Preface

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Speech and language exhibit temporal structure. At the very least, they are far from being random in time. This nonrandom structure is what we call rhythm. We can describe rhythms on a global scale, characterizing languages and groups of languages, as well as on a local scale, characterizing the flux of anisochrony and isochrony within a speech stream or across registers. We can describe rhythms on acoustic, sublexical, and supralexical levels, but also as a holistic percept emerging from a combination of linguistic features. The multiple rhythms in speech and language that we observe are attributes of a cultural form. Ultimately, they are aggregates of rhythmic behaviors that stem from physiological rhythms that fall into the scientific realm of biology. *Rhythms of Speech and Language* combines current descriptions of the rhythms of speech and language with current proposals for their biological and evolutionary foundations.

Following this agenda, we first need to describe rhythm in speech and language. What counts as rhythm? How much deviation from isochrony does the definition tolerate, and what is the baseline that we call arrhythmic? Which properties of the acoustic signal that speech really is shall we query – for instance, amplitude or frequency? What aspects of these and what events within their time series are relevant – bursts, modulations over time, modulations of modulations over time? On which timescale(s)? And how about the abstract rhythms of language, which are invisible in speech acoustics and only present in our minds and brains: Is there rhythm in word sequences and even on the level of syntax? Why? And how, then, do acoustic and abstract rhythms covary?

Beyond the description of the rhythms of speech and language, we then need to explain why behaviors and their aggregates—cultural forms—are the way they are: What are the biological forces in the human body that drive speech and language into rhythmicitiy—lungs, jaws, and brains—and what are the functional and evolutionary pressures that selected for these? What happens to the rhythms of speech and language when the body changes, either ontogenetically (e.g., during language acquisition) or as the result of a disorder?

There is no one language, and thus probably no one answer to the questions listed thus far: More than 7,000 languages live, and they differ on both the acoustic and abstract levels along a large space of typological parameters. Do the rhythms of speech and language allow us to order the languages of the world in some neat way? And does this order relate in some way to genealogy – cultural and even genetical? Another dimension of this sparkling variability is to be

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found within each language itself: Speech and language are a matter of communicative context. It makes a big difference whether we are in a professional setting, in the bar with colleagues or friends, or at home speaking to a kid, an adult, an elderly family member, or a person who suffers from a disorder of speech and language. Again, what properties and aspects of speech and language do we need to describe that change as a function of context, and can we explain why these changes occur in biological and evolutionary terms? And once you have answered these, how about neighboring cultural forms? In terms of rhythm, what are the differences between music on the one hand and speech and language on the other?

Rhythms of Speech and Language has seven major sections. We start with the physiological prerequisites of rhythm in Section 1. We explore the motor system with the jaw, respiration, and gestures, as well as the neural and vestibular systems as preconditions for human vocalization. Here, we see investigations ranging from auditory over sensorimotor to holistic accounts. Physiological rhythmicity shapes rhythmic behavior and ultimately speech and language as cultural forms.

After thus setting the stage, Sections 2 and 3 focus on the description of rhythm along the various phonetic and linguistic levels, concerning acoustics and phonological units and prosodic and syntactic units, respectively. These sections illustrate the many different dimensions of rhythm, and the many different ways of capturing it. In the neuroscientific or engineering approaches, speech rhythm is defined rather pragmatically as the modulation frequency allowing a continuous measure of rhythmicity. This is in contrast, however, to the classic linguistic understanding where the term *speech rhythm* might only be applied at the higher end of the scale as soon as regularities are observed. In addition to exposing this discrepancy, the sections also emphasize the key bottom line that while rhythm can be described physically in speech signals, our percepts of rhythmicity often deviate from, clash with, override, or arise from synthesis across multiple acoustic features of the signal – cognition creates and imposes rhythm, and we want to understand how and why.

Sections 4 and 5 host diversity, first across registers and neighboring cultural forms, and second across the languages of the world. The chapters of Section 4 focus on the question of how processing changes or stays constant when exaggerating the rhythmicity of speech either for rhetorical purposes or when engaging in music. A critical achievement of Section 5, then, is addressing the long-standing question as to whether it is helpful to order the languages of the world into rhythmic classes. We will see and list both advantages and disadvantages of using rhythm metrics.

The focus on rhythm has led to major breakthroughs in language acquisition research, which has its home in Section 6. Here, the reader can familiarize themselves with the fascinating evidence for a close relationship between physiological rhythms and the rhythms of infant-directed speech and language, yet also glimpse the challenges that lie ahead when language acquisition research faces, again, diversity across the languages of the world.

Finally, Section 7 explores a wide variety of conditions and clinical populations, the implications of altered physiological rhythms for alterations in the rhythms of speech and language, and the according role that rhythmicity could play for rehabilitation and for handling challenging communicative situations. To name a few, the chapters touch upon benefits for purely audition-related deficits (e.g., in cochlear implant users), motor and executive deficits (e.g., in

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stuttering or aphasia), and even pragmatic challenges (e.g., in the neurodevelopmental condition of autism). We again see the role of speech rhythmicity for building bridges, bootstrapping and compensating for altered language input or output, and initiating brain plasticity.

Our compilation arrives at a particular point in the history of science where the rather new disciplines of cognitive and systems neuroscience team up with discoveries made by physiologists and clinicians describing and possibly explaining key characteristics of rhythm in speech and language. Classically, speech and language are within the realm of phonetics and linguistics. Our book hopes to be the mediator. We hope to help in forming common ground across disciplines and stimulate synergistic research. Throughout the editing process, we worked with the authors to make their chapters approachable for readers from different scientific fields. Each chapter is framed by a tapered summary, a punch line of scientific implications and expected gains to help navigate the cosmos of *Rhythms of Speech and Language*, hopefully making it a useful resource for future endeavors.

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