35. Phonological Evidence in Syntax

Michael Wagner
McGill University

Abstract
Linear precedence is one of the key sources of evidence for the syntactic structure of complex expressions, but other aspects of the phonological representation of a sentence, such as its prosody, are often not considered when testing syntactic theories. This overview provides an introduction to the three main dimensions of sentence prosody, phrasing, prominence and intonational tune, focusing on how they can enter syntactic argumentation.

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1. Introduction

The prosody of an utterance can be characterized as all those phonological and phonetic properties that are not determined by the choice of words and morphemes it contains or their linear order, but rather by how they relate to each other syntactically and semantically, by what aspects of the utterance are foregrounded and backgrounded, and by the role of the utterance in discourse.

If certain aspects of the phonology of an utterance systematically reflect syntactic structure, then we should be able to make inferences about syntactic structure by looking at phonological evidence. Linear precedence—a phonological property—is standardly used as evidence in current syntactic research, but the same is not true for prosodic evidence. The relationship between syntactic constituency and linear order is usually taken to be entirely systematic, even if assumptions about linearization often remain implicit. A assumption shared across many syntactic theories is that there is a deterministic way in which syntactic structure maps to linear order. Examples of theories relating the two include the Linear Correspondence Axiom of Kayne (1994), and subsequent work in the antisymmetric framework; other recent approaches include current versions of OT syntax (e.g., Sells 2001), representation theory (Williams 2003), or the theory of cyclic linearization presented in Fox and Pesetsky (2005). Prosodic evidence, on the other hand, is generally considered to be an unreliable witness for syntactic structure, partly because it is harder to establish what the precise prosodic structure of an utterance really is, and partly because the relationship between syntax and prosody is considered to be more indirect and malleable.

This article provides an overview of types of prosodic evidence and about different theories of how they relate to syntax, and presents arguments that prosody may be a much more useful tool of syntactic analysis than is generally assumed, even if our understanding of the relation between the two is still emerging. Three dimensions of prosodic structure are discussed: *prosodic phrasing*, *prosodic prominence*, and *intonational tunes*. They are in principle orthogonal to each other in that they can be varied independently, although there are some intricate ways in which they interact. The weighting between the three parts of the paper is very uneven, with most of the discussion focusing on prosodic boundaries, followed by prominence, and only a very brief discussion of intonational tunes. This weighting probably reflects the amount attention given to these domains in the more syntactically oriented existing literature on prosody, but this is not to say that they are not ultimately of equal importance from a syntactic point of view. The differential attention they receive here is simply a reflection of the state of the field and also of an attempt at re keeping the length of the chapter under control. I will mostly use examples from English and French for illustration.

2. Phrasing

It is uncontroversial that prosodic phrasing reflects syntactic constituent structure at least to some extent. The following two utterances differ in the location of the boundary between the two clauses they include. Although they use the same words, typical renditions are acoustically quite different, the two readings are thus disambiguated prosodically:

(1) a. *If you wait | around it'll come.*

b. *If you wait around | it'll come.*

There is disagreement, however, about the nature of this relationship. In the following, we look first at diagnostics for prosodic phrasing, and then at theories that try to explain its relation to syntax.

2.1. Diagnostics for prosodic phrasing

How does one establish the prosodic phrasing of an utterance? The following sections review various types of criteria. They are usually assumed to converge on a single structure, an assumption which itself is not unproblematic.

2.1.1. Intonational cues to phrasing

One criterion for identifying prosodic domains are tonal events that align with the main prominence or the edges of phonological constituents. A common assumption is that pitch contours can be analyzed in terms of a sequence of tonal targets, consisting of high (H) and low (L) tones, and combinations thereof, following the lead of Pierrehumbert (1980). In the now often used convention for transcribing intonation called ToBI (Silverman et al. 1992), starred tones identify pitch accents, while tones with following diacritics (e.g., L-, L%) represent boundary tones of certain types of phonological constituents (e.g., intermediate phrase, intonational phrase). However, the proper phonological interpretation of pitch contours remains controversial (cf. Dilley 2005).

A salient acoustic difference between (1a,b) is the temporal location of certain modulations of fundamental frequency, called boundary tones. A transcription of a typical rendition of (1a,b) following the ToBI convention looks as follows:

(2) a. *If you wait around | it'll come.*

H* H* H- H*L-L%

b. *If you wait | around it'll come.*

H* H- H* H*L-L%

A fundamental assumption of ToBI and related representations of sentence prosody is that the intonational contour of a sentence can be broken down into pitch accents which align with prominent syllables and boundary tones which align with the boundaries of certain prosodic constituents. In the examples in (2a,b), the H- boundary tones associated with what ToBI calls *intermediate phrases* are placed in different locations, which in turn reveal the difference in the underlying syntactic structure. Intonational cues play an important role in chunking the signal into prosodic pieces, and these bear a systematic relationship to syntactic constituent structure.

The analysis of pitch contours in terms of tones makes very specific assumptions about the phonological inventory of tones in a given language. French, for example, has a quite different intonational system compared to English. In French, there is a tonal domain that is sometimes referred to as the *accentual phrase.* Its end is usually delimited by a high pitch accent on the last non-schwa syllable of the phrase (often preceded by a low target). The accent is often followed by a rise if another accentual domain follows, or by a boundary tone if it occurs at the end of an intonational phrase. The annotation of a typical intonation contour in French could look as follows (cf. Post 2000; Jun and Fougeron 2000; Féry 2001; Welby 2003):

(3)

Lorenzo		*est un petit enfant. [French]*		
|	|	|		|
L	H*	L	H*	L%

Just as in the case of English, there are conflicting opinions about how French prosody should be transcribed, including on whether tones should be linked to particular vowels or syllables at all. Recent analyses of French intonation and summaries of earlier approaches can be found in Post (2000); Jun and Fougeron (2000), and Welby (2003). It is important to keep in mind that how a pitch contour will be transcribed depends heavily on what phonological assumptions are made about the tonal inventory of the particular language, such that the same pitch contour will receive radically different transcriptions depending on the assumed transcription system. It is thus risky to run an experiment and only report results based on transcriptions, since, as transcription systems change over time, it will become harder and harder to interpret the results and compare them with new results. There is thus an important advantage in also reporting quantitative measures that are based on transcriptions based on theory-independent and easily replicable landmarks, or even in making available the entire data including the acoustic files, which of course requires special consent from the speakers involved in a study.

2.1.2. External sandhi

Phonological processes that apply across word boundaries are often referred to as external sandhi processes. Selkirk (1972), Nespor and Vogel (1986), and many others use French

liaison to exemplify external sandhi. French liaison consists of the pronunciation of an otherwise unpronounced word-final consonant, usually when a word beginning with a vowel follows (Selkirk 1972: 206):

(4) a. *Lorenzo est petit en comparaison de Jean.* [French]
b. *Lorenzo es[t] un peti[t] enfant.*

In (4a), both the [t] at the end of *est* and that at the of *petit* are lost, but for different reasons. The word *est* is followed by a consonant-initial word, *petit*, and hence there is no liaison. *Petit*, in turn, although followed by a vowel-initial word, remains unpronounced as well. The problem here is that it does not form a liaison context together with the following word, due to the syntactic relation between the two. In (4b), on the other hand, both [t]s are preserved since both words are followed by vowel-initial words and in addition, they bear the right syntactic or prosodic relation to the following words. Hence liaison applies.

Nespor and Vogel (1986) propose that liaison applies with a certain phonological domain, the phonological phrase, and whether words are phrased together into such a unit depends on their syntactic relation to each other. More generally, work within prosodic phonology assumes that phonological processes that seem to be sensitive to syntax are in fact sensitive to certain phonological domains, and it is in the formation of these domains that syntax indirectly exerts its influence on phonological processes.

An analysis of liaison in prosodic terms holds that in (a), but not in (b), there is a prosodic boundary that separates *petit* from the following syllable *en* and blocks liaison:

(5) a. *Lorenzo | est petit | en comparaison de Jean.* [French]
b. *Lorenzo | es[t] un peti[t] enfant.*

Looking at phonological processes that apply across word boundaries may thus provide evidence for prosodic domains. In English, as in French, there are such external sandhi processes. One is flapping, which turns [d/t] into [ɾ] at the onset of an unstressed syllable, as in (6b):

(6) a. *If you wai[ʔ] | around it'll come.*
b. *If you wai[ɾ] around | it'll come.*

The difference between (6a,b) suggests that flapping is bound by a prosodic domain. The glottalization in (6a), on the other hand, illustrates a phonological process that happens at the end of a prosodic domain. Phonological processes that apply at the edges of prosodic domains are another very common type of phenomenon that can be used to motivate prosodic phrasing. These segmental cues can in fact disambiguate syntactic structures. Scott and Cutler (1984), for example, present evidence from perception experiments that segmental cues such as flapping alone disambiguate structures if one holds all other acoustic cues to phrasing constant.

2.1.3. Quantitative effects

The choice between a flap, a glottal stop, and a [t], the choice between pronouncing a liaison consonant or dropping it, and the presence and absence of a tonal boundary tones—all of these might constitute categorical differences (although this is not obvious at least in the case of flapping). However, there are also cues for prosodic phrasing that are clearly quantitative.

Lehiste (1973), looking at various structural ambiguities and their prosody, found duration to be the most reliable cue in disambiguating them. The importance of durational cues in signaling prosodic phrasing has been confirmed in many studies since (e.g., Price et al. 1991; Wightman et al. 1992). There are actually various different durational effects induced by prosodic phrasing. Pre-boundary lengthening in English, for example, affects mostly the last syllable preceding a boundary and stressed syllables (Turk and Shattuck-Hufnagel 2000). In addition to pre-boundary lengthening, there are also durational effects at the beginning of prosodic domains. Fougeron and Keating (1997) found that there is a strengthening in the articulation of phrase-initial segments, resulting in longer duration. Both pre-boundary lengthening (Wightman et al. 1992) and domain-initial strengthening (Fougeron and Keating 1997) have been found to distinguish boundaries of different strengths by different degrees of lengthening; they are thus gradient cues to relative boundary strength.

Another important cue for prosodic grouping is pitch. A percept of juncture can be induced by the relative pitch scaling between accents and pitch resets between phrases. Resets, which some theorists represent as phonological events analogous to boundary tones (Truckenbrodt 2002), are perceived as discontinuities and form a strong cue for prosodic boundaries (Pijper and Sanderman 1994). Relative pitch scaling between phrases signals prosodic grouping (Ladd 1988; Féry and Truckenbrodt 2005), and van den Berg et al. (1992) have shown that scaling can be used in multiply embedded structures to signal several layers of bracketing.

Quantitative interactions at the segmental level also give important evidence for prosodic grouping. The degree of coarticulation and gestural overlap can reveal whether or not words are separated by a prosodic boundary. The divide between coarticulation and full assimilation as observed in sandhi phenomena may not always be clear-cut, but various previous studies have found clear patterns that contrast full assimilation and partial gestural overlap (Niebuhr et al. 2011). An example is palatalization in English (Zsiga 1995):

(7) a. *did you* → *di[ʤ]u*

b. *want you* → *wan[ʧ]u*

Palatalization is more common in fast speech than in careful speech (Cooper and Paccia-Cooper 1980), and is blocked if a "major syntactic boundary" which coincides with a prosodic boundary intervenes (Cooper et al. 1978). While palatalization can be complete, it

can also happen gradiently (Zsiga 1995), and thus it can provide gradient cues to how close a unit two words form.

2.1.4. Contradictory diagnostics and phonological representation

According to the influential theory of the prosodic hierarchy, prosodic boundaries of differing strengths are categorically different, and these categories are organized in a hierarchical way. Phonological processes are characterized by applying within or at the edge of prosodic domains of a certain category, and prosodic categories in turn can thus be identified by considering whether certain rules apply or not. Phonological categories lower on the hierarchy define boundaries that are weaker compared to boundaries of categories higher on the hierarchy:

(8) Prosodic Hierarchy (Selkirk 1986: 384):

(_____)	Utterance
(_____) (_____)	Intonational Phrase
(_____)(_____) (_____)	Phonological Phrase
(_____)(_____) (_____) (_____) (_____)	Prosodic Word
(__)(_____) (_____) (__) (_____) (_____)(__) (_____)	Foot
(__)(__)(__)(__) (__) (__)(__)(__) (__) (__) (__) (__)(__) (__)	Sylllabe

The prosodic hierarchy hypothesis holds that every utterance contains a full suite of prosodic constituents, and each one properly contains one or more constituents of the next lower kind. Recursive nesting of prosodic constituents should be impossible, although Ladd (1986, 1988); Dresher (1994); Truckenbrodt (1995); Wagner (2005b, 2010); Ito (2010); Selkirk (2011) and Elfner (2012) argue that some level of recursion should be allowed.

If all of the above-listed diagnostics for prosodic phrasing, both the various quantitative phonetic cues and the categorical phonological cues such as pitch events and sandhi phenomena, are really reflexes of the same prosodic representation, then a straightforward expectation is that they should converge on one and the same prosodic phrasing. This, however, is not always the case.

A prime example is French. While the phrasing motivated by accent placement in French is by all accounts in tune with quantitative cues to phrasing (Jun and Fougeron 2000), the same is not true for liaison. Post (2000); Fougeron and Delais-Roussarie (2004); Miller and Fagyal (2005) and Pak and Friesner (2006) all find that liaison sometimes applies across prosodic boundaries, sometimes even major ones. And furthermore, liaison quite often does not apply within a prosodic domain although it should, at least according to theories that closely link certain prosodic domains with the application of certain processes. But there is lots of variation, and it is clear that lexical frequency and collocational frequency play a big role (Miller and Fagyal 2005). This may not be all too surprising, given that liaison in French is heavily morphologized and lexicalized in instances of phonologically conditioned allomorphy. However, this implies that we can't, in fact, use liaison as

a criterion for establishing surface prosodic phrasing. It also means that liaison domains do not fit into a prosodic hierarchy, since contradictions with intonationally motivated boundaries exist.

This may in fact be quite characteristic of a fair number of sandhi processes that were used to establish the syntax–phonology relationship in the literature on prosodic phonology. Chen (1987), for example, points out that prosodic boundaries induced by focus do not affect the domains for tone-sandhi in Xiamen (Taiwanese), and even an intonational phrase break can interrupt them. So while Chen's insights into the formation of sandhi-domains were one of the main empirical motivations of the so-called *edge-marking approach* to the mapping of syntax to phonology (cf. Selkirk 1986), Chen's paper actually also provides falsifying counter-evidence against this theory. These inconsistencies would warrant a closer look at the syntax and prosody of Xiamen, and how sandhi and focus domains relate to it. More evidence for contradictions arising when using different phonological processes as criteria for establishing prosodic phrasing at the same time are discussed for Luganda in Hyman et al. (1987) and for Kimatuumbi in Odden (1990).

Other processes, such as flapping and palatalization in American English, or Mandarin tone-3 tone sandhi (Chen 2000) do not interact with morphology in the same way as liaison does, and do not appear to be sensitive to the particular syntactic environment, and are sensitive to speech rate. However, also here, there is some evidence for lexical factors to play a role at least in the case of flapping. High-frequency words are more likely to undergo flapping than low-frequency words (Patterson and Connine 2001), and whether flapping occurs across word boundaries or not depends on the mutual predictability between two words and collocational frequency (Gregory et al. 1999). Also, Cooper and Paccia-Cooper (1980) note that flapping does not necessarily occur even when there is no prosodic break intervening, and Ranbom et al. (2009) report evidence from a corpus study that sometimes flapping even occurs when the segment is followed by a prosodic boundary or a pause.

The influence of lexical frequency, mutual predictability, and the possibility of sandhi processes across even strong boundaries calls into question the widely held assumption of the prosodic hierarchy, which holds that prosodic domains completely determine whether or not a phonological rule will apply. One interpretation is that it is actually incorrect that the domain of segmental phonological rule application is necessarily and sufficiently characterized by prosodic domains. Alternatively, this might point to two different levels of representations that phonological rules can be sensitive to, an early more morpho-syntactically motivated parse and a later surface-prosodic one (Kaisse 1985; Seidl 2001; Pak 2008). In any event, when investigating the relationship between phonology and syntax it is therefore crucial to distinguish between processes that reflect the surface prosodic phrasing and processes that reflect syntactic or morphological relations directly. This point was already discussed in Kaisse (1985), but has sometimes been overlooked in the literature since.

An alternative perspective on the relation between certain sandhi phenomena like flapping is that they there are part of a family of related but orthogonal cues to *relative bound-*

ary strength, including intonational ones, segmental ones, and durational ones. Rather than being causal reflexes of rules applying within constituents of particular phonological category, they actually form a set of correlated but in principle orthogonal cues for relative boundary strength. Whether or not a particular sandhi rule applies is just one signal that contributes to the percept of a certain boundary strength, and conversely many other factors may influence whether a sandhi rule applies or not. As will be discussed in more detail in the next section, this alternative way of looking at things is still compatible with the idea that flapping is used as a cue for surface prosodic phrasing, and indirectly for syntactic structure: If there is flapping across one but not across another boundary, this may still be a strong cue for a difference in relative prosodic boundary strength between those two boundaries. Arguments in favour of this view are given in Wagner (2005b, 2010). Intuitions of naive listeners of prosody usually agree to a high extent on relative prominence and relative boundary strength, making an analysis positing relative strength as a primitive plausible, even if these observations are compatible with a categorical interpretation (Pijper and Sanderman 1994; Cole et al. 2010). The relational view of the syntax-phonology mapping also fits well with recent findings that in perception, prosodic boundaries are interpreted relative to earlier prosodic boundaries (Clifton et al. 2002; Frazier et al. 2006), and findings that in sentence production later boundaries are scaled relative to earlier occurring boundaries (Wagner 2005b).

An even more radical departure from the received view is that one could argue that for processes like flapping, the conditioning environment can in fact be characterized entirely segmentally by saying that a [t/d] flap if a vowel follows unless they are in the onset of a stressed syllable. The interaction with prosody could be entirely indirect: Across a prosodic boundary it is less likely that the following segmental context will be planned out already. Speakers don't consistently encode the next phonological word, so the conditioning environments may simply not be present at the point in time when the allomorph choice is made. The plausible assumption necessary for this view is that the prosodic strength of the boundary between two words correlates with the likelihood that the segmental content of the beginning of the second word will already be phonologically encoded at the time when the first word is planned (cf. Levelt 1992; Wheeldon and Lahiri 1997; Miozzo and Caramazza 1999; Wheeldon and Lahiri 2002). Such an account of the constraints on sandhi phenomena based on the locality of production planning is presented in Wagner (2011, 2012c).

Linking phonological locality directly to online processing and the locality of speech production is unconventional from the point of view of the generative tradition, but it actually makes for a highly parsimonious and modular characterization of the interaction between syntax and prosody. It also fits well with recent psycholinguistic models of phonological processing, which seek the explanation for certain phonological patterns in the interaction of processing constraints and the planning or retrieval of phonological representations (cf. Goldrick 2011). This move toward a theory informed by processing considerations has the desirable effect that it can connect the phonological substance of the structural change

and the structural environment of a process to the particular type of morpho-syntactic locality it should obey, and can also make predictions about whether or not it will be variable. Both types of predictions lie outside of what current models of the syntax-phonology interface can explain.

2.1.5. Summary: Diagnostics for phrasing

The main lesson to draw from the discussion of diagnostics for prosodic phrasing is that when evaluating whether syntax and phonology are in tune, it is crucial to use multiple tests for prosodic structure and assure that they converge on the same structure. In cases of contradictions, the quantitative phonetic cues and the evidence from less morphologized and less lexicalized phonological and phonetic processes are most likely to reveal the surface prosodic bracketing.

2.2. The nature of the relation between syntax and prosody

Most current linguistic theories propose a rather direct relationship between syntax and phonology and postulate a systematic mapping between syntactic and prosodic bracketing. They vary in the precise mapping function and the degree of isomorphism between the two structures they assume. There are, however, other theories that assume a much more indirect relationship between the two, and try to explain intuitions about prosodic grouping as a reflex of processing factors such as the cost of planning of upcoming and the integration of preceding constituents. The loci of high processing cost may correlate up to a point with syntactic constituency. The emphasis of the following review will be on theories that suggest a more direct, syntax-based mapping, but the processing based approach has been gaining steam over the past years, and since it provides a more parsimonious explanation by evoking general processing principles to account for prosodic phenomena it constitutes the null hypothesis against grammatical accounts have to be evaluated. Eurythmic effects on phrasing such as the tendency for binary prosodic constituents (e.g. Selkirk 2011) or constituents of equal size (e.g., Ghini 1993) complicate the picture, and they themselves by relate to ease of processing or grammatical constraints. The precise way in which syntactic and eurythmic factors interact will not receive much attention in this review.

2.2.1. Is prosodic structure isomorphic to syntax?

Most early quantitative work on prosodic boundaries such as Lehiste (1973); Grosjean and Collins (1979); Cooper and Paccia-Cooper (1980) and Gee and Grosjean (1983) made an assumption about the relation between syntax and phonology that assumes a close match between the two. The basic intuition is that constituents that form prosodic units also form syntactic constituents in surface structure. This assumption was also at the heart of most generative approaches up until the 1980s. Consider the recursive algorithms proposed to

derive a sentence-level prosodic representation in Chomsky et al. (1957) and Chomsky and Halle (1968). In Chomsky et al. (1957) and Chomsky and Halle (1968), the phonological representation of an utterance is a translation of the tree structure including the segments contained in the lexical entries in the terminal nodes into a linear segmental stream. Hierarchical relations are encoded by using n-ary sequences of # symbols. Every syntactic node is translated into a pair of # symbols that flank whatever phonological material the constituents dominated by that node contain. A simple right-branching structure [a [b c]] might correspond to the following transcription:

(9) [a [b c]] → ##a###b##c###

An issue with the particular mapping assumed in Chomsky et al. (1957) and Chomsky and Halle (1968) noted in Wagner (2005b) is that it runs into problems with respect to keeping certain constituents that internally less complex on par prosodically with more complex constituents that are syntactically at the same level. These cases require a fix similar to the Stress Equalization Principle proposed for the assignment of prominence in Halle and Vergnaud (1987).

In principle, this prosodic transcription of constituent structure could be pushed to be completely isomorphic and represent the entire tree structure in terms of boundaries of different strengths (as represented by the number of #-symbols). But the claim in Chomsky and Halle (1968) was actually a weaker one: Only certain nodes, roughly lexical words, NPs, and CPs, actually have the property that they induce boundaries around the words flanking them (similar to today's 'phases'). The mapping from syntax to phonology thus effectively "flattens" the tree structure into a less articulated prosodic structure which only partially encodes the syntactic tree it is based on. This captures the intuition that many expressions that are assumed to involve an articulated phrase structure are mapped to a comparatively flat sequence of prosodic phrases, for example a right branching structure (e.g. complex VPs in English) often maps to a sequence of phonological units separated by boundaries of equal strength. If one assumed an isomorphic mapping with boundary symbols added around every mode, this would suggest that every right-branching structure necessarily has a stronger juncture between a and b than between b and c, contrary to fact. This intuition is captured in SPE by assuming that only certain nodes induce boundaries around them (roughly the same nodes that many authors today assume to be "phases").

It is not the case, however, that an isomorphic mapping necessarily cannot account for the intuition that prosodic structure is "flatter" than syntax. There are many conceivable one-to-one functions between syntax and prosody. It seems that conveying many different degrees of prosodic boundary strengths is difficult either for production or perception reasons, so representing any syntactic embedding by boundaries of different strengths would be an efficient use of phonological resources. Wagner (2005b) argues that there could still be a one-to-one mapping between a syntactic structure and a prosodic structure (sometimes

overridden for eurythmic reasons) if certain articulated syntactic structures happen to map to a sequence of prosodic phrases matched in prosodic size.

A first basic intuition this approach is based on is that syntactic sisters are matched in prosodic size, as first proposed in Wagner (2005a: 359). This basic case is generalized to all nodes in certain right-branchingn structures that are derived mono-cyclically. The crux of the analysis is that there can be an isomorphic mapping between syntax and prosody, even though the phonology appears to be 'flatter' than the syntax. Such a mapping between syntax and phonology is an efficient use of phonological resources if (i) distinguishing prosodic boundaries of different strength is hard to process, and (ii) most structures are right branching. A right-branching-bias is exactly what is argued for on independent grounds in Haider (et seq. 1993) and Phillips (1996). The concrete model in Wagner (2005b) assumes that any structure assembled in a single cycle is right-branching, and the pieces assembled are mapped to prosodic constituents separated by boundaries of equal strength, they are matched in prosodic size. In other words, the mapping can be still be isomorphic, and yet account for the apparent flatness of prosodic structure compared to syntactic structure. A simpler assumption would be to posit that these structurs are actually syntactically 'flat' and involve more than two sister constituents (Culicover and Jackendoff 2005), in which case 'sister-matching' (Wagner 2005a) would be a sufficient account. The choice between these two accounts may in the end depend on theory-internal considerations (Wagner 2005b). A more recent account for sister-matching, formalized in an OT framework, is made in Myrberg (2013).

Of course, the assumption of isomorphism might be too strong a theory of how phonology reflects syntax, and the proposal in Wagner (2005b) actually notes that distinctions among boundaries of lower ranks that the algorithms derives are often not realized phonology and "washed out." So just as the proposal in SPE and almost all approaches since then, the actual mapping function proposed there is not isomorphic but merely homomorphic, that is, not all the details of syntactic bracketing is recoverable from prosody. Different homomorphic theories can be classified by which aspects of syntactic structure they preserve, and it is useful to make explicit how families of theories differ from each other.

2.2.2. Monotonic theories *vs.* non-monotonic theories

An assumption that is much weaker than a perfect isomorphism is shared by many theories of how syntax maps to prosody, including Chomsky and Halle (1968), Wagner (2010), and many other. These theories all assume a 'monotonic' mapping, in the following sense. This is a slightly revised version of the *Hypothesis on Attachment and Prosody* proposed in Wagner (2010), who argues for a monotonic view of the relationship between syntax and phonology, with limited adjustments for eurythmic phonological reasons.

(10) Monotonicity

A mapping from syntactic constituent structure to a prosodic representation is monotonic if the following holds:
In a sequence A $\prec$ B $\prec$ C, if the prosodic boundary separating A and B is weaker than the one separating B and C, then there is a node dominating AB that excludes C; if it stronger, then there is a node dominating BC that excludes A.

The hypothesis that the mapping is monotonic, although much weaker than assuming an isomorphism, still makes strong and easily falsifiable predictions. An influential theory that doesn't assume (10) and is hence non-monotonic is the theory of Edge-Alignment (Chen 1987; Selkirk 1986). Monotonicity is also not assumed in the mapping proposed in Nespor and Vogel (1986). At least some of the mismatches that the theory of Edge-Alignment is designed to capture, however, may only be apparent, and disappear once the syntax is looked at more closely. I will turn to (apparent) mismatches in the section (2.3).

Most recent proposals in the literature actually seem to have moved away from making strong claims about non-monotonic mapping. For example Selkirk (2011)'s Match Theory abandons the systematic non-monotonic predictions of Edge-Alignment, and argues for a monotonic mapping, modulo phonological factors that can override it. This is effectively the position argued for in Wagner (2005b). Match theory, although presented as a development of prosodic phonology, is hence a radical departure from a 25-year tradition of non-monotonic accounts within prosodic phonology, even if this is not made explicit in the exposition of the theory in Selkirk (2011).

The question whether the mapping between syntax and prosody is indeed monotonic is hardly settled, however. More work involving theory comparison would is needed. For example, there is a cross-linguistically recurring prosodic asymmetry in phrasing between heads taking a complement to the left and heads taking a complement to the right? If true, this is a generalization not explained by current monotonic theories of syntax-phonology mapping (for an insightful discusssion see Taglicht 1998).

2.2.3. Relational theories *vs.* designated categories

The recursive mapping algorithms deriving boundary strength in Chomsky et al. (1957) and Chomsky and Halle (1968), and also more recent accounts such as the one proposed in Wagner (2005b) and in Pak (2008), assume that syntax fixes relative but not absolute ranks of prosodic boundaries. They are thus *relational* theories, in contrast to theories that map certain syntactic types of objects to certain phonological categories, that is, theories that operate with "designated categories" (Hale and Selkirk 1987). Nespor and Vogel (1986), for example, provide generalizations that are intended to capture how phonological domains of different types are constructed by making reference to particular lexical or syntactic information. To give an example:

(11) Phonological Phrase Formation (Nespor and Vogel 1986: 168)

I. ϕ domain
The domain of ϕ consists of a C [clitic group] which contains a lexical head (X) and all C's on its nonrecursive side up to the C that contains another head outside of the maximal projection of X.

[...]

The definition of phonological phrases makes direct reference to syntactic categories (head, maximal projection). A crucial notion in this particular definition is that of the "recursive side of a constituent." Which side counts as recursive in a language is assumed to be a fixed parameter, which raises considerable issues in languages with mixed headedness such as any Germanic language. Other researchers have invoked c-command as the relevant notion in constructing phonological domains, such as Kaisse (1985), Hayes and Lahiri (1991), and Guimarães (2004), with considerable success.

Edge-based theories of mapping (Selkirk 1986; Chen 1987; Selkirk 1995) align the edges of certain syntactic constituents with the edges of certain phonological constituents, or enclose certain syntactic constituents in phonological domains of a certain kind (Truckenbrodt 1995). This idea of designated categories for prosodic domains was formalized in Selkirk (1996: 444) as follows:

(12) The edge-based theory of the syntax-prosody interface
Right/Left edge of $\alpha \rightarrow$ edge of β,
α is a syntactic category, β is a prosodic category.

The intuition behind both approaches is that syntactic objects of a certain size map to phonological objects of a certain size, for example, clauses tend to correspond to intonational phrases. The edge-based theory has been shown to run into trouble when the predicted mismatches between syntax and phonology are scrutinized more closely as will be discussed shortly. A more recent incarnation of this framework has moved closer to the approach that assumes that syntactic constituency and phonological constituency correlate, but still asumes a correspondence between certain syntactic objects (e.g., clauses) and certain phonological categories (e.g., intonational phrases).

A direct form of evidence for designated categories assumed by Match theory, Edge-Alignment, and many other theories would require looking at segmentally identical or near-identical utterances with varying syntactic structures. The following example is an admittedly awkward attempt at creating such an example in English. Provided that the predicate in the second example is accented, the pair is quite minimal. The theories positing designated categories would predict a categorical phonological difference in prosodic structure due to the difference between a clause boundary and a noun phrase boundary, with only the former inducing an intonational phrase break:

(13) a. *The dark things in the cool pools.*

b. *The lark thinks that the pool cools.*

It is not clear though that there is such a categorical phonological difference in prosodic phrasing that depends on the syntactic category of the constituents involved. To show that such differences are real, experimental evidence would be necessary since, apparently, intuition does not seem suffice to motivate distinct categorical representations. And care has to be taken that processing explanations for subtle differences are controlled for. For example, noun phrases and sentences might differ in processing time, and the conditional probability of the constituent following the crucial boundary has to be controlled for. The evidence for a close correspondence between syntactic category and phonological category based on controlled minimal examples is usually not provided (for example, I know of now such test for English). This is surprising, given how crucial these examples would be to justify the premise of theories with designated categories.

There are two types of processes that have been observed that pose challenges to the theory of designated categories. On the one hand, as discussed before, certain segmental alternations correlate well with syntax but not with surface prosody (e.g., liaison, Taiwanese tone sandhi, as discussed above); on the other hand certain segmental alternatives correlate well with surface prosody, are affected by speech rate, but do not line up with syntactic categories in any systematic way (e.g., flapping, or Mandarin tone sandhi). Both types of cases constitutes divergences from the predictions of theories that negotiate the interface between syntax and prosody via designated categories. There could of course be other types of processes that behave exactly as predicted, but the evidence provided in the literature is often not rich enough to evaluate this.

The relational view of boundary strength discussed before has the advantage that it can straightforwardly explain why it is that many sandhi rules such as flapping can optionally apply in wider or less wide domains, for example in coordinate structures. Speakers may simply have a lot of freedom in which particular line of the grid they map to which particular type of phonological unit:

(14) Syntax: *(a cat or a rat) and a hat*

Possible Prosodies:
(a car or a raʔ) and a haʔ
(a car or a rar) and a haʔ
(a caʔor a raʔ) and a haʔ

What is impossible is flapping across the stronger boundary when there is no flapping across the weaker boundary:

(15) Syntax: *(a cat or a rat) and a hat*
Prosody: **a caʔ or a rar and a haʔ*

Flapping is thus a tool that can be used with some flexibility to differentiate the strength of different boundaries, and this is exactly what is expected under the view that syntax fixes relative but not absolute ranks. Relational models are compatible with the view that flapping is in fact not tied to a particular phonological domain at all, but is simply used as one out of many cues for relative boundary strength, along with final lengthening, initial strengthening, and the presence/absence of boundary tones, a view that, as discussed above, gets some support from experimental studies on flapping that show lexical effects on the likelihood of flapping.

The designated-category approach would have to attribute such variation to be an effect of variable prosodic phrasing, that is, a phonological domain of a certain type (say, the phonological phrase) which provides the domain for flapping is assigned variably. Such an account is indeed proposed in Nespor and Vogel (1986), where various rules of restructuring are used to account for such variation. A serious question for this approach is, however, is whether there is any independent evidence for positing such variation in what counts as, to avoid circularity.

The second type of counter-evidence for designated categories, cases where phonological processes track syntactic domains but do not line up with prosodic surface constituents, is not easily accountable by theories that operate with relative boundary strength either. There are some languages that seem to provide evidence for clear categorical phonological reflections of clause boundaries, for example, the distribution of certain boundary morphemes and allomorphs in Mayan languages seems to be sensitive to whether they occur adjacent to a phonological boundary of a certain category, the intonational phrase (Aissen 1992; Henderson 2012). The prosodic analysis of the distribution seem to require reference to designated prosodic categories, since it is only intonational boundaries that are relevant. It is difficult though to assess whether the generalization is really phonological in nature rather than syntactic, since the proposed phonological IP-boundary correlates perfectly with the presence of a clause boundary, so the boundary itself could be analyzed as the spell-out of a functional head in the CP domain.

Similar questions arise in the analysis of the intonation of English, in particular in the analysis of tonal events at clause boundaries. On one end of the spectrum is the syntactic view, positing that intonational tunes are the pronunciation of syntactically represented elements that combine with syntactic constituents just like other nodes that are associated with segmentally content-full morphemes. This view was pioneered by Stockwell (1960) who proposed that the intonational morphemes combine with syntactic phrase markers by virtue of re-write rules, and was recently formalized in the context of categorial grammar by Steedman (2000). On the other end of the spectrum are approaches that view intonational tunes as emerging from an independently generated prosodic representation in phonology which aligns in complex ways with a syntactic representation (e.g., Selkirk 1995, 2005).

The aforementioned idea that phonological processes are actually not constrained by prosodic domains but rather by the locality of production planning might be another way to

make sense of the differing generalizations about domains of application. Taiwanese tone sandhi, for example, is sensitive to whether or not a lexical word is the last word within a certain syntactic domains. The number of upcoming words within a domain has been shown in the literature on production planning to be planned far ahead (e.g. Sternberg et al. 1978). The precise phonological content of upcoming words, however, is available in much more local domain. Mandarin tone 3 sandhi, in contrast to Taiwanese sandhi, is sensitive to the identity of the lexical tone on the following word. This could potentially explain why Mandarin tone sandhi is subject to a much stricter locality restriction. More generally, this view makes an interesting production: The locality domain of phonological sandhi processes should directly depend on the type of information that triggers it. The more fine-grained the information about the upcoming word is, the more local and sensitive to prosody should be the domain of application. Conversely, under this approach there is expectation that different phonological processes should converge on a small set of consistent domains of application.

Rigging up the mapping between syntax and prosody in terms of designated categories presupposes distinctions among phonological categories as they are embodied by the prosodic hierarchy. But it is important to note that conversely, the hypothesis of there being a prosodic hierarchy does not entail that the mapping between syntax and phonology functions in terms of designated categories, a point already made in Dresher (1994). For example, if the mapping from syntax actually only fixes relative prosodic ranks, and phonology uses a fixed hierarchy to implement those ranks, there could simply be a lot of flexibility regarding which line in the prosodic hierarchy should line up with which boundary rank (for discussion see Wagner 2005b). The relational view is of course equally compatible with a more recursive view of the phonological representation of prosody itself, and a smaller inventory of phonological categories. Since this is a handbook on syntax, I will not explore the issues that arise in determining what the right type of prosodic representation of boundaries is here, and simply point out that recent approaches have shifted away from some of the strong assumptions embodied in the prosodic hierarchy and have moved to more recursive representations (Ladd 1986; Ladd and Johnson 1987; Kubozono 1989; Truckenbrodt 2002; van den Berg et al. 1992; Wagner 2005b; Ito 2010; Elfner 2012; Ito and Mester 2012).

2.2.4. Is prosodic phrasing juncture-based?

Most accounts of syntax-phonology mapping and all of those mentioned so far make an assumption about intuitions about boundary strength and prosodic phrasing that seems so innocent that I know of no explicit discussion of it:

(16) Hypothesis about Juncture and Prosodic Phrasing
In a sequence A $\prec$ B $\prec$ C, if the boundary separating A and B is weaker than the one

separating B and C, then AB are part of a phonological constituent that excludes C; if it is stronger, then there is a phonological constituent including BC that excludes A.

This assumption is implicit in all theories discussed so far, independent of whether they are monotonic or not, and whether they are relational or operate with designated categories. Nevertheless, a recent analysis of the sentence prosody of Irish (Elfner 2012) departs from this assumption, at least to some extent. For example, in a VSO sentence, previous literature reported a weaker juncture morpho-phonological juncture between V and S compared to the one between S and O (Ackema and Neeleman 2003). The proposed phonological structure in Elfner (2012)'s analysis, however, groups together S and O to the exclusion of V. This prosodic structure has the advantage that it is line with the underlying syntactic structure assumed in most on the syntactic literature on Irish (cf. McCloskey 2011), but it constitutes a major departure from earlier work on prosody.

The pattern in the distribution of pitch scaling that Elfner (2012) is able to capture based on this account is intriguing. It seems too early to assess whether this analysis is the only feasible interpretation of the Irish data, and also whether more evidence for this kind of pattern will be found in other languages, but considering the possibility that (16) might not actually hold opens up a whole new perspective in how to look at sentence prosody.

It is not inconceivable that intuitions about juncture might find an alternative explanation, and that the actual prosodic structure indeed does not line up neatly with the prosodic constituency relevant for pitch accent and boundary tone assignment. This type of account might be able to explain the inconsistencies between Chen (1987)'s findings and the edge-marking theory based on it mentioned before. It could be that certain junctures in the sentence are realized at points of increased processing load, but do not directly affect phonological domains. This brings to processing explanations for boundary placement.

2.2.5. Processing accounts

The approaches discussed so far all assume that prosody directly encodes syntax to some extent or other, even if how this this is conceived of varies (monotonic vs. non-monotonic mapping, designated categories vs. relative boundary strength). An alternative view is that the distribution of prosodic boundaries can be explained by looking at processing factors, and syntax plays into this only indirectly as one factor contributing to processing cost.

One view holds that speakers deliberately employ prosodic means as a tool to facilitate processing (either for the listener or the speaker). Snedeker and Trueswell (2003), for instance, propose that prosodic boundaries are inserted whenever necessary in order to avoid structural ambiguities. Whether or not they are used depends on how aware the speaker is of the ambiguity. This hypothesis still assumes a reliable relationship between boundaries and syntactic bracketing, but posits that whether or not prosody will be used to encode syntax

is optional and depends on whether or not the speaker wants to deliberately disambiguate two relevant readings.

An alternative view is more production oriented, and holds that prosodic boundaries are inserted at locations of high processing cost (e.g. Watson 2002), thus facilitating planning of upcoming constituents and recovery from preceding ones. Effects of planning on prosodic phrasing were also discussed in Ferreira (1993). A third and related view, finally, holds that prosodic boundaries reflect a lack of mutual predictability between two words, and prosodic phrasing in general reflects the expectedness of material in context (Turk 2008). This view is part of a broader theory of how predictability shapes prosodic reduction, which also tries to explain prosodic prominence (Gregory et al. 1999; Aylett and Turk 2004; Jaeger 2006).

A problem for purely processing-oriented approaches was pointed out in Ferreira (2007), who argues that there are actually qualitative distinctions between acoustic reflexes of processing effects and those directly due to prosodic structure. For example, there may be pauses and disfluencies due to a retrieval difficulty of upcoming material that are noticeably different from planned intonational breaks, which come with preceding final lengthening and pitch cues. So some aspects of prosodic structure may be part of what is grammatically encoded in the message, while other aspects might indeed be reflexes of the on-line processing of the message. A model that ties prosodic phrasing and processing cost too closely together may not be able to explain such distinctions. However, it seems premature to draw any strong conclusions.

2.3. Mismatches between syntax and prosody

Prosody and syntax sometimes seem to mismatch. This might mean that we have to complicate the mapping function from syntax to prosody, or it might be evidence that our syntactic analysis is wrong. There is only one way to find out: We need to consider all the prosodic and syntactic evidence available to us in order to understand the apparent or actual mismatch. Wagner (2010) and Steedman (2001) have recently argued that several cases that would conventionally be considered mismatches, prosody may actually be quite in tune with syntax. I will discuss three examples to illustrate the issues that arise.

2.3.1. Post-verbal junctures

Gee and Grosjean (1983: 435) cite certain post-verbal constituents as a case where the main syntactic juncture should be between subject and predicate, but the main prosodic boundary falls between predicate and the PP modifier (cf. Ferreira 2007: 1158):

(17) a. Prosody:
They have been avidly reading | about the latest rumours in Argentina.

b. Assumed Syntax:
[$_{CP}$They have been avidly [$_{VP}$ reading [$_{PP}$ about the latest rumors in Argentina.]]]

Monotonic approaches seem to make the wrong prediction here, since they predict that verb and PP do not form a constituent. It is not so clear, however, whether the Edge-Alignment approach or any other existing non-monotonic account offers a straightforward explanation either, since aligning the left edge of an XP with a prosodic domain—as would be necessary to introduce a boundary between verb and prepositional phrase—would also result in a prosodic boundary before the verb. The overly strong implications regarding mismatches between syntax and prosody made by Edge-Alignment can be reined in by counter-acting constraints, for example, Truckenbrodt (1995) proposes a set of Wrap-Constraints, which favour representations in which certain syntactic constituents (e.g., XPs) are contained in certain phonological constituents (e.g., phonological phrases), although again this may not help in the present case.

However, before we complicate the mapping function between syntax and prosody based on examples like the one in (17a), we need to convince ourselves that it is really necessary or even desirable in this case. The strength of any claim about a mismatch between syntax and prosody depends on the strength of the arguments supporting the syntactic analysis it is premised on. So what we should first ask about (17a) is how compelling the syntactic evidence is that the PP necessarily attaches low, as is assumed in the statement that it constitutes a mismatch. Discussions of mismatches between syntax and prosody often stop short of even raising the question, the tacit assumption being that the syntactic analysis is obvious. However, it is clear that *about the latest rumors in Argentina* at least *can* attach much higher than is assumed here, including high adverbials such as 'unfortunately':

(18) *They have been avidly reading, unfortunately, about the latest rumours in Argentina.*

The apparent mismatch would be illusory if the mismatching boundary occurs exactly in those cases where the PP attaches high and is absent in cases where the PP attaches low. In order to test this, we would need ways to control the precise attachment site that do not involve intervening adverbs as in (18). Arguably, one way of forcing the verb and following PP to form a constituent is to coordinate the preceding material:

(19) *Some are planning to and or at least would like to read about the latest rumours in Argentina.*

In this example, it is intuitively much harder to separate the verb *read* from the PP by a prosodic boundary. This constitutes some initial evidence that the presence and absence of the prosodic boundary might in fact reveal something about the surface syntactic bracketing rather than pointing to a mismatch between syntax and prosody.

There are various potentially confounding factors regarding the information structure and phonology of 'right-node-raising constructions' as in (19) which would need to be considered here. What is important to note is that independent of how solid the phonological analysis is, it is impossible to say anything about the relationship between syntax and prosody based on examples like (17a) without syntactic tests that establish the constituent structure first. Figuring out the precise attachment of constituents is not trivial, and we cannot trust our first intuition about what the bracketing might be. So in order to establish whether (17a) can plausibly be claimed to constitute a mismatch, a much closer look at syntax and its interaction with prosody will be necessary.

A common response to laying too much emphasis on syntax when dealing with prosodic boundaries is that the observations is the variability in boundary placement make a syntactic approach implausible. This worry is moot if the variation that is observed is actually constrained by the bounds of syntax. For example, a typical case of 'mismatch' between syntax and prosody from the literature (Shattuck-Hufnagel and Turk 1996: 201) as the following can easily be account as a case of string-vacuous right-node raising:

(20) *Sesame Street is brought to you by: || The Children's Television workshop.*

An argument against a close match of between syntax and prosody based on it is only pausible if it is shown that (20) has a mismatching syntax, and by also providing an explanation why 'optional' boundary placement cannot arbitrarily violate syntax:

(21) a. *# Sesame Street is brought to || you by the Children's Television workshop.*

b. *# Sesame Street is brought || to you by the Children's Television workshop.*

Such syntactic restrictions are expected if the variation observed in boundary placement is in fact mediated through syntax.

2.3.2. Relative clauses and clausal complements

The example that epitomizes the discussion of whether syntax and prosody mismatch in the earlier literature involves relative clauses. The head of a relative clause tends to phrase with preceding material and to be separated from the relative clause by a boundary (Chomsky and Halle 1968: 372). Yet, at least according to a traditional syntactic analysis, head and relative clause should form a constituent:

(22) a. Prosody:
This is the cat | that caught the rat | that stole the cheese.

b. Assumed Syntax:
[$_{CP}$ This is [$_{DP}$ the cat [$_{CP}$ that caught [$_{DP}$ the rat [$_{CP}$ that stole the cheese.]]]]]

It could be that examples like this prove that the mapping between syntactic constituent structure and prosodic phrasing is complex. The edge-marking theory of prosodic phrasing (cf. Selkirk 1986) was specifically designed to account for such mismatches. If, for example, the left edge of clausal nodes is aligned with a prosodic boundary, perhaps an intermediate or intonational phrase, then the relative clause data in (22) can be accounted for:

(23) *$[_{CP}$ This is the cat $[_{CP}$ that caught the rat $[_{CP}$ that stole the cheese.*

And yet, even if much of the prosodic literature in the 80s and following took this to be a clear mismatch between syntax and prosody, this is not how Chomsky and Halle (1968: 372) originally presented it, namely as a case in which a restructuring must have taken place, since the underlying syntax and surface bracketing do not match. This restructuring, if there is one, might very well take place in syntax. It is well-known that relative clauses can attach much higher in the structure than to the head of the relative clause. Relative clauses can readily be placed to the right of a sentential adverbial:

(24) *I couldn't remember the name of the man, last night, that I had met at the market earlier in the day.*

Again, in light of the observation that the head of a relative clause can be separated by a boundary from the head, we have to ask whether these cases might involve high attachment, before concluding that there is a mismatch between syntax and prosody. According to Wagner (2005b, 2010), the mismatching prosody actually is only possible for those relative clauses which allow for high attachment (sometimes called 'extraposed' relative clauses).

Another apparent prosodic mismatch can be observed when looking at RCs. The boundary separating the RC from the head is usually stronger than that separating the determiner from the head, for example the one separating *the* and *cat* in (23) is intuitively weaker than the one following *cat*, even in the absence of a strong boundary. As has been observed already in Partee (1976), the interpretation of restrictive relative clauses seems to require a bracketing that groups head and RC together to the exclusion of the definite determiner. However, this does not necessarily mean that this is the bracketing we observe in surface structure in syntax—the fact that restrictive relative clauses can extrapose at all is already an indication that different bracketings are syntactically possible.

The claim that high attachment or extraposition and prosodic phrasing directly correlate receives further support from the prosody of complement clauses. Complement clauses differ from nominal arguments in a number of ways. For example, in many languages they obligatorily extrapose, that is, rather than being pronounced in the complement position of the selecting verb, they are pronounced after the clause of which they constitue an argument. A good example is extraposition in German:

(25) [German]

Er hat gesagt, es werde regnen.
he has said it would rain.

'He said it would rain.'

In fact, Moulton (2012) argues that clauses in general cannot saturate argument positions, and that they always move from the complement position of predicates in order to be interpretable. The derivation proposed in Moulton (2012) is similar to the analysis of head-initial complement clauses in Kayne (2009). I refer the reader to Moulton (2012) for other relevant work on this issue. Similar to cases of heavy noun phrase shift, first the shifted constituent, in this case the complement CP, moves left-ward and then the remnant constituent including the trace moves further to the left, resulting in placing the clausal complement all the way to the right edge of the clause. This serves to derive a number of otherwise hard-to-explain facts, such as the fact that complement clauses obligatorily follow other arguments, including PPs, or that complement clauses cross-linguistically seem to extrapose, unless they have nominal morphology.

Importantly for the present discussion, the quirky syntax of complement clauses seems to be matched by a quirky prosody: In contrast to nominal arguments, clausal arguments are usually separated from the selecting verb by a prosodic boundary (for evidence from German see Truckenbrodt 2010), but not if they bear nominal morphology and precede the predicate. This provides further evidence for the correlation between prosodic boundaries and extraposition construals argued for in Wagner (2005b, 2010), and it provides an argument against a superficial mapping principle that says that the left-edges of clause boundaries should map to a boundary of a certain type, since any such theory would reduce the fact that the observed prosody goes along with evidence for extraposition to an accident.

2.3.3. Complex NPs

A strong version of a close link between prosody and syntactic constituent structure makes some seemingly odd predictions. Consider the prosody of NPs with post-nominal modifiers or arguments. When asked to group the NP into two intuitive subgroups, many native speakers will draw the boundary between the nominal head and a following PP argument or PP modifier:

(26) a. *the inventor* | *of the disco ball*

b. *the inventor* | *with the weird hair-cut*

Cross-linguistically, this seems to be the preferred phrasing. For example, French is reported to have obligatory liaison between an article and a following noun, and as not showing liaison or only showing optional liaison with a following PP modifier or argument. Based on the claim of monotonic theories about how boundary strength reflects syntax

(10), we are driven to the conclusion that the article and the head noun form a constituent to the exclusion of the following PP, be it an argument or an adjunct. But should the argument not be the complement of the head noun and form a constituent to the exclusion of the determiner? And doesn't a PP modifier directly modify the head noun rather than an entire determiner phrase? The prosodic phrasing of complex NPs would have believe us otherwise.

Contrary to received wisdom, Adger (2013) presents compelling evidence in favour of a constituent structure that analyzes the arguments of nouns as attaching much higher than conventionally assumed. Adger's main arguments are typological in nature: across different languages, word order facts suggest that arguments attach high and outside constituents that modify the nominal head itself (as has been to some extent already noticed in some language previously and often been analyzed as a head-raising of N):

(27) Adger's generalization (p. 93): When AP modifiers and PP 'complements' both occur to one side of N inside a noun phrase, the PP is separated from the N by the AP.

One piece of evidence that arguments indeed attach high are cases in which we can observe a post-nominal demonstrative intervening between the head noun and the argument:

(28) a. *El cuadro y el foto estes de Juan* [Spanish]
the picture and the photo this.PL of Juan
'This picture and this photo of Juan.' (see Adger 2013: 91)

b. *Cette peinture et ce photo-là de Jean* [French]
the frame and the photo-there of Jean
'This painting and this photo of Jean'

The post-nominal demonstrative in Spanish shows plural agreement with the coordinated noun phrases, indicating that it already attaches to the conjoined expression above the singular determiners, and the PP argument attaches outside the demonstratives. This provides evidence that arguments indeed attach rather high—just as their prosodic phrasing suggests. Many more arguments based on data from a typologically varied set of languages are discussed by Adger (2013).

The important lesson we can learn from Adger's work is: Even some of our most basic assumptions about syntax, such as the assumption that the apparent complements of nouns are indeed syntactic complements, can turn out to be wrong. By implication, this means that there can be no argument about syntax-phonology interactions without establishing the syntactic structure first, and this step is unfortunately often skipped in the literature on the topic. This case also suggests that trusting the prosodic constituent structure as a guide to the underlying syntax might pay off even when it seems crazy at first sight.

2.4. Summary: Syntax and phrasing

A high-level summary of this section could be this: There can be no claim about how syntax relates to prosodic phrasing without first establishing the prosodic phrasing-based on whatever diagnostics one can find, and without establishing on independent grounds the syntactic structure based on all the syntactic evidence one can leverage. The fact that this is not too obvious a point to make in light of the existing literature on prosodic phrasing shows that there is much room for improvement. If, as argued here, it is indeed the case that syntax and prosody match to a much greater degree than is commonly assumed, then this casts a more positive light on the project of using prosody as evidence about syntax.

There are some studies that do use experimental prosodic evidence to adjudicate between syntactic analyses. For example, Dehé and Samek-Lodovici (2009) use prosody to probe the structure internal to DPs. But this type of work is still the exception rather than the rule, and before we become more confident about how prosody and syntax relates by more rigorous work that brings together phonological and syntactic evidence, this state of affairs is unlikely to change. One domain in which there has been substantial progress in the past ten years is the relation between the scope of various operators and prosody. Sugahara (2003); Ishihara (2003) and Hirotani (2005), for example, look at the relationship between post-focal prosodic reduction and the scope of focus-related operators such as question particles and Blaszczak and Gärtner (2005) discuss the relationship between the scope of negation and prosodic boundaries. Closely related to the question of how syntactic domains line up with prosodic domains is the recent literature that tries to derive prosodic domains by cyclic spell-out. Various proposals that directly touch on prosodic constituency have been made by Ishihara (2003); Dobashi (2003); Guimarães (2004); Kahnemuyipour (2004); Wagner (2005b); Adger (2007); Kratzer and Selkirk (2007) and Pak (2008).

One issue that this review didn't discuss is the question whether constraints on prosodic phrasing in turn can affect syntax. One of the most compelling cases for such an effect is made in Truckenbrodt (1994), who argues that certain syntactic constraints on extraposition can be explained by evoking constraints on intonational phrasing. Another proposal in the same vein involves constraints on movement that require the moved constituent to have a certain size (Zec and Inkelas 1990). I refer the reader to these earlier studies and the later work that cites them, rather than discussing these ideas here.

3. Prominence

Prosodic prominence within a sentence is affected by a number of factors, and syntactic relations and information structure—the two that this article will focus on—are of particular importance. As in the case of phrasing, frequency and predictability have also been shown to be relevant, and syntactic approaches to prominence compete with explanations in terms of processing.

3.1. Diagnostics for prosodic prominence

Prominence, just like prosodic phrasing, is not trivial to establish. It is often not possible to tell by purely instrumental tools which of two words is perceived as more prominent, although a shift in prominence goes along with many acoustic differences. One major cue for the prominence of a word is whether or not it is accented, and also whether adjacent words are accented. Accented words are more prominent than unaccented words, and the last accented word within a prosodic domain is generally taken to be more prominent than non-final ones. The last accented word within a particular domain is often described as carrying the main or 'nuclear' stress (Newman 1946; Truckenbrodt 1995). Consider one of Newman's classic examples (capitalization reflects accentedness, not necessarily focus):

(29) Newman (1946: 179)

a. *I have INSTRUCTIONS to leave.*
'I am to leave instructions'

b. *I have INSTRUCTIONS to LEAVE.*
'I have been instructed to leave.'

The last word carrying an accent is felt to be the most prominent. When *leave* carries the nuclear stress, the preceding word *instructions* can carry an accent of its own, but words following the nuclear stress, such as *leave* in (29a) usually remain unaccented or at least prosodically reduced.

One prominence distinction often taken to be categorical is the distinction between syllables carrying an pitch accent and those that do not. However, the degree of prominence can also vary quantitatively. More prominent words are louder and longer, and emphasis is often associated with an increase in pitch range (Ladd 2008; Ladd and Morton 1997). Contextually salient material is shorter, even when accented (Bard et al. 2000; Wagner et al. 2010). Furthermore, contextually salient material is often realized with a reduced pitch range. While this may result in complete lack of accentuation, it is often the case that accents in the subordinated domain remain intact and only the pitch range is adjusted. This was observed for French (Jun and Fougeron 2000) and for English (Xu 2005). It is therefore often not quite accurate to talk about "deaccentuation" of material marked as less prominent, when in fact only a pitch range reduction may be at play, so I will use the term *prosodic subordination* in the following, and many authors assume that what is relevant from the point of view of how syntax relates to prominence is relative prominence rather than absolute states of being accented or unaccented.

There is still no model that can successfully simulate a native speaker's intuition about prominence, even if instrumental approaches have identified many of the acoustic cues that are most useful (cf. Ladd 2008). In an experimental situation, one can get a handle on this issue by creating stimuli that are segmentally matched and vary context or the underlying syntax, such that instrumental comparisons across conditions can be informative about

relative levels of prominence even in cases where absolute levels of prominence such as whether or not a constituent is accented are hard to establish.

When running an experiment is not an option, one useful tool to sharpen one's intuitions about prosodic prominence are intonational tunes. A particularly useful tool in English is the well-known vocative chant (Liberman 1975). The vocative chant is a melody that can be imposed on any utterance, typically a name, and one use is to call someone. It consists of a low plateau followed by a high pitch accent on the syllable carrying main word stress, followed by a mid tone on a secondary stress following the main stress if there is on, or else a the mid aligns in the syllable following the main stress. If main stress falls on the final syllable, the mid tone is realized on that syllable along with the high tone. Liberman (1975) illustrates how the vocative chant can be used to uncover the fine structure of the prominence relations within words. One can also superimpose the vocative chant on a bigger constituent and even sentences, and interestingly, the same generalizations scale about where the tune alines scale up to sentence prominence. The location of the high pitch accent aligns with the main prominence of a sentence, and the following mid tone aligns with the syllable that is the next most prominent. The downside is that it is pragmatically somewhat odd to superimpose this tune on bigger constituents.

3.2. Nuclear stress

The term *nuclear stress* is usually used to refer to the main sentence prominence. Whether there is such a thing as a unique nuclear stress per utterance, as assumed in Chomsky and Halle (1968), for example, is itself controversial. Newman (1946), in his influential analysis of prominence in English, allowed for the possibility of there being several. A simple, if admittedly unconventional, operational definition of the nuclear stress of an utterance is the syllable on which the high tone of the vocative chant would be placed, should one pronounce it superimposing the vocative chant, and leaving other factors such as syntactic relations and givenness and focus constant. A common assumption across a number of approaches is that there is a default distribution of accent placement, and deviations from this pattern are used to encode focus and givenness presuppositions, while alternative accounts assume that accent placement is always determined by information structural considerations.

3.2.1. Syntax or semantics?

Prosodic prominence was one of the main sources of evidence used to investigate the relationship between syntax and phonology in Chomsky and Halle (1968). One main insight was that generalizations about sentence-level prominence must be stated in a recursive fashion. Rather than giving hard and fast rules that are applied to entire sentences, the *transformational cycle* successively negotiated prominence between the phonological

representations associated with sister nodes in syntax.

Schmerling (1976) and Fuchs (1976) raised some doubts with respect to the syntax-oriented approach, and proposed a semantic approach instead, based on the observation that, in Schmerling's words, "predicates receive lower stress than their arguments," independent of their relative order. For example, in German and English a direct object is always more prominent, independent of whether the word order is OV or VO, within both languages. Newman (1946: 179) first observed that in English, prominence by default falls on the internal argument (the "logical object") of a predicate, independent of whether it precedes or follows it, as was illustrated in (29).

Fuchs (1976) proposed that arguments and predicates become prosodically *integrated*, an idea which has been influential in various proposals that try to capture Newman's basic information. In the theory of sentence stress proposed in Gussenhoven (1983), the decisive factor that makes one constituent integrate into a single accent domain with a second constituent is semantic: If two adjacent constituents form argument and predicate, they form a single accent domain. This view is of course still compatible with a recursive statement about prominence, it just shifts attention from syntactic relations between sister to semantic relations. Note, however, that forming a single accent domain as is proposed in Gussenhoven (1983) doesn't itself actually assure that the argument will be more prominent—a predicate could form a single accentual domain with its argument also if the predicate carries prominence. This is one reason for why later accounts have often implemented this idea underlying this approach differently.

The generalization that prominence falls on the argument independent of linear order, for example in OV contexts as well as in VO contexts, is unexpected under the analysis presented in SPE where prominence should always go to the right-hand sister at any syntactic node. Bresnan (1971), however, offers one way of saving the syntactic theory: By interleaving the syntactic derivation with stress assignment, she argues that in certain cases, including residual OV orders in English, stress can be assigned before movement. This proposal could account for OV orders on the assumption that they are derived from a previous VO stage in the derivation to which the nuclear stress rule applies (or alternatively one could argue that the argument reconstructs at LF and that prominence relations are computed based on the position in which a constituent is interpreted).

One reason not to abandon the syntactic approach too readily is that the notions *predicate* and *argument* alone may not be sufficient to capture the generalization. Arguments are often adjacent to their predicates, and yet the predicates fail to subordinate prosodically, for example in the case of secondary predication (Gussenhoven 1992; Wagner 2005a), here illustrated by an example from Marantz (1984):

(30) *Elmar ate the porcupine raw.*

On the other hand, these cases may not constitute counterexamples to a semantically-based generalization, since the kind of depictive predicate occurring in (30) is probably actually a

predicate over events, which includes an anaphor referring to the noun that it also predicates over. Marantz (1984) and Pylkkänen (2002) provide arguments against analyzing them as simple predicates over individuals. An interesting observation in relation to the question whether generalizations about prominence relations are more syntactic or more semantic in nature is the prosody of modification, where again the notion of functor versus argument seems to play a crucial role (Birch and Clifton 1995, 2002; Wagner 2005a).

The pattern observed based on predicates and nominal arguments is part of a much broader pattern of prominence among predicates and their complements, observable in the various word orders in predicate sequences attested across Germanic dialects. Independent of the word order, main prominence falls on the complement of the most deeply embedded predicate, both in infinitival constructions and in predicate clusters. The pattern can be illustrated by an example from German which allows for at least four out of six possible word orders between three predicates in so called *extraposition orders* (The numbers reflect the syntactic embedding with 1 being the highest predicate and the head of its complement is labeled with the next number down. Nuclear stress is marked by an accent, secondary stresses are not marked):

(31) a. *... weil er versprach*$_1$ *zu versuchen*$_2$ *zu schwéigen*$_3$. [German]
because he promised to try to be.silent

b. *... weil er versprach*$_1$ *zu schwéigen*$_3$ *zu versuchen*$_2$.
because he promised to be.silent to try

c. *... weil er zu schwéigen*$_3$ *zu versuchen*$_2$ *versprach*$_1$.
because he to be.silent to try promised

d. *... weil er zu schwéigen*$_3$ *versprach*$_1$ *zu versuchen*$_2$.
because he to be.silent promised to try

e. *? ... weil er zu versuchen*$_2$ *zu schwéigen*$_3$ *versprach*$_1$.
because he to try to be.silent promised

f. *?? ... weil er zu versuchen*$_2$ *versprach*$_1$ *zu schwéigen*$_3$.
because he to try promised to be.silent

'...because he promised$_1$ to try$_2$ to be silent$_3$.'

In each of the word orders, main prominence falls in the most deeply embedded constituent in the selectional chain, a fact expected under the syntactic view of nuclear stress as it is proposed in Cinque (1993) and Arregi (2002). The prosodic facts in predicate clusters across dialects of West Germanic are analogous, except that any given Germanic language usually doesn't allow this many different permutations. However, all six orders are attested in some Germanic language (Wurmbrand 2003), and the prominence relations are always such that prominence falls on the complement (Wagner 2005b). There is more to the pattern, however, than just the observation that the last complement according to the selectional

chain receives nuclear stress, since prosodic subordination also occurs when predicate 2 precedes predicate 1, and in the order $2 \prec 1 \prec 3$, in other words, when only part of the complement precedes. The full generalization about nuclear stress in predicate sequences that holds true across Germanic dialects can be stated as follows (Wagner 2004: 587; 2005b: 226):

(32) A Descriptive Generalization
A functor is prosodically subordinated if at least part of its complement precedes.

While the last two word orders in the German examples in (31) may be marginal, native speakers nevertheless have an intuition about where prominence should fall. In other words, native speakers have intuitions about prominence even for a cases that lie beyond their own grammar, or at least at its margin. And the intuitions about prominence match the actually observed pattern in dialects that allow for the relevant order. This is compelling evidence that speakers have internalized a rather abstract generalization, similarly compelling as the argument in Halle (1997) that speakers of English must have internalized a rather abstract rule of voicing assimilation based on loan words. Speakers of English devoice even when encountering segments that are not part of English phonology, as in the plural of *Bach*, *the Ba[xs]*.

Note that the generalization as stated in (32) mixes semantic and syntactic vocabulary, since there is talk about the *complement*—the difference between complements and non-complements indeed seems to play a role. Two possibilities to account for the full pattern are discussed in Wagner (2005b), one based on a syntactic nuclear stress rule with a Bresnanian interaction with movement, one with a more semantically formulated principle about the prosodic prominence relation between argument and functors. But no particular argument to choose between these possibilities is offered.

The role of syntax becomes apparent when looking at the complement clauses, which were already discussed in the section on phrasing. Truckenbrodt and Darcy (2010) present evidence that complement clauses do not form a single domain with a preceding selecting predicate, and in contrast to nominal arguments, the predicate is usually accented and separated by a boundary. This difference is most likely due to the fact that complement clauses in German obligatorily *extrapose*, that is, they are treated very differently from other syntactic complements. For example, they follow the verb instead of preceding it, and the complement clause is not in fact the sister of the preceding predicate. There are thus syntactic conditions on prominence above and beyond the semantic conditions on adjacent constituents proposed in Gussenhoven (1984).

The work by Cinque (1993) constitutes a major landmark in the discussion on nuclear stress, first because it revived the recursive sister-based approach to sentence prominence pioneered in Chomsky et al. (1957) and Chomsky and Halle (1968), and second because it made a strong typological claim. Cinque proposed a universal generalization about syntax

and prominence directly related to syntactic embedding, thus trying to explain Schmerling's insight that, independent of linear order, it is the argument and not the predicate that receives nuclear stress. The rather baroque definition of depth of embedding was updated and related to syntactic selection in the insightful analysis of Basque sentence phonology in Arregi (2002).

An problem with Cinque's proposal is that it is not clear that there is indeed a universal generalization about nuclear stress. There is evidence, for instance, that in Romance languages the generalization observed in Germanic does not hold (Ladd 2008; Wagner 2005b). In French, for example, the predicate *to do* is happily accented in a construction whose Germanic parallels show prominence on the argument of the predicate (based on my consultants, Dutch, German, and Norwegian pattern with English; Spanish, Brazilian Portuguese and Italian with French):

(33) a. *I have some shópping to do.*

b. *J'ai des courses à fáire.* [French]

Verb and complement are often assumed to form a prosodic domain in French, as predicted by Gussenhoven (1983), but do not show the prominence relation that one would expect under the syntactic account in Cinque (1993). Of course, everything hinges on the question whether the two sentences in (33) indeed have a syntactic structure that is comparable in all relevant respects. Another issue with the approach in terms of depth of embedding is whether the relative prominence between, say, two DP arguments is really parallel in nature to the prominence relation between a verbal predicate and its complement, as is assumed in Cinque (1993)'s approach, but not in Schmerling (1976) or Gussenhoven (1984).

3.2.2. Is nuclear stress mediated by phrasing?

Rather than directly stating conditions on prominence relations between sister constituents, a popular approach is to derive prominence relations as an emerging property of the Edge-Alignment of syntactic and phonological domains and additional constraints that guide the distribution of prominence within domains. The approach mediates the derivation of prominence by constraints on phonological phrasing. A serious problem for this idea is that it has been shown time and again that phrasing and prominence can be independently manipulated. In French, for example, prosodic phrasing remains intact even in the pitch-reduced domain following an early focused constituent (Jun and Fougeron 2000). Similar results of intact phrasing in the postfocal domain were obtained for English in Jaeger and Norcliffe (2005) and for Japanese in Sugahara (2003) and Féry and Ishihara (2012). This constitutes a paradox for the phrasing-based view of prosodic prominence, which would hold that post-focus subordination in fact involves phrasing all material into a single prosodic domain, and thus altering prosodic phrasing.

It is instructive to look at why the original account of edge-marking (Chen 1987; Selkirk 1986, 1995) alone is not sufficient to capture prominence patterns in Germanic. If a language only showed either OV orders or VO orders, one could argue that OV languages mark the left edge of XPs and VO languages the right edge, in order to capture the fact that in both orders argument and predicate phrase together. This would not explain, however, why prominence falls on the object in both orders. Also, it doesn't actually explain why OV languages show right-alignment and VO languages show left-alignment resulting in separate phrasings of predicate and object, and it could just as well be the other way around. Maybe this additional power is needed, but most current accounts assume that such languages should be ruled out.

Setting this typological question aside, an even bigger problem for this approach is that one can find both OV and VO word orders within a single language, and the data discussed above from English and German are examples of this.

A promising modification of the alignment-based approach is presented in Truckenbrodt (2006a), who uses the constraint Stress XP from Truckenbrodt (2005), which interacts with other constraints that minimize the number of accentual domains, and serves to derive the nuclear stress pattern in English and German:

(34) Stress-XP
Each XP is assigned a beat of phrasal stress.
(Truckenbrodt 2006a)

This constraint indeed can be used to explain nuclear stress in OV and VO contexts, since in both cases an accent on the object can provide an accent for both the DP and the VP:

(35) a. $[_{VP}\ [_{DP}$ Ó] V]
b. $[_{VP}$ V $[_{DP}$ Ó]

The underlying assumption is that every lexical word heads a maximal projection, and that every XP needs an accent (unless it is discourse given). This account can account for various of the predicate orders in (31). However, it fails to capture the full generalization in (32). A predicate is subordinated whenever it is preceded by (part of) its complement. For crucial test cases the account based on Stress XP makes very different predictions. Consider the following German word orders, repeated from (31d):

(36) [German]

...weil er $[_{VP3}$ *zu schwéigen*$_3$ $]_i$ $[_{VP1}$ *versprach*$_1$ $[_{VP2}$ *zu versuchen*$_2$ t_i *].*
because he to be.silent promised to try

'... because he promised to try to be silent.'

In this case, whether or not $VP1$ contains an accent depends on whether VP3 is located within its specifier. But crucially, it is clear that $VP2$ does not contain an accent. The generalization from Wagner (2005b, 2007) that at least part of its complement precedes holds, and the account in terms of Stress-XP proposed in Truckenbrodt (2006a) cannot actually capture the full pattern in (32) without making special assumptions for some of the predicate orders.

Büring (2012) develops a new account and proposes a promising notion of *structural strength* to account for relative prosodic strength, including for cases in which there is "long-distance integration", similar to the case in (31d). Alternative proposals use that combine edge-marking with a notion of cyclic spell-out (Kahnemuyipour 2004; Kratzer and Selkirk 2007). I will not discuss these approaches in detail here.

3.3. Information structure

An important factor affecting prominence is information structure. The interaction of focus and prosody and what we can learn from it about the architecture of grammar has been a major concern at least since Chomsky (1971).

3.3.1. Focus and givenness

Various proposals have been made to account for the distribution of accents depending on context, framed in terms of focus (Jackendoff 1972; Rooth 1985: i.a.) or theories of newness/givenness (cf. Schwarzschild 1999), or both (Selkirk 1995; Reinhart 2006).

Core phenomena that have played a major role in shaping ideas in this domain are question/answer congruence, contrastive focus, anaphoric destressing of discourse-old material, and association with focus. Question-answer congruence has the effect that the last accent of an answer is usually contained in the constituent that corresponds to the wh-word in the question under discussion (I will mark the last accent in a sentence with capital letters, and following prosodically subordinated material by underlining):

(37) Question-Answer-Congruence (Sentence Focus)
A: *Who arrested Smith?*
B: *The DETECTIVE arrested Smith.*

A second factor is contrast. If there is an expression that is partially overlapping and partially contrasting with a previous expression, then accent placement is often affected:

(38) Contrast
A: *Did the policeman arrest Smith?*
B: *No, the DETECTIVE arrested Smith.*

A third factor is givenness. Accent placement can change if a constituent that otherwise would have borne an accent refers to an individual that has already been introduced to the discourse:

(39) Givenness
A: *Smith walked into a store. What happened next?*
B: *A detective ARRESTED Smith.*

A fourth factor is association with focus:

(40) Focus association
Mary only introduced SMITH to Sue.

One major point of divergence among various to information structural effects on prosody is whether these four factors are treated as reflexes of one and the same underlying phenomenon, or receive different explanations. Accounts assuming that these are underlyingly one and the same phenomenon include Rooth (1992a); Schwarzschild (1999); Williams (1997); Wagner (2006) and Büring (2008). Accounts that view them as different phenomena include Selkirk (1995); Szendröi (2001); Reinhart (2006); Féry and Samek-Lodovici (2006) and Katz and Selkirk (2011), who separate anaphoric destressing of given material from instances of true focus.

An interesting question, originating in Chomsky (1971), is why it is that certain renditions of a sentence seem to be compatible with different focus values, a phenomenon often called *focus projection*, following Höhle (1982). Selkirk (1984) proposed an account of this phenomenon in which a syntactic focus features literally projects in syntax. As pointed out in von Stechow and Uhmann (1984), Selkirk's proposal doesn't account for differences between internal and external arguments with respect to whether or not focus can be projected from them upward to the sentence node, that is, it doesn't account for Newman's observations about the special status of internal arguments. The more recent approach to focus projection in Selkirk (1995) incorporates von Stechow and Uhmann's insight to restrict upward focus projection to only be licit from internal arguments. To what extent syntactic focus projection is necessary, however, remains questionable, partly because there may be other ways to account for the data that do not require the projection of a syntactic feature (Rooth 1992b; Schwarzschild 1999). There are also various very basic empirical problems with the formulation of focus projection in Selkirk (1995), as discussed in Wagner (2005b); Büring (2006) and Wagner (2012b). The often made assumption that object focus and VP focus in English are not distinguished phonetically in production has been shown to be false in Gussenhoven (1984) and Breen et al. (2010), which is unexpected under certain views of focus projections.

All of the proposals mentioned so far share the assumption that marking a constituent as focused or given introduces a condition on the context that calls for the presence of some

salient information in the discourse. A lot of the issues that distinguish different approaches are semantic and pragmatic in nature, but the assumed representation of focus often predicts interactions with syntax. Movement, for example, can change the semantic condition introduced by focus simply by virtue of changing the syntactic sister relation, and there is indeed evidence that movement plays an important role, in the syntax of both focused and given constituents (Neeleman and Reinhart 1998; Reinhart 2006; Wagner 2006; Neeleman and Van De Koot 2008; Kucerova 2007). These approaches share the idea that there are certain syntactic configurations that lead to particular information structural effects, either because the syntax of a focus operator interacts with movement (Wagner 2006; Kucerova 2007), or because certain discourse templates directly associate information-structural impact to certain tree geometries (Neeleman and Van De Koot 2008).

A very different approach to informational structural effects is the cartographic approach, pioneered in Rizzi (1997), which assumes that information theoretic notions such as Focus and Topic are syntactically encoded in functional projections that constitute the syntactic spine of a sentence. Focus and topical constituents move to the specifier of these functional projections. Under this view, the assumption is often that they are part of a universal hierarchy of functional projections (Cinque 1999). A comparison between these two types of approaches is beyond the scope of this overview article, but I refer the reader to Neeleman and Van De Koot (2008) and Wagner (2012a) for some relevant comparative discussion.

3.3.2. Is focus prominence mediated by phrasing?

Many approaches to focus assume that focus directly affects prosodic phrasing, and the negotiation of focus prominence is mediated by phrasing in some way or other (Pierrehumbert 1980; Kanerva 1990; Truckenbrodt 1995; Selkirk 1995). One common assumption is that phrasing is obliterated post-focally, since they rule out positing higher level phrasing in the absence of pitch accents (Beckman 1996). There is some evidence, however, that post-focal reduction leaves phrasing intact Sugahara (2003), (Jaeger and Norcliffe 2005), Féry and Ishihara (2012), and Mandarin (Xu 2005), in which case prominence and phrasing might actually be orthogonal dimensions of prosodic representation.

3.4. Processing accounts

A different perspective on variation in prominence is pursued in Jurafsky et al. (2001); Aylett and Turk (2004) and Jaeger (2006), who link prominence to predictability measures, or in terms of discourse accessibility, e.g. Terken (1984) or Terken and Hirschberg (1994), see Arnold (2008) for an overview. A word that is highly expected will be realized as shorter and less prominent, while a word that is highly unexpected will be realized with more prominence. A model that predicts these asymmetries is the smooth signal hypothesis

of Aylett and Turk (2004), which holds that the way language works results in a constant entropy throughout the signal. The information density across an utterance is held constant by lengthening an amplifying unexpected material and by shortening and reducing expected material.

An attractive feature of this type of account is that it has the potential of tying together the prominence distribution of the default prominence distribution in which no material is marked as being salient in discourse, and the special case where prominence is influenced by the question under discussion or by previously mentioned or salient information. That said, a model in terms of entropy or predictability alone cannot easily explain why focus and givenness marking are subject to grammatical constraints that differ dramatically between languages (Ladd 2008). Even if these types of grammatical constraints turn out to be grammaticalized instances of predictability effects, they nevertheless call for a model of grammar that goes beyond purely quantitative acoustic effects of reduction and strengthening, so both levels of analysis are likely to be necessary to understand the complete picture.

Unfortunately there has been no attempt at trying to account for core phenomena such as prosodic question-answer congruence, contrastive stress or givenness-deaccentuation in terms of predictability. There are only particular studies that show such effects in particular examples, but no one has taken on the challenge of trying to account for the some of the core phenomena using this theory. Moreover, many studies purporting to show accessibility or predictability effects are actually confounded with focus effects. Wagner and Klassen (2012) show evidence that once focus is controlled for, at least some accessibility effects reported in earlier studies disappear. This is an area where clearly more research is needed that takes into account insights from different disciplines.

3.5. Summary: Syntax and prominence

Many of the same issues arise in the study of syntactic effects on prosodic prominence and as in the study of prosodic boundaries. How does syntax interact with prominence? Is the effect of syntax limited to the negotiation of relative prominence or are there absolute prominence constraints that syntax imposes (Wagner 2005b; Calhoun 2012)? Are certain non-phonological generalizations about syntactic or semantic in nature? To what extend are apparent effects of syntax reducible to more basic processing effects? This review did not touch at all on the question of what the phonologically categorical distinctions of prominence levels or accent types are, and how they relate to syntax and semantics (cf. Breen et al. 2010). Also, we did not address the question the role of metrical and rhythmic constraints on prominence (cf. Calhoun 2010), and how they might interact with syntactic ones. This overview was only able to give a small glimpse of all the open research questions in this domain, and similar to the discussion of boundaries we focused on issues related to syntax and didn't discuss issues in phonological representation in any detail.

Another issue arising both for boundaries and prominence is whether phonology can

affect syntax. One compelling case of syntactic movement being motivated by the need of a constituent to receive prominence is the analysis of focus movement in Hungarian in Szendröi (2003). Related proposals have been made in the analysis of other languages. The question whether such back-channelling effects are indeed attested or whether there could be alternative accounts of apparent cases of prominence-driven syntax remains controversial and constitutes an area of active research.

4. Intonational tunes

Intonational tunes encode meanings that tend to be related to the type of speech act of an utterance (e.g., interrogative vs. declarative), trigger implicatures (e.g., the contrastive topic intonation of Büring 1997), or encode attitudinal meanings (for example, sarcasm/irony or speaker uncertainty, cf. Ward and Hirschberg 1985). Phrasing and Prominence can be varied independently of the choice of the intonational tune (Liberman 1975; Ladd 2008).

Bolinger (cf. 1986) proposed separating out intonational units as meaningful elements in their own right. Recent research has converged on the view that treats at least some elements of the intonational representation as independent elements with their own meaning (Gussenhoven 1984; Pierrehumbert and Hirschberg 1990). The precise analysis of tunes remains highly controversial, including very basic questions about representation and about how much decomposition of complex tunes into smaller meaningful units is necessary.

An exemplary case of an intonational tune is the so called (Rise-)Fall-Rise contour (RFR) (cf. Ward and Hirschberg 1985). It consists of a rise followed by a fall on the syllable carrying main sentence prominence, and a sentence-final rise. According to the ToBI convention, it is transcribed as [L*H L- H%] (example from Ward and Hirschberg 1985):

(41) A: *Did Victor get tickets for the Fellini triple feature?*
B: *Veronica did.*
L*H L- H%

The RFR can be superimposed on any sentence, and will align with sentence prominence in a systematic way. Sometimes the pitch accent is realized on several prominent constituents. It is associated with a systematic meaning, and according to Ward and Hirschberg (1985: 756) it "conveys uncertainty about the appropriateness of some utterance in a given context (...)." Alternative characterizations can be found in Ladd (1980); Bolinger (1982); Gussenhoven (1984); Constant (2012) and Wagner (2012a).

There is a growing body of recent work on the precise semantics and pragmatics of intonational tunes, and how they interact with syntax, for example the work by Gunlogson (2003); Truckenbrodt (2006b), and Trinh and Crnič (2011) on the rises in yes/no-questions and how they contributes to the meaning of inverted questions and rising declaratives, or

Pruitt and Roelofson (to appear) on the intonation and syntax of alternative questions. This is another area where our understanding of the syntactic and semantic issues is still very preliminary.

5. Conclusion

Prosodic phrasing, prominence, and intonational tunes directly relate to syntactic structure in complex and interesting ways. Careful attention to prosodic properties of utterances can in principle guide the development of syntactic analyses. One fundamental problem, however, that often stands in the way of using prosodic evidence in developing syntactic arguments is that the understanding of this relationship is still rudimentary and controversial.

So while this chapter is programmatically called *Phonological Evidence for Syntax*, the current reality is that we still need to understand the relation between syntax and prosody better to be able trust the phonological evidence in guiding our syntactic analysis. This state of affairs is a result of a long tradition of work that focuses either on phonology or syntax, but not both, and restricts itself on making plausible but untested assumptions about the underlying syntactic structure or prosodic structure respectively. Unfortunately, what seems plausible often turns out to be wrong once proper evidence is considered.

The hopeful result of recent work in syntax and prosody is that figuring out the correct syntactic representation often makes much more sense of the observed prosodic structure and vice versa. Much more work that is both syntactically and prosodically responsible is needed to accomplish the goal of turning prosody into a reliable source of evidence for syntax, or at least identifying the circumstances under which it is. This overview over current thinking on the syntax-phonology relationship will hopefully will be of help for syntacticians and phonologists alike who want to embark on this project.

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Michael Wagner, Montréal (Canada)