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CAS Research Focus

Speech and Language Processing: How Words Emerge and Dissolve

Jonathan Harrington, Marianne Pouplier

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Language: Birth and Decay

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Abstract

Our CAS Research Focus is concerned with how the sounds of speech are acquired by infants and young children in first language acquisition, how such acquisition stabilises in healthy individuals, and how such patterns may dissolve following the onset of brain lesions. The Research Focus integrates models of speech production and perception in healthy adults with research on child speech development as well as clinical speech sound disorders following brain lesions. The innovation potential of the research program lies in the capacity to provide fresh insights into speech acquisition and its loss, into how speech is controlled by sensory information, and into the relationship between clinically disordered speech and spoken language performance errors in healthy individuals. This objective is partly pursued by means of collaborative research between scientists based at LMU and leading researchers from abroad who are invited to Munich as Visiting Fellows. A lecture series with major international contributions has been designed to broaden the reach of speech research to encompass other areas of research strength at LMU in disciplines such as biology, psychology, and sociology. An international symposium disseminated the results of the ongoing research to the wider scientific community and displayed the combined strengths of LMU researchers in this area.

Research Program

The CAS Research Focus investigates how the sound patterns of speech are acquired by children, how they stabilise, and how they may dissolve following brain damage and neurodegenerative disease. The larger background for this research is the ongoing attempt to understand the cognitive and physiological boundary conditions of human language. Spoken language is a defining human behaviour and it is the very basis of our interaction with the environment as well as of our identity as individuals. For this reason, it is important to understand both how this faculty emerges during child development and the highly damaging effect that speech disorders has on so many aspects of life. Error patterns when language is learnt and when it unravels in speech disorders also provide a unique window into the mind, and are of prime importance for our emerging understanding of how linguistic diversity arises, how languages change, and how physiology and cognition interact to form the sound patterns of human language. Yet speech acquisition and disorders remain poorly understood because they are usually investigated separately from basic research on speech production and perception in healthy individuals. The objective of this Research Focus is therefore to lay the foundations for a comprehensive research program in which modern experimental phonetic thinking hooks up with neurobiological and clinical reasoning, while embracing linguistic diversity.

Our aim is to bring together the expertise that is required to understand how the sounds of speech are acquired in young children and how they are lost after lesions to those brain areas in which the acquired knowledge is apparently processed. An associated objective is to relate language acquisition and language attrition due to brain damage with performance errors such as slips of the tongue that typically occur in healthy adult speakers, and to patterns of historical sound change. This main objective will be explored by pursuing the following three overarching research themes.

1. The dynamics of speech planning and articulation.

The focus of this theme is on how linguistic structure governs and interacts with the temporal and spatial control of speech: that is, on how the movements of the tongue, lips, and jaw are orchestrated in syllable structures of varying complexity in different languages in both healthy children and adults, as well as in aphasic adults. This will advance our understanding of how the procedural knowledge governing articulation can be characterised, how it evolves during speech acquisition, and how and where this knowledge is stored in the adult brain and is affected by brain lesions. This theme will bring together scientists concerned with abstract processes of speech planning with those working on the physical implementation of speech. While it is well known that speech planning and the physiology of speech production are closely intertwined, both are usually studied as separate disciplines with little cross-fertilization. The Research Focus provides a platform for discussions amongst proponents of different theories that formalize the grammar underlying a language's sound pattern (Articulatory Phonology, Optimality Theory, conventional rule-based phonology) regarding the explanatory power of their theoretical frameworks in the fields of typical speech development and adult speech disorders. This exchange will also encompass universalist vs. statistical/language particular accounts of how sound patterns are acquired in childhood, as well as some of the heavily discussed questions relating to whether and how general cognitive or physiological factors may constrain linguistic diversity, or determine patterns of breakdown in speech errors.

2. The role of sensory information in speech production.

Auditory and somatosensory information are important in adult speech, since they serve as feedback channels and as sensory goals in speech movement planning. There is evidence that speakers can predict the likely sensory consequences of their own speech production before they start to speak. That is, adult speakers have knowledge through experience about how producing speech is likely to be related to somatosensory feedback and its perceptual consequences. The neural substrate of this knowledge base is the ventral-dorsal stream system of the left hemisphere. Feedback control is currently among the most rapidly advancing topics in cognitive neuroscience. A largely unresolved issue to be explored here is whether children are more reliant on feedback than adults and how these predictive capacities develop in first language acquisition. Likewise, it is also unknown whether patients with lesions to auditory or somatosensory cortical regions of the left ventral-dorsal stream experience changes in the degree to which they can rely upon these sensory channels during speaking, and what the consequences of such changes are for their speech output. Central to the work of the Research Focus is the issue of whether production-perception relationships are more unstable in children than in adults, which would establish a potential link between language acquisition and change. Such processes may also be more prevalent in aphasic patients and therefore provide a model of how impaired auditory representations in aphasics may trigger speech errors.

3. The acquisition and loss of phonological information.

The main focus here is on the pattern of speech errors made by children in early childhood during first language acquisition, and on error patterns made by aphasia patients based on analyses of speech production and perception data from structurally diverse languages. For this purpose we consider why some speech sounds are acquired before others and why this order varies across languages. For aphasic patients, the main issue is why certain sound patterns are known to be more error prone than others, but there is to date a limited understanding of the underlying causes and a dearth of cross-linguistic knowledge. Special attention is also being paid to the role of prosody (syllable structure,

stress) for explaining error patterns. Languages display vastly different prosodic systems, but the ramifications of this diversity for acquisition and disorders have scarcely been explored. Further factors include the role of social identity and group membership for acquisition and disorders, especially in bilingual/multilingual situations. We will also consider the implications for acquisition and disorders of the anatomical and neural maturation/aging of the speech organs and the brain, the role of general cognitive preconditions to language such as long-term and verbal working memory, and cross-linguistic differences in the production-perception dynamics. Another focus will be on methodological issues: there are enormous complexities in obtaining comparable data from 2-6 year old children and patients at recording sites from around the world. Of relevance here are technological issues involved in obtaining, archiving, and sharing physiological and perceptual data from vulnerable populations such as young children and adults with aphasia; and how to obtain relevant data under comparable conditions for lesser studied languages.

Fellows and Activities

The CAS Research Focus comprises several instruments designed to open interdisciplinary perspectives onto our research themes and to consolidate the expertise assembled at LMU.

Lecture Series "The Birth and Decay of Language"

 A highly successful lecture series designed to provide an interdisciplinary discussion platform took place during summer term 2015 and drew a consistently large audience from a great variety of disciplines. The lectures by internationally renowned scholars covered the wide horizon of speech and language research from behavioural, psychological, neural and developmental perspectives. The following speakers participated:

- Stefanie Shattuck-Hufnagel (MIT):
  Speech Errors: A Window to the Mind
- Marilyn Vihman (University of York):
  How Children Learn Language
- Josef Rauschecker (Georgetown University):
  The Neural Basis of Language
- Nicholas Evans (Australian National University) and Klaus Zuberbühler (Université de Neuchâtel):
  The Evolution of Linguistic and Cultural Diversity.

Visiting Fellows

The visiting research fellows are an integral part of our aim to forge an interdisciplinary alliance of speech and language research at LMU. We specifically invited both young and senior researchers who shared their expertise on speech dynamics, neuroscience, language acquisition and linguistic diversity. Professor Khalil Iskarous (USC, Los Angeles) is a word-leading expert on the interaction of speech motor control with linguistic structure and on how the physiology of producing speech has a fundamental impact on how human language is structured. Professor Lucie Ménard (University of Québec at Montréal) has done pioneering experimental work on first language acquisition with normal and disordered children. Her work investigates how speech motor skills develop in children in the face of a growing vocal tract and the role of sensory information in speech production, including disordered speech. Professor Georgia Zellou (University of California, Davis) is a talented younger researcher studying at a fine-grained level cross-dialectal and cross-linguistic variation in order to understand how sound patterns of languages evolve and change dynamically over time. Professor Josef Rauschecker (Georgetown University, Washington, D.C.) is one of the world's leading researchers for the neural basis of language. His research aims to unravel the brain's means of implementation for auditory perception and language.

CAS CONCEPTS

International Workshop

During summer term 2016 we hosted an international workshop at CAS entitled "How Words Emerge and Dissolve: Evidence from Speech Production, Speech Perception, Acquisition and Disorders" with participants from several universities in France and the US. This workshop was used as a forum especially for young scientists to present their work to an international audience. One thematic focus was on how regularities across languages in the phonological code are constrained by the physiological and perceptual boundaries of the human speech communication system. Other talks looked at the contribution of second language acquisition and spoken language disorders to understand how speech dynamics and phonological abstraction are related and how foreign accent and phonological disorders are situated between the grammar and the physics of speech. Finally, several contributions asked whether the very rare types of phonological categories and sequences in the world's languages place different demands on the speech production and perception system (or are processed differently in speech communication) compared with those that more commonly occur. A related issue is whether such rare sequences are acquired differently or later in both first and second language acquisition, and whether they are affected differently in speech disorders.

International Symposium

A highly successful international symposium entitled "Abstraction, Diversity, and Speech Dynamics" was held in May 2017 and attracted 90 participants from all over the world. The aim of the conference was to advance the discussion on these issues by bringing together scientists from various disciplines engaged in research on areas such memory and its relationship to abstraction, feedback and feedforward control systems, and modelling the association between discrete categories and continuous speech dynamics.

It is only with a deeper understanding of the semiotic-signal association that breakthroughs can be achieved in understanding how the sounds of language are acquired, in how far normal and disordered mechanisms of speech are related, and how social and linguistic information interact and are transmitted in speech communication. Invited speakers were Ann Bradlow (Northwestern University), Jennifer Cole (Northwestern University), Jan Edwards (University of Maryland), Adamantios Gafos (University of Potsdam), Matthew Goldrick (Northwestern University), Esther Janse (Radboud University), James McQueen (Radboud University), Caroline Niziolek (Boston University), Pascal Perrier (Grenoble INP), Janet Pierrehumbert (Oxford University), and Douglas Shiller (Université de Montréal). We plan to publish an edited volume as a special issue in a major international journal with invited papers from the lecture series and the international workshop.

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