Introduction

The present volume contains eleven original chapters, each of which is based on a presentation at the Conference on Stress and Accent, held at the University of Delaware from 29 November to 1 December 2012.[1] All chapters were submitted by mid-2013 and after an anonymous double peer-review procedure, final versions came in our possession during the last quarter of 2014. The conference was the third in a series of conferences which form part of the StessTyp2 project.[2] StressTyp2 is a typological database that supplies information about stress/accent systems of the world's languages. This database is based on two previously designed databases, StressTyp (ST1) and the Stress Pattern Database.[3] The goals of StressTyp2 (ST2) are to improve, verify, and enrich the combined dataset in a variety of ways and to develop a web-based interface (1) that makes the information in ST2 easily available to researchers and citizens around the world, and (2) which meets or exceeds professional and scientific standards. The third goal of this project is to adopt (and, where necessary, establish) best practices for the collection, organization, dissemination, and presentation of typological data pertaining to sound patterns in natural language. Currently StressTyp2 is available on the internet (http://st2.ullet.net/).

The first chapter in van der Hulst (2014) provides a broad introduction to the study of word stress/accent, as well a detailed description of the StressTyp2 project. As with the previous volume, chapters in the present volume are not concerned with the technical details of the StressTyp2 project, but are based on some of the public talks in which more general issues were addressed, relating to typologically based theoretical work.

[1] Two previous conferences were held at the University of Connecticut on 30 April 2010 and 3 December 2011, respectively. A volume based on these conferences appeared in 2014 (van der Hulst 2014). Meanwhile, a fourth conference has taken place in Leiden on 15–17 August 2014. A volume based on this conference is in preparation.

[2] NSF grants NSF#1123661 (PI H. van der Hulst), NSF# 1123692 (PI J. Heinz).

[3] The project is a broad collaboration between Harry van der Hulst (University of Connecticut), Rob Goedemans (Leiden University), developers of StressTyp1, and Jeffrey Heinz (University of Delaware), developer of the Stress Pattern Database.

In the introductory chapter for the present volume our goal is to provide summaries of the eleven contributions and to briefly discuss the common threads in these chapters. Broadly speaking, these chapters divide into two main themes: Representation (Chapters 1–6) and Acquisition (Chapters 7–11), but many sub-themes run throughout these chapters as well.

While terms such as stress or accent are often used holistically, as if there is a simple unitary phenomenon underlying them, the reality is that there are several dimensions along which prominence phenomena must be analysed. A first important consideration is that we must separate the location of stress (first syllable, penultimate syllable etc.) from its phonetic realization (in terms of duration, pitch etc.). This separation brings out that stress is both covert (in terms of formal representation) and overt (in terms of phonetic correlates). Additionally, there is primary stress and there is rhythm (secondary stress). At the level of realization, phonetic cues of stress, such as duration and pitch, may overlap with phonetic cues of other aspects of the phonology, such as length and tone. Another dimension is the prosodic domain; there is the foot, the word, the phrase. All these dimensions clearly illustrate that stress or accent is not holistic, but rather multifaceted.

Clearly then, there is a tension between concrete and abstract representations of prominence, and both the concrete and abstract representations are multidimensional. Just as duration and pitch are examples of concrete, acoustic dimensions, foot types, lexical marking, and the grid are examples of dimensions along which abstract representations can vary. While it seems clear that both types of representations persist and interact within languages, the precise nature of these representations and their interactions continues to be a source of mystery and wonder. These issues come to the forefront in acquisition, where the multifaceted tension between the abstract and the concrete is deeply reflected. Exactly what representations are acquired? When and how?

In the first part of the book, dealing with Representation, an important sub-theme is *competition* and *conflict.* Representations *compete* and *conflict* with each other. In Chapter 1, Matthew Gordon studies how distinct metrical systems come to coexist within the same language. In Chapter 2, Brett Hyde argues that it is normative for surface prominence and underlying metrical accent to mismatch. In Chapter 3, Eugene Buckley's analysis of the conflict between lexical and phrasal patterns of accent in Spanish obviates the need for gradient alignment of feet. In Chapter 4, Yanyan Sui studies both representations of stress and representations of tone in Standard Chinese and concludes that the structure of the former determines the distribution of the latter. In this competition, metrical structure is in control. In Chapter 5, Irene Vogel and her colleagues conduct a cross-linguistic study to examine the hypothesis that phonetic cues involved in lexical contrasts are less likely to be used as marking stress. In Chapter 6, Nina Topintzi argues that metrical structure interacts

with the colon, a level of representation between the foot and the word. The sub-theme of competition and conflict among different metrical structures and representations within languages is a common thread of these first six chapters, which we now describe in more detail.[4]

Chapter 1 (Matt Gordon: Metrical Incoherence: Diachronic Sources and Synchronic Analysis). This chapter explores the typology of **metrical incoherence**: the coexistence of orthogonal metrical systems in the same language. Focusing on three representative language families, it is shown that, although heterogeneous in its synchronic properties, metrical incoherence characteristically stems from a shift in prosodic structure while vestiges of the original metrical system are preserved. Gordon explores one theoretical consequence of metrical coherence: there is a need for mixed metrical theories employing distinct representations. One possibility that is discussed is to use feet for the older, abstract structure and a separate tier of grid marks at the word or phrasal level.

Chapter 2 (Brett Hyde: The Role of Phenomenal Accent). This chapter also argues for mismatching representations, but in a different context. Hyde argues that distinguishing surface prominence from underlying metrical accent has not been fully exploited in theories of metrical stress. He refers to surface prominence effects as 'phenomenal accents' which are based on salient acoustic contrasts – for example, abrupt changes in pitch, duration, or volume. What he calls 'metrical accents' are prominent positions in temporal organization. As Hyde shows, theories of musical rhythm employ the distinction to account for the perception of meter when, as is often the case, there is a mismatch between prominent notes and strong metrical positions. He then discusses the implications that a distinction between phenomenal accent and metrical accent has for the typology of stress patterns. One conclusion Hyde draws is that the existence of so-called single and dual metrical systems is unlikely and that such languages should be analysed as having 'binary metrical organization'. He provides an analysis of single and dual stress patterns in terms of a binary metrical organization, which is much more straightforward than one might expect.

Chapter 3 (Eugene Buckley: Foot Alignment in Spanish Secondary Stress). Like the previous two chapters, this chapter addresses a conflict; here between lexical and phrasal patterns of prominence in Spanish. Previous students of Spanish have observed that secondary stress has two attested patterns: the common, colloquial pattern with an initial dactyl, and a more formal or 'rhetorical' style with full right alignment. Importantly, the initial dactyl pattern is found not just within a word but also across a phrase. Buckley adopts a view that is similar to the proposal of Roca (1986) in suggesting that the formal, right-aligned pattern is lexical, while in colloquial style a potentially new trochaic

[4] References in the abstracts can be found in the reference list of the relevant chapter.

foot is left-aligned with a prosodic phrase. Most often the left-aligned foot overrides faithfulness to lexical foot structure; but in formal style, faithfulness wins and the lexical pattern remains.

Buckley's proposal settles an interesting debate that has occurred in the OT literature. Some theories of metrical structure in Optimality Theory rely on gradient alignment of feet, whereas others permit only categorical alignment. Although they are formally more restrictive, categorical theories face a challenge in apparent cases of the initial-dactyl effect, where all feet align rightward except for the leftmost, especially when combined with End Rule Right. Thus, for example, Hyde and McCord (2012) argue that Spanish requires gradient directional alignment given its colloquial pattern. Buckley's account of Spanish stress makes such gradience unnecessary.

Chapter 4 (Yanyan Sui: The Interaction of Metrical Structure and Tone in Standard Chinese). This study shows that metrical structure and tone interact asymmetrically in Standard Chinese. Metrical structure determines the distribution and the phonetic realization of tones in words, but tone does not participate in the construction of metrical structure. Sui assumes, with reference to prior work, that Standard Chinese has a generalized trochee system. She proposes that syllables in metrical head positions are associated with tones, which means that the underlying tones are maintained in head position, but also that when a toneless syllable is placed in a metrical head position through a morphological operation such as reduplication, a High-level tone is inserted in the surface representation. Toneless syllables, on the other hand, are restricted to metrical non-head positions, which in this case also means that the syllable is toneless, lexically or due to tone deletion. The author then shows that the head/non-head distinction also affects the phonetic realization of tones since tones in metrical head positions tend to be realized more faithfully to their tonal targets, while tones are subject to reduction in metrical non-heads. Pursuing the theme that Hyde discusses in Chapter 2, Yanyan's study shows that tone influences prominence judgments in that syllables with the Falling and the High-level tones are often judged to be more prominent than the other tones. However, crucially, tonal prominence does not make tones structurally more prominent. It is thus necessary to distinguish the metrical structure of words from native speakers' prominence judgment.

Chapter 5 (Irene Vogel, Angeliki Athanasopoulou, and Nadya Pincus: Prominence, Contrast, and the Functional Load Hypothesis: An Acoustic Investigation). These authors investigate the overlap of acoustic properties used for prominence and phonemic contrasts (e.g. duration, F0) in terms of the Functional Load Hypothesis, as extended to prominence relations. Specifically, they ask whether the use of an acoustic property for phonemic contrast in a language affects its use for expressing prominence (stress and focus), and also whether the use of an acoustic property for prominence at one level affects it use at another level. As part of a broader cross-linguistic study, they examine large corpora of Hungarian, Turkish, Greek, and Spanish speech recorded

using similarly constructed stimuli and data collection methods. The authors are careful in distinguishing between lexical and sentential prominence, while many previous studies confound the two. This study for the most part supports the Functional Load Hypothesis. Specifically, the existence of contrastive vowel length in Hungarian appears to coincide with absence of duration as a manifestation of either stress or focus, the main cue being F0. By contrast, in Spanish and Greek, duration does serve as the main property of prominence (i.e. for focus at the sentential level); however, they avoid the overlapping of cues, since lexical stress is primarily expressed with F0. Finally, the authors find evidence in support of the idea that prominence phenomena, like other phonological phenomena, tend to be expressed more clearly and consistently when they are contrastive. Thus, the cues for stress in Spanish and Greek are more distinct than those in Hungarian and Turkish, since the former, but not the latter, have contrastive, or unpredictable, lexical stress.

Chapter 6 (Nina Topintzi: Iquito: The Prosodic Colon and Evaluation of OT Stress Accounts). Topintzi makes a case for a metrical unit which comes in between the foot level and the word level. She examines the metrical system of Iquito. To account for the occurrence of 'degenerate feet' in certain types of words, her proposal is that the asymmetrical tolerance of degenerate feet in odd-parity words is attributed to the existence of the colon κ, a constituent that has marginally been considered in past literature. She then considers evidence in support of the colon from other languages and suggests that this constituent interacts with the existence of foot structure beyond the purely metrical one, e.g. tonal feet in Bambara as well as prosodic-templatic feet in Japanese. Three OT-analyses of the Iquito data are then examined, all of which share use of κ. Based on conceptual and technical grounds, Topintzi argues that one of them, Harmonic Serialism, must be preferred.

Beyond addressing the multidimensional nature of stress, the next five chapters share an interest in the acquisition of stress. While Jarosz and Dresher focus on the logical problem of acquisition, taking a formal point of view, the last three chapters adopt an experimental perspective.

From one perspective, it may seem strange to study language acquisition by developing abstract computational models, or to conduct experiments in sterile laboratory settings. After all, both these approaches seem far from the natural playgrounds where human infants and children engage with language and learn it. What can an algorithm teach us about human language learning? What can perceptual experiments teach us? And how about experiments which manipulate acoustic signals and play them back to infants only months old? As with other sciences, there are many methods by which one can peel back the mysteries of nature to glimpse the truth. At its core, language learning is about making some distinctions, but not others. As Gleitman (1990:12) explains, 'The trouble is that an observer who notices everything can learn nothing for there is no end of categories known and constructible to describe a situation.' What do listeners

(especially infants) perceive and what do they not perceive? What do they respond to? What kinds of distinctions does any computing device – whether it is a human mind or a computer program – need to make to learn stress patterns in language? It is these issues that the subsequent chapters address.

Chapter 7 (Gaja Jarosz: Investigating the Efficiency of Parsing Strategies for the Gradual Learning Algorithm). Jarosz's point of departure is the fact that abstract representations such as feet, syllable structure, and other prosodic structure currently pose one of the most significant obstacles to realistic modeling of phonological learning. Although the correctness and complexity of learning without such hidden structure in Optimality Theory and Harmonic Grammar are relatively well understood, little is known about the correctness and complexity of constraint-based learners facing hidden structure. Recent work exploring parsing strategies for the Gradual Learning Algorithm has shown that end-state success rates of constraint-based learning models vary greatly depending on the choice of parsing strategy and mode of constraint interaction. OT learners perform poorly and substantially worse than HG learners when Robust Interpretive Parsing (RIP) is used as the parsing strategy. However, as Jarosz has shown in previous work, alternative parsing strategies, Resampling RIP (RRIP) and Expected Interpretive Parsing (EIP), significantly improve success rates for both OT and HG learners and eliminate the differences in performance between them. The present study investigates the efficiency of learning with RIP, RRIP, and EIP in the domain of metrical stress. The results indicate that RRIP and EIP improve not only end-state success but also the learning speed: learners equipped with these parsing strategies converge on correct target grammars after fewer iterations of learning. The results suggest these parsing strategies allow learners to extract information from the learning data more efficiently, improving the potential for learning to scale to the full problem of phonological learning.

Chapter 8 (B. Elan Dresher: Covert Representations, Contrast, and the Acquisition of Lexical Accent). Lexical accent poses, in a particularly sharp form, two basic problems that learning models must overcome: the Credit/Blame Problem; which parameters or constraints are responsible for any given success or failure? – and Meno's Problem; how can we find the solution if we don't know what we're looking for? Dresher and Kaye (1990) address these problems in the context of a learning model for metrical phonology. Dresher shows how this model can be revised and extended to learn the lexical accent system of a constructed simple language inspired by Russian. He assumes that the grammar of stress builds metrical representations consistent with the Simplified Bracketed Grid theory. Acquiring lexical accent involves dealing with covert structures (see the previous chapter). Dresher argues that the categories 'overt' and 'covert' are fluid, not fixed: structures that are initially covert to the learner gradually become overt in the course of acquisition. The notion of contrast plays an important role in the acquisition of lexical representations, so the author extends the approach of Dresher (2009), which considers contrast in the context of segmental features, to

lexical accent. Recognizing the role of establishing contrasts in the lexical inventory will also help to streamline the system of cues proposed by Dresher and Kaye (1990): cues can now be limited to searching for the presence or absence of a grid mark associated with a parameter, or for contrasting forms.

Chapter 9 (Anthi Revithiadou and Angelos Lengeris: One or Many? In Search of the Default Stress in Greek). This chapter examines whether speakers of Greek, a language with a three-way accentual contrast (antepenultimate/APU, penultimate/PU, and ultimate/U stress), show a bias for a specific stress pattern and, if so, whether this bias depends on morphological and/or lexical information, or reflects the predictable APU stress (i.e. the phonological default). To this end, two perception experiments testing Greek listeners' detection of stress were performed using stimuli with neutralized acoustic cues. The results indicated that even when the acoustic cues that signal stress prominence are neutralized, Greek listeners still made stress detection judgments more than 70 per cent of the time, relating certain stress patterns with specific noun classes. More specifically, across experiments, PU and APU stress were closely related to *-as* and *-a* noun classes, whereas U stress was more favoured in *-o* and *-os* classes than in any other class, suggesting that listeners neither show a preference for a single stress pattern nor blindly apply the phonological default. The authors conclude that Greek listeners therefore exploit all three patterns permitted in their language, albeit not evenly. Their results also show that Greek listeners' stress decisions were influenced, to some degree, by lexical statistics in the case of the unproductive noun classes (*-o/-os*) but remained unaffected in the case of the productive classes (*-a/-as*). The experimental findings are integrated in a formal analysis of lexical stress couched within the Stochastic OT framework. The constructed grammars make extremely accurate predictions regarding the probability distributions of stress patterns across noun classes and, more importantly, are highly learnable.

Chapter 10 (Brigitta Keij and René Kager: The Development of Rhythmic Preferences by Dutch-learning Infants). This chapter reports on a study of rhythmic preferences for either SW or WS stress patterns of Dutch-learning infants between 4 and 8 months of age. It is complementary to previous rhythmic preference studies investigating infants learning similar stress-timed, trochaic (Germanic) languages, such as English and German. Instead of using the traditional head-turn preference procedure, an innovative looking-while-listening procedure using eye tracking is employed to test the development of rhythmic preferences. The research questions raised by the authors are: do Dutch-learning infants show a language-specific rhythmic preference? And if so, at what age does this preference appear? In total, 102 Dutch-learning infants aged 4, 6, and 8 months have been tested and the results show that the infants present a language-specific rhythmic preference for the SW stress pattern at all ages, which, however, is strongest at 6 months of age. These results converge with results found in previous studies investigating English- and

German-learning infants. However, as Dutch is another stress-timed, trochaic (Germanic) language, the authors claim that these results cannot be generalized to languages with a different rhythm or word stress pattern and future research should investigate infants learning these languages.

Chapter 11 (Yuanyuan Wang, Amanda Seidl, and Alejandrina Cristia: Acoustic Characteristics of Infant-directed Speech as a Function of Prosodic Typology). Infant-directed speech is characterized by marked differences from adult-directed speech in both prosodic and segmental properties. This chapter offers a review of studies that examine three acoustic cues (pitch, duration, and vowel space) in speech directed to infants with the aim of addressing two important questions. First, do infant- and adult-directed speech differ in similar ways, and to similar extents, in languages with different prosodic profiles? Second, are the relevant prosodic contrasts similarly cued in IDS and ADS? Both similarities and differences are observed. Based on examining a broader scope of languages, including those with different prosodic systems, such as stress languages, tone languages, and pitch-accent languages, the authors suggest a need for a greater investigation of the ways in which prosodic typology interacts with the properties of infant-directed speech.

While the collection of studies in this volume display a variety of approaches it is clear that the theme of Representation and Acquisition goes to the core of understanding the complexity of word stress. A central concern that cuts through both themes is the general notion of dimensions, i.e. the fact that stress is many conflicting things at the same time. It is both concrete and abstract. The physical, acoustic manifestations of words with stress and rhythm can be many, as can the mental, grammatical representations of these words. Detailed study of the interaction between these dimensions of stress and rhythm first requires that we identify what they are. The chapters in this volume go, we believe, a long way in laying out these dimensions and their interactions.

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1 Metrical Incoherence: Diachronic Sources and Synchronic Analysis

Matthew Gordon

1.1 Introduction

A perennial debate in phonological theory centers around the proper representation of stress, where there is a salient divide between theories that capture stress directly in terms of prominence relations between syllables versus those that encode prominence relations through constituents, termed "feet," consisting of a metrically prominent, or "strong," syllable and one or more non-prominent, or "weak," syllables.

In the former approach, stress is represented as a grid structure (Prince 1983; Selkirk 1984; Gordon 2002), where distinctions in degree of stress are reflected in terms of differences in the number of marks in a hierarchically arranged grid structure. For example, the representation of the English word *alligator* in a grid-based approach would be as in (1).

(1) Grid-based representation of *alligator*

Level 3 (Primary stress)	x
Level 2 (Secondary stress)	x x
Level 1 (Syllable)	x x x x
	ˈal liˌ ga tor

Syllables lacking a grid mark above the syllable tier, i.e. the second and fourth syllable in *alligator*, are unstressed, whereas a syllable associated with a single grid mark above the syllable tier, i.e. the third syllable in *alligator*, has secondary stress, and one dominated by two grid marks above the syllable tier,

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i.e. the first syllable in *alligator*, carries primary stress. A distinguishing feature of grid-based theories of stress is the lack of word-internal phonological constituents larger than the syllable.

Another approach (e.g. Liberman & Prince 1977; Hayes 1980, 1995; Halle & Vergnaud 1987; Idsardi 1992, 2009; Halle & Idsardi 1995) assumes that grid marks are embedded in feet, which in most theories consist of a single strong, i.e. stressed, syllable and a single weak, i.e. unstressed, syllable. The word *ˈalliˌgator* in a foot-based approach could thus be represented as in (2) using Hayes's (1995) representations.

(2) Foot-based representation of *alligator*

Word level	(x . . .)
Foot level	(x .)(x .)
	ˈal li ˌga tor

The first two syllables are grouped into one foot and the last two into another foot. Grid marks play a crucial role in distinguishing the type of foot. Feet are trochaic in (2) since the strong syllable precedes the weak one, in contrast to iambic feet, in which the prominence relations are reversed and the strong syllable follows the weak one within a foot. The higher tier of constituency is the word level, on which the first syllable is metrically strong, i.e. carries primary stress. An important well-formedness condition on feet that (2) illustrates is the requirement that every foot has exactly one head. Configurations like the one in (3) with a two-headed foot and a stressless foot are thus precluded.

(3) Ill-formed foot structure in *alligator*

Word level	(x . . .)
Foot level	(x x)(. .)
	ˈal ˌli ga tor

Although it is traditionally assumed that metrical strength, i.e. grid marks, have a phonetic exponent in terms of stress or other prominence, this is not a prerequisite for a foot-based theory. Metrical strength can be inferred from phenomena other than stress, such as segmental alternations of the type described in this chapter for certain Uralic languages (Section 1.3.1) or the placement of other prominent acoustic events that are dependent on a binary metrical parse, e.g. tonal accent in Creek (see the section on 'Metrical Incoherence in Muskogean: Synchronic Distribution and Historical Development').

Representations like the one in (2) can be supplemented with additional tiers of prosodic constituents corresponding to different levels in the prosodic