Brain & Language 127 (2013) 34–35

Contents lists available at ScienceDirect

Brain & Language

journal homepage: www.elsevier.com/locate/b&l

Editorial

Current themes in the neurobiology of language: Highlights from the third annual Neurobiology of Language Conference (NLC 2011)

This special issue of Brain and Language includes a collection of 6 papers that illustrate current issues in the neurobiology of language and which originate from a subset of the research groups selected to give slide presentations at the third Neurobiology of Language Conference (NLC 2011, http://www.neurolang.org/), held in Annapolis, Maryland, USA, on November 10–11 2011; two of the papers are based on the Discussion Panels that were held during the meeting. Together with Steven Small, we began organizing the Neurobiology of Language Conference in 2009 with the hope of contributing to the organization and promotion of the field of language neurobiology. With the fifth annual meeting quickly approaching, and the continued participation in all four previous meetings (Chicago, San Diego, Annapolis, San Sebastian), we believe we have reached our objectives and contributed to making the neurobiology of language a field of research of its own, strongly multidisciplinary, but not reducible to the sum of the fields that contribute to it, which includes cognitive neurosciences, neuropsychology, linguistics, speech pathology and neurology. The emerging field of Language neurobiology strives to understand the brain mechanisms by which language, one of the most celebrated hallmarks of human cognition, and an amazingly complex, and uniquely human, function, emerges from existing and unique neurocognitive mechanisms.

Following in the steps of the first two meetings that took place in Chicago in 2009 and in San Diego in 2010, the third annual meeting was attended by over 450 scientists, clinicians and students from around the world, who met to discuss issues related to the neurobiology of language. As shown in this special issue, the field of Language Neurobiology is growing and becoming increasingly diversified both in terms of themes and methods. The articles in this special issue cover a breadth of topics, demonstrating the remarkable diversity of the research questions in the field of language neurobiology. Although the content of each paper was left entirely to those who agreed to contribute and based upon their presentation at the third annual NLC meeting, four notable themes emerged: (1) Temporal processing in speech perception (Scott & McGettigan), (2) Predictions in speech and language (Karuza et al., Dikker & Pylkkänen), and (3) Relationships between Language and the motor systems (Fernandino et al., Pulvermüller, Garagnani & Pulvermüller). The articles in this special issue present a selection of contemporary approaches, including behavioural approaches (Fernandino et al.) functional magnetic resonance imaging (Karuza et al.), magnetoencephalography (MEG) (Dikker & Pylkkänen), and computational modeling (Garagnani & Pulvermüller), to meeting the challenges faced by the field as a whole, which includes, notably, understanding the relationship between language and motor systems, and between language and cognitive processes.

In their paper, **Scott and McGettigan** provide a thorough and insightful review of the issue of the issue of the leftwards sensitivity to temporal processing for speech perception. The paper goes back to the historical route of the issue, for example reviewing the early findings of Efron (Efron, 1963). The authors focus on early research on the processing of heard speech and how results from different experimental paradigms (temporal order judgments, dichotic listening) with non-speech and non-speech sounds in different populations (aphasics and specific language impairments) led researchers to conclude that speech was preferentially processed in the left hemisphere. The authors discuss several important issues such as the temporal scale associated with the processing of speech, the lack of clear hemispheric advantage for the acoustical cues that are representative of speech (temporal processing). The authors also discuss more recent findings from neuroimaging studies, which only partially support the notion of hemispheric preference (left) for temporal processing.

The next two papers focus on predictions from two very distinct perspectives. While **Karuza et al.** explore the neural bases of statistical information processing in a word segmentation task, **Dikker and Pylkkänen** explore the issue of semantic-based predictions and pre-activations in language comprehension using a picture-word task. In their studies, Karuza shows that human adults are capable of detecting statistical structure in streams of artificial language described in a previous study from the group (Newport & Aslin, 2004) and that the ability to extract words from these streams correlate with BOLD signal in the inferior frontal gyrus which they suggest may play a role in auditory sequencing, perhaps even modality-independent, though this was not directly tested in the study. Using a completely different approach and MEG instead of fMRI, this study found that, before the presentation of predictable words (based on the picture preceding it), activation in left mid-temporal cortex (which has been implicated in lexical access), ventro-medial prefrontal cortex, and visual cortex, successively, suggesting that the processing of predictive language recruits a top-down network in which predicted words are activated at different levels, from more abstract' lexical-semantic representations in temporal cortex, to visual word form features. Both papers present highly novel findings that build on previous research to demonstrate the importance of predictions in speech and language processing.

The final three papers focus on the controversial issue of language embodiment (Bedny & Caramazza, 2011; Hickok, 2009; Mahon & Caramazza, 2009) that is, the organisation of meaning in the

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http://dx.doi.org/10.1016/j.bandl.2013.09.007

sensorimotor neural system. **Fernandino et al.** present the behavioural results which show that performance at various language tasks in individuals with Parkinson's disease, which presents with a damage to the basal ganglia affecting the motor system, is selectively impaired when it comes to impaired for action verbs compared to healthy, age-matched adults, suggesting that the motor system plays an essential role in the processing of action-related language and, more generally, in semantic processing. Next, **Garagnani and Pulvermüller** examine the decisions to speak and act by means of computational modelling and Hebbian learning based on a neuroanatomical model of frontal and temporal areas. Their results provide a framework for understanding the emergence of spontaneous actions at the cortical level. Finally, **Pulvermüller** presents a throughout and comprehensive review of the issue of semantic embodiment, discussing disembodiment along and minimal-compromise positions, and finally presenting an alternating view, the Action-perception theory (APT) of semantic circuits, which supports the idea that semantic systems of the brain include action-perception mechanisms as functionally important components.

Summary

This representative snapshot of work presented at the third Neurobiology of Language Conference is a good illustration of the breadth of methods and topics that were discussed at the meeting. This special issue thus provides a heterogeneous collection of papers that use sophisticated experimental designs, acquisitions and analyses to provide a deeper understanding of language mechanisms. Each paper provides valuable literature reviews, methodological ideas and a host of new and exciting results that will contribute to shaping future investigations into the neural systems underpinning speech and language functions. The remarkable diversity of themes illustrates the development of the field of language neurobiology and reveals the enormous variety of novel and important questions addressed as well as many new research techniques and research directions being introduced. In closing, I would like to thank the attendees for their continued interest in language neurobiology.

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Guest Editor
Pascale Tremblay
Centre de Recherche de l'Institut Universitaire en Santé Mentale de Québec, Université Laval, Rehabilitation Department, QC, Canada
E-mail address: Pascale.Tremblay@fmed.ulaval.ca