Handout #1: Background, Origins, and Overview of OT

1. Goals and outline of this handout

Goals:
Describe OT’s historical antecedents, its basic principles, and some methods of sound analysis.

Outline:
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2. Constraints in rule-based phonology

SPE (Chomsky and Halle 1968):
- Principal analytic tool: context-sensitive rewrite rule (A → B/C_ D).
- Rules aren’t teleological (not goal-oriented).
- A rule is package that specifies an input configuration (the structural description) and an operation to perform on it (the structural change).
- Well-formedness constraints on underlying forms (morpheme structure constraints).
- Conditions on rule application (e.g., can’t stipulate absence of “+”) and ordering (e.g., conjunctive vs. disjunctive).

Kisseberth (1970):
- Conspiracy: several rules in a language respond to same output condition.
- Conspiracies include both blocking and triggering/repair.

(1) Conspiracy in Yawelmani
a. Processes that are blocked from creating *CVCC syllables
   Syncope
   V → Ø/VC_ CV /p’um’-in-a/ → [p’um’na] ‘full-blooded one’
   Apocope
   V → Ø /VC_ # /pana:-mi/ → [panam] ‘arrive (cons. ger.)’
b. Processes that repair CVCC syllables

Epenthesis:

\[ \emptyset \rightarrow i/C\_CC \]

\(/\text{logw-taw/} \rightarrow [\text{logiwtaw}] \text{‘pulverize (ger.)’}\

Protective vowel \(a\):

\(/\text{pu:lm/} \rightarrow [\text{polma}] \text{‘husband (obj.)’}\

- Kisseberth’s proposal: simplify statement of blocked processes by eliminating context that’s predictable from output condition.
- Critique (also see Kiparsky 1973): doesn’t account for triggering/repair; *CV:C is also an output condition, repaired by shortening, but it won’t block syncope or apocope because there’s a repair (e.g., [panam]). (On this sort of interaction, see especially Myers (1991) and Paradis (1988a, 1988b).)

How is blocking of obligatory rules implemented? What if the rules are optional (as in syntax — cf. Chomsky and Lasnik (1977)). And how to address [panam] problem?

Why is triggering/repair a harder problem than blocking? What’s missing from the explanation?

Related issue: the duplication problem

- Clayton (1976), Kenstowicz and Kisseberth (1977): Restrictions on lexicon (morpheme structure constraints or lexical redundancy rules) duplicate restrictions on derived phonological structures.
- “In many respects, [lexical redundancy rules] seem to be exactly like ordinary phonological rules, in form and function” (Chomsky and Halle 1968: 382).
- Example: no morpheme-internal CCC clusters in Yawelmani.

Nonlinear phonology:

- Helps with some aspects of triggering/repair problem.
- Epenthesis as syllabic overparsing (Selkirk 1981 and others), so no epenthesis rule per se.
- Deletion as syllabic underparsing with stray erasure (Ito 1986 and others), so no deletion rule per se.
- Goldsmith (1976) and Prince (1983), for example, tried hard to achieve nearly rule-less theories, but subsequent work returned in the same empirical domains to more complex rule-based models with diminished role for constraints (e.g., Pulleyblank (1986) and Hayes (1995)).
- Furthermore these structural approaches don’t generalize to full range of triggering/repair cases, such as…

The OCP: “adjacent identical elements are prohibited”

- Leben (1973), Goldsmith (1976): condition on underlying representations only, ruling out tone melodies like LHH.
A further issue:

- Like many putative universal principles of the era, the OCP doesn’t hold in every language (Odden 1988). Should we reject it outright?
- In fact, a principle or output condition may be active in only some contexts in a language but inactive in others. Example …

(2) Hiatus resolution in Dutch (Booij 1995: 65-66)

a. V1 is mid or high: insert homorganic glide

<table>
<thead>
<tr>
<th>Word</th>
<th>Output</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>bioscoop</td>
<td>[      ]</td>
<td>‘cinema’</td>
</tr>
<tr>
<td>zee+en</td>
<td>[      ]</td>
<td>‘seas’</td>
</tr>
<tr>
<td>Boaz</td>
<td>[ u    ]</td>
<td>‘Boaz’</td>
</tr>
</tbody>
</table>

b. V1 is low and V2 is stressed: insert

<table>
<thead>
<tr>
<th>Word</th>
<th>Output</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>paella</td>
<td>[      ]</td>
<td>‘paella’</td>
</tr>
<tr>
<td>aorta</td>
<td>[      ]</td>
<td>‘aorta’</td>
</tr>
</tbody>
</table>

c. But if V2 is unstressed: hiatus is unresolved

<table>
<thead>
<tr>
<th>Word</th>
<th>Output</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>chaos</td>
<td>[      ]</td>
<td>‘chaos’</td>
</tr>
<tr>
<td>farao</td>
<td>[      ]</td>
<td>‘Pharaoh’</td>
</tr>
</tbody>
</table>

Why are cases like Dutch particularly problematic for parametric theories of why principles or constraints aren’t universal truths? How else could you deal with this example?

Further examples of principles or constraints that express contingent truths (McCarthy 2002: 16):

- The OCP prohibits adjacent identical elements except across morpheme boundaries (McCarthy 1986).
- Hayes’s (1995: 95) Priority Clause involves implicit comparison of alternative outputs and explicit reference to another constraint prohibiting degenerate (e.g., monosyllabic) feet: “If at any stage in foot parsing the portion of the string being scanned would yield a degenerate foot, the parse scans further along the string to construct a proper foot where possible.”
- Halle and Vergnaud’s (1987: 10, 15) theory of metrical parsing implements several interdependent constraints. The Exhaustivity Condition says that parsing is exhaustive “subject to” a Recoverability Condition. And the Maximality Condition says that parsing constructs constituents that are as large as possible, “provided that other requirements on constituent structure are satisfied.”
Summary:

“As the theory of representations in syntax has ramified, the theory of operations has dwindled in content, even to triviality and, for some, nonexistence. The parallel development in phonology and morphology has been underway for a number of years, but the outcome is perhaps less clear … What is clear is that any serious theory of phonology must rely heavily on well-formedness constraints … What remains in dispute, or in subformal obscurity, is the character of the interaction among the posited well-formedness constraints, as well as the relation between such constraints and whatever derivational rules they are meant to influence. Given the pervasiveness of this unclarity, and the extent to which it impedes understanding even the most basic functioning of the grammar, it is not excessively dramatic to speak of the issues surrounding the role of well-formedness constraints as involving a kind of conceptual crisis at the center of phonological thought.” (Prince and Smolensky 2004: 1-2)

3. *Naturalness*

The problem:

“The entire discussion of phonology in this book suffers from a fundamental theoretical inadequacy. … The problem is that our approach to features, to rules, and to evaluation has been overly formal. Suppose, for example, that we were systematically to interchange features or to replace [αF] by [–αF] (where α = +, and F is a feature) throughout our description of English structure. There is nothing in our account of linguistic theory to indicate that the result would be the description of a system that violates certain principles governing human languages. To the extent that this is true, we have failed to formulate the principles of linguistic theory, of universal grammar, in a satisfactory manner. In particular, we have not made any use of the fact that the features have intrinsic content.” (Chomsky and Halle 1968: 400)

“Any adequate theory of phonology must contain postulates that will define natural sound changes. Although many of these can be expressed by appeal to the notion of assimilation defined over the features of a feature system, it is clear that not all natural sound changes fit into this mold. For example, many languages have a rule converting consonants to /h/ in preconsonantal and final position. Such a process is clearly not assimilatory in nature. Nevertheless phonological theory must have some apparatus for expressing the fact that neutralization to a glottal stop in these positions is a natural rule as opposed to, say, neutralization to l.” (Kenstowicz and Kisseberth 1979: 251)

Anderson (1985: 328ff.) is very helpful for understanding these issues.


- Innate natural processes. They “are mental substitutions … which respond to physical phonetic difficulties” (Donegan and Stampe 1979: 136).
- (Also learned rules for lexicalized alternations like electri[k]/electri[s]ity.)
- Learning = suppression or limitation of natural processes. Processes tend to eliminate contrasts for phonetic reasons; antithetically, phonological intention (i.e., the lexicon) asks for preservation of contrasts. This is core functionalist idea: ease of articulation is opposed to clarity of perception.
Critique of SPE:

“The tension between clarity and ease is one of the most obvious, and oldest, explanatory principles in phonology. Modern theories, however, to the extent that they incorporate analogous principles, tend to make them monolithic, like the principle of … simplicity in generative phonology. … In that framework, positing conflicting criteria would be like pitting Ockham’s razor against an anti-Ockham who multiplies entities as fast as the razor can shave them off: it would defeat their purpose of evaluating alternative analyses.” (Donegan and Stampe 1979: 130)

4. Harmony


- Offers a way of abstracting over a whole connectionist network, giving it the kind of high-level interpretation that can be usefully connected with symbolic theories of cognition.
- In (3) you have a simple connectionist network. Each link between the two layers has a numerical weight. The weight of the link between $in_i$ and $out_j$ is $w_{ij}$. The activation of a specific output node $out_j$ — which ultimately translates into some linguistic property of the predicted output form — is a function of the activation of all the input nodes linked to it $in_i$, $\forall i, m$, and the weights associated with those links $w_{ij}, \forall i, m$. If $w_{ij}$ is positive, then activation of $in_i$ will tend to excite $out_j$; conversely, if $w_{ij}$ is negative, then activation of $in_i$ will tend to inhibit $out_j$. Training a network like this one consists of taking known input-output pairs and adjusting the weights ($\approx$ prioritizing the constraints) until the correct outputs are predicted (starting from random or uniform activation levels).

(3) A simple connectionist network

\[ in_1 \quad in_2 \quad \ldots \quad in_m \]
\[ out_1 \quad out_2 \quad \ldots \quad out_n \]

- The **harmony** of the network (3) is defined as the sum of the product $in_i * w_{ij} * out_j$ for all $i$ and $j$ (where $in_i$ and $out_j$ stand for the activation values of the respective nodes). For the entire network to yield a relatively high harmony value, then, there must be many specific connections where $in_i$, $w_{ij}$, and $out_j$ are all relatively high.
- High harmony value $\approx$ constraints are satisfied.

Harmonic Phonology (Goldsmith 1990, 1991, 1993)

- Insight: exploit capacity of Harmony Theory to link numerically-optimizing connectionism with symbolic (linguistic) data.
Legendre, Miyata, and Smolensky (1990a) describe an application of Harmonic Grammar to the problem of predicting which French verbs are unergative and which are unaccusative. There is no simple mapping from the lexical properties of verbs (such as telicity or animacy of the argument) to the unaccusative/unergative split. Furthermore, the split itself is not so sharp, since putatively unaccusative verbs differ in how they perform on various syntactic tests of unaccusativity, and the syntactic acceptability judgments are graded.

Harmony Theory/Harmonic Grammar compared to OT:

- Harmony Theory and OT are both about finding optima in systems of ranked, violable constraints. But OT is symbolic, not numerical, and concomitantly it has strict domination constraint hierarchies, not weights:

  “Optimality Theory, by contrast, seeks to strengthen the higher-level theory of grammatical form. It can be viewed as abstracting the core idea of the principle of Harmony Maximization and making it work formally and empirically in a purely symbolic theory of grammar. … The property of strict domination is a new element, one quite unexpected and currently unexplainable from the connectionist perspective, and one which is crucial to the success of the enterprise.” (Prince and Smolensky 2004: 238)


Central premises in outline:

- Linguistic well-formedness is relative, not absolute. Perfect satisfaction of all linguistic constraints is attained rarely, and perhaps never.
- Linguistic well-formedness is a matter of comparison or competition among candidate output forms (none of which is perfect).
- Linguistic constraints are ranked and violable. Higher ranking constraints can compel violation of lower ranking constraints. Violation is minimal, however. And even low-ranking constraints can make crucial decisions about the winning output candidate.
- The grammar of a language is a ranking of constraints. Ranking may differ from language to language, even if the constraints do not.

**Eval:**

- OT’s evaluative component.
- Eval gives meaning to notions like ranking and minimal violation.
- Essence of Eval (Grimshaw 1997 formulation): Of two candidates C1 and C2, the more harmonic candidate is the one that is favored by the highest-ranking constraint on which they differ. The most harmonic or optimal candidate is the one that is more harmonic, in this sense, in all its pairwise comparisons with all other candidates.
- Functional characterization of Eval: Eval is a function from a set of candidates $\mathcal{C}$ to either (i) a subset of $\mathcal{C}$ (Samek-Lodovici and Prince 1999) or (ii) a stratified partial ordering of $\mathcal{C}$ (Coetzee 2004). (If A and B are in a stratified partial ordering, then A $\gtrdot$ B, B $\gtrdot$ A, or A and B have the same ordering relations with respect to all other elements in the ordering. Sorting a group of people by their year of birth yields a stratified partial ordering. Sorting them by their SAT scores yields a non-stratified partial ordering, since some people never took the SAT.)
- Eval as function composition (Karttunen 1998, Samek-Lodovici and Prince 1999): A constraint is a function from a set of candidates $\mathcal{C}$ to a subset of $\mathcal{C}$. If we have an OT grammar $A \gg B$, then $B(A(\text{input})) = \text{output}$. 
• Note the parallel between evaluation by a single constraint and evaluation by a whole constraint hierarchy.

**GEN:**
• OT’s candidate generator. Replaces the operational part of phonological rules.
• GEN was discussed more in early OT work than today. Originally, it was severely restricted in what it could do, so as to support the PARSE/FILL model of faithfulness.
• GEN overgenerates. This is not a problem; if GEN offers [dog] as a candidate for /cat/, we rely on EVAL to ensure that no language countenances the mapping /cat/ \( \rightarrow \) [dog].
• Restrictions on GEN are hard universals, so there’s a temptation to encode observed language universals in GEN. Resist this temptation! As we’ll see in Handout #4, observed language universals are best explained in the theory of CON, not GEN.
• What principles does GEN encode? Obvious formal universals, such as the list of distinctive features or prosodic categories.

**CON:**
• OT’s constraint component.
• Constraints come in two types:
  o Markedness constraints evaluate outputs without reference to input.
  o Faithfulness constraints favor identity between output and input.
• Together, these two constraint types unpack the rule “package” and, arguably, dispense with the need for rules.
• Null hypothesis: There are no other constraint types.
• Null hypothesis: CON is universal. All languages have the same constraints, but different rankings. (Universal doesn’t necessarily imply innate, if learners can consistently induce constraints from universally shared experiences (the point of Hayes 1999).)

What privileges these statements as “the null hypothesis”?
• A constraint is a function from a set of candidates \( \mathcal{C} \) to (i) a subset of \( \mathcal{C} \) or (ii) a stratified partial ordering of \( \mathcal{C} \).
• Research questions: What is the internal structure of CON? Is there a theory of CON, or just a list of constraints? See ATGtOT pp. 11f. for an overview and references and McCarthy (2003) for recent related discussion.
• The naturalness of phonological processes derives from substantive properties of CON (which may be phonetically based — see, e.g., Hayes, Kirchner, and Steriade eds. (2004)). Unfortunately, we’re probably not going to have time to go into this very much.

Factorial typology: If CON is universal and ranking is language-particular, then (i) every permutation of CON is a possible grammar of a human language and (ii) every grammar of a human language is a permutation of CON. Handout #4 discusses factorial typology and its role in accounting for linguistic universals.

**H:**
• A language-particular constraint hierarchy.
• An ordering of CON.
• Strict domination: if \( A >> B \), then even perfect performance on B can’t overcome inferior performance on A. (Like alphabet order: az > ba.)
• EVAL is defined for constraint hierarchies that are total orderings, but …
• ...the analyst (and the learner) can’t always discover a total ordering for $H$, since not all constraints conflict, and constraint conflict is the basis of ranking arguments.
• ...and there are proposals that $H$, as learned, is a properly partial ordering that includes unranked but conflicting constraints (Anttila 1997, Anttila and Cho 1998) or a probabilistic system (Boersma 1997, 1998, Boersma and Hayes 2001). These proposals retain the standard OT assumption that $EVAL$ is supplied with a specific total ordering selected from among the possibilities afforded by these looser theories of $H$.

Some not-so-central (but still important) premises of OT:

Richness of the base (ROTB):
- There are no language-particular restrictions on inputs. No morpheme structure constraints, lexical redundancy rules, or equivalent.
- So all linguistically significant generalizations are expressed by the grammar, not by restrictions on the lexicon. (Lexicon is limited to stipulation, not generalization — i.e., vocabulary.)
- ROTB is source of much confusion.
- Lexicon optimization is source of even more confusion.
- More about both in Handout #2.

Parallelism:
- The candidates consist of complete output forms. Derivations map directly from underlying to surface structure, without intermediate forms.
- Why consider this hypothesis? Because derivations with intermediate forms allow rules to express generalizations that are not surface true. OT has its own way of expressing generalizations that aren’t surface true: ranking. Is that enough?
- If there’s sufficient time and interest, we may return to this topic in the last class. You can also read more about it in ATG/OT pp. 138-177.

Full specification:
- Much (though certainly not all) work in OT eschews underspecification.
- This is clearly not a necessary concomitant of OT.
- Why, then? Underspecification is a representational theory of markedness (unspecified = unmarked). OT has a substantive theory of markedness (obeys a markedness constraint = unmarked). Is the substantive theory sufficient? Is it necessary?
- We won’t be discussing this matter further, but see, e.g., Prince and Smolensky (2004: 212ff.) and Causley (1999) for the two positions.

6. Analysis in OT

Basic method (not always sequential):
- Conventional phonological analysis: determine underlying representations and formulate ordinary-language descriptive generalizations about underlying $\rightarrow$ surface mapping.
- Identify active constraints (and perhaps some inactive ones that are crucially dominated by active constraints). A constraint is active in a dataset (or whole language) if and only
if it favors a winner over a loser and no higher-ranking constraint favors that winner over that loser.

- Construct ranking arguments.
- Posit new constraints as need for them is revealed, then go back and redo ranking arguments.
- Check the results for correctness of winners and validity of ranking arguments, using all relevant constraints and candidates.

Identifying active constraints:

- Faithfulness: basic theory of faithfulness constraints is fairly well understood, so it’s usually easy to identify which faithfulness constraints are being violated. Identifying faithfulness constraints that are crucially obeyed may require some cleverness in thinking of losing candidates that offer alternative ways of satisfying an active markedness constraint. (This implies that the identification of active constraints cannot be separated from the formulation of ranking arguments.)
- Markedness: there’s a consensus around some basic markedness constraints, but beyond that lies controversy. Familiarity with typical phonotactic requirements usually helps.

Faithfulness in correspondence theory (McCarthy and Prince 1995, 1999)

- A candidate consists of an ordered 3-tuple: \((\text{input}, \text{output}, R)\), where \(R\) is a relation between the elements of \(\text{input}\) and the elements of \(\text{output}\). (See McCarthy and Wolf 2005 for a somewhat different formalization.)
- Faithfulness constraints check various properties of this relation and assign violation-marks for non-conformity. Some heavily used faithfulness constraints:

(4) \(\text{MAX}(\text{input}, \text{output}, R)\)

\(R\) is a total relation on \(\text{input}\). Assign one-violation mark for each element of \(\text{input}\) that has no correspondent in \(\text{output}\). (Effectively, no deletion.)

(5) \(\text{DEP}(\text{input}, \text{output}, R)\)

\(R\) is onto \(\text{output}\). Assign one-violation mark for each element of \(\text{output}\) that has no correspondent in \(\text{input}\). (Effectively, no epenthesis.)

(6) \(\text{IDENT-[FEATURE]}(\text{input}, \text{output}, R)\)

If \(s_i \in \text{input}\) and \(s_o \in \text{output}\), \(s_i R s_o\), and if \(s_i\) is [\(\alpha\)feature], then \(s_o\) is [\(\alpha\)feature]. Assign one violation-mark for each such non-conforming pair. (Effectively, no changes in the value of [feature].)

Constructing ranking arguments:

- This is central to OT. It is not intrinsically difficult, but some care is required.
- A necessary condition for a valid ranking argument is the comparison of two candidates, a winner and a loser, where the higher-ranking constraint favors that winner over that loser, and the lower-ranking constraint favors that loser over that winner. (For sufficiency of a ranking argument, see below.)
- Ranking arguments are presented in the form of a tableau, either a conventional violation tableau or preferably a comparative tableau (Prince 2002).
In a properly ranked comparative tableau, every loser-favoring L is dominated by (= to the right of) some winner-favoring W, and there is at least one W in every loser row. Why are both of these conditions necessary? (Cf. the Cancellation/Domination Lemma of Prince and Smolensky (2004: 174).)

Ranking by assertion or with bigger tableaux leads to errors.

(7) Violation tableau

<table>
<thead>
<tr>
<th>/input/</th>
<th>CONSTRAINT-1</th>
<th>CONSTRAINT-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>winner</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>loser</td>
<td>*!</td>
<td></td>
</tr>
</tbody>
</table>

(8) Comparative tableau

<table>
<thead>
<tr>
<th>/input/</th>
<th>CONSTRAINT-1</th>
<th>CONSTRAINT-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>→ winner</td>
<td>1</td>
<td>W</td>
</tr>
<tr>
<td>~ loser</td>
<td>L</td>
<td></td>
</tr>
</tbody>
</table>

Positing novel constraints:

- This is a big responsibility, not to be undertaken lightly. Exhaust interactional possibilities first.
- Constraint definitions shouldn’t include “except when”, “only when”, “as many/few/much as”, or other conditions that mimic effects that can be obtained from constraint domination and minimal violation.

Why such a big responsibility?

How can you tell when you need another constraint?

Checking the results:

- The winner > loser argument for the ranking CONSTRAINT-1 >> CONSTRAINT-2 can’t be certified as valid until you’ve checked that there is no other constraint ranked higher than CONSTRAINT-2 that, like CONSTRAINT-1, also favors winner over loser.
- If a constraint settles a tie between winner and loser, then winner and loser offer no information about how to rank that constraint.

Why?

7. Topics for class discussion

How does OT address the various issues raised in §2 and §3 of this handout? (Much of this course will be devoted to answering this question, so don’t worry if the answer isn’t clear yet.)

Work through the schematic tableaux in ATGiOT on pp. 31-32. Which express valid ranking arguments?

Translate them into comparative tableaux. Is the task of determining ranking argument validity made easier?

Construct an analysis of Dutch (2). If you posit any new constraints, attend to the criteria immediately above under “Positing new constraints”.

Attempt an analysis of Yawelmani (1). (Ignore the protective vowel.)
8. References


