Generative Phonology Models of Universal Grammar: Constraint-Based Optimality Theory as Opposed to the Rule-Based SPE Model

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Abstract

Current linguistic theory presumes languages to be essentially similar because individuals have a genetic inclination to acquire language. Linguists strive to create a model of this abstract universal grammar that captures the core commonalities among different languages while allowing room for all the subtle differences that naturally occur in human speech. This all-encompassing theory of universal grammar would accurately distinguish between possible grammars and impossible grammars. This paper examines the main tenets of the two major generative phonology models of universal grammar: SPE's Generative Phonology theory representing rule-based, derivational universal grammar models, and Optimality Theory as a representative of constraint-based models of universal grammar.

Keywords: generative phonology, universal grammar, constraint-based, optimality theory, rule-based, SPE model

نموذجين للنحو الشامل وفق علم الأصوات التوليدي: نموذج نظرية الافضلية القائمة على القيود مقابل نموذج النمط الصوتي للغة الإنجليزية القائم على القواعد

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الملخص

تفترض النظرية اللغوية الحالية أن اللغات متشابهة في جوهرها لأن لدى الأفراد ميل وراثي لاكتساب اللغة. ويسعى اللغويون إلى وضع نموذج لهذا النحو الشامل المجرد يغطي فيه القواسم الأساسية المشتركة بين اللغات المختلفة مع إتاحة مساحة للتعامل مع جميع الاختلافات الدقيقة التي تظهر بشكل طبيعي في الكلام البشري. حيث ستمكننا هذه النظرية الاجمالية للنحو الشامل من التمييز بدقة بين القواعد النحوية الممكنة والقواعد النحوية غير الممكنة. تتناول هذه الدراسة المبادئ الرئيسية لنموذجين أساسيين للنحو الشامل وفق علم الأصوات التوليدي: نظرية علم الأصوات التوليدي المبنية على كتاب النمط الصوتي للغة الإنجليزية والتي تمثل نماذج النحو الشامل الاشتقاقية والقائمة على القواعد ، ونظرية الافضلية كممثل لنماذج النحو الشامل القائمة على القيود

الكلمات الرئيسية: علم الصوتيات التوليدي ، النحو الشامل ، نظرية الافضلية ، القائم على القيود ، القائم على القواعد

Introduction

Today, people all across the globe communicate using any one of thousands of different languages. In India alone, there are more than 700 different languages in use, whereas the relatively small nation of Papua New Guinea is home to more than 839 distinct languages. In addition, throughout history, humans have spoken thousands of different languages, and in the future, they will continue to speak thousands more. Anyone who is fluent in more than one language or who has gone through the process of learning a new language can attest to the fact that these human languages are distinct from one another not only in the vocabulary that they use but also in the sound systems, grammatical systems, and writing systems that they employ (Fernández & Cairns, 2018, p. 27).

Despite the myriad of distinctions that exist between different languages, the dominant paradigm in linguistics today presupposes that languages are, on a fundamental level, similar. This is mostly owing to the functional and structural similarities that exist across all human languages. Linguists believe that human languages are comparable not only in terms of the capabilities they bestow on individuals who are conversant in those languages but also in terms of the fact that each and every one of them has a grammar (comprised of phonological, morphological, and syntactic components) as well as a lexicon that is specific to that language. These two components (namely, the grammar and the lexicon) comprise the building blocks that are utilized to produce what would be an infinite number of sentences. In addition, the organization of lexicons and the formal characteristics of grammatical systems are very similar across the board for all human languages.

Given that all languages have essentially the same functions and organization provides compelling evidence that individuals have a genetic tendency to acquire language much in the same way that each animal species has its own distinctive communication systems. This suggests that individuals have a genetic predisposition to learn language (Chomsky, 1957, 1975, 1986; Prince & Smolensky, 1997, p. 1604.) However, it is thought that this resemblance across languages only exists on an abstract level since even a cursory acquaintance with a variety of languages is enough to demonstrate that no two languages are identical to one another.

In current linguistic theory, the ultimate goal of linguistics is to develop a model of this abstract universal grammar (Radford, 1997, p. 5). Accordingly, linguists strive to construct a model of human linguistic ability that captures the core commonalities while allowing room for all the subtle differences that naturally occur in human speech. This all-encompassing theory of universal grammar would accurately distinguish between possible grammars (i.e., grammars of specific languages) and impossible grammars (Archangeli, 1999, p. 533).

In phonology, the perfect model of a universal language will make it possible to recognize the fundamental parallels that exist between different languages, to articulate the differences that exist between them, and to make accurate predictions regarding the types of sound patterns that should and should not occur. The following two sections present the fundamental principles that underlie the two major generative phonology models of universal grammar: SPE's Generative Phonology theory and Optimality Theory.

SPE's Generative Phonology Theory

The issues of similarities and variations among human languages were first addressed by Generative Grammar, a rule-based, derivational universal grammar pioneered by the linguist Noam Chomsky in the 1950s and popularized by Noam Chomsky and Morris Halle in their book *The Sound Pattern of English,* also known as *SPE* (Chomsky & Halle, 1968).

The emphasis of Generative Grammar was on speakers' competence (i.e., knowledge of language) rather than their performance. An important part of Generative Grammar, as laid forth in SPE, is that it is necessary to understand the language in order to understand how it works. This approach is called Generative Grammar because its rules govern the generation of surface forms from the underlying representations.

According to SPE's Generative Phonology theory (Chomsky and Halle, 1968), each morpheme has a unique underlying representation in the lexicon where arbitrary sound-meaning associations are stored. These stored underlying representations are formed of bundles of distinctive features. However, not all distinctive features are specified for each segment. Unary features are missing from most segments, and even binary features are not specified for every segment. This omission of certain feature values is called *underspecification*. Within this perspective, underlying representations should include as few distinctive features as possible: the only information that is really nonpredictable should be retained in the lexicon. Predictable features should be removed from underlying representations and then filled up by rules. In general, enough features are defined to uniquely identify each sound in the language, but no more. Thus, Carr and Montreuil (2013, p. 99) liken the underlying phonological form of a morpheme to "a representation of its surface forms, stripped of all predictable phonetic properties; it is the phonological rules of the language which supply these properties."

The lexicon contains all of the morphemes required to create words and sentences. To produce surface representations, rules are applied in a serial derivation, adding and altering features as needed. The grammar would be where the morphemes are put together to form the end result. To begin a derivation, morphemes are selected from the lexicon and combined to form words and sentences. After the syntactic component of the grammar has sorted out the word order, the ordered collection of morphemes is passed to the phonological component, where a series of rules check for particular configurations. When they find them, the rules make alterations based on the instructions supplied. If a certain string of morphemes does not include the stated configuration, the lexical item is unaffected by the rule. The final surface representation is sent out to be pronounced once the lexical item has gone through each rule. Languages will vary in terms of the items in their lexicons and the rules that apply in various ordering (Zsiga, 2013, p. 277).

To sum up, SPE and post-SPE derivational theory views the lexicon as "the repository of 'unpredictable information' – it contains morphemes (or words) and their unpredictable properties" (De Lacy, 2007, p. 20). In other words, these theories assume that each morpheme has a distinct underlying representation saved in the lexicon and that all of a morpheme's nonpredictable phonological features are included in that underlying representation (McCarthy, 2008, p. 6). De Lacy further elaborates that in SPE, as much predictable information as feasible was removed from the vocabulary and provided by rules. Pre-consonantal nasals in lexical items, for example, were not defined for place of articulation since medial nasal consonants usually have the same place of articulation as the following consonant. This concept was adopted in the 1980s and 1990s underspecification theories. SPE and its subsequent rule-based descendants' explanatory capacity was partly predicated on the fact that the input to the phonology was constrained in predictable ways.

Optimality Theory

Optimality Theory (OT), on the other hand, is a constraint-based model first proposed by Prince and Smolensky (1993/2004) in the early 1990s. As a universal grammar for phonology, OT addresses the universal grammar issues raised above more clearly than any other phonological paradigm. At its core, OT is built on the notion of universal constraints that are nonetheless violable. Because the constraints are universal, they give an explicit way of describing the cross-linguistic commonalities that occur. Violation provides a mechanism for conveying linguistic variation: the degrees of violation permissible for each constraint are distinctive to each language. OT presents a unified method for describing which constraints are violable, called constraint ranking, in which breaches of lower-ranked constraints are permitted in order to meet higher-ranked constraints.

Grammar, according to this model, enforces a set of limitations or "constraints" on what are appropriate surface or output forms in any given language. It is assumed in OT that constraints are universal, that all languages have the same set of constraints, and that there are no language-specific constraints. Even though all constraints exist in all languages, the ranking in which they appear changes from one language to the next. Different rankings of the same set of constraints are used to create specific language patterns.

Another characteristic of OT constraints is that they can be breached and that they are not strictly followed in all languages. However, while no output form may satisfy all restrictions, violations must be kept to a minimum. A breach of a higher-ranking constraint is more serious than one of a lower-ranking constraint. As a result, the most harmonic output of a grammar is chosen as the one with the fewest violations of high-ranked requirements.

While Prince and Smolensky (1993/2004, pp. 5-6) and McCarthy (2007, p. 4) speak of OT as distinguishing two grammar components, GEN and EVAL, others talk about three components GEN, EVAL, and Lexicon (Kager, 1999, p. 19), or GEN, CON, and EVAL (Malmkjær, 2002, p. 197), (Carr, 2013), or even four components: Lexicon, GEN, CON, and EVAL ((Zsiga, 2013, p. 324; Cooper, 2015, p. 9). The remaining part of this section provides a brief overview of each of these components:

By introducing the fundamental OT principle of the *richness of the base*, Prince and Smolensky (1993/2004, pp. 205, 225) have managed to flip SPE's lexical underspecification premise on its head, as McCarthy (2007, p. 17) puts it. To them, the *base* is the collection of inputs for the grammar, and it is "rich" in the sense that it is not constrained by the limitations imposed by a specific language. The importance of a rich base in phonology lies in the fact that it prevents devices stated underspecification, such as morpheme structure constraints, from preemptively eliminating forms from the set of potential inputs to the grammar. The richness of the base in syntax implies that variations across languages cannot be traced to systematic differences in their lexicons' content. Rather, it is EVAL (the Evaluator component in OT) and constraint hierarchies that control all elements of well-formedness. Hence, any systematic changes across languages must be accounted for by a difference in the ranking of constraints.

In short, OT views the lexicon as "the storehouse of underlying forms of morphemes, which contains all aspects thereof and lacks language-specific restriction" (Cooper, 2015, p. 9). Under OT, lexical entries are assumed to be fully specified, with the lexicon comprising all phonological, morphological, syntactic, and semantic features of a language's morphemes (roots, stems, and affixes) and accordingly defining the input requirements that will be sent to GEN. (Kager, 1999, p. 19).

The second component of an OT grammar is GEN, the universal candidate generator, which is the operational component that generates an infinite set of candidate output forms for some input and sends these to EVAL. (Kager, 1999, pp. 19-20; McCarthy, 2002, p. 76; Uffman, 2011, p. 192; Cooper, 2015, p. 9). GEN is *universal* because the candidate forms that GEN produces for a given input are the same regardless of the language used (McCarthy 2007, p.16). This characteristic of GEN necessitates having diverse candidates to cover all the ways in which languages differ, which takes us to the second crucial property of GEN, i.e., freedom of analysis.

According to Kager (1999, pp. 19-20), GEN may create any possible output candidate for a given input. In other words, GEN is the same across all languages, and as a result, it must, in effect, anticipate all of the possible transformations that a given input may undergo across languages to ensure that all of these possibilities are included in the candidate set McCarthy 2007, p.16. The only real limitation imposed on all output candidates created by Gen, according to Kager (1999, pp. 19-20), is that they must be composed of licit components from the standard linguistic representation vocabulary, such as phonemic structure, suprasegmental structure, morphology, and syntax. The fact that Gen creates all logically conceivable candidate analyses of an input rids OT grammar of the requirement to have rewrite rules in order for inputs to be realized as outputs. All structural modifications are applied at once, in parallel.

In phonology, GEN can get segments deleted, synthesized, or get their feature values altered. The members of the candidate set can be derived by doing these procedures freely, optionally, and repeatedly. Gen specifies the number of potential rivals for a given input. For this range to be complete, the input must incorporate all feasible realizations of the input in every human language and every possible segment combination. In other words, the pool of potential candidates is unbounded (McCarthy, 2008, p. 16). Thus, if the input form is /kæt-z/, the set of candidates will include output forms that help facilitate pronouncing the problematic /tz/ cluster, such as /kæts/, /kædz/, and /kæz/, in addition to the faithful candidate /kætz/. Additionally, the set of candidates will contain not only output forms in which features were modified for no good reason, such as /kætʒ/, /ketz/, and /gæts/, but also useless candidates like [dagz], where too many feature changes have rendered the original input unintelligible (Zsiga, 2013, p. 332).

The third OT grammar component is EVAL, or the Evaluator, which according to McCarthy (2007, p. 5), is a constraint component that selects a member of a set of candidates "to be the actual output of the grammar." Kager (1999, p. 20) views EVAL as the grammar's most important component since it must account for all of the observable patterns of the surface forms. GEN may propose any possible output, but it is Eval's primary function to evaluate the outputs' "harmony" with regard to a specific ordering of constraints. In other words, after receiving the candidate set from Gen, EVAL uses a constraint hierarchy to assess it and pick the most harmonic or optimal candidate as the grammar's output.

Kager (1999, p. 20) views EVAL as being structured as three devices. The first device is a hierarchy of universal constraints that comprises all of the universal constraints (collectively referred to as "Con"), which are ranked differently according to different languages. Here two assumptions are made about constraint ranking. First, we assume that all constraints are ordered in relation to one another, and this is done in order to discard uncertain or fluctuating rankings. The second assumption is "transitivity of ranking," which states that dominance relations are transitive. In other words, if constraint 1 dominates constraint 2, and constraint 2 dominates constraint 3, then through "transitivity of ranking," we learn that constraint 1 dominates constraint 3.

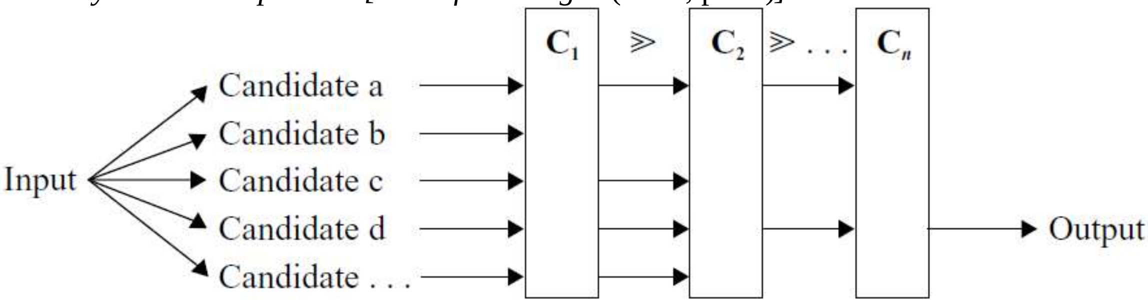
The second device in EVAL has to do with the marking of violations. Regarding marks for violating constraints, we assume each output candidate receives the same number of marks as its number of violations. Thus, infinite markings are possible here, but an unlimited number of marks will never be significant in identifying optimal outputs. An essential principle of minimal violation of constraints is that every violation serves an important function: to avoid violating an even higher constraint. Prince and Smolensky (1993, p. 27) summarize this notion as follows: "Economy: banned options are available only to avoid violations of higher-ranked constraints and can only be banned minimally."

Kager (1999, p. 21) further clarifies this with the following example. GEN can provide any analysis of (English) /bed/ that fits inside the universal alphabet, including suggestions like /pɪləʊ/ and /mætrəs/, which are both exceedingly unfaithful. However, regardless of the ordering of constraint violations, these candidates will be discarded due to their failure to obey faithfulness constraints or to compensate for this through reductions in markedness.

The third and final device in EVAL has to do with harmony evaluation. This device is responsible for ranking the infinite candidate outputs in terms of constraint hierarchy and picking the optimal candidate. To achieve this, a language-specific constraint hierarchy procedure is used to decrease the number of potential candidate outcomes until only one output is left. According to McCarthy (2008, p. 16) and De Lacy (2007, p. 10), Eval selects the optimal candidate by applying the following to the candidate set. At the outset, Eval takes the top-ranked constraint and extracts the subset of candidates most favored by that constraint. Next, this most favored subset of candidates is sent to the following constraint, which repeats the same process, locating its most favored subset of candidates and discarding the remainder. This procedure is then repeated until only one candidate remains: the optimal or most harmonious candidate which outperforms every other candidate in the original pool of candidates, as illustrated in the schematic representation in Figure 1 provided by Kager (1999, p. 22)

Figure 1

Harmony evaluation process [taken from Kager (1999, p. 22)*]*



One important characteristic of this process of evaluation is "strict domination." According to Zsiga (2013, p. 333), this characteristic entails that a candidate will be eliminated from consideration if it breaches a higher-ranking constraint when other candidates do not, regardless of whether this candidate complies with all of the lower-ranking constraints or not.

The fourth and final component of an OT grammar is CON which is the set of grounded, universal, violable constraints on linguistic structure (Zsiga, 2013, p. 310; Cooper, 2015, p. 9). Thus, the first characteristic of CON is that it is grounded. According to Zsiga (2013, p. 311), the reason behind the existence of constraints may be found in one of three areas: articulation (e.g., the difficulty of switching vocal cold vibration within a consonant cluster), acoustics (e.g., the difficulty of perceiving the difference between front rounded and back unrounded vowels), or processing (e.g., ease of detecting word boundaries when aspirating all initial voiceless plosives).

The second characteristic of CON is that it is universal, meaning that all human languages possess the same constraints (de Lacy, 2007, p. 10) and (McCarthy, 2007, p. 6). Zsiga (2013, p. 310) claims that this characteristic may be due to one of two facts. First, it may be attributed to the first characteristic of grounding since all human languages operate within the same articulatory, acoustic, and processing confines. The other explanation mentioned by Zsiga is that of a genetically based Universal Grammar.

Still, despite constraints being grounded and universal, they are not always obeyed and are often violated. To explain this, we need to refer to CON's third characteristic, i.e., constraints are violable. According to Kager (1999, p. 3), this characteristic entails that constraint violation does not create ungrammaticality, nor is it necessary that all constraints be met for a language to produce grammatically correct sentences. Instead, it is the least costly violation of the constraints that defines the optimal output of a language. There are inherent conflicts between constraints; therefore, every logically feasible language output violates at least one constraint. It is essential that grammars be able to handle conflicts between universal constraints in order to determine the optimal output form.

According to Kager (1999, p. 9), a constraint is "a structural requirement that may be either satisfied or violated by an output form." In other words, an output form is said to obey a constraint as long as the structural requirement is fully met. Any form that does not fulfill such a requirement violates a constraint. Generally, CON can comprise two basic types of constraints: markedness and faithfulness. Markedness constraints evaluate the linguistic well-formedness of the structure of the output form (Kager, 1999, p. 9; De Lacy, 2007, p. 10; Cooper, 2015, p. 9). Thus, markedness constraints only deal with the output forms and do not look at input forms. Another characteristic of markedness constraints is that they may be expressed either positively, requiring "unmarked configurations," or in the form of a prohibition (Archangeli, 1999, p. 536; Kager, 1999, p. 9). An example of the former is the markedness constraint ONSET which requires each syllable to have an onset, while the constraint No-Coda which does not allow consonant-ending syllabic units, is an example of the latter.

Faithfulness constraints, on the other hand, evaluate the relationship between the input and the output in terms of the preservation of input structure in the output (De Lacy, 2007, p. 10; McCarthy, 2008, p. 13; Cooper, 2015, p. 9). Identity constraints are one kind of faithfulness constraint. The constraint IDENT-PLACE, for example, mandates having the same place of articulation for corresponding segments in the input and output. For example, a violation of IDENT-PLACE occurs if the /n/ in the input form /ɪnpʊt/ corresponds to /m/ in the output form /ɪmpʊt/ (Zsiga, 2013, p. 309).

Even though features may be added or removed, another set of faithfulness constraints requires that the number of segments in the input and output be the same (irrespective of the change), which disallows any insertion or deletion of linguistic elements. Constraints that prevent deletion are known as MAX, whereas those that prohibit insertion are known as DEP.

As a result, MAX effectively forbids segment deletion since a segment that has been removed has no output representation. In addition, DEP prohibits insertion, as an inserted segment is new and does not relate to any input segment.

Markedness constraints prefer some linguistic structures to others. For this reason, it is common to see markedness constraints clashing with faithfulness constraints that prevent input structures from changing. This kind of conflict is referred to as "constraint conflict," and OT uses ranking to settle it.

Conclusion

Both constraint-based optimality theory and the rule-based SPE model try to account for the patterns that languages have for determining what sounds these languages use and how they put them together. Both of these generative phonology models of universal grammar attempt to do this by formalizing the relationship between a speaker's implicit knowledge (input) and their actual production (output). So, the difference between them has more to do with the process than the outcome. While the rule-based SPE model shows how inputs turn to outputs by using language-specific inviolable rules that are ordered serially and applied one at a time, Optimality theory tries to do this by proposing a universal set of constraints that are ranked in parallel, and where depending on how each language ranks those constraints, it ends up with its own distinct phonological patterns.

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