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The phonological shape of morphemes constructed by Merge

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ABSTRACT. This paper argues that phonology should be, in its usual sense, reinterpreted as a set of linguistic operations of any type—they may refer to phonological, morphological or syntactic units. It also argues that Merge, which is seen as a core and unique property of the computational system of human languages, takes not only syntactic and morphological units but also phonological features as arguments, to generate a set of linguistic constructs. This leads to the conclusion that the part of the language faculty which interfaces with the Articulatory-Perceptual (AP) systems contains only Merge and a set of operations that are related to phonetic externalisation.*

Keywords: morpheme-internal phonological representations, Merge, elements, Precedence-free Phonology, externalisation

1. Introduction

In the Generative Grammar approach to the study of language evolution, the presence/absence of recursion is a key consideration not only in the debate on the organisation of the language faculty but also when it comes to the question of the origins of language itself. From an evolutionary perspective, researchers (Reuland 2009, Chomsky 2010) have claimed that human language in its present form emerged from single-word expressions by employing a recursive merge device. This naturally leads to the assumption that recursion is found only in syntax.

Contrary to the widespread view that recursion is absent in phonology, this paper argues that a syntax-like recursion operation is required in order to produce the phonological shape of a morpheme/word. This then prompts us to reconsider the organisation of the language faculty—a move which impinges on the study of the origins of language.

In more precise terms, I will argue that Merge, which is a core and unique property of the computational system (CS) of human language, applies not only to (morpho)syntactic objects, but also to the phonological units present in the phonological structure of morphemes. This implies that phonological categories are engaged not only in the externalization of internally-constructed expressions but also in internal computation.

Given that Merge is the only property associated with the CS, at least the following three points relating to phonological representations should be addressed.

(1) *Issues under the Merge-only model of the CS*
   a. While Merge is believed to be responsible for (morpho)syntactic structure building, how is the phonological shape of a morpheme/word constructed before being stored in the lexicon or the relevant memory space in the brain?
   b. Merge takes syntactic and morphological objects as arguments, but there is no clear reason why Merge cannot also take phonological units as arguments.

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c. Syntactic structure that has been constructed by Merge is precedence-free. So why is it assumed that precedence relations between phonological units (e.g. between segments, between nodes in contour expressions, between left and right edges) must be specified in a morpheme's internal structure?

Sections 2 and 3 discuss (1a) and (1b) respectively, claiming that, in the spirit of minimalism, the phonological shape of a morpheme is constructed by Merge by taking features as arguments. Then in section 4 it is argued that expressing precedence relations between units is unnecessary not only in morphosyntactic representations but also in morpheme-internal phonological representations. This claim is made in pursuit of theoretical consistency and representational redundancy/economy. Section 5 introduces phonological elements as the most appropriate arguments for Merge. In the final section it is argued that the part of the language faculty which interfaces with the Articulatory-Perceptual (AP) systems contains only Merge and a set of operations related to phonetic externalisation.

2. Constructing the phonological shape of a morpheme/word

In the minimalist approach to syntactic analysis, it is assumed that syntactic objects (SOs) are constructed by the recursive application of Merge onto syntactic items. For example, the lexical items α and β are taken from the lexicon (although there is still controversy over whether or not the lexicon actually exists as part of the language faculty) and are concatenated by Merge to construct a new object {α, β}. Merge applies not only to lexical objects such as α and β, but also to derived objects such as {α, β} which were themselves constructed by Merge (e.g. γ + {α, β} → {γ {α, β}}). The repeated application of Merge to its own derivatives generates an infinite number of recursively structured expressions, which are then submitted to the interface systems, Sensorimotor (SM) and Conceptual-Intentional (CI) (Chomsky 2010 and Hauser, Chomsky and Fitch 2002). Since this repeated application of Merge is infinite, at least in principle, there is no limit on the length of a phrase and sentence (e.g., [[[The thief] the policeman caught] was gazing at the building] ..., van der Hulst 2010; Nasukawa 2017). In this way, sentences generated by a grammar are infinite not only in length but also in kind.

In principle, morphology (word formation) works in the same way as syntax. For example, the morphemes α and β are taken from the lexicon and are concatenated by Merge to form a new object {α, β} (e.g. nation + -al → national). Merge may apply repeatedly to its own derivatives (e.g. nation + -al → national; national + -ize → nationalize; nationalize + -ation → nationalization). As in syntax, this generates an infinite number of recursively structured expressions (e.g. [[de-[[[nation]-al]-iz]]-ation] …). Morphologically complex words generated by a grammar are, like sentences, infinite not only in length but also in kind. The assumption is that the reason we rarely encounter very long sentences and very long words is primarily to do with our limited memory capacity (Nasukawa 2017).

In the case of morpheme-internal structure, it is widely assumed that recursive Merge is not involved. Instead, the phonological shape of a morpheme is thought to derive from a linearly-ordered set of segment-sized units such as C/V, timing units, skeletal positions or Root nodes. Thus, a morpheme's phonological shape is the result of concatenating segments in a linear fashion, with hierarchically recursive structure playing no part (Bromberger and Halle 1989). And most mainstream theories of phonology share this idea that a linearly-ordered string of segments (or equivalent units) is lexically specified, although they disagree on the specifics of how syllable structure should be constructed (for a detailed discussion, see Nasukawa 2011). Regardless of any differences that may exist between one theory and another, however, these approaches all fail to explain how phonological representations are constructed before being stored in the lexicon.

In contrast to the position just described, Nasukawa (2017) shows that, in observing the properties of the phonological shape of words, we find a parallel with sentence/phrasal and morphological construction. The words of a language vary greatly in length: some consist of just a single vowel (e.g. the article [ə] 'a' in English, [o] 'tail' in Japanese) while others have 40 or more segments (e.g. *Pneumonoultramicroscopicsilicovolcanoconiosis* (generally known as silicosis) /njuː ˌmɒnoʊ ˌʌltrə ˌmaɪkrə ˈskɒpɪk ˌsɪlɪkoʊvɒl ˌkeɪnoʊ ˌkɒnaɪ ˈoʊsɪs/, 44 segments, the longest artificial and technical word in the OED). Also, it is easy to find place names which are very long despite being just single morphemes, such as *Massachusetts* /ˌmæsəˈtʃuːsɪts/ (10 segments).

So, as with sentences and morphologically-complex expressions, there is in principle no limit on the length of a phonological string corresponding to a lexical item (although in the case of very long words, there is usually some kind of internal morphology involved). On this basis we can say that the difference between morphosyntactic and morpheme-internal phonological constructions comes down to whether a constructed expression is *stored in the lexicon or not*. Here again, it is implied that the reason why we rarely encounter very long words is chiefly to do with our limited long-term memory.

If word construction and sentence construction are essentially the same, in that an infinite number of objects can be constructed from a finite repertoire of units, then it is natural to assume that Merge targets not only morphosyntactic categories for sentence construction, but also phonological categories for constructing the phonological shape of a word. Following Nasukawa (2017), I claim that the mechanism operating in morphosyntax is also at work in phonology, where it is responsible for constructing the phonological shape of morphemes and words before these are stored in the brain.

This then begs the question as to what units are employed as arguments of Merge when constructing the phonological shape of a morpheme. This relates to the issue highlighted in (1b), which asks why it should be assumed that Merge takes syntactic and morphological objects—but not phonological objects—as arguments.

3. Arguments of Merge

Given that Merge is engaged in building the phonological structure of a morpheme before being stored in the lexicon or in some other location for memory, it is necessary to specify particular phonological units as the targets of Merge. Note that this position contradicts the established view that phonological objects are invisible to the syntactic computational system containing Merge as a core and unique property of human language (Chomsky 1995, et passim)—if Merge takes phonological categories as arguments, it is no longer necessary to maintain the idea of invisibility between different components. A further implication is that the language faculty need not employ any device for converting syntactic structures into something that is readable by the phonology (Translator's Office: Scheer 2008, 2011; cf. Selkirk 1984).

When Merge builds the phonological shape of a morpheme/word, there are two types of phonological units which could conceivably function as arguments. These are described in (2a) and (2b), where each type has a three-way function (Nasukawa 2011).

(2) a. timing/space units (e.g. C/V units, X units, the Root nodes)
  i. indicators of precedence relations between segments
  ii. building blocks for constructing syllable structure
  iii. bundles of phonological primitives (features)

b. phonological primitives (e.g. features, elements, components, gestures)
   i. minimal contrastive units
   ii. linguistic primitives contained in segment-internal structure
   iii. phonetically externalisable units (acoustics and articulation)

The timing units referred to in (2a) provide the interface between melody and prosody through their roles (2aii) and (2aiii). To determine whether these units are arguments of recursive Merge, we focus on (2ai). Timing units are generally thought to be arranged in a linear order—as opposed to a hierarchical arrangement—where no recursive structure is involved. For this reason, timing units are unlikely to function as arguments of recursive Merge (cf. Samuels 2011).

The phonological primitives referred to in (2b) require further explanation before we address the question of whether they could function as arguments of Merge. In principle, the three roles in (2b) should apply in any theoretical approach to melodic (segmental) representation. In reality, however, each role must be interpreted in the context of particular theoretical assumptions. Regarding (2bi), for example, some approaches employ bivalent (equipollent) features as minimal contrastive units while others use monovalent (privative) features. Bivalent (two-valued, equipollent) features are found in most Distinctive Feature Theories (DFT: Chomsky and Halle 1968, at passim), where a phonological contrast is created by assigning opposing values (typically plus and minus) to a given feature. For instance, the contrast between nasal and oral is captured by specifying [+nasal] or [–nasal] to a representation. On the other hand, in approaches which use monovalent features, a phonological contrast is expressed by the presence or absence of a given feature. For example, a structure that includes the single-valued feature [nasal] contrasts with an otherwise identical structure that lacks [nasal].

These two different ways of expressing melodic contrasts make different predictions (Nasukawa 2005, et passim). First, in a model based on monovalent features, where the nasal/oral opposition is captured by the presence/absence of [nasal], it is only features that are present in a representation which can be active in phonological processes (e.g. nasalization); the absence of a feature means that the property associated with that feature cannot participate in any processes. By contrast, the use of the bivalent feature [±nasal] creates three possibilities with respect to feature participation in processes: [+nasal] is active, or [–nasal] is active, or both [+nasal] and [–nasal] are active. However, the behavior of phonological features in natural languages indicates that only the first of these possibilities is actually attested—nasalization (via active [+nasal]) is observed whereas the opposite effect of oralization (via active [–nasal]) is not. Moreover, theories that employ bivalent features substantially over-generate the number of unattested processes (Harris 1994, Backley 2011). In comparison, the level of over-generation is significantly reduced in monovalent approaches.

Regarding (2bii), the internal structure of segments is represented differently from one theory to another. For example, theories based on the SPE tradition (Chomsky and Halle 1968, et passim) assume that each segment consists of an unordered set of features, whereas in other theories including Feature Geometry (Sagey 1986), Dependency Phonology (Anderson and Ewen 1987) and Element Theory (Harris 1994, Nasukawa and Backley 2005) features are hierarchically organized within a segment. In the case of SPE-based approaches, it is obvious that features cannot be arguments of recursive Merge since there is no hierarchical recursive structure. But even in the case of approaches where features are hierarchically arranged, we might not expect features to function as arguments of recursive Merge. This is because structures characterized by geometric or hierarchical relations between features are generally based on structural templates determined by language-specific parameters; they cannot be considered as objects constructed by the application of Merge to features. However, it will be shown below that the Precedence-free approach to phonological representation, which employs no template-like structure, can explain how the phonological shape of a morpheme is constructed before being stored in the lexicon. In addition, it will be argued that Merge takes features as arguments and that the recursive application of Merge creates the phonological representation of a morpheme before it is stored in the lexicon (Nasukawa 2014, 2015, 2016, 2017).

With respect to (2biii), there are two different conditions for determining the phonetic externalisation of features: contingent interpretability and full interpretability. DFT is associated with contingent interpretability, where a feature is phonetically interpretable only if the values of all the other features in a segment are specified/predictable. This is because a single feature cannot be phonetically interpreted independently. By contrast, the features (or 'elements') used in Element Theory, Dependency Phonology and Government Phonology are independently interpretable. From this it follows that, unlike in DFT, a segment may consist of any number of features—including just a single feature.

Returning to the question of whether features may function as arguments of Merge, let us consider what kinds of units are targeted by Merge in syntax. The units that are used to build syntactic structures are *words*, which have monovalent rather than bivalent values since they are either selected (present) or not selected (absent) as arguments of Merge—assigning plus/minus values is irrelevant here. So, in the same vein, we can expect phonological arguments of Merge to be also represented in terms of monovalent oppositions. This line of reasoning leads us to identify *elements* as suitable arguments of Merge because, like words but unlike distinctive features, elements are monovalent units which are phonetically interpretable in isolation—they do not need support from other elements. Furthermore, elements form head-dependency relations with one another in order to generate melodic contrasts (Kaye, Lowenstamm and Vergnaud 1985, 1990; Harris 1990, 1994; Backley 2011; Nasukawa 2016, 2017), which is entirely in keeping with the head-dependent nature of structural expressions created by Merge.

4. No precedence in phonology

Before describing how elements are manipulated by Merge to create phonological structure, this section addresses the issue introduced in (1c) above. Under the proposal that Merge is the only operation at work in the CS, the question arises as to what differences there are between syntax and morpheme-internal phonology. The consensus is that in syntactic structure that has been constructed by Merge, there is no encoding of precedence relations between words. On the other hand, it is generally assumed that precedence relations do exist in phonological structure (e.g. between segments, within contour expressions, between left and right edges) and that these are specified in morpheme-internal structure. Although theories of phonology vary on specific points, there is nevertheless a general agreement that, unlike in syntactic structure, these relations should hold between structural positions. In addition to controlling the linear ordering of segments, precedence applies to the description of contour segments such as affricates and prenasalised obstruents, where ordering relations are thought to hold between units smaller than a segment (e.g. the features [±continuant] and [±nasal]) (Sagey 1986). What this indicates is that precedence plays a central role in relations between segments at the skeletal level and also within individual segments. On the other hand, it appears to have no bearing on another important domain within phonology, that of syllabic/prosodic structure.

In phonology, the relational properties expressed in morpheme-internal structure include not only precedence relations between positions but also the network of prosodic relations holding between 'higher' phonological units such as onset, rhyme, foot and the phonological word. When it comes to representing these prosodic relations, the convention is to utilize the notion of dependency. A point which is often overlooked, however, is the fact that the term 'dependency' actually defines a more general structural property which is present in other modules of the grammar too.

During the last decade, however, it has been argued that the precedence relations which characterize contour segments should be seen merely as a natural outcome of the way speakers interpret these structures, rather than as a phonologically encoded structural property per se (Lombardi 1990, Takahashi 1993; Schafer 1995; Scobbie 1997, Scheer 2003, Nasukawa and Backley 2008). If this is correct, then the role of precedence is limited to encoding only those relations which hold between skeletal positions. To justify this approach, however, it is necessary to explain why this special status is exclusive to skeletal positions.

Nasukawa (2011) addresses this issue by evaluating the variety of different relational properties currently used in linguistic representations, with the aim of collapsing these into a single notion of dependency. This allows precedence relations to be excluded from all components of phonology, leading to the conclusion that precedence is merely the natural result of computing and interpreting the dependency relations which hold between units in a structure. By adopting this approach, the competence side of the language faculty (which includes intra-segmental structure) gains the advantage of being able to maintain a greater degree of representational coherence throughout derivation, right up to the level at which it interfaces with the articulatory-perceptual facilities.

5. Elements as arguments of Merge

In the preceding discussion it has been proposed that in order for Merge to operate in phono-syntax, it must operate on phonological units which are not structurally fixed and which may concatenate freely. In addition, each unit must be able to exist independently of other units. The phonological units which best fit these criteria are those developed in the Element Theory approach (Kaye, Lowenstamm and Vergnaud 1985, Harris 1994, et passim).

(3) *Elements* (Nasukawa 2017: 65)

elements	*label based on acoustic pattern*	*manifestation as a consonant*	*manifestation as a vowel*
|A|	'mAss'	uvular, pharyngeal POA	non-high vowels
|I|	'dIp'	dental, palatal POA	front vowels
|U|	'rUmp'	labial, velar POA	rounded vowels
|ʔ|	'edge'	oral or glottal occlusion	laryngealised vowels
|H|	'noise'	aspiration, voicelessness	high tone
|N|	'murmur'	nasality, obstruent voicing	nasality, low tone

Elements are monovalent units, so lexical contrasts are captured through their presence versus absence. In addition, each element can be phonetically realised on its own; that is, it does not need support from other elements in the same structure. For this reason, Element Theory does not require any template-like organization of elements, nor does it assume any universally-fixed element matrix (cf. distinctive feature matrices). Thus, elements appear to be ideal for constructing the phonological shape of a morpheme via Merge.

In a development of Element Theory called Precedence-free Phonology (Nasukawa 2014, 2016, 2017; Nasukawa and Backley 2017; Nasukawa, Backley, Yasugi and Koizumi under review), elements not only function as the building blocks of melodic (segmental) structure, they also represent prosodic properties. Moreover, they do this without referring to prosodic positions or to syllable structure constituents. This approach has the advantage of removing from representations all arbitrary correlations between prosodic constituents and melodic features. (For example, the feature [stiff vocal cords] is regularly associated with word-initial onsets but rarely with word-final or syllable-final position, even though there is no obvious link between the melodic unit [stiff vocal cords] and prosodic units such as onset and syllable.) Instead of referring to prosodic constituents, elements are themselves projected to higher structural levels as organizing units, where they concatenate to form prosodic constituents without the need for traditional prosodic labels. For a detailed discussion of the model which uses only elements in recursive structure, the reader is referred to Nasukawa (2014, 2016, 2017), Nasukawa and Backley (2017) and Nasukawa, Backley, Yasugi and Koizumi (under review).

6. Final remarks: Merge and a set of operations

The internal objects (π) that have been constructed by Merge have properties which must be readable by the sensorimotor (SM) systems; these include the phonological primitives (elements) and their relational properties (hierarchical structure). Also, the relational properties in words and phrases/sentences are assumed to be part of π since prosodic phenomena are determined by these relational properties.

In this model, there is no translation between syntactic structure and prosodic structure (cf. Selkirk 1984). And in the interests of maintaining a minimalist approach, it emerges that no reorganization of existing structure should be permitted. Rather, I claim that properties should conform to a visibility requirement and that all structural properties constructed by Merge should be readable at the SM interface. This is because phono-syntactic structure created by Merge is necessary for determining morpheme-internal stress and tonal assignment and is also responsible for shaping segmental alternations such as lenition and fortition. Assuming that the same processes function at the word level, we need morphological structure established by Merge at the SM interface. In addition, syntactic structures are also assumed to be active in establishing phrasal and sentential stress patterns.

In this model, all forms constructed by Merge may be considered syntactic objects—they differ only in terms of the types of constituents involved. From this it follows that all constructed objects are subject to a phonology (i.e. a set of operations) which is located between CS and the SM interface. And if the same operations apply to both syntactic structure and phonological structure, then there is no need for a formal distinction between syntax and phonology. After all, the only thing which distinguishes them is the set of units that each one uses.

The final point to make is that Merge, which targets all types of linguistic units rather than just syntactic objects, is associated with the view of language evolution developed within the generative grammar approach. By comparison, the set of operations assumed in standard models of grammar are related to language variation in a broader sense which includes phonological phenomena such as historical change and dialectal variation (Nasukawa 2018, cf. Chomsky 2010).

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