The SPE-heritage of Optimality Theory

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Abstract

In this article, we start out discussing the issue of how many phonological levels one might like to distinguish. In addition, we discuss how each level is characterized and how the mapping between levels is handled. Then, against the background of a more general discussion of constraint-based approaches to phonology, we assess phonological Optimality Theory (OT), arguing that this theory is formulated within the conceptual framework of Standard Generative Phonology (SGP) and thus has not freed itself from its SPE-heritage. By implicitly adopting many aspects of SPE (such as an intra-lavel input/output distinction and one holistic mechanism), OT compares unfavorably with other available constraint-based models in needing the notion of extrinsic ordering and failing to characterize the notion of what a possible language is.

1. Introduction

The purpose of this article is to assess phonological *Optimality Theory* (OT) in the context of a broad discussion of both other constraint-based phonological theories as well as the preceding derivational theories that stem from the tradition of *The Sound Pattern of English* (SPE; Chomsky and Halle 1968). Our main conclusion will be that OT is closer in its basic design to SPE than to the other constraint-based models that are its contemporaries.

In section 2 of this article, we first discuss different views of phonological levels of representation, converging on a view that acknowledges more than one level, while lacking the notion of an intra-level input/output distinction. Then, in section 3, against the background of a more general discussion of constraint-based approaches to phonology, we critically evaluate phonological OT, focussing on its input/output distinction, the notion of faithfulness and the issue of constraint ordering, i.e. the critical trademarks of OT. Section 4 offers our conclusions.

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2. Rule types and levels

A theory of phonology can be seen as comprising three parts (cf. Goldsmith 1993): a theory of *levels* (e.g., lexical, phonological, phonetic), a theory of *representations* (for each level, including *intralevel rules* or *constraints* that apply to or characterize phonological representations) and a theory of the relationship or *mapping* between levels. In this section, we will discuss a view on the overall architecture of phonology, which will provide us with a general frame of reference for discussing a number of actual theories such as declarative phonology, constraint-and-repair type theories, government and head-driven phonology, SPE-type theories and, finally, phonological optimality theory.

2.1. Levels of representations

Phonological generalizations can be classified in terms of various properties such as their 'motivation' (morphological, phonotactic, phonetic,) the kind of operation (deletion, insertion etc.) being neutralizing or allophonic, and so on. Depending on how a theory weighs these properties, different classes of rules will be formally distinguished. Two rules may be considered as belonging to different rule classes in one theory, while they form part of the same class in another. Usually, each class of rules defines a separate level. The discussion in this section will take, as its point of departure, some of the kinds of regularities or rule types that have been distinguished in traditional structuralist theories.

2.1.1. Allophony. In structuralist theories, complementary distribution of (surface) phonological segments (acknowledged in a narrow phonetic transcription) leads to postulating a set of invariant phonemes from which the surface segments (called allophones) are derived by rules. Allophony may be non-neutralizing (i.e., the surface segments are unique to one phoneme) or neutralizing (some of the allophones of different phonemes are identical).

If allophones and phonemes are taken to be formal objects of the same type (i.e. bundles of features), allophones will be either identical to the phoneme or differ from the phoneme in having extra feature-specifications or lacking feature-specifications. Usually, it is assumed that the phoneme is identical to the allophone that has the least restricted distribution (as stated in the 'elsewhere case'). We use, for example in English, /p/ for a phoneme and [p], [p^h] (among others) for its allophones, although the notation using square brackets should not be taken to imply that allophones are actual speech events. In both cases the symbols represent constellations of features (unordered bundles or more fancy, arboreal objects).

If allophony rules are recognized as a distinct class, this may lead to postulating two levels: the phonemic level and the allophonic level (sometimes called, the phonological and phonetic level).[1] Alternatively, we can regard these two levels as the input and output representations of one level. We will get back to the difference between these two views immediately below.

2.2. Redundancy

We now focus on regularities that do not involve multiple allophones. Firstly, we look at paradigmatic contextual rules for properties that are predictable on the basis of other properties of the same segment. Such predictable properties can be left unspecified in the phonemic representation. This means that, in that case, the phoneme is not identical to its (only) surface realization. An example of this situation is the case where all back (non-low) vowels are round so that roundness can be predicted on the basis of backness.

Assuming that the phonemic representation does not need to specify roundess for non-low back vowels, the question could be raised why the addition of roundness is not also a matter of *allophony*. Usually, the idea has been adopted that the addition of a property in all occurrences of a phoneme is *not* due to an allophonic rule. Rather it is said that a rule of this type belongs to a class of rules that *defines* the set of phonemes and thus the phonemic level. The same point of view arises in the following type of case where, likewise, we have predictability without multiple allophony.

The (unique) allophone of some phoneme may have predictable properties *in some environment*. For example, the phoneme /s/ (in Dutch) has only one allophone [s]. However, in the context [_CC all feature values of the [s] are predictable. Again the question arises whether the rule(s) that predict all the relevant features of [s] are in the same class as allophony rules, and again, tradition has it that this is not the case. Again it is taken to be the case that the rules that fill out the [s] are statements about the distribution of phonemes, about the phonemic level. In this case, they say that in the context [_CC all phonemes except /s/ are prohibited.

Predictability (in terms of paradigmatic or syntagmatic context) that does not involve allophony (in the sense of complementary distribution), then, is expressed by a distinct class of rules called *redundancy rules*.

Redundancy rules can be construed as rules that map an underspecified (redundancy-free) level into a fully specified level. The first level is a not-fully specified *phonemic* level and the second is a fully specified *phonemic* level. Another perspective on redundancy statements is that they are redundancy *conditions*, the idea being that the phonemic level is fully specified from the beginning and that the redundancy rules merely indicate which values are predictable.[2]

1. The issue can be further complicated by separating neutralizing allophony and non-neutralizing allophony.
2. The amount of underspecification depends on the kind of feature theory that is used. In unary

If the set of redundancy rules (or conditions) is taken to define or characterize the phonemic level and if these rules or conditions are kept separate from allophonic rules that characterize multiple allophony, one might suggest that the latter class of rules characterizes the allophonic level. Thus, the two classes of rules characterize two different levels and instead of using the terms phonemic and allophonic, one might refer to these levels as the phonological and the phonetic level or the *lexical* and the *post-lexical* level, respectively.

Now if the phonological/lexical generalizations can be expressed as either rules or conditions, one might ask whether the phonetic/post-lexical level can also be characterized by a set of conditions stating what is wellformed at that level:

(1) Lexical level ⇔ wellformedness conditions

MAPPING

Post-lexical level ⇔ wellformedness conditions

The phonetic/post-lexical conditions could include those that govern prosodic, rhythmic and temporal organization of utterances. Since the regularities at the post-lexical level are dependent on production factors such as rate and style of speech and, in general, on sociolinguistic variables, each lexical representation corresponds with an infinite variety of post-lexical representations, each of which is characterized by its own set of conditions.

Since each layer is characterized by its own set of wellformedness conditions, we prefer to refer to them as separate levels, rather than as input and output of one level. The so-called mapping rules can now be construed as rules that express correspondences between objects on both levels. Thus the segment /p/ in English corresponds to various segment types at the phonetic level.[3]

Although we have not provided here a compelling argument for the two levels, we do believe that a separation of this kind is required. The separation of the lexical and the post-lexical level is, in general terms, motivated by the phenomenon of *opacity*. Opacity involves the fact that conditions on post-lexical wellformedness may contradict and thus obscure regularities at the lexical level, so that mismatches arise. These mismatches can involve segmental facts (e.g. segments that occur in the 'wrong' environment, or are missing) or structural facts (e.g., different hierarchical groupings).[4]

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feature systems we require less fill-in rules.

3. Below we argue that the classical separation of phoneme and allophone cannot be fully maintained. Certain allophonic effects must be integrated with the 'phonemic' level (thus causing the latter term to be inadequate).
4. The structural mismatches have been labeled structure paradoxes in van der Hulst (in press a). Kiparsky (this volume) also argues that segmental opacity effects can be reduced to mismatches between the lexical and post-lexical level.

2.2.1. Allomorphy. It is common to assume that the system of word-formation rules has access to free-occurring units ("words") as well as units that are not themselves necessarily complete words, i.e. morphemes. In particular, bound morphemes are not words by definition. Bound morphemes may be affixes or bases to which affixes must attach (sometimes called roots). Not being words themselves, the shapes of these units need not necessarily be in accordance with the wellformedness statements that bear on the word unit at the lexical-phonological level. Thus, there is no guarantee that a word that is formed out of such units is a wellformed word at that level. To deal with this, traditional accounts postulate a set of 'repair rules' that transform the phonological output of word-formation rules to conform to the wellformedness statements of words. As a consequence, the building blocks of morphology will occur in various forms. This phenomenon is called allomorphy.

Suppose, to take an imaginary case, that we have a prefix /p/ that can be attached to all nouns to indicate plurality. Adding this prefix to a noun that starts with two consonants already will lead to an illformed word if the language in question (like English and Dutch) has the regularity that the first consonant of a triconsonantal cluster must always be /s/. If the prefix /p/ is attached to the noun /trol/ leading to /p+trol/, a rule must apply to save the word. Various possibilities, in fact, exist:

(2)
- /p/ → /s/
- insert a vowel /a/ after the /p/
- insert a vowel /u/ before the /p/
- place the /p/ at the end of the word
- etc.
- do not attach /p/ at all (avoidance, blocking)

Clearly the *repair rules* listed here are not identical to the wellformedness statement that bars segments other than /s/ before two consonants. Following the tradition of standard generative phonology, in most generative accounts of such cases, however, one will find that the constraint is actually *built into* the repair rule as a context:

(3) /p/ → /s/ / [_CC

In this approach, then, adopted in Chomsky and Halle 1968 (SPE), conditions and repair rules are collapsed into one mechanism, the *phonological rule.* Given the above rule, we cannot, however, eliminate the condition 'no other segment than /s/ in the context [_CC' from the grammar, because, independent from the prefixing issue, this constraint expressed a generalization over the inventory of words, both derived and underived. Thus it would seem that phonological rules duplicate the conditions that, in a sense, they serve.

Singh (1987) advocates a response to this duplication problem that involves stripping the condition that motivates it from the repair rules. Thus, his analysis of our imaginary example would be:

(4) Constraint / Repair

$CCC \rightarrow [SCC$[5] $/p/ \rightarrow /s/$

It would seem that the most straightforward interpretation of the notion of repair rules is that of *inter-level mapping rules*. A repair rule applies to the output of the morphological component and transforms it into a representation which is well-formed at the lexical phonology, or, to state it in non-derivational terms: a repair rule establishes a correspondence relationship between a phonological string at the morphological level and a corresponding string at the lexical-phonological level. In addition, repair rules are needed when 'new' forms enter the lexicon for other reasons than being morphologically formed. New forms may be loan words, or they may result from processes such as blending or lexical innovation or creation (making up new words from scratch or by pronouncing acronyms).

If we regard the mapping rules that relate the morphological and the lexical level as repair rules, we might also view the mapping between the lexical and the post-lexical level as a form of repair. Thus a rule relating /poteto/ (lexical) to [pteto] (post-lexical) can be seen as a repair rule which is necessitated to get from the lexical to the post-lexical representation, triggered by a post-lexical wellformedness condition which states that there cannot be a pretonic unstressed vowel in a stranded syllable (or in a degenerate foot) (in the relevant style of speech).

The notion of 'repair' (i.e., 'doing or changing something') seems relevant when we think of the levels as derivational stages in a production model or perception model. Otherwise, if we abstract away from production and perception, we can simply think of the repair rules as static, bidirectional relationships stating correspondence relations (including mismatches) between different levels.

(5) Morphological level

MAPPING ("repair")

Lexical phonological level ⇔ conditions

MAPPING ("repair")

Post-lexical phonetic level ⇔ conditions

This "conditions-and-mapping" approach would not have been possible in SPE since it presupposes, in fact, conditions on words and utterances, rather than on morphemes. In SPE, however, there were no such higher level conditions; there were only morpheme conditions (both segmental and sequential). Since morpheme structure conditions may express properties that are also valid at the lexical level,

5. The constraint that bars any other segment than /s/ in the first position of a triconsonantal cluster is formulated here as an if-then condition.

the duplication problem still arose in that the context of many phonological rules seemed to be identical to morpheme structure conditions.

Once we recognize wellformedness conditions that hold for words at the lexical level, it can, in fact, be argued that morphemes themselves do not have a phonological wellformedness as such and that, therefore, we do not need morpheme structure conditions. This point has been argued for in a whole line of work (referred to in Singh 1987, and also discussed in Hooper 1976; a recent statement is in Paradis and Prunet 1993). As mentioned above, it is to be expected that morphemes will reflect the wellformedness constraint on words to some extent, because after all, their form is, acquisitionally speaking, acquired on the basis of their occurrence in actual words. A totally crazy form that is illformed in all its occurrences (that has entered the language by way of an act of God) will be repaired in all its occurrences and hence a next generation of language learners will have no evidence for postulating the crazy form; this course of events has recently been called *lexicon optimization* (Prince and Smolensky 1993). Hence, we conclude that there is no need for so-called morpheme-structure conditions. All we need are constraints that bear on words and post-lexical utterances.[6]

The picture developed so far is distorted by the fact that some repair rules relating to the morphological and the lexical level cannot be motivated in terms of the conditions on the wellformedness of words because, apparently, these repair rules only apply in certain morphologically derived environments. An example would be the rule of velar softening in English:

(6) $/k/ \rightarrow /s/ \ / - X$

The context 'X' can be specified in phonological terms (some high front vowel) or in morphological terms (*-ity* and some other suffixes). Such rules are not motivated by word-level conditions because there is no condition in English that bars the sequence ... kI ... (cf. the word *king, lucky*).[7]

Hence, we appear to have two types of repair rules in between the morphological and the lexical level: rules that 'serve' a condition on general word wellformedness (sometimes called phonotactically motivated rules) and rules that apply in morphologically derived contexts (morphologically motivated). How do we fit the latter type into the model developed thus far?

6. It may be the case that the set of morphemes reflects certain regularities that are not identical to regularities that occur at the word-level. Such regularities will be historical residues of word-level regularities that are no longer active. The important question is whether such morpheme structure conditions are psychologically real. We refer to Paradis and Prunet (1993) and Booij (1999) for discussion and arguments con and pro. In Natural Generative Phonology (Vennemann 1984, Hooper 1976), a class of rules called *via-rules* was proposed to express phonological generalizations at the M-level that language users may or may not be aware of depending on their level of etymological sophistication.
7. We also have *looking,* but this may be a result of relevant intra-word domains; cf. below.

An option is to say that we don't, i.e., that we deny morphologically motivated repairs the status of rules all together, the idea being that allomorphy that is not motivated by the phonotactic rules that govern the inventory of words is not created by repair rules. It has indeed been proposed that rules like the velar softening rule are relics of a phase of the language when a certain condition existed that is no longer valid, or that such rules have been 'imported' from another language along with vocabulary that contained the effect of those rules (because they served a condition in the donor language). However, to 'account' for allomorphy that is not phonotactically motivated, in this manner (which is essentially *not* accounting for it) may seem inconsistent in cases in which the morphological rule that triggers the allomorphy involved is *productive*. In that case, after all, the repair rule that comes with the morphological operations is also productive, and therefore in some sense 'real'. To deal with this problem, many have argued to make such productive 'repair rules' part and parcel of the morphological operation, and this approach makes sense to us. We will use the term *morpho-lexical* rules for such cases.[8]

The model that emerges from the discussion is the following. Words are stored in the lexicon in a fully specified 'phonemic' (but see below) form. There is a set of wellformedness conditions that characterizes the notion of a possible phonological word. This set of conditions can act as a device that checks the wellformedness of new forms. New forms can arise from productive morphology, lexical creation/innovation or borrowing. A constraint set, however, can do no more than determine whether a new form is illformed or wellformed. A possible response of the grammar to illformed products could be that they are simply not accepted or blocked. However, even though blocking sometimes occurs, we know that languages do not typically work like that. Rather the grammar has access to rules for repairing illformed forms, not only for the new words that morphology produces, but also for checking (limited) instances of lexical innovation, or for adapting loan words.[9]

Subsequent to producing the representation of a wellformed word, a word has to be pronounced (in isolation or as part of a larger utterance). The 'pronunciation' of a word is represented at the post-lexical level. At this level, a different constraint set rules the way, and it may therefore happen that a certain amount of repair is again necessary. We assume that the post-lexical or phonetic representation is a representation that provides all the information to get to an actual speech event. We take it that language-specific phonetics is represented at this level, whereas

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8. In this class, we must put all the so-called 'derived environments' rules, i.e. rules that repair strings that result from morphological concatenation, but leave identical strings in underived words unaffected. Also, we believe that so-called prosodic constraints on word-formation are part of this level in as far as the prosodic conditions are not independently motivated at the lexical-phonological level.
9. Repair rules that apply to loan words may or may not be independently needed for morphologically complex words.

'universal phonetics' is part of the 'machinery' that transforms the phonetic level to actual speech events.[10] Thus, the post-lexical level, like the deeper levels, is here regarded as cognitive in nature; it is not equated to the actual speech event.

(7) Morphological level (cum morpho-lexical rules)

MAPPING ("repair")

Lexical phonological level ⇔ constraints

MAPPING ("repair")

Post-lexical phonological level ⇔ constraints

Using terminology from Goldsmith (1993), we will say that the model sketched here acknowledges three *levels* of representation (the morphological, the lexical and the post-lexical level). In fact, Goldsmith (1993) and Lakoff (1993) propose phonological models that also appeal to three *levels*, referring to the models as *Harmonic Phonology* and *Cognitive Phonology*, respectively, and the current section owes a great deal to the views developed in those works. The following description of the three levels in harmonic phonology is taken from Goldsmith (1993: 32):

(8)
M-level: a morphophonemic level, the level at which morphemes are phonologically specified.
W-level: the level at which expressions are structured into wellformed syllables and well-formed words, but with a minimum of redundant phonological information; and
P-level: a level of broad phonetic description that is the interface with the peripheral articulatory and acoustic devices.

Each level in this model is subject to an unordered set of *intralevel* rules. Levels are related in terms of *interlevel* mapping rules. The three-way distinction that we have introduced here is rather similar to this model, in particular since, according to Goldsmith, intra-level rules are non-ordered. Likewise, we assume that the conditions that characterize wellformedness at the lexical and post-lexical levels are not extrinsically ordered. With respect to the notion of ordering, we will also assume (as do Goldsmith and Lakoff) that the mapping rules are not extrinsically ordered, but rather, that these rules state correspondences between elements at different levels in a parallel (rather than serial) fashion. In general, we believe

10. We prefer to use the term phonetic *interpretation* with reference to the mapping between the lexical and the post-lexical level, using phonetic *implementation* with reference to the step that takes the post-lexical representation into real speech events. This is perhaps similar to the distinction Hale (this volume) makes between cognitive phonetic representation and acoustic/gestural phonetic representation.

that the need for extrinsic ordering arises in models that do not separate intralevel wellformedness conditions from interlevel mapping (i.e., models such as SPE and Optimality Theory to be discussed in section 3).

The most important difference between our conception and the one in (8) is perhaps whether or not we have a set of conditions that state wellformedness at the M-level (i.e., morpheme structure conditions). We suggested that such conditions are perhaps not necessary and rather see this level as the phonologically specified output of the morphological component (cf. footnote 6). Despite this difference, and other potential smaller differences between the details of fleshing out the levels, we will adopt Goldsmith's abbreviations for the three levels in the above (essentially similar) conception of phonology.

We wish to conclude this section with discussing a particular issue that concerns the lexical or W-level. In English and other languages, the morphology creates two cycles that seem relevant for W-level phonological conditions. One cycle is the output of so-called class 1 morphology, while the second is the output of class 2 morphology. The latter class, we assume, includes certain types of affixation (*-hood*, *-ness*), inflection and compounding. The output of class 1 is governed by certain regularities that are preserved after class 2 morphology is applied. These regularities apply equally to underived words and words derived by class 1 morphology. In addition to the W-level conditions that seem limited to the domain created by class 1 morphology, there are conditions that make reference to the larger domain that is created by the class 2 morphology.[11] However, as is well known, most of the W-level phonological conditions bear on the smaller domain.[12] Following SPE, Borowsky (1994) refers to this level as the *word-level.*[13] She discusses a specific class of generalizations that makes reference to this domain, and it is this class that we wish to draw attention to here. In the beginning of this section, we implicitly assumed that all allophonic variation is factored out from the lexical or W-level. However, this cannot be maintained in view of the facts that some allophonic variation is crucially conditioned within the smaller, synthetic domain.

11. Kaye (1992, 1995) refers to the smaller domain and the larger domain as *synthetic* and *analytic*, respectively. The synthetic/analytic distinction differs from the level 1/2 distinction in that the former is not an inherent property of affixes, although there are regular correlations. Despite these correlations, a certain affix that is regularly analytic may be synthetic in specific words. (This expresses what traditionally is meant by 'lexicalization'.) Kiparsky (this volume) makes a comparable distinction between the *stem* and the *word* domain.
12. We do not discuss here whether the parts of the analytic domain are, by themselves, all synthetic domains, or whether we must make a distinction between [[x][y]] (two synthetic domains, e.g. for compounding) and [[x]y] (one synthetic domain, e.g. for affixation).
13. For us, this term is confusing because Borowsky's word-level refers to the *synthetic domain* within our W-level.

An early discussion of such allophonic variation is found in Strauss (1982).[14] In certain dialects of American English, there is a complementary distribution between [æ] and [a] such that [a] occurs before tautosyllabic /r/, while [æ] appears in open syllables:

(9) bar [bar] barrister [bæ.rɪ.ster]
car [kar] carry [kæ.riy]
par[par] parity [pæ.rɪ.Diy]

However, this regularity does not hold in words derived by level 2 suffixes:[15]

(10) jar [dzar] jarring [dza.rɪŋ]
star [star] starry [sta.riy]
tar [tar] tarrer [ta.rər]

Crucially, this generalization cannot be stated at the post-lexical level on the assumption that the syllabification of words like *carry* and *starry* is not different at that level. Hence, the generalization must be stated at the lexical level with reference to the smaller domain.

Such cases are interesting for two reasons. Firstly, they illustrate that allophonic variation can be part of the lexical phonology and thus, that it is not the case that all allophonic variation is post-lexical. In other words, it is true that all lexical rules are "structure preserving" or neutralizing. Secondly, they show that lexical conditions are, in fact, subject to a distinction between the two domains.

Given the conclusion that the allophonic [a]–[æ] variation must be encoded at the lexical W-level, one must now ask whether other cases of allophonic variation, e.g., aspiration in English is lexical or post-lexical. Each case must be inspected in its own right. We have no conclusive answer for the English aspiration case. Aspiration could be lexical, and it probably is, if our intuition is correct, that in a word like *canapé* (synthetic), the last consonant is aspirated, while in *galopping* (analytic) the penultimate consonant is not. Both words seem to have the same rhythmic structure so that the /p/ in both cases is followed by a strong syllable. *Canapé* would form a synthetic domain by itself ([kǽnəpè]), but *galopping* would be analytic such that the /p/ is final in the small domain rather than being followed by a rhythmically strong vowel ([[gǽləp]ìŋ]). Hence the condition for aspiration is met in *canapé*, but not in *galopping*.[16]

A rule like flapping, on the other hand, seems uncontroversially post-lexical since it does not appear to be sensitive to the synthetic/analytic distinction. Moreover, as opposed to aspiration, flapping is suppressable (or 'optional'). Rules that

14. In fact, Strauss used these regularities to argue in favor of morpheme structure conditions. We, however, regard them (following Borowsky 1994) as synthetic word-level conditions.
15. Interestingly, truncated forms maintain the [æ]: Harry [hæ.riy] – Har [hær]. We regard truncations as a post-lexical word-formation process.
16. An alternative, post-lexical account would be based on the idea that the final vowel in *canapé* is full, while the final vowel in *galopping* is reduced and therefore not strong.

are sensitive to the synthetic/analytic distinction must be lexical (even when allophonic), but rules like flapping, that are not, can be treated as post-lexical.[17]

2.3. *Constraint-based models*

The general idea of separating wellformedness conditions and repairs (or mapping) has been advanced in several models, which may differ, however, in the number of levels that are postulated.[18] We will not discuss all these approaches in detail here (cf. LaCharité and Paradis 1993; Bird 1995 for further discussion) but mention only some of them briefly. Earlier, we already mentioned the models proposed by Goldsmith and Lakoff. The general term for the wellformedness conditions in these types of works is *constraints*.

2.3.1. Constraint-and-repair phonology. Singh (1987) proposes a model of phonology that is very much like the one we have sketched above. He also proposes to relegate morphologically-motivated repair rules to the morphology and he leaves room for stylistic processes, which we read as 'post-lexical processes'. Singh discusses a lot of earlier work that paved the way for his line of thinking (e.g., Hockett 1955; Kisseberth 1970; Shibatani 1973; Sommerstein 1974; and others). Furthermore, he pushes the idea that certain repairs, or the choice between potential repairs, can be predicted (universally, or for the language under study), so that sometimes the repairs themselves need not be stated in the grammar. This is, in fact, an important point. It would seem that the array of repairs is, in general, very limited, and it is therefore possible that all repairs are predictable if enough is known about the grammar in which they occur.

The model of Paradis (1988 and later work) also formally separates constraints and repairs. Paradis explicitly addresses the issue of *conflict resolution*. Potential conflicts between repair rules are resolved by assuming that repairs that are motivated by constraints on larger constituent types take precedence over repairs that are motivated by constraints that bear on smaller constituent types. In her model, constraints can thus be violated in case the repair of some constraint A violates some other constraint B in which case the repair will not happen if B bears on a larger domain than A. In appealing to a notion of repair, Paradis' theory assumes at least two levels, the M-level and a phonological level that is under the control of constraints. Her theory also seems to make reference to a lexical and a post-lexical level, but even though it allows for certain constraints to be limited to certain 'lexical strata', both 'levels' are not kept apart as clearly as in the model we discussed

17. Cf. Kiparsky (1985) and Kaisse & Shaw (1985) for a discussion of the lexical/post-lexical distinction in terms of properties that rules have at either level.
18. Sometimes, the issue of levels is not explicitly discussed.

in section 2.1. Rather, the lexical/post-lexical distinction seems to be embedded in the fact that constraints refer to different layers in the prosodic hierarchy.

2.3.2. Declarative phonology. In several works (Scobbie 1997; Bird 1990, 1995; Coleman 1995) a model is proposed that advocates phonological generalizations in terms of surface-true (i.e. non-violable) constraints.[19] Being surface-true, constraints cannot contradict each other (except when they stand in an elsewhere relationship, in which case the more specific formula takes logical precedence). All structure and specification that is general is left unspecified and 'filled in' by unifying the lexical items with the constraints.[20] The declarative phonology model does not allow 'repair' rules nor does it make a distinction between levels. Thus, instead of separating an M- and W-level to account for wellformedness of morphologically derived words, and thus allomorphy, declarative phonology must crucially rely on underspecifying morphemes in ingenious ways, or postulate morphemes with disjunctive representations (with the result that the allomorphs are essentially lexically listed). With respect to potential mismatches between the W- and the P-levels, declarative phonology appeals to a concept of phonetic interpretation, thus treating the P-level as the actual speech event rather than as a level of representation.[21]

2.3.3. Head-driven phonology. We now briefly turn to our own views. *Head-Driven Phonology* (HDP) (van der Hulst and Ritter 1999, 2000a, 2000b, in prep) is a development of *Government Phonology* (GP; Kaye, Lowenstamm and Vergnaud 1990; Kaye 1992, 1995) and *Dependency Phonology* (Anderson and Ewen 1987). HDP essentially incorporates the three levels of representation discussed in section 2.1, although the focus of attention in HDP (and work in government and dependency phonology) has been on the lexical W-level.[22]

We have already established that the so-called M-level is probably 'not interesting' from a phonological point of view in that it merely gives us the phonological shape of lexical entries (words and morphemes); cf. footnote 6. The W-level differs from the M-level in containing the result of a computation which involves the assignment of a structural description to the phonological string of the M-level representation. This structural description essentially determines the pronunciation of

19. The requirement for rules being surface-true was proposed earlier by Hooper (1976) in the model of Natural Generative Phonology, based on Vennemann's work (e.g. 1984).
20. This creates a harmless input/output distinction in the sense that the input is properly contained in the output; no information is destroyed.
21. Ogden (1995, 1999) offers a declarative phonology formalization of Firthian phonology, which, according to him, embodies an explicit view on the issue of phonetic implementation.
22. Proponents of GP have not explicitly accepted the three levels that we have argued for, but this may simply be a matter of not having discussed the relevant issues in detail. The M-level and the P-level (as understood above) are simply implicit in the government model.

the phonological units that make up the string and, in that sense, it is sometimes (misleadingly) called the 'phonetic interpretation'.[23]

The structural description at the W-level is characterized by an unordered set of statements or propositions in the sense explained by Mohanan (this volume). These statements take the form of general *principles* (which may, in fact, also be applicable in other components of the grammar) and parameters that have been set for a particular value. Taken together, these statements determine the well-formedness of strings at the W-level. We propose a typology of the principles and parameters that hold at the W-level in van der Hulst and Ritter (1999), arguing that all constraints make reference to a head – dependency relationship between units in the representation; in this sense, we regard the phonology as being 'head-driven'.

We could refer to HDP as a *constraint-based* model, since there are no intra-level serial derivations involved in the phonological computation. Despite this strictly technical, *correct* use of the notion constraint, we are reluctant to refer to the set of principles and parameters in HDP as 'constraints' because of the fact that in optimality theory (discussed below), constraints are often rather ad hoc descriptions of obligatory or disallowed output configurations. Principles and parameters, on the other hand, characterize structural and thus more abstract configurations.

Bearing in mind the old (but still relevant) abstractness issue (discussed in section 3.1.2.), HDP recognizes the need to constrain the distance between the different levels, especially between the M- and the W-level. Its goal is to postulate no language-specific mapping rules at all (cf. Singh's point above). Thus, with respect to the *mapping* of the M-level onto the W-level, in practice, only very limited use has been made of 'repair' rules. This is a consequence of the assumption that the M-level incorporates, as *lexically listed* units, many words that would be treated as *derived* in theories like SPE (and OT). For example: *electricity* and *electric* are both listed, and we therefore do not need a velar softening repair rule. As argued in section 2.2., the *k/s* alternation can be incorporated in the morphological rule for *–ity* affixation. As such it is not a phonological statement, but a morphological statement. Thus, HDP (following GP and models such as Natural Generative Phonology) takes a rather conservative view with respect to the notion of morphological derivation and, at the same time, a concrete view with respect to the phonological specification of lexical entries. Using terminology introduced in section 2.2., words that have morphological composition *and* that are lexically listed constitute "synthetic domains"; the phonological computation treats these complex words on a par with underived words. Complex words, whose morphological structure is visible to the phonology are called "analytic", and here it may happen that a certain amount of "adjustment" or repair must be applied at morpheme boundaries. For example, at the edge of morphemes, some 'overlapping' empty

23. However, the *actual* phonetic interpretation takes place in the mapping onto the post-lexical representation which we have, in fact, referred to as the phonetic interpretation (cf. footnote 10).

structure sometimes needs to be removed (cf. Yoshida 1993). Apart from such marginal adjustments (which may be a matter of general convention), the W-level differs from the M-level only in the *addition* of structural head – dependency relationships that tie everything together and determine the pronunciation of the string. Thus, the bulk of the mapping (if not all of it) involves the addition of *structural information*, rather than information-changing operations. In many cases, where other theories would postulate destructive repair rules involving deletion or insertion, these effects are derived in HDP and GP from the structural relations that are assigned at the W-level string. This is so because these relations inform the phonetic interpretation to not pronounce certain segments ('deletion') or to pronounce certain unlicensed empty positions ('insertion').

The distinction between a W-level and a P-level is not usually made explicit in government phonology. However, one might argue that the P-level is, in fact, the phonetic interpretation of the W-level. With respect to the mapping from W- to P-level, we have mentioned earlier, and shown elsewhere, that this mapping can involve segmental mismatches that are generally known as *opacity effects* (van der Hulst and Ritter 2000a).[24] Other types of mismatches are structural. Mismatches can arise because the P-level may be under the control of wellformedness conditions that are not valid at the W-level, or vice versa. Thus, a certain string may be structured differently at the two levels creating the effect of a *structure paradox* (cf. van der Hulst in press a). For example, a W-level wellformedness condition in English states that lax vowels must be followed by a tautosyllabic[25] consonant. Thus the string *happy* is syllabified at the W-level as [hap][y]. The subcategorization condition for lax vowels overrules the principle of *Coda Licensing* which yields the effect of onset maximization (i.e. by the elsewhere principle because it is more specific). At the P-level, we assume there is no subcategorization requirement for lax vowels. Here, some onset principle ("assign an onset to a following vowel if possible") rules the way. The same string *happy* will now be parsed differently: [ha][py] (or perhaps the P-level allows improper bracketing so that we get [ha[p]y]).[26]

Van der Hulst (in press b) proposes to regard the P-level as *post-lexical*, i.e., as referring to the output of the syntactic component. He assumes that every W-level structure corresponds to an infinite set of P-level representations if the P-level takes into account effect of style and rate of speech (cf. Anderson and Ewen 1987). Van der Hulst (in press b) also proposes that what is usually called prosodic structure (involving different domains and rhythmic organization) forms part of the

24. The P-level is as cognitive as the W-level, and it must therefore not be thought of as the actual speech event, which we take to be the result of phonetic implementation.
25. We assume that this consonant *must* be tautosyllabic in order for this type of 'subcategorization' to be locally satisfied within the constituent that contains the lax vowel.
26. Selkirk (1982) proposed that exactly this mismatch defines a so-called ambisyllabic consonant. For this analysis of lax vowels in Dutch see Trommelen (1983).

post-lexical, P-level structure. In practice, phonologists limit their attention to one post-lexical representation, perhaps to be characterized as belonging to a 'careful' style of speech.

3. Phonological Optimality Theory

In this section, the focus is on discussing another constraint-based model, phonological *Optimality Theory* (OT). This model is, in many ways, not only a response to, but also (much more than the other constraint-based models discussed thus far) a *continuation* of the model of The Sound Pattern of English (SPE, Chomsky and Halle 1968). To drive that point home, we start with a brief discussion of the SPE-model.

3.1. SPE (and descendants)

3.1.1. Levels. In SPE, a holistic set of phonological rules relates two 'levels', called the *underlying* (or systematic phonological) and the *surface* (or systematic phonetic) level, respectively. The surface, phonetic level was formally distinct from the phonological level in allowing scalar values of the features. It must be said, however, that even though SPE refers to the surface level as 'phonetic', in practice this level was far too abstract to count as the input to a universal phonetic implementation component. Rarely would analyses refer to scalar features.[27] In reality, the surface level looked more like a phonological representation that was simply closer to the phonetic form than the underlying representation.

Below the underlying phonological level, SPE postulated a distinct *dictionary level*. This level differed formally from the underlying phonological level in allowing unspecified features, as well as features marked with 'm' (marked) and 'u' (unmarked) or with '+' and '−'. Features at the phonological level had to be fully specified, in terms of '+' and '−' values by an unordered set of feature-filling 'marking conventions' and 'redundancy rules'. To the extent that all three 'levels' (dictionary, phonological, phonetic), in practice, were built from the same basic vocabulary and had the same formal properties, it was not unusual to regard them as different *representations* characterizing *one level*. Thus we can summarize the SPE theory as follows:

27. Except in the case of stress, when this was still thought of as corresponding to segmental features. Here, however, we were dealing with a different type of scalar distinction than in the case of, say, [1 nasal], [2 nasal] and so on.

(11) *The phonological level ('early' or pre-SPE)*

lexical representation (underspecified)
| Fill-in rules (intrinsically ordered)
underlying representation (fully specified)
|
intermediate representations Phonological rules (extrinsically ordered)
|
surface representation

Observe that the P-rules, being extrinsically ordered, create a set of intermediate representations. However, SPE did not attribute any privileged status to any of these intermediate representations.

In a later development (already incorporated in Chomsky and Halle 1968), the distinction between the dictionary level and the phonological level was eliminated. Only the latter was maintained, being fully specified, and redundant values were encoded in a set of *morpheme structure conditions* (MSCs). In this version of the SPE-model, the underlying representation requires the properties of a level by being characterized by an independent set of phonological conditions:

(12) *The phonological level (SPE)*

underlying representation (fully specified) MSCs
|
intermediate representations Phonological rules (extrinsically ordered)
|
surface representation

In still later developments following SPE (Ringen 1977; Kiparsky 1982; Archangeli 1984), phonologists assumed, as SPE did, that there was no real distinction between the underspecified dictionary level and the fully specified underlying representation, but this time it was proposed to eliminate the latter rather than the former. Thus they restored the morpheme structure conditions as rules that fill in feature-values, and they put them in the same class as the phonological rules that modify the input representation. In this conception, there are only two significant representations, the underlying phonological input, which is operated on by a set of rules that fill in, spread and remove feature-values in order to produce the surface phonetic output, and the representation of the surface phonetic output:

(13) *The phonological level ('late' or post-SPE)*

underlying representation (underspecified)
|
intermediate representations Phonological rules (ordered[28])
|
surface representation

The need for extrinsic ordering came from a couple of related sources. Firstly, there are what we would call *genuine opacity effects*, which, from our perspective result from mismatches between the W- and the P-level. If no levels are distinguished, one is bound to end up with extrinsic ordering in order to account for such mismatches. Secondly, the need for extrinsic ordering in SPE was further enhanced by also including in the holistic set of rules those rules that we have called morpho-lexical rules in section 2.2., and especially by the desire to formulate these rules in purely phonological terms, rather than allowing them to make reference to grammatical (i.e., morphological and lexical) information. This, of course, was part of the holistic program that tried to account for phonological patterns in terms of one formal mechanism, the phonological rule. Thirdly, and related to the second point, extrinsic ordering was required because the underlying representations (necessary to express all relations in phonological terms) could become very 'abstract' (in the sense of being quite remote from the surface forms) because there were no realistic limitations on the notion of lexical relatedness. The second and third reason for extrinsic ordering involve what we call *fake opacity effects*, i.e., opacity effects that will not appear in models that do not attempt to 'phonologize' all cases of allomorphy in terms of derivations from overly abstract input forms.

The move toward complete holism (shown in 12) was counterbalanced by introducing the distinction between a lexical and a post-lexical level (cf. Kiparsky 1982, 1985; Kaisse and Shaw 1985). According to this idea, the phonological derivation involves two levels, each with several representations:

(14) *Two phonological levels* (Lexical phonology)

lexical level

input lexical representation

|

intermediate representations — lexical rules (extrinsically ordered)

|

output lexical representation

|

post-lexical level

input post-lexical representation

|

intermediate representations — post-lexical rules (extrins. ordered)

|

output post-lexical representation

In some versions of this theory, the lexical mapping is split up into two phases which are defined in terms of two different classes of word-formation rules (Class

28. Ringen (1977) did not allow extrinsic ordering, which, in effect, makes her model constraint-based.

1 and Class 2 affixation). In section 2.2., we acknowledged this distinction, not in terms of levels, but in terms of domains that are a part of the lexical level. In the same spirit, Inkelas (1989) proposed to replace the two 'phases' in the lexical derivation by lexical-prosodic or phonological domains. In the model proposed by Inkelas, morphological rules create two different types of domains, which are of relevance for the application of phonological rules. This approach implies that there is only one mapping from the lexical input representation to the lexical output representation, as far as the lexical level is concerned.

3.1.2. How abstract is the input? In the above discussion, we have made a distinction between the notion of *level* and the notions of (intra-level) *representations* (cf. Goldsmith 1993). The model in (14), for example, has two levels (lexical and post-lexical) and each level has a number of representations including an input, intermediate ones and an output representation. In the model that we sketched in section 2.2., on the other hand, we have three levels, each one being characterized by *one* representation. Thus, in a model of the latter type we do not refer to input and output representations, because there is no *intra*-level derivation that creates two representations at any given level.

In SPE (and descendants), each level seems to involve a distinction between input and output, mediated by a *serial* derivation involving ordered rules and intermediate representations. The nature of neither inputs nor outputs is, in itself, self-evident. Therefore, distinguishing between an input and an output leads to two questions:

(15) a. How abstract (i.e., deep, remote from the output) is the input
b. How concrete (i.e., how 'phonetic') is the output

In the SPE 'period', discussions on the nature of inputs prevailed because this model put all explanatory burden on inputs. A guiding idea was that maximal generality of analysis could be obtained by *relating* as many surface forms as possible, where 'relating' meant deriving surface forms from the same input. With no independent (morphological, phonological or semantic) criterion for relatedness, this strategy, in principle, opened the door for deriving the entire lexicon from one input. Although nobody made that extreme proposal, some analyses went very far in the postulation of inputs that were far removed from all of their corresponding outputs (e.g., Lightner 1972). Various proposals were made to prevent such excesses.[29] Clearly, as might be expected, pushing lexical relatedness very far leads to formulating a lot of rules that account for segmental changes that are not required from the viewpoint of the surface wellformedness of the language. In many

29. Kiparsky (1968) initiated the idea that the input form should be identical to at least one of the related outputs. This was called the *Alternation Condition*. However, the same result was obtained in terms of Ringen's (1977) proposal to restrict feature-changing rules to derived environments.

cases, the rules recapitulate the historical developments, and, as pointed out above, extrinsic ordering was required to control their 'synchronized' historical order of application.

With the focus of SPE being on the explanatory force of the input, not much ink was spent on the exact nature of the output. In practice, as we have seen above, the output was a 'phonetic' representation that was still pretty far removed from the articulatory mechanisms underlying a physical acoustic event. In fact, SPE postulated a class of phonological rules that would convert binary feature specifications into more 'phonetic' representations that would involve multi-valued feature-specifications. Such rules were seldomly spelled out in analyses. Thus, the output level would in practice be a careful pronunciation of isolated words. This changed somewhat when more attention was directed toward phrasal and sentence-level (or post-lexical) phonology; but, still the notion, and in particular the concreteness, of the output level, which was called the *phonetic* representation, was never clearly defined. Then, in the seventies, gradually more attention was given to outputs, not so much to their phonetic properties, but rather to fact that there is a distinct class of wellformed conditions that governs outputs.

Kisseberth (1970) pointed out that it could easily happen that different phonological rules would perform operations that all conspired to avoid (or create) a certain output configuration. For example, suppose that a language disallows consonant clusters on the surface and that this language has various morphological processes that produce CC clusters. We could imagine that in different environments, different rules repair the illformed CC string:

(16)	Suffixation:	CVC + CV	⇒ CVCV	+ CV	V-insertion
	Suffixation:	CVC + C	⇒ CV	+ C	Final C deletion
	Prefixation:	C + CV	⇒ C + VC		Metathesis

Even though these rules conspire to avoid a certain output configuration, nothing in the SPE-approach unites their effects. Morpheme-structure constraints, as we have seen, cannot be used to unite rules that conspire to achieve an output effect. SPE did not have constraints on outputs. Indeed, in SPE, wellformedness at the word-level was an epiphenomenonal consequence of the regularities stated in terms of MSR's and phonological rules.

This problem clearly cannot arise in a theory that adopts wellformedness constraints on words and phonotactically-motivated repair (i.e., mapping) rules that are triggered by strings that violate the W-level conditions. We have discussed several such approaches in the preceding sections and, in a sense, all these approaches pay their respect to Kisseberth's article.[30] For unclear reasons, however, these approaches did not become 'mainstream' developments, and for a long time rules that 'look ahead' (i.e., rules that are sensitive to properties of their own out-

30. Except those, such as Hockett (1955), that predate this important article.

puts or outputs of later rules) were considered a bad thing.[31] Then, in the beginning of the nineties, another theory based on output constraints was proposed and this time, so it seems, the phonological community was ready for 'something new'.[32] In the next section we discuss this approach, called optimality theory.

3.2. *Optimality Theory (as an SPE-descendant)*

In essence, OT is not a phonological theory. It is a theory of constraint interaction and as such it can be applied to virtually anything. The theory was first applied in the domain of phonology, but is now also used in morphology, syntax and semantics. Since its inception, OT has been modified several times. Here we do not differentiate between all the variants that now exist, rather we assume a rather standard version of OT (see Prince and Smolensky 1993; and Kager 1999 for an introduction). The critical assessment that we offer here necessarily reflects our 'understanding' of the essence of OT (or lack of it).

3.2.1. Levels. Standard OT acknowledges only *one level* that has an input and an output representation. The correct output for any input is selected from an infinite set of *possible* outputs (produced by a 'generator'), by an extrinsically ordered set of universal constraints. In any grammar, this set appears in a particular order.[33] Constraints are claimed to be markedness statements (expressing positive or negative properties of outputs) or faithfulness statements (expressing reluctance to 'change' the input in order to acquire these desirable properties).

(17) *The phonological level (OT)*

input or underlying representation	
|	Generator (GEN)
set of output candidates	
|	Constraints (CON) (extrins. ordered)
output or surface representation	

A possible division of labor between GEN and CON could be that the former specifies all that is universally invariant, whereas the latter accounts for differences between languages (by selecting from what GEN makes available).[34] However, in practice this division is not maintained in OT. Universal invariance is accounted

31. Kiparsky (1973) refers to look-ahead rules as global and he argues that globality adds to much power to the grammar.
32. Why certain ideas, which have been around for a while, all of a sudden 'become fashionable' usually remains a mystery. The 'PR' campaign of OT and the eloquence of its architects, and the internet have certainly all played an important role.
33. The OT conception is, in fact, identical to a theory proposed in Cairns & Feinstein (1982) and Lapointe & Feinstein (1982) with one difference: in the latter theory the constraints were not ordered.

for in terms of so-called top-ranked constraints, but top-ranking is not a well-defined theoretical concept in OT, since it is also maintained that *in principle* every constraint can be violated in some language. Thus the model really claims that there are no universal invariant properties. It seems, then, that the function of GEN is minimal. Its content is merely the statement: let there be outputs.

OT accounts for the mapping between input and output in a holistic way. In fact, OT is as holistic as the post-SPE models that combined all phonological generalizations into one rule type and one mapping from input to output; compare (17) with (12). Instead of relying on a holistic set of phonological rules, OT relies on a holistic set of phonological constraints. OT has not inherited from SPE the reluctance to refer to non-phonological properties. As far as constraints are concerned, it seems that anything goes.[35] One reason for this liberal attitude is the fact that OT, as noted above, is not a phonological theory and as such it is not committed to any specific view on phonological primes and structures.

3.2.2. How concrete is the output? Where SPE, as we have seen, focused on inputs, the prime concern of OT is outputs (cf. Hale this volume for a similar discussion). However there is no clear conception of what the output is. In some approaches, the output, apparently, is 'very phonetic' (containing detailed information about articulation, acoustic properties and auditory aspects of speech). This excessive *concreteness* is, one might say, the historical counterpart to the excessive *abstractness* of SPE. The former focused on inputs, and drove their abstractness to absurdity, while the latter, being focused on outputs, gets deeper and deeper into phonetic details. This applies especially to the "Californian School" of OT (cf. Hayes 2000). We might therefore legitimately raise the question: how concrete is the ouput?

The role of outputs in accounting for phonological facts is also pushed to its limits in another manner. In the Correspondence Theory variant of OT, output/output-constraints are invoked to account for 'unexpected properties' of words, which in standard SPE would need the cycle or extrinsic ordering or a notion of 'backformation'. It is historically interesting that Kiparsky, who in 1968 protested against phonological analyses that relied on postulating excessively abstract inputs, now,

34. Paradoxically, OT has problems accounting for variation within languages; cf. Mohanan, McMahon, Coleman, this volume).
35. A difference between SPE and OT is that the set of constraints is claimed to be universal, whereas SPE did not claim that there was a universal set of rules. The claim for universality is not, however, testable, and is, in practice, unconvincing. New constraints emerge in the literature with great ease and many of them seem specially tailored for the analysis in which they are introduced. Here we ignore the universality claim, which is not a crucial part of OT, in that one can conceive of a variant in which constraints emerge in the process of language acquisition.

30 years later, argues against explanations that rely on excessive reference to comparing output forms (cf. Kiparsky this volume).[36]

3.2.3. The input/output distinction. It seems, then, that standard OT inherited the 'derivational' SPE-notion of making a distinction between input and output. The crucial difference is that there are no intermediate representations in OT. OT-evaluation is said to be *parallel* instead of *serial*. Since standard OT also lacks distinct levels (in the sense of section 2.1.), the theory is entirely non-derivational.[37]

It should be clear at this point, however, that theories such as HDP are, in a sense, even less derivational than OT in that no distinction at all is made between an input and an output representation.[38] On the other hand, since a distinction *is* made between a morphological level, a lexical level, and a post-lexical level (as we proposed), some degree of derivationalism is added. There seems to be a trade-off relationship between recognizing levels and recognizing an intra-level input/output distinction.

In principle, there is nothing in the design of OT that prevents making a level distinction and, in fact, this is advocated in Kiparsky (this volume), who, correctly in our view, shows that allowing a lexical and post-lexical level (each with their own ordered constraint set) allows one to handle opacity without compromising the OT-formalism with addenda such as "Sympathy Theory" (McCarthy 1999).[39]

If indeed one adopts an OT conception that acknowledges the lexical/post-lexical distinctions, one might ask what motivation remains for the distinction between input and output representations? We claim that the answer is: none. It would seem (as also observed by Mohanan this volume) that the I/O distinction is simply inherited from SPE. In fact, one might say that even if no lexical/post-lexical distinction were made, it still would seem that the I/O distinction is contradictory in a theory that is claimed to be non-derivational.

A hint that the distinction is dubious within OT can be derived from the claim that (as the story goes) it does not matter what the input looks like. This claim is called *Richness of the Base* (cf. Reiss this volume for arguments against this claim). At the same time, however, OT makes crucial use of the I/O distinction

36. In Kiparsky (1968), we also already find a protest against stating phonological generalizations in terms of reference to different output forms (then called transderivational constraints).

37. Here we ignore the two steps in diagram (17), given the seemingly superfluous role of GEN.

38. Classical OT, while claiming to be non-derivational, contains two levels: the input and the output. Golston (1996) proposes a variant, 'direct OT', which makes no distinction between input and output: a set of constraints directly characterizes the wellformedness of a single level of representation.

39. We note here that the distinction between lexical and post-lexical phonology opens the possibility for a compromise between an OT-type approach and a 'principles and parameter' approach. It is conceivable that the lexical system makes use of principles and parameters, while the post-lexical approach (closer to the eternal battle between perception and production) operates in an OT-style of constraint interaction.

in the formalism of tableaux. It would seem that once the distinction is made, it *does* matter what the input is. /kæt/ is *not* a proper input for [dɔg], i.e., we take it that no OT account of English will ever deliver [dɔg] as the most optimal O(utput) for /kæt/. We believe that the confusion arises from having the I/O distinction in the first place. As pointed out in section 2.2., we can conceive of a phonological grammar as consisting of a set of constraints (ordered or not) that directly characterizes the wellformedness of phonological expressions, either at a single level (declarative phonology), or at several levels (cognitive phonology, HDP).[40]

If the distinction is abandoned, however, one might ask what then remains of so-called *faithfulness constraints*, i.e., constraints that militate against changes of the input, like insertion or deletion. In addressing this question, we must first make clear why we need faithfulness constraints in the first place. In understanding this question, it is probably useful to draw attention to the fact that faithfulness constraints, in effect, function like the equivalent of repair rules in the type of models discussed in section 2.1. Violations to markedness constraints, which are present in the input, are "repaired" by the repair constraint(s) that are dominated by these markedness constraints. Thus it would seem that the input/output distinction is *necessary* because repairs are built *into* the constraint set. In the next section, we will argue that this move, in fact, also is the main reason for needing extrinsic constraint ordering. Hence, the input/output distinction, and extrinsic constraint ordering are a necessary by-product of mixing constraints on representations with repair constraints. In the models that we have discussed in section 2.3., repair rules are mapping rules that account for mismatches between levels. As such, they are kept separate from wellformedness constraints. This move, we claim, makes it possible to do away with the (intra-level) I/O distinction and makes extrinsic ordering superfluous.

Note, in addition, that OT's decision to mix faithfulness constraints and markedness constraints (combined with the notion of richness of the base) prevents OT from making real predictions with regard to (im)possible phonological patterns. According to OT, any conceivable string of segments can potentially surface in some language. We only have to allow faithfulness to outrank markedness (which means that we do not repair). At best, then, OT accounts for 'relative markedness'. A language with onsets consisting of 20 consonants is more marked than a strict CV language because there will be more violations of some constraint (e.g., *COMPLEX). However, in principle, the theory does not account for the fact that languages of the former type do not exist at all. To explain this, OT-proponents must crucially rely upon an additional theory that constrains the richness of the base hypothesis. This additional theory could be a theory of language change that is formulated in such a way that it predicts the impossibility of long clusters as the

40. Golston (1996) proposes 'direct OT' in order to remove the I/O distinction from OT, arguing that the input representations are themselves (sets of) constraints, as also argued in declarative phonology; cf. also Mohanan (this volume).

outcome of phonological change. If, however, one would claim (as we do) that phonological theory must limit the range of possible synchronic grammars and their potential outputs, OT fails the test.

3.2.4. Against constraint ordering. In this section, we turn to the notion of constraint ranking, which seems to be the crucial trademark that separates OT from other constraint-based models. It would seem that there are two reasons for extrinsic ordering in OT. The first has to do with the fact that by ranking markedness constraints, these constraints can be formulated in more general terms. The second reason is, as stated above, that the set of constraints contains "repair" constraints in addition to markedness constraints. We start with discussing the second reason.

3.2.4.1. Building repair into the constraint set. OT needs extrinsic ordering because it builds 'repair rules' into the set of constraints that also contains markedness constraints. In OT, 'repairs' are a consequence of violations of low-ranking faithfulness constraints that forbid repair. Thus, epenthesis results from violating a constraint that forbids epenthesis. Consequently, if some language gets rid of a final CC cluster by appending a vowel rather than by deleting a consonant or inserting a vowel, the constraint 'do not append' corresponds to the lowest ranked repair strategy:[41]

(18) Input: CVC+C
a. *CC]
b. *DELETE-C , *INSERT-V >> *APPEND-V
Ouput: CVCCV

Since, in this example, *APPEND-V is the least offensive (i.e. lowest ranked) constraint, the optimal form corresponding to the ill-formed CVCC is CVCCV. The crucial point is that in order to select the correct repair, the potential 'repairs' must be extrinsically ordered with respect to each other and with respect to the markedness constraint *CC] and the general constraint that demands complete faithfulness to the input. Thus, in this example, the constraint *CC] accounts for the wellformedness of outputs (i.e., they cannot have a final cluster), while the constraints in (18b) are needed for repair. By ranking the crucial repair below *CC] we achieve that the repair actually takes place. Note that the constraints in (18b) have nothing to do with wellformedness of outputs, only (18a) has that function. This shows, that, whereas OT allegedly offers an account in terms of output constraints, a great deal of the constraints do not specify properties of the output at

41. This strategy, which does not link a repair to a specific markedness constraint, runs into problems, for example, when a language uses deletion for initial CC clusters, but insertion for final CC clusters.

all, but, instead, are constraints on repairs and on the distance between input and output.

This type of ordering of the constraints (assuming that repairs can in fact be ordered for the grammar as a whole) will not be necessary in an approach that attributes the appropriate repair to the mapping between levels and thus keeps constraints on wellformedness and repair separate. In such models, faithfulness (the old 'naturalness conditions' proposed in Postal 1968) then bears on the degree to which different levels may differ and on the type of operations that repair rules are allowed to make.

3.2.4.2. Capturing generalizations. A second reason for extrinsic ordering is to achieve the effect that the markedness constraints can be stated in a maximally general form. This goes back to the argumentation in Prince and Smolensky (1993). Imagine that a language L has only short vowels, except in the stressed syllable where there are only long vowels. To express this we seem to need the following constraint:

(19) Vowels are short, except in stressed syllables

Prince and Smolensky (1993) argued that statements containing 'except clauses' point to the presence of conflicting constraints. As a first move, we can replace (19) by two constraints:

(20) a. Stressed syllable: *short
b. Non-stressed syllables: *long

By ordering (20a) before (20b), we can remove the 'Non-stressed' part from the second constraint, which then essentially says 'there are no long vowels':

(21) a. Stressed syllable: *short
b. *long

Thus ordering attributes to the generality of constraints. Outranked by a constraint that requires long vowels in stressed syllables, the generality of the statement about long vowels can do no harm. (This strategy is, of course, the very same motivation that introduced rule ordering in SPE). In OT, then, such facts are accounted for as follows:[42]

(22)

CVCVV	*V́	>>	*VV
⇒CVVCV			*
CVCVV	*		*
CVCV	*		
CVVCVV			**

42. Note that, in a sense, this strategy introduces its own form of opacity. Constraint (20b) is technically opaque because the language in question has long vowels.

In this case, however, the ranking/ordering can be predicted from the Elsewhere Principle: the more specific rule/constraint takes precedence. It may be that all cases of ordering that aim at achieving generality of constraint formulation are of this type. If so, then, *these* cases of ordering are harmless.[43]

Elsewhere (in van der Hulst and Ritter 2000b), we have argued that most (perhaps all) cases that are of this nature can be analyzed in terms of parametric choices that differ depending on whether we look at *head* or *dependent* positions. Hence, in this schematic example we would argue that the setting of parameters governing vowel length may differ for stressed (head) and unstressed (dependent) syllables.

In fact, this approach can be used to eliminate another type of faithfulness constraint, i.e., the type of constraint that stipulates that certain parts of the input must surface in tact when in certain positions (Beckman 1998). Such positional faithfulness can, in our view, be handled by markedness constraints (i.e., parameter settings) that characterize the wellformedness of representations with reference to certain positions.[44]

3.3. *Summary*

In this section we have given a critical assessment of OT which centers on the notions of the input – output distinction, holism and extrinsic constraint ordering. We believe that these notions form a related package that we call the "SPE heritage of OT". Once the input – output distinction is replaced by two levels (i.e., the morphological and the phonological level), extrinsic ordering is largely superfluous. Remaining cases of extrinsic constraint ranking may then turn out to be instances of distinct wellformedness conditions for head versus dependent positions. It may, of course, also turn out that ranking is a genuine phenomenon either among wellformedness constraints or among repair rules. Our point here is that in order to test that, we need to look at a 'clean' constraint set, consisting only of constraints on representations[45] and at a 'clean' set of mapping rules.[46]

4. Conclusions

Given that constraints on output wellformedness can be grounded in different functional domains (perception, production, acquisition, storage, cognitive computation), no language can have it all the way. Each language, at any given point in

43. Even declarative phonology admits ordering of this type.
44. In van der Hulst & Ritter (in prep.) we argue that these positions are 'head positions'.
45. Discussions of extrinsic constraint ranking in the context of government phonology can be found in Ritter (1995), Cyran (1996) and Polgárdi (1999).
46. Of course, as stated earlier, one might have such a limited array of repair rules that the need for ordering them evaporates.

time, presents a possible 'compromise' between all the forces that act upon it and that shape it. We are, in fact, willing to accept this assessment from the viewpoint of language change. In this sense, we believe that there are indeed different and conflicting forces operating on the shape of language. This being so, it comes as no surprise that a model that *mimics* the historical course of events can straightforwardly deal with everything languages seem to offer. OT, like standard generative phonology, seems to build diachrony into the synchronic account. In particular, the sequencing of events in real time is recapitulated in the form of extrinsic ordering. OT inherits from SPE this tendency to reconstruct historical development in the synchronic grammar. In fact, OT is more rigorous than SPE. With the addition of O/O-constraints in "correspondence theory", devices have become available to express the paradigm uniformity type of analogy directly in the synchronic grammar in the form of an extended version of faithfulness.

However, accepting the 'conflict and choice' model, and factors like analogical leveling for language change, does not commit one to assume that children acquiring their language reconstruct the historical course of events of that language. We believe that the mind has a different, and, in fact, more constrained way of grasping or representing the startling complexities of language. The theory of principles and parameters (embedded in HDP) claims to be a model of the relevant section of the human mind.[47]

We conclude that while OT embodies a possible constraint-based approach to phonology, it is not the only one, and presumably not the best one. Its use of the I/O-distinction, holism, and extrinsic ordering, as well as its use of complete parallelism (cf. Clements this volume) seem to cause many problems both conceptual and empirical. In the light of alternative approaches that have been designed over the years to remedy certain defects of SPE, it seems obvious to question the popularity of this approach and wisely to recommend students of phonology to look at other ways of doing phonology.

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47. All things being equal, a parametric model (using, one might say, *binary constraints*) is more constrained than a model that appeals to extrinsically ordered 'unary constraints'. Adding one parameter multiplies the grammar by 2, adding one constraint multiples the number of grammars by the number of constraints already present (plus 1).

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