How many constraints are there? A preliminary inventory of OT phonological constraints

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Abstract

In this project we document a total of 1666 unique OT constraints published in the phonological literature. These span a period of time from 1993 through 2008 and come primarily from four major journals. The main constraint database contains the following information for each entry: name, abbreviation, type, subtype, definition, violation example, comments, author, year, and journal. This catalog is presented all together in a single Excel spreadsheet, allowing the user to quickly find and sort constraints based on a number of individualizable parameters. In this paper we also include a summary analysis of the quantity of constraints divided according to three independent variables: type, date of publication, and source.

1 Introduction

A commonly-heard question among students of OT, especially beginners, is "How many constraints are there?" This project represents an initial attempt to provide a principled and systematic (albeit indirect) answer to that query. In this paper we describe the design of an accompanying constraint inventory contained in an Excel spreadsheet (*constraint catalog.xls*). Here we list and explain the column headings used to organize that document. We also sketch the history behind it, summarize the results we obtained, and provide some preliminary statistical analysis and discussion.

The main purpose of this work then is to document all of the formal phonological constraints that have been proposed and used in a substantial corpus of the OT literature. This will allow practitioners of OT to search for constraints based on a number of powerful and useful parameters such as name, type (markedness, faithfulness, etc.), definition, subtype (phonotactic, tonal, metrical, etc.), author, year, journal, etc. Consequently, it is now possible to provide a rigorous answer to several intriguing and potentially important issues such as the following:

(1) a. In what year was a given constraint first proposed, where, and by whom?
b. How many specific, individual distinctive features have been the target of faithfulness constraints of the type IDENT(ft)? (Our answer: 27.)
c. How many constraints has a particular author (e.g. Alan Prince) proposed? (Our answer: Alan Prince has been involved in proposing at least 151 constraints.)
d. During the history of OT, has the average number of new constraints proposed each year gone up or down overall? (Our answer: up.)
e. How many functionally-different definitions are there of the constraint called NONFINALITY? (Our answer: 10.)
f. In which journal did the mechanism of local constraint conjunction first appear in print? (Our answer: *Linguistic Inquiry*.)
g. What proportion of all constraints is of the markedness variety? (Our answer: 54%. To

a certain degree of course the answer to this question depends on how one defines a markedness constraint, as well as how certain types of constraints (such as general schemas for families of related constraints) are counted. See §4.3-4.4 for further discussion and clarification.)

With respect to the questions posed in (1), as well as the answers we provide, a few comments are in order. From a theoretical point of view the list of constraints appearing in our database is somewhat arbitrary rather than unified. By this we mean that no attempt has been made to ensure that the constraints included here are necessarily compatible with each other. Rather, any number of different models and subversions of OT are freely mixed together, with little discrimination between them. Consequently, many of the cited works not only propose their own constraints but reject certain others. For example, McCarthy's (2003b) paper on categorical constraints repudiates many of the gradient alignment constraints that he himself originally invented. Hence there is undoubtedly no variety of OT which would accept all the constraints in our list as being simultaneously viable as part of one single theory.

At the same time, however, we still believe that this project is very worthwhile. We hope that it will serve as a helpful methodological tool in evaluating the validity of general assertions about OT. For example, any claim about the capabilities of a universal constraint set depends on ***all*** the members of CON. Our list provides an efficient way for theoreticians to make sure they have considered all extant constraints when considering the typological ramifications of their new proposals. It also has practical value in helping researchers know where to start in documenting references to work about OT.

The remainder of this paper is organized as follows. In §2 we present an overview of our findings. In §3 we note the criteria used to narrow down the sample of sources for this project. In §4 we list and explain each field (column) appearing in our database. In §5 we provide some preliminary statistical analysis and discussion of our results. In §6 we briefly review a few previous lists of OT constraints and compare them with our own. Finally, in the conclusion we reflect on some of the implications of this work.

2 Overview of results

In this section we present an initial summary of the types of statistical generalizations discussed in more detail later in the paper (§5). In response to the main issue of how many constraints exist overall, we can now offer the following conclusion. In a tightly-controlled sample consisting of four major linguistic journals plus four other seminal OT works (§3), ranging between the years 1993 and 2008, the total number of unique, newly-proposed phonological constraints is 1666:

Table 1: Overall numbers of constraints in our entire sample, distinguished by type, and displayed in decreasing order of frequency

constraint type	number
markedness	902
faithfulness	492
alignment	241
local conjunction	11
other/miscellaneous	11
antifaithfulness	9
total	1666

All of the details related to classifying these constraints into the six categories in Table 1 are fully fleshed out in §4.3 and 5.1. For example, in this tabulation we have chosen to make a split between markedness and alignment constraints. This is certainly not necessary, although it does have precedents in the literature, e.g., Kager (1999:451-52). For someone interested in alignment as a specific topic, this should prove useful. Otherwise, it is a trivial matter to lump these two categories together if one wishes to underdifferentiate them. A complete breakdown of all 1666 individual constraints by type, source, and the year they were first proposed is provided in the Appendix to this document. The table there allows us to group, compare, and contrast the numbers of constraints by factors such as the journal in which they appeared. When we do this we discover that, not surprisingly, *Phonology* is at the top of the list. The following table ranks four major journals in terms of the numbers of new constraints they contain:

Table 2: Overall numbers of constraints in our sample, distinguished by journal, and displayed in decreasing order of frequency

journal	number of constraints
Phonology	558
Linguistic Inquiry	371
Natural Language & Linguistic Theory	340
Language	261
total	1530

In Table 2 the total number of constraints taken from these four journals is 1530. This is less than the total number of constraints appearing in our entire exhaustive sample (1666 in Table 1). This is because we supplemented these four journals with a few other major OT works in order to make our constraint inventory more complete and representative of the field. See §3 and 5.2 for further discussion.

Finally, another statistical measure we can also pursue is the number of constraints distinguished by date. Among the four journals listed in Table 2, the fewest new constraints (n = 34) were proposed in 1995, the first year in which articles on OT appear in this venue. The most prolific year is 2008 (209 new constraints). On average the proportion of new constraints proposed in the span between 1995 and 2008 increases overall by about 30% per year. From this

fact we conclude that, despite frequent claims to the contrary, OT is still very much alive and well.

3 The sample of sources

In this section we explain the criteria used to restrict the corpus of works we examined in searching for constraints to document. As noted in §1, our overall goal in this project is to compile a list of phonological constraints that is more or less exhaustive, within a well-defined sample of published works representing a selective yet robust subset of the OT literature. The group of journals we decided to review is the following four, arguably the most prestigious ones in the field (cf. Table 2):

(2) The four journals included in our sample, with the corresponding abbreviations used in our database

- *Phonology* (Phono)
- *Linguistic Inquiry* (LI)
- *Natural Language & Linguistic Theory* (NLLT)
- *Language* (Lang)

There certainly exist other established journals which also publish significant articles on OT and are therefore worthy of consideration. However, the time frame in which we carried out the groundwork for this study was limited, so we had to narrow down the corpus to a logistically manageable set. Specifically, this research was conducted as a course project lasting for eight weeks during the fall bimester of 2009.[1] Consequently, we could not reasonably take on more journals than these four. Furthermore, at that moment of time none of these journals had yet released its final issue for calendar year 2009. Therefore, in order to establish a consistent, a priori stopping point, we scanned the four selected journals through the final issue of each one up to the 2008 volumes only. We began searching these journals with the 1993 volumes. Nevertheless, as foreshadowed in §2, the first year in which OT articles appear in any of them is 1995 (see the Appendix). Therefore, in order to round out this survey with all of the foundational constraints, we supplemented the journals with four other seminal OT works. The latter are the original sources for many of the most important and commonly-invoked constraints at the beginning of the OT period (and some of these constraints are still in use today). These four monographs were widely-circulated at the time, in various stages of revision and (pre-) publication:

(3) Four important pieces of early OT literature not found directly in the journals we scanned

- Alan Prince and Paul Smolensky. 1993. Optimality theory: Constraint interaction in generative grammar.
- John McCarthy and Alan Prince. 1993a. Generalized alignment.

[1]This course, called "Frontiers in Phonology", was taught by Steve Parker at GIAL. The other eight co-authors of this paper were all students in that course.

- John McCarthy and Alan Prince. 1993b. Prosodic morphology: Constraint interaction and satisfaction.
- John McCarthy and Alan Prince. 1995. Faithfulness and reduplicative identity.

The complete bibliographic details of these four works are found in the list of references at the end of this paper. We also include there an entry for each article on OT from the four journals that we surveyed. Consequently, our bibliography amounts to an essentially exhaustive list of all the papers on OT phonology published in the four major journals between the years 1995 and 2008, inclusively. However, a note of clarification is in order. An important issue is, what counts as a "paper on OT phonology"? The answer to this is necessarily somewhat subjective. Many articles mention OT only in passing, or in order to criticize and reject it, etc. Works of this sort are normally not included here. Rather, in order to limit our corpus to all and only those papers which are "OT-friendly," we adopted the general working criterion of including an article in our survey iff it contains at least one tableau. Nevertheless, we sometimes loosened this guideline and included a specific constraint from a paper not having a tableau, if it appears from the context to be a serious proposal (as further defined below). Similarly, in our constraint catalog we strive to document only those constraints which the author(s) intend to represent the final, official, formal versions of their analysis. Therefore, we purposely exclude here those constraints which the authors identify as preliminary, informal, tentative, speculative, to-be-rejected, temporary, ad hoc, brute force, etc. In other words, we have taken pains to keep our list of constraints as theoretically cogent and compelling as possible. At the same time, however, we have intentionally left out of this study just a few OT works which are very important, yet orthogonal to our purposes. For example, in focusing on the question of what makes a feasible (valid) constraint, Potts and Pullum (2002) elucidate a number of interesting and significant issues. Nevertheless, most of the constraint definitions they posit are restatements of previously-proposed constraints using the more formal and restrictive devices of extinsible modal logic. Since these newer definitions do not generally affect how these constraints have been used in actual practice, we have chosen not to include Potts and Pullum (2002) in our survey, despite the undeniable contribution their work makes to the theory overall.

Another related issue is that we have limited our inventory of OT constraints to those which are *phonological* in nature only. Thus, we have intentionally avoided constraints pertaining strictly to syntax, semantics, etc., such as STAY, which militates against traces and therefore movement in general (Grimshaw 1997, McCarthy 2008a). Once again this distinction is sometimes hard to navigate, but in general we err on the side of inclusivity. That is, we have opted to include here any constraint referring in some way to phonological features, structures, or representations, even though the rest of the constraint definition may technically lie in another realm. For example, one subtype of constraint we do document in our catalog is the family of phonosyntactic WRAP-XP constraints originally proposed by Truckenbrodt (1995, 1999).

Finally, we close this section by discussing another well-known repository of OT works, the Rutgers Optimality Archive (ROA). This is also a logically-organized and important subset of the OT literature which could have potentially been selected as an alternative sampling base for a work of this sort. Initially we did in fact consider this as one option to pursue. The ROA has some distinct advantages *vis-à-vis* the journals. One obvious strength is that it is more inclusive, in the sense that it contains works such as theses, dissertations, etc., which are too big for journals. Furthermore, it includes many good papers which, for one reason or another, have not (yet) made it into the paper journals. A second advantage of the ROA is that it is free (modulo

Internet access) and therefore available in more places to more people. At the same time, however, these very factors can also be seen as a disadvantage of the ROA. Many of the works posted on it are preliminary working drafts designed to solicit feedback from the field. The four journals we surveyed, on the other hand, are well-established venues characterized by a rigorous and highly-competitive peer review process, ensuring theoretical respectfulness. This is normally lacking on the Archive. In the end we made this criterion — scientific precision rather than inclusiveness — our main priority and thus opted for the four journals. Another factor that confirmed this decision is logistical: it would have taken too long to survey every item posted on the ROA. In summary, then, all of the constraints contained in our catalog come from one of two sources: either (a) the four journals listed in (2), ranging between the years 1995 and 2008, or (b) the four additional works listed in (3). What is more, all of the constraints we document here relate specifically to phonology, to one degree or another.

4 Description of the constraint catalog

In this section we describe and explain the general organization of our constraint inventory in terms of the various fields (columns) used to annotate it. As noted in §1, the list of constraints is contained in the Excel file called *constraint catalog.xls*. In the comments here we introduce and discuss the individual parts of each entry, one-by-one, following the left-to-right order in which they appear in the first row of that document.

Both in this paper and in our Excel database, the default typeface font we use is Times New Roman. This is standardly included in all Microsoft Office applications. However, in order to display special phonetic characters which do not appear in the basic Office packages, we use the Doulos SIL unicode-compliant font. This will need to be installed in order to read the constraint spreadsheet correctly. This font is available for free download from the SIL International site: http://www.sil.org/computing/catalog/show_software.asp?id=91. Furthermore, it is important to note here that in our constraint entries we normally follow the transcription conventions of each source. Therefore, it is definitely ***not*** the case that we consistently transcribe all phonetic characters using the IPA system only.

Throughout the whole database we tend to follow a couple of general conventions in the interest of saving space. Specifically, to make the data as compact as possible, we leave out spaces between words when this does not obscure the meaning. We also substitute the ampersand symbol (*&*) for the word *and* whenever possible. These adjustments are made especially in conjunction with the first column in the constraint catalog (the constraint name; see §4.1). However, we often employ them elsewhere as well, i.e., in other fields.

4.1 Name (column A)

This cell displays the official name of the constraint, as specified by the author. Usually this is taken from the point in the article where the constraint is first introduced and discussed. In some cases, however, the author initially considers a loose version of the constraint in question but later rejects it. In these situations we just give the final name of the constraint which the author ultimately settles on. In entering our data into the spreadsheet we strove to make our task as typists as easy as possible. Therefore, we do not format the constraint names with the small caps font typically used for non-initial letters in the published literature. Rather, we capitalize the first letters of all major words and just enter all other letters as regular lower case.

4.2 Abbreviation (column B)

In this column we give the abbreviation for the corresponding constraint name listed in the cell to the left (in column A). We do not make up any of these abbreviated names ourselves, but strictly follow the abbreviations employed by the authors, such as in a tableau. In the numerous cases when the original author does not utilize an abbreviated name for a newly-proposed constraint, we just leave this cell blank.

4.3 Type (column C)

In this column we list the major type or variety of each constraint, following the six-way classification scheme outlined in Table 1. In many cases when we were unsure of the appropriate category for characterizing a constraint, we consulted the original source and followed its classification. See §5.1 for further discussion of this point. The current, default order of appearance of all constraints in our catalog is sorted by this field (type). Therefore all faithfulness constraints are grouped together in one block, all markedness constraints are listed consecutively in one block, etc. The six classes of constraints are arranged alphabetically, so they appear in the following order:

(4) Linear (top to bottom) order in which the six categories of constraints are listed in our database, and their corresponding abbreviations

a = alignment
af = antifaithfulness
f = faithfulness
lc = local conjunction
m = markedness
o = other/miscellaneous

Within each of these six groups the individual constraints are sorted next by name (column A), following Excel's default parameters for alphabetization. Thus, for example, the markedness constraint called *GEMINATE appears earlier in our list than the markedness constraint AGREE(place).

We now explain and clarify how we define the six-way typology of constraints in (4) for the purposes of this project. Alignment (*a*) and antifaithfulness (*af*) types are self-explanatory, so we have simply used these two labels as they are commonly understood in the OT literature. For faithfulness (*f*) constraints we assume the default type to be input-output (IO), following McCarthy and Prince (1995). Consequently, in most cases we have intentionally left this annotation out of the constraint names and abbreviations in columns A and B, respectively. For other varieties of faithfulness constraints, however, we include the standard subcategorization provided by the source. This includes base-reduplicant (BR), output-output (OO), etc. When no such abbreviation is given in columns A and B, faithfulness constraints can be assumed to be of the IO variety.

The abbreviation *lc* in column C of the spreadsheet stands for *local conjunction*. This is followed by a colon and then the abbreviations for the names of the two more basic types of constraints which are being combined. For example, entry #752 is named [*ŏ/SON≥e,o &

IDENT(high)]. We classify this as a local conjunction of the markedness constraint *ŏ/SON≥e,o ([e,o] must not belong to an unstressed syllable) plus the (input-output) faithfulness constraint IDENT(high) (output correspondents have the same specification for high as the input). Consequently, the type (column C) for this entry is *lc:m/f*, which means the local conjunction of a markedness constraint and a faithfulness constraint.

Constraints of the type (*m*) are markedness. In this category we include not only "pure" markedness constraints such as *VOIOBS (voiced obstruents are prohibited), but also many other subvarieties of constraints such as those which are sometimes referred to as "structural" in nature.

The constraint type abbreviation (*o*) stands for *other/miscellaneous* (see (4)). This is a small, residual set of hodge-podge constraints which do not fit nicely into any of the other five categories. One such example is Padgett's (2003) family of dispersion theory paradigmatic constraints, e.g., SPACE(color)≥1/3, which dictates that "potential minimal pairs differing in vowel color (backness and roundness) differ by at least ⅓ of the full vowel color range." This is entry #1665 in our catalog. In general we have tried to use the type (*o*) sparingly, pushing constraints into one of the other five canonical groups whenever possible. Hence there are only 11 entries of type (*o*) in our inventory. In contrast to this we have used the type markedness (*m*) very liberally, preferring to label ambiguous constraints as type (*m*) rather than (*o*) in most cases. Given the alphabetical order of these six constraint categories, the other/miscellaneous group (*o*) appears at the very end (bottom) of the Excel spreadsheet.

4.4 Subtype (column D)

In this column we give a more specific idea of what type of linguistic element, level, or structure is being referred to by each constraint. For example, both the markedness constraint *VOICE and the antagonistic faithfulness constraint IDENT(voice) are annotated in this column as *featural*. Every constraint in the database has at least one such subtype designation, and most constraints in fact have more than one. A list of all subtypes contained in our catalog is provided in the following chart:

Table 3: Exhaustive list of constraint subtypes occurring in our spreadsheet, displayed in decreasing order of frequency

subtype	*n*
featural	915
prosodic	770
phonotactic	766
segmental	661
morphological	348
metrical	249
tonal	102
general	61
autosegmental	57
syntactic	21
accentual	16
antialignment	3
phonetic	3
perceptual	2
antihomophony	1
intonational	1
total	3976

When all 3976 tokens of the subtype annotations in Table 3 are divided by the total number of constraints in our inventory (1666), the average yields an overall mean of 2.4 subtype designations for each constraint. When a particular cell in column D contains more than one subtype, these are concatenated with a diagonal slash between them, without spaces, and in decreasing order of importance and relevance; e.g., *prosodic/morphological*. It is not uncommon in our catalog for a specific constraint to be described with four or even five subtypes. For example, constraint #1219, defined as "a syllable has crisp edges with respect to any occurrence of [Round] that it dominates," is annotated as *autosegmental/prosodic/featural/phonotactic*. The linear order in which multiple subtypes have been listed in each cell was not determined in any rigorous way, but rather somewhat impressionistically. Consequently, there are undoubtedly some inconsistencies in how the subtypes for similar, related constraints have been entered in terms of left-to-right directionality.

Most of the constraint subtype labels in Table 3 are obvious and self-explanatory. We now discuss a few of them which may not be. The term *metrical* is used for constraints which make reference to stress, feet, and/or the corresponding grid representations. The label *autosegmental* indicates aspects of non-linear representation such as association lines, e.g., #638 MAXPATH[ATR]. The term *accentual* does not normally refer to stress per se but rather to pitch-accent and related notions. Finally, the label *general* is used for schema of related constraint families ranging over variable options, such as #36, Align(GrammaticalCategory,GEdge,ProsodicCategory,PEdge). In terms of numerically counting up the different types of constraints (as reported in the tables and figures throughout this paper), these 61 general constraints are tabulated only once each. That is, we have not attempted to estimate all of the different logically possible instantiations which could be theoretically generated by plugging specific arguments into these formulas. Rather, the only tokens of such

constraints which also enter into our calculations are those actually occurring in our database (because they were invoked in the specific analyses proposed among our sample of sources).

4.5 Definition (column E)

In this column we spell out the definition of each constraint. In all cases our default preference is to list the definition exactly as the source author has given it. This usually comes from the point in the article where the constraint is first presented. In some cases the author does not provide a formal definition. When that happens, we attempt to put together a definition gleaned from the corresponding discussion. In those rare and frustrating situations when a new constraint is proposed with no indication of what it means, we attempt to deduce the definition by examining a candidate in a tableau which violates it, and/or by analogy to similar, related constraints. In a few instances we note in this column a page number in the source where the constraint is discussed.

We reiterate here that, for the purposes of this project, we document unique constraints only, meaning those that have functionally distinct definitions. Consequently, we have made no attempt to keep track of all the variant formal names and paraphrased definitions of constraints proposed by different authors yet which have the same ultimate effect. Rather, we only include in our database the chronologically first reference to each constraint among our sample of sources. We include "duplicate" constraints (those having the same or a similar name) only when the later source defines the constraint in such a way that it behaves differently. In some cases this distinction may be rather subtle. For example, constraint #106 is named ALIGN(σ́,L,PrWd) and is defined as "the main stressed syllable coincides with the left edge of the prosodic word" (Gordon 2004). Entry #757 is named *#[-main] and is defined as "the syllable at the left end of the word has the main stress" (Hayes and Wilson 2008). At first glance these two constraints seem to do the same thing. Indeed, both would presumably be equally satisfied by a hypothetical candidate such as [táta]. However, since the first of these two constraints is expressed specifically in terms of alignment, it is intended to assess violations in a gradient fashion. The second constraint, on the other hand, is a markedness constraint and therefore probably assigns violation marks categorically. Thus, these two constraints potentially diverge in their evaluation of a less harmonic candidate such as [tatatá] (two *'s vs. just one *, respectively). For this reason we decided to include both of them in our list.

4.6 Violated (column F)

In this column we give an example of a particular output candidate violating the constraint in question. Again our normal preference is to use a phonetic form actually provided by the author proposing the constraint, especially one that occurs in a tableau. In general we try to employ candidates which violate the constraints minimally (fewest number of *'s), but that is not always possible. When no example of a constraint violater is given by the source, we try to contrive one ourselves. In doing so we often use default, unmarked segments and structures such as [ta], [tan], [tá], etc. When the constraint being violated is a faithfulness constraint, we normally give both an output candidate and its correspondent input form, separated by an arrow (→), with no spaces in between, and without diagonal slashes or square brackets. For example, to exemplify a violation of constraint #551, MAX (no deletion), this column contains the following "derivation": *tax→ta*. In some cases when examples of violation necessitate a detailed

diagram that cannot be easily entered into an Excel cell, we leave this column blank. These typically consist of complex autosegmental representations, metrical grids, etc. In most such instances we try, at the very least, to give a page number in the article where such a tableau can be found, or where violation of the constraint is discussed.

4.7 Comment (column G)

This column is used to annotate any further details of the constraint that are especially important or pertinent. For example, to document a previous source where the constraint was originally proposed, we list an abbreviated reference to that work here as *Author Year*. Such an entry normally refers to a book, a thesis, a dissertation, an unpublished paper, or a journal other than the four we surveyed. All such references are also listed in our bibliography at the end of this file.

To indicate that the constraint in question refers primarily to one specific language, we list that language in this column. Other common uses of this field are to note a particular framework or theoretical assumption of the author, such as BR (base-reduplicant) faithfulness, OO (output-output) faithfulness, sympathy theory, positional faithfulness, comparative markedness, etc. We also include here cases where the constraint is part of a larger family of related constraints, such as the universally fixed (impermutable) rankings characterizing the sonority hierarchy. Other annotations give further details about how the constraint is defined, how its violations are assessed, other constraints it may be similar to, etc. We also use this column to indicate more specific applications of constraints such as in loanwords, blends, hypocoristics, cophonologies, etc.

4.8 Author(s) (column H)

In this column we list the surname of the author who first proposed the constraint (within our sample). If there are two co-authors, both names are provided, separated by the ampersand symbol (*&*). If there are three or more co-authors we give the surname of the author listed first in the published source, followed by *et al.* In such cases the corresponding bibliography items at the end of this file give full details (first and last names) of all co-authors. A few cells in this column contain the surnames of two different authors, separated by a diagonal slash (*/*). This indicates that both authors proposed the same constraint, with the same name and definition, in the same year, but in two different works. For example, column H of constraint #1460, OCP-COR[αson], contains the entry *Anttila/Coetzee & Pater*. This means that this constraint was introduced by Anttila in one article, and by Coetzee and Pater in a different article, in two separate papers published in the same calendar year (2008). We do this so as not to have to determine which article actually appeared in print first.

4.9 Year (column I)

This column indicates the year in which the constraint in question first appears among our sources. For more than one article written by the same author in the same year, we append a lower case letter (*a*, *b*, *c*, etc.) to the end of the year. These correspond to the order in which the respective entries occur in our alphabetized bibliography list at the end of this document.

4.10 Journal (column J)

This column notes the journal in which each constraint was originally proposed (by the author in column H and in the year in column I). The names of the journals in our spreadsheet are abbreviated as follows (cf. (2)):

(5) Journal abbreviations

Phono = *Phonology*
LI = *Linguistic Inquiry*
NLLT = *Natural Language & Linguistic Theory*
Lang = *Language*

If the source of a new constraint is one of the other four major works listed in (3), we leave this column blank. In those cases when a constraint appears twice in the same year (but in two different articles), we give the names of both journals in this column, separated by a diagonal slash. The two journal names are listed in the same left-to-right order as the two corresponding authors in column H (see §4.8). For example, constraint #921, *DORSAL, has the names *Smolensky/Golston* in the author(s) column, *1996* in the year column, and *LI/Lang* in the journal column. This means that this constraint was first proposed in 1996 by Smolensky in a paper in *Linguistic Inquiry*, as well as by Golston in a paper in *Language*, also in 1996.

4.11 Number (column K)

Finally, this column contains a fixed, unique number for each constraint, to serve as a persistent identifier for that entry. For example, when the database is sorted in different ways, individual constraints can still be referred to using this numbering system. Furthermore, in order to return the catalog to its current, default state (see §4.12), all the user has to do is sort the entire spreadsheet by this column, in ascending order. Similarly, sorting this column in descending order has the effect of reversing the entire constraint list, etc. This column is placed last in row 1 of the Excel file since it will often be the least important detail of each constraint to keep in mind. Thus on a normal sized computer screen it will tend to protrude off to the right, beyond the viewing area of the pane. This allows the user to focus on the other, more important fields appearing earlier (farther to the left) in the database.

4.12 Sorting order

As noted in §4.3, the default order in which the 1666 constraints are currently listed in our database has been sorted first by type (column C), then by name (column A), and finally by year (column I). All of these are in ascending alphabetical order (or numerical for the year), using the default parameters built into Excel. Thus the year in which a constraint was first proposed is crucial (with respect to the order of constraints in our spreadsheet) only when there are two or more constraints of the same type and with the same name, but with functionally different definitions. For example, Ussishkin proposed OCP-Place in 1999, and Frisch et al. proposed a constraint with the same name but a slightly distinct definition in 2004. Consequently, the 1999 version of this constraint appears first in our catalog (#1475), and the

2004 counterpart appears right after it (#1476). One advantage of presenting our constraint inventory in an Excel spreadsheet is that it allows the user to reorder the entire list simultaneously using a number of fast and customizable search options. Conversely, a fixed table in a Word document would not have provided the same amount of flexibility.

5 Statistical analysis and discussion

In this section of the paper we further develop the results previewed in §2. First we consider the relative proportions of the distinct constraints by type. Then we discuss the distribution of all the constraints among the four major journals. Finally, we make a few observations about the numbers of newly-proposed constraints per year.

5.1 Constraints divided by type

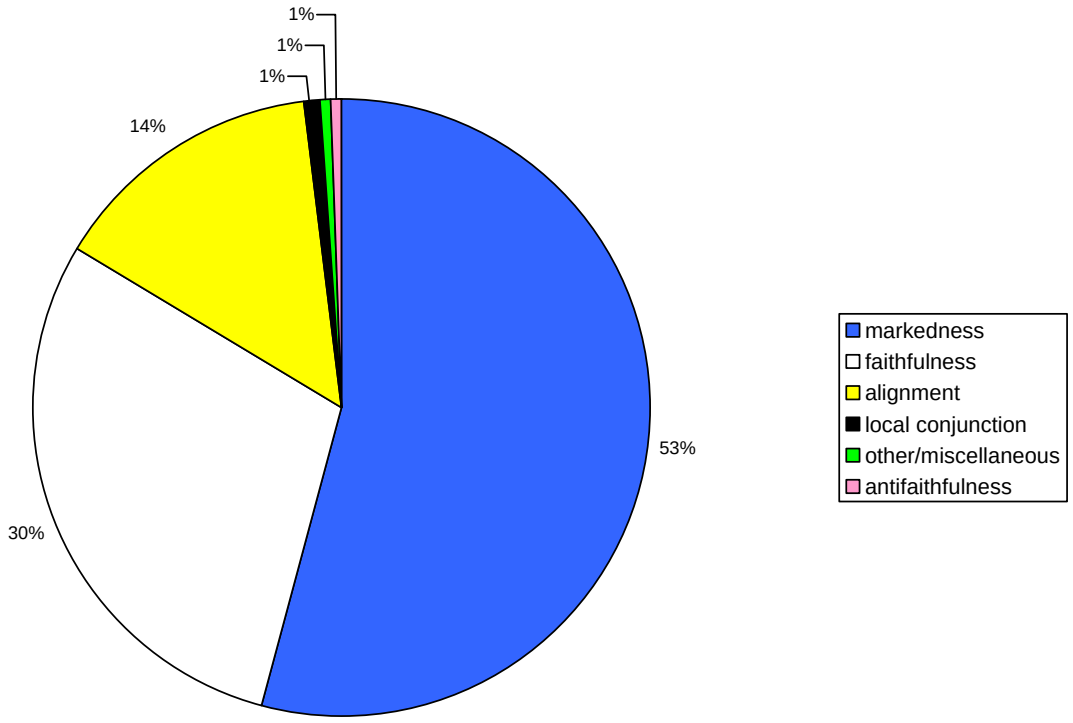
As already stated, a total of 1666 unique constraints are documented in our database. Their distribution according to type is displayed in the table below. This is a copy of Table 1, supplemented with relative percentages:

Table 4: Overall numbers of constraints in our entire sample, distinguished by type, with percentages

constraint type	number	percentage
markedness	902	54.1%
faithfulness	492	29.5
alignment	241	14.5
local conjunction	11	.7
other/miscellaneous	11	.7
antifaithfulness	9	.5
total	1666	100%

As Table 4 indicates, markedness constraints are more frequent in our sample (54.1%) than the remaining five categories of constraints combined. With a sample size this large, a skew in distribution of this magnitude is obviously going to be astronomically significant from a statistical point of view: $\chi^2(5) = 2346.3$. The preponderance of markedness constraints is nicely illustrated in the following pie chart. For some reason Excel rounds its percentage value to 53% rather than 54%. We presume this is because local conjunction, other/miscellaneous, and antifaithfulness are each rounded up to 1%, and the total of all six categories must add up to 100%:

Figure 1: Relative proportions of the six major constraint types, from Table 4



As Figure 1 graphically shows, the three most common types (markedness, faithfulness, and alignment) together account for about 97% of all constraints. The remaining three categories (local conjunction, antifaithfulness, and other/miscellaneous) are clearly of marginal weight (frequency) in our inventory overall. Recall from §4.3 that we consciously chose to classify a constraint as markedness (*m*) rather than other (*o*) whenever possible. This is obviously part of the explanation for why markedness constraints are so predominant. However, it cannot be the full story since there are just not very many ambiguous constraints which could have gone either way. Of the 902 total constraints we have classified as markedness, we estimate that fewer than 100 would be in question if someone wishes to dispute our categorization. Consequently, the fact that markedness "wins", and by such a large degree, is not in doubt.

Even the distinction between markedness and faithfulness constraints is sometimes also debatable. In three such cases we contacted the original authors to get their input. For example, Rose and Walker (2004) propose a family of IDENT-CC(feature) constraints. Building on the analogy with the name IDENT(feature), Rachel Walker (p.c.) considers these to be a kind of output-output faithfulness constraint. Hansson (2007) proposes a related type of constraint which has a very similar name, definition, and function, citing Rose and Walker (2004). Nevertheless, when we contacted him, Gunnar Hansson (p.c.) interpreted his constraints to be a kind of long-distance agreement by spreading, and therefore markedness in nature. In the final analysis we chose to side with Walker, somewhat arbitrarily.[2] Since there are only 14 constraints of this kind among our sample, the overall outcome would not be affected significantly either way.

[2]Thanks to Rachel Walker and Gunnar Hansson for discussion of this issue. We also received personal input from Outi Bat-El about a different kind of constraint.

5.2 Constraints divided by journal

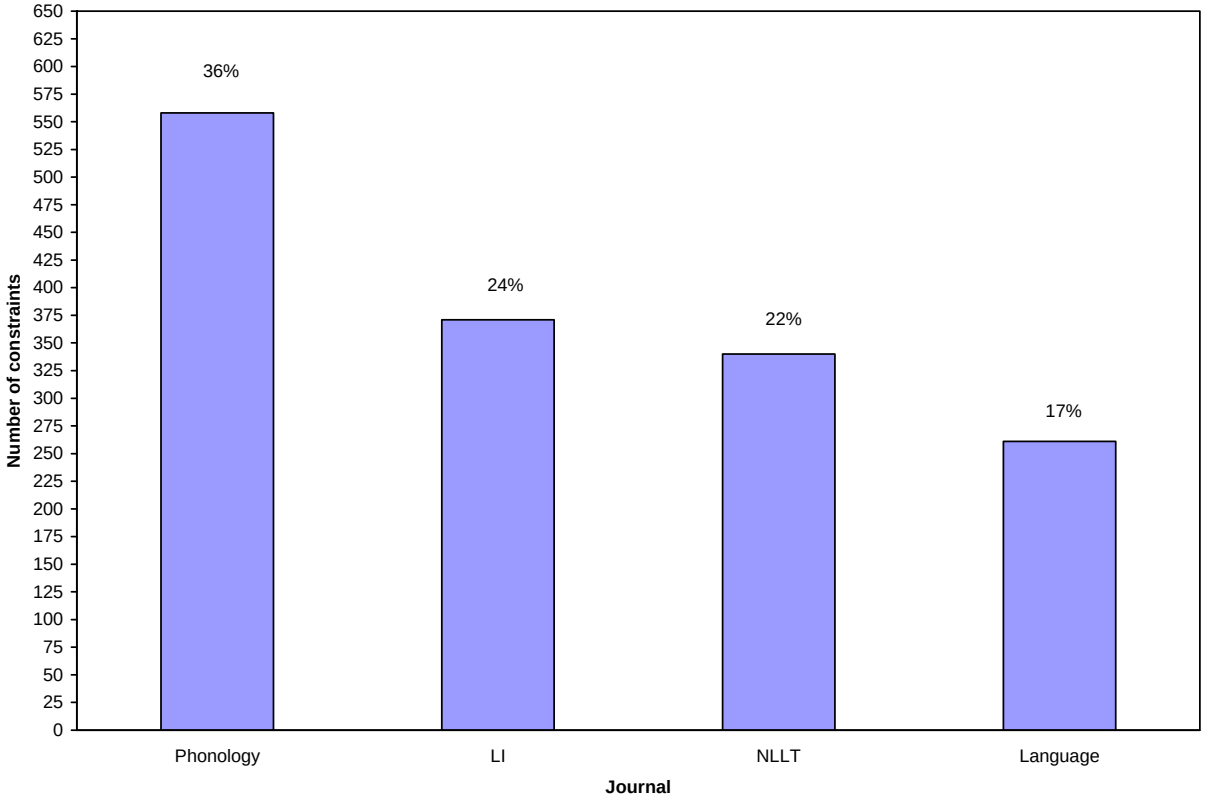
In this section we return to the issue of which journal publishes the most new constraints overall. As noted in Table 2, *Phonology* is the most prolific among our sample, while *Language* is the least of these four. The following table repeats this breakdown, including relative percentages, in decreasing order of frequency:

Table 5: Overall numbers of newly-proposed constraints distinguished by journal, with percentages

journal	number of constraints	percentage
Phonology	558	36%
Linguistic Inquiry	371	24%
Natural Language & Linguistic Theory	340	22%
Language	261	17%
total	1530	100%

In Table 5 the combined number of constraints (1530) is less than the overall total of 1666 contained in our database (Tables 1 and 4). This is because we are focusing here only on the journal venue. This implies that the remaining number of unique constraints comes from the four other seminal OT works which we also surveyed (see (3) and the Appendix). The following histogram depicts the proportion of constraints ascribable to each journal:

Figure 2: Relative percentages of constraints distinguished by journal, from Table 5



In order to help interpret Figure 2, we calculated chi-square tests on the numbers of constraints by journals from Table 5. These confirm that there are some reliable differences among our obtained values:

Table 6: Results of χ^2 tests on the numbers in Table 5

comparison	χ^2	df	*p*	significant?
all four journals simultaneously	124.2	3	.0000	yes
Phonology vs. LI	37.6	1	.0000	yes
LI vs. NLLT	1.4	1	.2449	no
NLLT vs. Language	10.4	1	.0013	yes

df = degrees of freedom

As the results in Table 6 demonstrate, a four-way comparison of all journals simultaneously is significantly different from chance. This is expected, but it does not directly tell us where in the distribution this asymmetry comes from. For this reason we also performed chi-square calculations on each pair of journals which are adjacent to each other in Table 5 and Figure 2. For example, in Table 6 we observe that *Phonology* publishes more new constraints overall than *LI*, to a degree that is statistically significant. By transitivity we may assume that the value for *Phonology* is also greater than those of *NLLT* and *Language*. This is not surprising (§2) since, of these four journals, *Phonology* is the only one devoted exclusively to the field it is named for. Furthermore, it is somewhat expected that *Language* would exhibit the fewest number of new constraints since it is a more eclectic journal than the other three. By this we mean that *Language* is less oriented in general to formal theories such as OT. Thus, the difference in constraint numbers between *NLLT* and *Language* is reliably distinct. However, the difference between *LI* and *NLLT* is not. We therefore conclude that, in terms of the quantities of new constraints uncovered by our sampling methodology, *LI* has not published a significantly greater number than *NLLT*.

5.3 Constraints divided by year

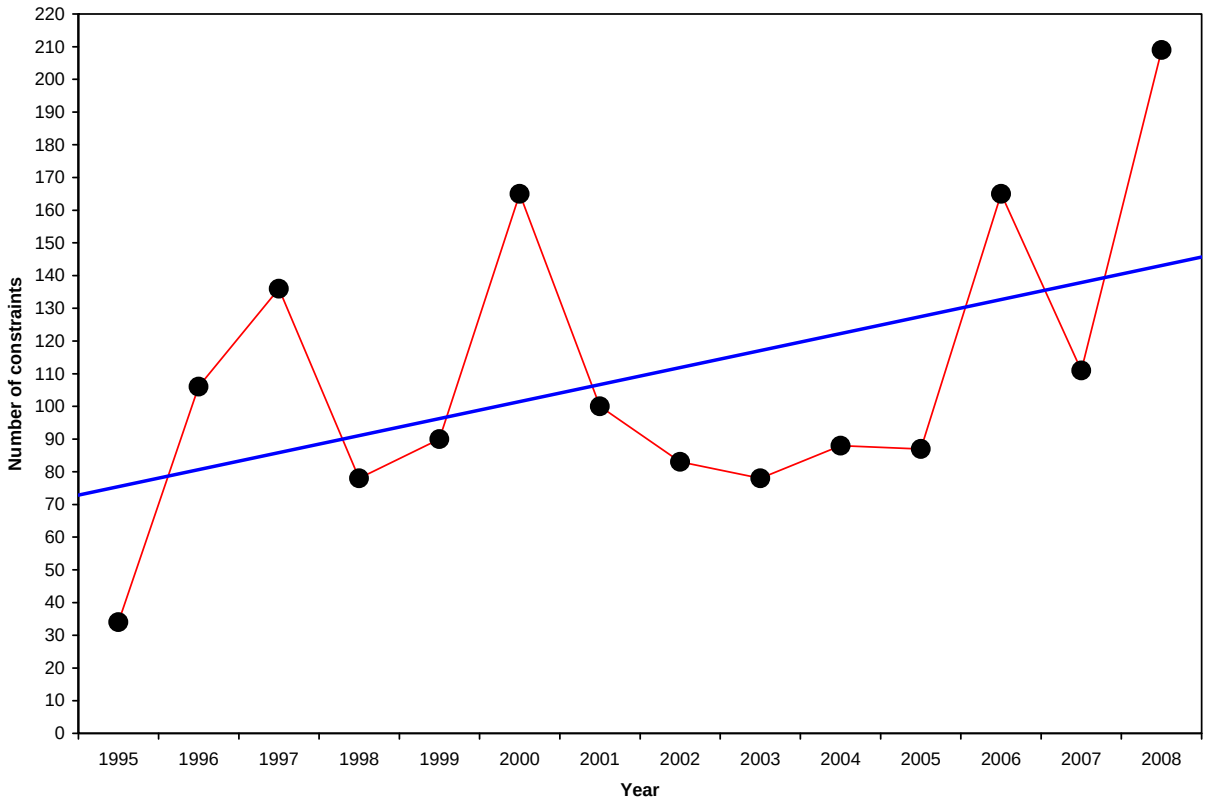
In this section we consider the relative numbers of new constraints published each year for which we sampled the four journals (see §5.2). The corresponding breakdown for the four other foundational OT works in (3) is given in the Appendix. As noted previously, articles about OT first appeared in the journals in 1995 (§2). Furthermore, the cut off date for finishing our sample goes through calendar year 2008 (§3). The following table displays the numbers of constraints proposed across this range of dates:

Table 7: Overall numbers of newly-proposed constraints among the four journals combined, distinguished by year of publication

year	number of constraints
1995	34
1996	106
1997	136
1998	78
1999	90
2000	165
2001	100
2002	83
2003	78
2004	88
2005	87
2006	165
2007	111
2008	209
total	1530

Once again, the total number of constraints in Table 7 (1530) is less than the overall sum contained in our inventory (1666). This is because we are focusing only on the four journals in this section (cf. §5.2). The following scatterplot shows that the general trend across years gradually rises upwards (see §2):

Figure 3: Relative numbers of constraints distinguished by year of publication, from Table 7



In Figure 3 the jagged red line directly connects each data point with its successor. The thicker blue line running horizontally through the entire window represents the corresponding linear regression equation. This is the formula which best fits the distribution of data points using the least-squares method. As this diagram shows, the slope of the regression line runs in a mildly positive direction, at an overall average rate of about 30% per year (§2). From this fact we conclude that OT has not yet reached a point of saturation. That is, at the moment there is no evidence that the amount of cutting-edge work on OT has begun to decline. At the very least this inference is suggested by the numbers of new constraints still emerging annually. However, given the typical lag time for publishing in these journals, perhaps it would be more accurate to say that OT was not yet declining as of 2006 or so.[3]

6 Previous constraint inventories

Several previous researchers have also compiled lists of OT constraints. In this section we briefly review a few of these works and compare them with our own database. The bottom line is that none of these other inventories comes close to ours in terms of two important criteria: (1) completeness, and (2) potential for searchability.

A number of textbooks and other standard OT references contain summary lists of constraints. Examples include Kager (1999), McCarthy (2002), and McCarthy (2008a). Most of these sources, however, limit their lists to just those constraints actually used and discussed in those books. To illustrate, the mean number of constraints appearing in the indices at the back of

[3]Thanks to Paul de Lacy (p.c.) for pointing this out.

each of the three references above is 122. In some cases such works also provide more focused sublists. For example, McCarthy (2008a:223-29) offers the reader a "classified list of common phonological markedness constraints" involving 55 constraints, including brief notes, definitions, and references. We have also encountered one journal article which does something similar: Hargus and Beavert (2006:51-54) present a list of 34 constraints which "refer to consonants and/or vowels." All of these are no doubt helpful and useful, albeit limited in scope (by design).

We are also aware of one electronic repository of OT constraints: Constraint Catalogue (ConCat).[4] This is a public wiki conceived of by Curt Rice and Marc van Oostendorp in 2006. In 2009 a few hundred constraints were entered by Anna Fragkiadaki and Sofia Kousi, students at Meertens Institute. Each entry includes a constraint name, definition, references, links to related constraints, and an indication of how its violations are assessed. This is obviously a very important resource that should benefit any serious researcher interested in OT.

In contrast to all of these works, however, our database offers a much more exhaustive inventory of constraints. These have been selected using a number of rigorous and principled criteria (§3). Furthermore, the fact that they appear all together in a single Excel spreadsheet allows for very rapid, efficient, and powerful searching on demand. Consequently, we conclude that our project is arguably the best constraint catalog of its kind which currently exists.

7 Conclusion

For those linguists who are concerned about the total number of OT constraints ever proposed, our final figure of 1666 constraints is probably disheartening. However, to maintain a bit of perspective, it is important to keep in mind that the ultimate test for evaluating a linguistic model is ***not*** what it looks like on paper on how much ink it takes to write up its formalisms. Rather, the ultimate test to evaluate a linguistic theory is what you can and cannot do with it. The factorial typology of different languages which can be generated by all 1666! permutations of this constraint set is undeniably staggering, and likely impossible to even compute in practical terms. Nevertheless, a large number of these grammars are formally indistinct since many constraints do not directly conflict with each other. Furthermore, many constraints form part of subhierarchies characterized by fixed internal rankings. Also, as we highlighted in §1, not all of these constraints can co-exist in CON simultaneously, i.e., many of them are theoretically incompatible with each other. Therefore, the final number of constraints is undoubtedly less than 1666. At the same time, however, we have not included here any of the new constraints proposed since 2008, so we are in no position at this time to speculate about how high or low this total will ultimately go.

Perhaps the most crucial issue facing this collection of constraints is that of learnability: even with ±1666 constraints, is the human computational apparatus capable of learning specific grammars, i.e., rankings plus lexical items? In this respect what ultimately matters is not the number of constraints per se, but rather the ability of the learner to reach an appropriate language-specific ranking of them. We leave this question — the viability of the acquisition process — as a topic for future research.

[4]The main page is found at the following URL: http://concat.wiki.xs4all.nl/index.php?title=Main_Page.

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Appendix: Complete list of numbers of newly-proposed constraints broken down by type, year of publication, and source

This table is referred to at various points in the body of the paper (§2, 3, 5.2, and 5.3). The sum of all the values here is greater than the total number of constraints in our database (1666; see Tables 1 and 4). This is because some constraints were proposed by more than one author in the same year (cf. §4.8 and 4.10). Hence there are a few duplications in this table.

		constraint type							
		M	F	A	LC	O/M	AF		
year→	1993	29	6	5				Prince & Smolensky	←source
	1993	1		16				McCarthy & Prince a	
	1993	16	5	12				McCarthy & Prince b	
	1995	24	39	1				McCarthy & Prince	
	1995	7	4	5				Phono	←journal
		11	4	3				LI	
								NLLT	
								Lang	
	1996	17	12	2				Phono	
		9	9		3			LI	
								NLLT	
		31	3	20				Lang	
	1997	40	11	20				Phono	
		4	4	3	1			LI	
		10	17	3				NLLT	
		17	6					Lang	
	1998	11	10	1				Phono	
		4	5	7				LI	
		16	7	17				NLLT	
								Lang	
	1999	18	9	9		2		Phono	
		8	12	6				LI	
		15	1	4				NLLT	
		4		2				Lang	

2000	49	40	12	3			Phono
	18	13	1				LI
	7	8	3				NLLT
	4	6	1				Lang
2001	5	9	2			7	Phono
	22	10					LI
	23	12	3				NLLT
	5	2					Lang
2002	20	8	8	1			Phono
	6	1					LI
	14	4	8				NLLT
	8	4				1	Lang
2003	4	6	9			1	Phono
	18	8	4				LI
	9	2		1	3		NLLT
	3	10					Lang
2004	14	7	1				Phono
	3	2	1				LI
	4	1	14				NLLT
	22	19					Lang
2005	17	11	8				Phono
	1	2					LI
	19	7	4	2			NLLT
	13		3				Lang
2006	32	24	1		1		Phono
	10	7	3		3		LI
	21	17	8				NLLT
	23	13	2				Lang
2007	30	14					Phono
	27	13	3				LI
	1						NLLT
	1	20	2				Lang
2008	16	17	1		2		Phono
	93	5	4				LI
	48	2	5				NLLT
	10	6					Lang

legend of constraint types (cf. (4)):

M = markedness
F = faithfulness
A = alignment
LC = local conjunction
O/M = other/miscellaneous
AF = antifaithfulness

legend of journals (cf. Table 2 and (5)):

Phono = *Phonology*
LI = *Linguistic Inquiry*
NLLT = *Natural Language & Linguistic Theory*
Lang = *Language*

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