Sentence Stress in Information Structure

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Abstract. A typical English utterance is marked with a sentence stress, that is, a prominence on one word or syllable that is greater than other lexical stresses in the clause or utterance. This stress consists of a pitch prominence that demarcates the intonational phrase. An Optimality Theory analysis of sentence stress is presented here, which integrates insights from the generative and applied linguistic approaches under one framework. Sentence stress is explained in terms of the interactions between prosodic structure, stress, syntax, and information structure, that is, stress assignment on the main focus or most prominent information. The constraints and constraint interactions can explain some non-canonical stress types that are not handled so well by traditional generative approaches, and also address some stress patterns and linguistic structures that functional accounts do not address. The Optimality framework can explain this interface of different linguistic domains, and this interface can better explain the behavior of English sentence stress.

Keywords: sentence stress, nuclear accent, focus, information structure, language interface

1. Introduction

English sentences typically bear at least one greater stress prominence known as a sentence stress (or nuclear accent), which is heavier than other lexical and phrasal stresses. Sentence stress typically

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marks the flow of new information, in that sentences, clauses or utterances typically contain older or topical information, and a set of newer information. The following recorded sample of a family dinner conversation about movies[1], shows some typical characteristics of sentence stress, which are also well documented in the literature. Each stress-bearing utterance unit appears on a separate line.

(1) Recorded conversation sample

1 A. He would make diagrams of almost all the **shots** and –
2 B. **Really?**
3 K. Yeah... that's how they were able to make that new **Psycho,** uhm...
4 They used all of his his **notes**, yes.
5 So it was actually – it was **exactly** the same as the original
6 except for the **actors**.
7 B. Including the **dialogue**?
8 A. I **think** so.
9 C. Oh, please pass the **salad**.
10 And **both** dressings.

As seen above, the new information, often in the predicate, is marked with a sentence stress. Most often, it relates the flow of new information in an utterance, in that it falls on a content word, often the last content word bearing new information. However, it can sometimes mark emphasis instead (line 5, line 10), in which case it may not fall near the end of a clause, and can readily occur on function words ('both' in line 10). A single stress often occurs on a full syntactic clause (S), but it can also occur on an incomplete sentence functioning as a complete utterance (e.g., 'really' in line 2). Sentence stress is marked by greater amplitude, duration, and most importantly, intonation, namely, rises and falls in the fundamental frequency (F0) of the utterance (Gussenhoven 2004). The sentence stress typically aligns with an existing lexical and phrasal stress, e.g., *Psycho, really, actors, exactly, dialogue.* While these content words

1) This recording of an American family's dinner conversation was made and transcribed by this author, who is a native speaker of English.

each bear a lexical stress, one word in each utterance is regarded as the main focus, i.e., the most important piece of information, which receives a greater prominence than the other lexical stresses in the utterance; this greater prominence is the sentence stress.

The stressed item represents a semantic or pragmatic feature known as focus, that is, the most informationally salient item from the speaker's point of view. Thus, sentence stress primarily marks new information in sentences, or more specifically, the pragmatic or semantic feature of focus; this is the so-called normal, new, or presentational focus and normal stress, the most common form of sentence stress. The use of special emphasis or contrast, however, overrides the normal focus and stress, and hence, the so-called special focus and special stress.

The two basic types of approaches to explaining sentence stress have been (1) generative accounts, and (2) applied linguistic accounts, i.e., pragmatic and functional accounts. These will be briefly reviewed and compared, showing that both have advantages, but both suffer from drawbacks and cannot explain some interactions and some examples of stress placement. While both accord an important role to focus, neither generally attempt to provide a satisfactory account of how focus and phonology interact in stress assignment. Focus, as a feature from information structure, will be incorporated into an Optimality Theory analysis of sentence stress by means of alignment constraints that take focus domains as input into stress assignment. This will be illustrated primarily for normal focus and stress, though special stress will be covered briefly. This will yield a better analysis of sentence stress than previous models, in that it will account for some problematic cases in the data such as stress on non-final items (e.g., final parentheticals and unstressed words) that do not necessarily follow the standard nuclear stress rule. It will also explain how different language components interact with each other in sentence stress assignment. This analysis integrates the insights from the generative and pragmatic approaches into a more unified analysis.

1.1. Prosodic Domains

The prosodic domain of sentence stress or nuclear accent has traditionally been the intonational phrase (IP), which consists of smaller intermediate phrases (ip), and the IP is bounded at the end with a nuclear accent consisting of pitch accents, such as a high, low-high, or high-low (Pierrehumbert & Hirschberg, 1990). Sentence stress operates over the domains of the ip, IP and the global utterance phrase, that is, the phonation of a sentence, clause or shorter utterance as a turn-taking unit in conversation. It naturally coincides with the pitch accent of an ip, such as the stress of a noun phrase or verb phrase that essentially correlates with the ip. More importantly, it operates over the domain of a whole IP, since the right edge of an IP by default is demarcated by a nuclear stress accent or sentence stress. While it is common for sentence stresses and IPs to coincide with the very end of the sentence, and this seems to be a preferred or default pattern, sentence stresses can many times be non-final, as seen in the above examples. Final non-new or less salient items may occur sentence-finally after the sentence stress, constituting an ip or a final parenthetical phrase. The primary domain of sentence stress is thus assumed to be the utterance phrase, though sentence stress is relevant to the other prosodic domains as well. This level of prosody has received less attention in the phonology literature, but is commonly assumed in pragmatic and functional analyses of stress and discourse (such as those others cited below). The utterance unit will be invoked in the Optimality Theory analysis below.

1.2. Generative Accounts

Typical generative accounts include Chomsky and Halle (1968), Selkirk (1995), and Zubizarreta (1998), which typically involve aligning the focus feature with the prosodic prominence. The Chomsky-Halle model involved assigning sentence stress with the last lexical stress of a clause (the nuclear stress rule, or NSR), but this fails to account for how sentence stress at times does not fall on the final content word or last available lexical stress, e.g., when a content word other than the last one is stressed, as in the above dialogue (lines 5, 8, and 10). The NSR, especially in its original formulation,

does not consider focus or communicative intent, but only syntactic and phonological structure. In fact, the non-canonical stress patterns that the NSR does not address are common in conversational discourse.

Selkirk (1995) and similar analyses make use of the concept of broad focus that can percolate from a smaller constituent up to higher constituents, even to the level of an entire predicate or sentence. It is not clear why percolation from a local feature (narrow focus on a particular word) to an entire phrase (broad focus) is necessary or parsimonious; this assumes that focus can percolate like other syntactic features, though it is not actually a syntactic feature. Gussenhoven (1999) points out another problem with this approach, in that a higher-level focused constituent can contain old information within it, which conflicts with the notion of focus being a marking of new information; that is, the wider, higher-level focus is not a uniform, consistent, contiguous domain, but can be interspersed with older elements, making a principled assignment of broad and narrow focus and stress problematic, as in this example. Square brackets indicate the likely broad focus domain, with angled braces marking old items within it.

(2) A. Where did she go?
B. She went for a **drink**.
A. She went for a **drink**?
B. Yes, and [then <she> slurped <it> down **voraciously**.]

The last line above contains a wider focus domain – the bracketed section that indicates the set of new information – but within this set are pronouns (*she, it*) that encode old information, and their placement is required by the syntax. Thus, the wider focus – the whole set of new information in an IP – can be noncontiguous.

Zubizarreta (1998) proposes a somewhat similar analysis in which prominence mediates between focus and intonation. The NSR is distinguished from an emphatic-contrastive stress rule, the latter being more freely assigned but more constrained than the NSR. NSR assignment depends on syntactic position and relations, and focus is defined as nonpresupposed items, i.e., in theoretical semantic and

pragmatic terms, what interlocutors cannot presuppose from the context. Focus can be projected to a higher domain when a larger consituent is involved. For example, in a sentence such as *Not even a professor of classics could be so pendantic* in commenting on someone's pedantry, *classics* is stressed even though the whole phrase *professor of classics* is in focus (so-called broad focus) with the main point being such a professor, but the narrow focus and stress fall on *professor*. Here the focus projects upward to the highest level of non-presupposed information, i.e., the XP corresponding to this complex noun phrase. It cannot project further up to a higher constituent containing non-focal or presupposed items. The stress is then realized on the rightmost element of this XP. Focal projection likewise occurs on compounds, projecting up to the compound XP node, but with stress falling on the natural prosodic head of the compound (with nouns, usually the first element), e.g., *Not even a **classics** professor would be so pedantic*, again, even though *professor* might be the more important in the context. However, such generative accounts fail to capture the rationale for these two different focus projection patterns. In *professor of **classics**,* rightward stress alignment is a realization of the general linguistic tendency for sentence stress to fall as rightward as possible in utterances, which is a tendency well noted in the functional accounts discussed below. In a compound like ***classics** professor*, the sentence stress aligns with the prosodic head rather than *professor* to prevent a stress clash from two adjacent stresses, i.e., a phrasal stress and a sentence stress (***classics professor***). It should be noted that focus projection or other feature projections are not so well understood, as they have not been subject to rigorous empirical study in linguistic corpus studies. Focus projection seems to affect only complex noun phrases and compound structures, and OT constraints will be formulated accordingly in the analysis below.

Linguistic information structure such as the given/new information distinction is somewhat discounted in Zubizarreta's analysis as nondefinitive for focus, based on the problem of repetition, i.e., when a noun is reintroduced later into the discourse, again with focal stress. However, repetition serves discourse informational and sociolinguistic purposes (e.g., see Tannen 1989); e.g., the repetition question above (*She went for a drink?*) contrasts or emphasizes the whole sentence (or cf. identificational or contrastive focus in Kiss

(1998). The discourse functions of repetition call into question the logic of dismissing a discourse based account of focus on the basis of repetition. However, relegating discourse identity of an item to a purely nonlinguistic domain is of little help in a linguistic analysis of a linguistic feature. Repetition is a type of contrast or emphasis, and thus falls under the purview of special focus and special stress.

A syntactically based account will encounter problems with some data (as seen below), because it fails to take discourse structure or information structure into account, particularly when final nouns are not stressed when they are seemingly new, as in this example.

(3) I need a good **book** <to read> <today>.

This sentence would be felicitous with *book* stressed in many contexts, though *read* and *today* have not been mentioned. The pragmatic accounts mentioned below point out a number of such items that can be unstressed in final position; such occurrences cannot be explained well by positional syntactic assignment of stress, as a better explanation is needed for what can constitute a main focus.

1.3. Pragmatic and Functional Accounts

Another type of analyses comes from various pragmatic or functional frameworks, most notably, Bardovi-Harlig (1986) and Cruttendon (1986). Such approaches distinguish crucially between new information stress or focus, and special focus and stress for emphasis or contrast. Their main contributions are in attempting to explain focus (new information, contrast, emphasis) as the driving force behind sentence stress, and in classifying a number of structures and expressions that are likely or less likely to receive stress. The last content word in a sentence that is informationally new typically takes the main stress, and this is often a noun. Yet some content words do not necessarily take the normal informational stress, though they would seem to be potential candidates for stress assignment. For example, the items in angled brackets represent the types of categories that Bardovi-Harlig (1986) and others have pointed out as less likely to take the main stress.

(4) a. I need a good **book** <to read> <today>.
b. I don't have all **day**, <you know>.

The descriptive infinitival (or infinitival relative phrase) *to read* is semantically closely associated with *book*, as reading is the main, prototypical activity for books. General temporal adverbs like *today* is are not new, but part of the context that is shared and understood between listeners and speakers; it would only be new and stressable if the purpose of the statement is to actually indicate when the reading is to be done. Similarly, discourse markers (*you know*), fillers (*and stuff*), and quotatives (*he said*) fall into the similar category of information that is contextually conditioned – that is, implicit or inferable from the context.

Such analyses also provide helpful discussions of types of contrastive and emphatic stress, which is nonetheless highly speaker-idiosyncratic, but show some quasi-regularities, in that some types of items can be more likely to receive the main stress, e.g., emphatic modifiers and focus particles (*only, too, also, even* and others; see König (1991)); contrasts (*I'll take the **high** road, and you take the **low** road*); and emphatic pronouns (*I can easily do it **myself***). Many of these are discussed in Bardovi-Harlig (1986), Cruttenden (1986), and elsewhere, as well as the fact that special emphasis can be placed on any kind of word in an utterance.

Another observation from this paradigm is the propensity for content words to take stress, especially predicate nouns. Szwedek (1986) cites older studies (of unspecified genres) finding that 78-85% of nouns were stressed, almost always predicate nouns, and indefinite nouns more so than definite nouns; 50-60% of verbs were stressed; and other word types were rarely stressed, especially function words. Very similar findings were found by this author in an analysis of a family dinner conversation. Six minutes of a natural conversation of five family members were transcribed, excerpts of which are cited in this paper. Of the 133 sentence stresses, 52% of the sentence stresses were on nouns, 20% were on verbs, 11% on adjectives, 2% on adverbs, and 15% on function words; 56% of the stresses were on final content words, and 29% were on non-final content words.

1.4. Comparison

The generative accounts often do not provide a clear definition of focus, or a detailed explanation of new information stress and special emphasis work. Focus is often simply considered a type of input from the semantics or pragmatics – a type of input that may not be linguistically defined. These approaches also do not explain why content words, especially nouns, should be more likely candidates for focus and stress, or why some final, non-old content words are not stressed.

The pragmatic accounts provide some insightful explanation of focus, emphasis, contrast, and common stress patterns, which are particularly useful for pedagogical purposes. However, they are not able to provide a formal account of stress assignment or determination of focus domains, other than the tendency for the final content word of a clause to receive the main stress. These accounts do not address the interaction of syntax, focus domains and stress in a principled manner. They also do not address focus projection, even in compound nouns. For example, in this phrase from the aforementioned dinner conversation, *Hitchcock* in line three receives the main stress, though this noun is not new information, having been mentioned in line one.

(5) A. Hey, you wanna pick up one of those uh **Hitch**cock movies tonight?
B. **I** don't know. Ya know, I'm not a real **Hitch**cock fan.

It is stressed because the new idea being put forward is *Hitchcock fan*, but *Hitchcock* is the prosodic head of this compound, so the sentence stress aligns with the existing compound stress; this is not accounted for in pragmatic or functional accounts. If a generative rule simply says, "align sentence stress with last main compound stress or lexical stress," that might work here, but would fail to explain non-stressed items like *tonight* in the first line above, though it seems new. Pragmatic approaches would equate (normal, new information) focus with the last new word, and would not explain why *Hitchcock* is stressed rather than *fan*. Generative accounts do not explain why some final content words like *tonight* above are not stressed.

Both approaches encounter difficulty with syntactic interactions, as in the following, repeated from above.

(6) Yes, and [then <she> slurped <it> down vo**rac**iously.]

If one recognizes the existence of a wider focus domain, i.e., the whole set of new information, then a problem for either approach is how lexemes representing both new and old can appear intermingled in the syntax, and thus, how the broader focus domain of new information can be non-contiguous. That is, predicates can contain a mixture of new and previously mentioned contents, so the set of new information is not strictly separated from the old. How the focus interacts with the syntactic structure is not addressed well in either framework, especially in the functional accounts.

Both traditions encounter other problems, in that a clear definition is lacking for focus, particularly, one that would explain how it interacts with syntax and prosody. For example, in the above repetition question (*She went for a* ***drink****?*), if focus equals new information, then the second mention of *drink* is not new. If repetition entails emphasis or contrast, and thus the whole reiterated sentence is under special (contrastive or emphatic) focus, then why is stress reassigned only to *drink*? Is *drink* a type of focus that is more privileged than the rest of the sentence?

Generative approaches tend to not provide or allow for a rationale for focus and stress assignment other than syntactic structure or position in the sentence. Pragmatic approaches provide a stronger rationale, but as descriptive theories, they do not provide specific, systematic principles of stress assignment for inclusion in a formal framework. Neither framework provides an insightful explanation of how different types of focus interact with the syntax and prosody. However, alignment constraints in Optimality Theory (OT) can specify the interactions involved. Sentence stress involves different linguistic modules – information structure, prosodic structure, stress features, and syntax. Alignment constraints can specify the structures and features involved, and the types of interactions that are permitted in a language.

The next section will sketch out the relevant elements of information structure and their relevance to an OT account of sentence stress. Then the following section will explain the types of linguistic interactions involved, how they account for sentence stress, and how

they can explain some non-standard stress patterns.

2. Information Structure

Information structure is generally defined in terms of old and new information, or topic-comment, topic-focus, or presupposition (e.g., Lambrecht 1994, Steedman 2000, Erteschik-Shir 2007, Krifka 2007, Walker et al. 1998, and others). Psycholinguistically, it is to be understood as levels of linguistic salience, i.e., the relative amount of cognitive resources allocated to processing the semantic content of sentences, namely, working memory and attentional focus in the speaker's or listener's conscious processing of the discourse. Experimental findings, for example, show that old and new items, content words, and function words affect mental processing in the comprehension and production of language. Whether words and sentence contents are new or old affect how much speakers use mental effort and attentional resources to construct the newer sentences constituents in production (see, e.g., Arnold et al. 2003), and these processes are affected by memory constraints in comprehension (see, e.g., Carpenter et al., 1994).

The distinction between content and function words constitutes a lower level of information structure. Content words (nouns, lexical verbs, adjectives, adverbs) are more salient in comprehension than function words (Chafe 1994). Content words, especially nouns, are more salient to comprehension and incur greater mental processing effort, as shown in psycholinguistic studies of reading (see, e.g., Rayner 1998, Haberlandt et al. 1986). Content words, especially nouns, affect processing effort, and language processing studies show that sentence stress helps experimental participants to correctly identify an intended noun referent in spoken sentences (see Speer & Blodgett 2006, and references therein). Processing old and new information and content words entails more semantic processing. The salience at the lexical, constituent and clause level plays a significant role in language processing – a role that has thus far not been considered much in generative theories[2]. Content words are more perceptually salient, and naturally are better candidates for the main focus and stress marking.

For this reason, a constraint system (as in OT) would preferentially stress-mark content words and new information, to heighten their perceptual salience and to aid listeners in processing by highlighting more importance semantic contents. For this reason, constraints will be invoked in the analysis below that align stress preferentially on new material, and on content words versus function words.

2.1. Focus and Informational Domains

Different types of focus are discussed in the linguistics literature in regard to stress patterns, syntax, and non-canonical structures (see, e.g., Selkirk 1995, Choi 2001). For sentence stress, the relevant types of focus or information status are: (1) wider focus, or presentational focus – the whole set of new information in a sentence, and (2) the primary focus on a single word (or XP), which is a smaller subset of the wider focus, which more directly determines stress assignment. This is easily illustrated with examples like sentence (7) from above, with the wider focus in brackets, older items in angled brackets, and the primary focus item *voraciously* bearing the main stress.

(7) Yes, and [then <she> slurped <it> down vo**rac**iously.]

The main stress is assigned to a smaller set of the wider focus, the one item that is in primary, narrow focus, which is the more important point of the sentence. A noteworhty point here is that wider focus can be noncontiguous (Gussenhoven 1999) as in the above example. English syntactic constraints require SVO word order; but in the above example, the subject (*she*) and the object (*it*) are old, while the verb and adverb are new. This is because syntactic well-formedness constraints override constraints on the contiguity or integrity of a broad focus domain. While topic-focus structure usually maps well onto

2) Information structure is also understood here as an interface component, along the lines of interface components in Jackendoff (1996, 2002), similar to the interface among conceptual structure, linguistic semantics, the mental lexicon, and syntax (Jackendoff, 2002). It serves as an interface module, mediating between conceptual structure, syntax, and phonology.

English SVO structure, some mismatches occur, and in cases like this, the best way to satisfy the syntactic constraints is to break up the broad focus domain. This kind of interaction of different language components is one reason why Optimality Theory (OT) is well suited to explain sentence stress and how focus interacts with syntax. Syntactic constraints (e.g., on syntactic well-formedness, alignment of constituents, and integrity of constituents) override constraints on focus domains, allowing wider focus material to be broken up, and allowing unstressed constituents to follow sentence-finally after the sentence stress. For examples of syntactic constraints and interaction with focus domains, see Samek-Lodovici (2005).

In addition to old (topical) and new (focal), an intermediate category is illustrated in the following example, repeated from above.

(8) I need a good **book** <to read> <today>.

As mentioned, these final items are inferable from the context – "new" but not really "new"; this is the domain of inferable or implicit items (see Chafe 1994). They are new to the discourse, but not new to the listener, as they are apparent in the context, according to criteria for givenness or old/new in the Centering Theory framework (Walker & Prince 1996). Informationally, they pattern with the domain of old or topical items and are not candidates for the main stress.

The canonical new information focus (wider and narrow-scope domains) is of course to be distinguished from special focus, the latter being a distinct type of pragmatic focus – the more idiosyncratic or less predictable use of contrast and emphasis, with a special sentence stress that overrides the canonical new information stress. Special focus includes both contrast (*I said **X**, not **Y***) and special emphasis (*I said get in the house **now!***), which is most indiosyncratic and intentional, i.e., depending on the speaker's specific intentions that may not be predictable from the context.

Thus, we have the following informational domains. The primary focus corresponds to the greatest prominence, the most important new item (this term is preferred to narrow focus, to avoid confusion with the narrow/broad focus distinction in focus projection). This is a subset of the wider focus, which refers to the whole set of

new information in a sentence; one item within in is selected for a greater level of focus and prominence, the primary focus. New information status is hereby paramaterized to the wider and more local focus types, and special focus (Special) for contrast and emphasis.

(9) Types of information structure domains
   a. Topic (old information)
   b. Implicit / Inferable
   c. Wider Focus [New]
   d. Primary Focus [New]
   e. Special Focus (contrast and Emphasis)

Focus is not a syntactic or phonological feature, but is part of the information structure that interacts with these language modules; and likewise, since sentence stress is a phonological feature, its assignment is determined by interaction with these other modules. OT alignment constraints can conveniently explain these interactions; as discussed below, alignment constraints on narrow focus account for stress placement, while alignment constraints on broad focus affect how focus and syntax interact.

Stress aligns with utterances (and IPs), in that stress aligns with prosodic domains, which align with focus domains. Aligning stress and focus domains is motivated from the standpoint of language comprehension and processing. The intonational features of prosodic boundaries and stresses enhances perception and comprehension of speech (Wang & Hirschberg 1992, Chen et al. 2003), in that pitch peaks and intonational durations enhance the perceptions of words at the prosodic boundaries. For this reason, stresses (which demarcate the IP boundaries) enhance the perception of words placed under primary focus. Thus, constraints will be proposed below to specify alignments of the focus domains and stress, and to preferentially align the main focus with content words. The proposed constraints are grounded in the benefits that focus and stress marking confer on processing and comprehension of speech. The next section presents the constraint system for sentence stress.

3. Sentence Stress in Optimality Theory

Optimality Theory often makes use of markedness and faithfulness constraints. Another class of OT constraints is alignment constraints, which align features and/or structures with each other, especially for structures larger than individual phonemes. An advantage of alignment constraints in OT is that they can align items of different domains in order to account for the interface of the subsystems of language, such as syntax, phonology, and information structure. This analysis will focus on alignment of the relevant focus domains with the syntax, and alignment of sentence stress with the appropriate components of information structure – narrow focus, special focus, and content words. Focus alignment as an OT constraint has been proposed before, e.g., in Costa's (2001) account of canonical sentences. Costa's formulation was rather simple: a simple constraint that places stress on the main focus, though the different types of focus were not addressed or delineated. Here we shall specify focus alignment (1) to the particular types of focus above – wider focus and the more local-scope primary focus on a specific new discourse entity or referent; and (2) by alignment of stress and the primary focus.

The tendency for the stress to occur at or near the ends of sentences is a product of the alignment of the primary scope focus with the end (right edge) of the broad focus, and right-alignment of wider (new, presentational) focus with the syntactic domain of the sentence. This is because the placement of the most important information at or near the end of sentences enhances listeners' perception and comprehension of the flow and conceptual structure; thus, speakers tend to put the most salient content word at the end or near the end, as much as possible. Thus, we have the following constraints, which are motivated by sentence stress data and language processing. These constraints align focus domains with prosodic domains, align focus preferentially with content words, align sentence stress with focus, and align sentence stress (SStress) with the already existing lexical or compound stress (the last two constraints will be discussed in regard to special cases further below).

(10) Table 1. Constraints for sentence stress

Align-R(WFocus, S)	Wider focus domain is right-aligned with clause (S) boundary
Align-R(PFocus, S)	Primary focus is right-aligned with end of clause (most salient item at end)
Align-R(SStress, U)	Sentence stress at right edge of utterance phrase
Align(SStress, PFocus)	Sentence stress on the primary focused item (new information)
Align(SStress, SpecFocus)	Sentence stress on special focus item
Align(SStress, LexStress)	Sentence stress aligns with existing main stress on a prosodic word
Align(SStress, CpdStress)	Sentence stress aligns with existing main stress on a compound word
Align-R(SStress, NP)	Right-alignment of stress with NP
Align(PFocus, CW)	Focus aligns with content words

The parser may "choose" to align sentence stress with the primary focus, the end of the utterance, or the special focus, since it is a prosodic feature that interacts directly with focus. Aligning focus with the syntax is also assumed, since sentences are phrased based on speakers' intentions in chunking and phrasing information[3]. Separate constraints for lexical and compound stress are assumed due to a possible constraint conflict here (see below). These constraints can explain sentence stress as well as the tendency for new information to appear at or near the end of clauses. These constraint interactions will be shown below for normal focus and stress, and briefly, for special focus and stress. Unless otherwise noted, the following sentence examples are from the author's dinner conversation corpus.

3) For purposes of explaining IS and syntax interface, another constraint might exist to right-align the primary focus with the end of a wider focus domain.

3.1. Normal Focus: New Information Flow

The constraints for new information focus can be shown below. Brackets indicate the domain of wider focus, and prosodic words. The first example shows the prototypical sentence-final stress pattern, which satisfies all the constraints relevant for new information focus (since special focus and special stress are not invoked, those constraints are not shown here). Because the last new content word occurs at the end, wider and primary focus align with the right edge or end of the clause.

(11) Table 2. Constraint tableaux, final stressed new item.

He [would make diagrams of almost all the [**shots**]$_{PFocus}$]$_{WFocus}$	✓Align-R(WFocus, S) ✓Align-R(PFocus, S) ✓Align(SStress, PFocus) ✓Align(SStress, U) ✓Align(SStress, LexStress)

If the focused word in question were multisyllabic, the above constraints would hold, with Align(SStress, LexStress) ensuring that the sentence stress falls on the pre-existing lexical stress, e.g., for *ímage* it would align with the stressed first syllable. For compounds, the sentence stress would align with the the prosodic head (usually the first element), e.g., *cámera shots*, by virtue of the compound stress constraint, Align(SStress, CpdStress). Compounds usually stress the first element, though other patterns exist (see Blag et al. 2008, Giegerich 2004), and the sentence stress aligns with whichever syllable is normally stressed in the compound. These same constraints can of course hold true for single-word utterances (such as *Réally?*). These above constraints, all unviolated, account for stressed sentence-final content words.

Oftentimes, the last new and stressable content word is not at the very end of the clause due to syntactic constraints that override the focus domain constraints. However, minimal violations of focus domain constraints are entailed if the primary focused word is near the end of the clause as possible. These syntactic constraints might be alignment constraints, well-formedness constraints, or constraints on

structural integrity (see Samek-Lodovici 2005, regarding syntax and focus constraints). These would be a few high-ranking constraints that enforce the integrity of syntactic constituents, and will be simply abbreviated as “Syntax” in the constraint rankings below.

The next sentence illustrates non-final stress, because syntactic constraints override the right alignment of the broad focus domain, in that the pro-form *so* must come after the new content word, *think*. However, the violations of focus constraints are minimal and non-fatal. Right-alignment of stress with the utterance is also violated by stress alignment with the narrow focus. Since this verb is the only new information, the wider and primary focus domains are identical or coterminous.

(12) Table 3. Constraint tableaux, non-final new content word

I [[**think**]$_{PFocus}$]$_{WFocus}$ so.	✓Syntax
	* Align-R(WFocus, S)
	* Align-R(PFocus, S)
	✓Align(SStress, PFocus)
	*Align(SStress, U)
	✓Align(SStress, LexStress)

Hence, these constraint rankings hold: “Syntax” >> Align-R(WFocus, S); “Syntax” >> Align-R(PFocus, S); and Align(SStress, PFocus) >> Align(SStress, U).

The same holds true when the syntax requires implicit or inferable items to occur sentence-finally, with the main stress on a non-final new word. For final old or final inferable items, syntactic constraints likewise override and incur non-fatal violations of the focus alignment constraints. Syntactic phrasing and integrity also override the broad focus domain, in a sense, when new and old items occur together, i.e., when the broad focus domain is noncontiguous.

(13) Hey, you [wanna pick up one of those uh [**Hitch**cock]$_{PFocus}$ movies]$_{WFocus}$ tonight?

(14) Yes, and [then <she> slurped <it> down **voraciously**.]

Syntactic well-formedness constraints are satisfied, overriding the integrity of the wider focus domain in English, as violation of the latter is not a fatal violation in English.

The main stress in example (13) above falls on a compound noun, which requires a constraint for compound stress. The next sentence shows a preference for aligning the main stress on the existing compound word stress (the first syllable of *Hítchcock fan*), sometimes overriding the preference for aligning the main stress with the lexical stress of the new item. As indicated by the asterisk, the lexical stress constraint is violated in favor of the compound stress constraint.

(15) Table 4. Constraint tableaux, compound noun.

Ya know, I'm not [a real [[**Hitch**cock [fan]$_{PFocus}$]$_{PWord}$]$_{WFocus}$	✓Syntax ✓Align-R(WFocus, S) ✓Align-R(PFocus, S) ✓Align(SStress, PFocus) *Align(SStress, IP) ✓Align(SStress, CpdStress) *Align(SStress, LexStress)

An alternative rendering with a different syntax is also possible, which would satisfy the constraints differently, with non-fatal violation of the focus alignment constraints, satisfying the SStress-LexStress constraint.

(16) Ya know, I'm [not a real [**fan**]$_{PFcus}$]$_{WFocus}$ of Hitchcock

The alternative is not an exact semantic equivalent of the first, since the compound *Hitchcock fan* expresses a slightly different idea than the prepositional phrase *fan of Hitchcock*, which has two noun referents and two noun arguments. As shown above, sentence stress on compound stress overrides sentence stress on lexical stress, or Align(SStress, CpdStress) >> Align(SStress, LexStress).

The constraint ranking for compounds above captures one type of focus projection, which is motivated by economy and processing demands. The stress aligns with the prosodic head of the compound to

avoid a stress clash from two adjacent or nearby major stresses (cf. the obligatory contour principle), which would be more confusing for listeners to process (e.g., ***Hitch**cock **fan**,* or the aforementioned ***classics professor***). The other type of focus projection involves complex NPs such as complex noun phrases. This involves no potential stress clash, and involves rightward alignment of stress on any such NP that is under so-called wider focus. This rightward alignment seems more consistent with a general preference for the primary focus or stress to be realized at or near the end of sentences. No sentences with complex NP focus projection were found in the dinner corpus, so the constraints are illustrated with a fictive example below, where the main stress falls on the right edge of an XP, even if the stressed word is not the main point of the message.

(17) [Not even a [[professor]$_{PFocus}$ of classics]$_{NP}$]$_{WFocus}$ would be so pendantic.

Another constraint thus comes into play here: Align-R(SStress, NP) to enhance the perception and salience of a complex NP, when the whole NP is part of the wider focus. In this case, Align-R(SStress, NP) seems to dominate the normal alignment of stress and primary focus (Align-R(SStress, PFocus), leading to this form of focus projection. Thus, we have compound focus projection, and complex NP focus projection. These are accounted for by different constraint interactions, as they are functionally two different types of feature projections.

Sentence stress usually falls on content words. However, the constraint Align(SStress, CW) could be violated if no new content words are present, and only new function words that are normally unstressed are available to express the new information. This could hold true for a sentence like *What **is** it?* or for these fictive examples.

(18a) I [know where the [**monster**]$_{PFocus}$ is.]$_{WFocus}$

(18b) No, [but I [**should**]$_{PFocus}$]$_{WFocus}$ have.

In (18a) the constraint Align(SStress, CW) ensures that stress is on the final new content word rather than a new function word, due to the semantic prominence of content words over function words, and thus,

speakers would prefer to highlight these as more relevant to the interpetation of the message. In (18b) no new content word exists, so Align(CSStress, CW) cannot apply; the rightward alignment constraints, namely, Align-R(SStress, PFocus) assign stress to *should* as the last new item. The auxiliary *have* is anaphoric for having gone, so *should* encodes the final new information. These sentences are accounted for by the constraint rankings, when a final new word is a function word, but a preceding new content word is stressed.

Another issue with new information stress is chunking (perhaps more so for applied linguists concerned with performance issues). Speakers can choose to chunk their sentences into smaller utterances, each with a unique stress. For the following fictive utterances, different possibilities exist, with vertical bars between likely utterance boundaries.

(19) I will faithfully execute the powers and trust **reposed** in me | as Prime **Minister**.
I will **faithfully** | execute the powers and **trust** | **reposed** in me | as Prime **Minister**.

Here the wider focus domains are smaller, at times corresponding to smaller sections of the syntactic clauses. In these cases, the chunking invokes smaller utterance phrases, each with its unique stress. The same also hold true for stressed single-word utterances (e.g., *Réally?*).

3.2. Special Focus

Special focus of course overrides normal (new) focus in the constraint system. This is accomplished by ranking the stress-special-focus constraint over the constraint aligning stress with the primary new focus. This ranking accounts for various forms of special focus, such as explicit contrasts (*I said **X** not **Y**!*) between two items, or the more idiosyncratic use of emphasis. Emphasis is in essence an implied contrast; for example, when one says *Get in the car **now**!*, the stressed item *now* by implicature means “not later, not whenever you feel like it.” Contrast and emphasis in turn perform a number of discourse functions, such as repair, highlighiting,

foregrounding, clarification, and topic management. New or old items can be contrasted or emphasized, and such items take stress instead of other new items. Nonetheless, they all fall under the category of special focus, and can be described with a single constraint ranking.

A couple of sentences from the dinner corpus show examples of special focus stress overriding a potential new information stress. The relevant constraints are shown below, where stress assignment passes over the new information focus (primary focus) in favor of special focus. This special focus can easily lead to a main stress on a function word rather than on a new content word, as in (20b) from the dinner corpus.

(20) a. ...it was [**exactly**]$_{\text{SpecFocus}}$ the same as the [original]$_{\text{PFocus}}$

b. And [**both**]$_{\text{SpecFocus}}$ [dressings]$_{\text{PFocus}}$

c. ✓Align(SStress, SpecFocus) >> *Align(SStress,PFocus)

Thus, stress and special focus alignment override stress alignment with normal focus, that is, Align(SStress, SpecFocus]) >> Align(SStress, PFocus).

Repetition is one case where the broad special focus domain comes into play. A whole sentence or phrase can be repeated for emphasis or contrast, e.g., *She went for a **drink**?*, in which drink becomes special focused. In this case, the stress on *drink* may have a greater intonational range – an exaggerated pitch contour – that often occurs in emphatic and contrastive stress. Since the whole sentence is emphasized, this may implicate a broader domain of special focus as well as the narrow special focus on drink that can receive special stress.

Special focus patterns are fairly common in spoken discourse. In the dinner corpus cited here, special stress accounted for 30% of all sentence stresses, and this was split evenly between stressed content words and stressed function words. The special focus constraint accounts for the stress patterns in these and other forms of contrast and emphasis. This includes implicatures in emphasis, emphatic adverbs (e.g., stress on words like *even, only*; see König 1991), contrastive topic shifts, and noncanonical sentence patterns such as cleft sentences (e.g.,

It's the ***red*** *one that I like*), which express contrasts between topics and propositions (Werth 1984). Repetition in discourse also seems to serve various emphatic functions (e.g., *She went for a* ***drink****?*, as above). Nonetheless, for the various pragmatic forms of emphasis and contrast, their stress assignment is captured by the special focus constraint and its ranking above the other constraints.

4. Discussion and Conclusion

The above analysis shows how focus domains, prosodic domains, the sentence stress feature, and syntax interact with each other. The wider focus domain interacts with the syntax, in that it preferentially right-aligns with the clause, while respecting the integrity of syntactic constituents. The primary focus is situated within the wider focus domain, and sentence stress right-aligns with the primary focus, except in cases of focus projection. Two types of focus projection exist: (1) compound projection, to preserve the prosodic salience of compounds and stress clashes; and (2) complex NP projection, which likely serves to enhance the salience, perception and processing of complex NPs. Sentence stress also preferentially aligns with content words within the focus domain. These constraints account for stress characteristics discussed in different approaches, and brings them under a single constraint based framework. This includes focus projection in the generative literature, the tendency for stress to fall near sentence boundaries and at IP boundaries, and the role of focus in stress assignment.

Special stress is explained by positing a special focus constraint that outranks the others. Special focus is not addressed in the generative literature, but though it is idiosyncratic to the speaker's intentions, a highly ranked special focus constraint can at least describe its interaction with the rest of the grammar. This constraint (as one reviewer noted) would probably be an undominated constraint in the grammar for English or any language that employs intonational prominence for contrast and emphasis. A potential problem for OT, then, could be that the theory seems to allow for undominated constraints, but cannot constrain what constraints would be

undominated either universally or in a particular grammar. Some undominated constraints in a grammar seem desirable. In English, syntactic integrity constraints may be undominated, but not so in some free word order languages. A putative constraint that right-aligns sentence stress with the IP boundary would be undominated, since IPs by definition terminate with the nuclear stress. It seems desirable to have some undominated constraints, but to also have limitations in the theory on what or how much can be undominated. This remains an unresolved issue in OT.

The above analysis shows how alignment constraints can work to specify how different modules interact in the grammar, such as focus structure, syntax, prosodic domains and stress features. Alignment theory was originally developed to explain morphophonological phenomena like reduplication, but it has great potential for describing linguistic interface among different modules of linguistic systems; this potential so far has not been developed much in interface theory. However, another theoretical problem arises. In OT, it would be hypothetically possible to align any feature or structure with any other feature or structure, leading to very unlikely and unattested grammars. This is another unresolved issue in OT. This author suspects that recourse to the connectionist and cognitive roots that gave rise to OT may provide some insights for developing an alignment theory that is not overly powerful.

Here alignment has nonetheless proven useful for focus and stress patterns. Formulating focus and information structure as outlined above, based on constraints and interactions between different parts of the language, provides a psycholinguistically plausible view of stress, focus, and the interaction of different levels of the linguistic system. It is able to handle apparent exceptions of syntactically conditioned old information or less salient information occurring at the end of sentences after the primary focus. The OT analysis above can account for various sentence stress patterns, including some non-canonical types, while integrating insights from both generative and pragmatic analyses into one framework. These include non-final stress; the interaction of special focus and normal focus; stress on content words cf. function words, including stressable function words in the absence of new content words; stress assignment on compound words; and NP focus projection. The interface of different linguistic modules here explains

how stress assignment behaves pragmatically, phonologically and syntactically. Sentence stress is thus an interesting aspect of the grammar, since it showcases the interface of linguistic modules in a constraint based framework.

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