993. *Optimality Theory: Constraint Interaction in Generative Grammar*. Technical Report RUCCS. Rutgers University, New Brunswick, NJ.
- Robinson, O., 1976. A 'scattered' rule in Swiss German. *Language* 52 (1), 148–162.
- Smolensky, P., 1996. The Initial State and 'Richness of the Base' in Optimality Theory. Technical Report JHU-CogSci-96-4. Cognitive Science Department, Johns Hopkins University.
- Stanley, R., 1967. Redundancy rules in phonology. *Language* 43 (2), 393–436.
- Steriade, D., 1995. Underspecification and markedness. In: Goldsmith, J. (Ed.), *The Handbook of Phonological Theory*. Blackwell, Oxford, pp. 114–174.
- Vago, R., 1976. Theoretical implications of Hungarian vowel harmony. *Linguistic Inquiry* 7 (2), 243–263.
- Vaux, B., 1998. *The Phonology of Armenian*. Oxford University Press, Oxford.
- Vaux, B., 2005. Formal and empirical arguments for Morpheme Structure Constraints. In: Paper Presented at the Linguistic Society of America Annual Meeting.
- Vaux, B., 2008. Why the phonological component must be serial and rule-based. In: Vaux, B., Nevins, A. (Eds.), *Rules, Constraints, and Phonological Phenomena*. Oxford University Press, Oxford, pp. 20–61.
- Vaux, B., 2010. *Conspiracy Theory*. MS. University of Cambridge.
- Wölck, W., 1965. *Phonematische Analyse der Sprache von Buchan*. Carl Winter, Universitätsverlag, Heidelberg.
- Youssef, I., 2010. Laryngeal assimilation in Buchan Scots. *English Language and Linguistics* 14 (3), 321–345.
- Zoll, C., 1996. *Parsing Below the Segment in a Constraint Based Framework*. Ph.D. Dissertation, UC Berkeley.