ALESSANDRO BENATI
Centre for Applied Research and Outreach in Language Sciences. University of Portsmouth, United Kingdom
STEFANO RASTELLI
University of Pavia, Italy – University of Greenwich, United Kingdom

The teaching and acquisition interface in neurocognition research.

The Centre for Applied Research and Outreach in Language Education (CAROLE), led by Professor Alessandro Benati in Faculty of Architecture, Computing and Humanities at the University of Greenwich organized a one-day symposium in October of 2014. The symposium was entitled "Second Language in the Brain: immersion, instruction, interaction". The event hosted leading scholars working in the area of the neurocognition of language and renowned experts in second language acquisition (SLA henceforth).

The purpose of the event was to sum up and describe to a larger audience the results of various neurophysiological and neurofunctional research programs. This research focuses on what changes in the brain following second language instruction. Neurolinguistic research in this field started in the early years of this century at the University of Washington (Seattle) and at Georgetown University (Washington D.C.).

Over the last decade, similar research programmes sprang up in other centers across the US, Canada and Europe. All those research programmes found evidence that an adult learner's brain too is capable of undergoing rapid anatomical and functional changes following second language instruction. These changes concern the electrophysiological responses to stimuli (detected via the ERP technique, see below), the density of gray matter in language-related areas (detected via voxel-based morphometry) and the levels of blood oxygenation in brain tissues in critical areas for language representation and processing (detected via functional magnetic resonance imaging – fMRI). Over the years, it has become increasingly clear that these brain changes may be also modulated by various kinds of pedagogical intervention, beside learners' mere, spontaneous exposure to the L2 input. Such intervention comprises automatized feedback, explicit or implicit teaching of grammar rules, extensive practice and drilling, structured input. All articles in this special issue contribute to define a field of contemporary experimental language research dubbed "the neurocognition of the teaching/acquisition interface". In fact, they all revolve around the basic research question of the extent to which different teaching-related variables impact those patterns of brain adaptation in adult learners.

In order to fully appreciate the articles, it is important that the non-specialist reader gets at least an elementary knowledge of the Event Related Potentials (ERP) technique because most of the contributions make explicit reference to studies that utilize this technique (more details can be found in Steinhauer, 2014 and especially in Luk & Kappenman, 2013). ERPs record electrical fluctuations on the scalp (measured in terms of microvolts) which are time-locked to the presentation of visual or auditory stimuli, typically, sentences containing errors of various kinds (syntactic or semantic anomalies). In language studies, researchers place a variable number of electrodes on

the scalp of participants and show them – one word at a time – the same sentence twice, once in the correct version and then in a version where some mistakes are present.

Differences in the electrical fluctuation from the correct to the incorrect conditions are regularly observed. These brain responses reflect postsynaptic electrical activity of a limited population of cortical neurons sharing shape and orientation. When the signal has been correctly amplified and averaged across many participants, one can observe that different errors elicit qualitatively different brain responses or brainwaves called 'components'.

Three of these components are the most studied in SLA. When sentences with gross, categorical or syntactic violations are presented, one gets a left anterior negativity (LAN) which is a negative-going brainwave with peaks 200–300 ms after the presentation of the critical word (e.g., the word containing the error). When sentences with infrequent, rare words, semantic anomalies or words in implausible contexts are presented, one gets an N400. It is assumed that this negative-going wave reflects difficulty with lexical access and integration. Finally, morphosyntactic anomalies (such as violations of agreement, tense, case and verb subcategorization) elicit a large positive-going wave with a peak around 600 ms post-stimulus. It is assumed that P600s reflect controlled processing and structural reanalysis for word order and morphosyntactic difficulties.

The special issue is opened with two position papers. The first one is written by Michael Ullman's and Jarrett Lovelett (forthcoming) and is entitled *Implications of the declarative/procedural model for improving second language learning: the role of memory enhancements techniques*. In the first part of this paper, the authors provide an updated version of the declarative/procedural (DP) model, a well-known neurocognitive framework that enables prediction on the teaching/acquisition interface in SLA. Compared to other introductions to the DP model existing in the literature (see Ullman, 2005), the current one addresses in a clear matter some points that are crucial for those interested in L2 teaching. Above all, the idea is elaborated that declarative and procedural memories are *redundant* in L2 acquisition, meaning that the same or analogous knowledge (e.g. morphosyntactic items) can be acquired twice by learners, statistically (as chunks or wholes) and grammatically (computed by a rule). This dual route of acquisition could have implications for L2 syllabus-design and for considerations on how the grammar should (or should not) be presented in the classroom. In the second part of this position paper, the authors address the issue of how memory and L2 learning can be enhanced, given the premises of the DP model. They analyse the neurocognitive advantages for acquisition of two special teaching techniques: 'spaced repetition' (study schedules in which the repetition of the same item or task occur with intervening temporal gaps) and retrieval practice (studying by testing, trying to retrieve information by memory rather than simply re-reading). It is easy to predict that new exciting strands of classroom-based experimental neurolinguistic research are likely to stem soon from the points raised in the second part of this seminal paper.

The second position paper is written by Leah Roberts, Jorge Gonzales Alonso, Christos Pliatsikas and Jason Rothman and is entitled *Evidence from neurolinguistic methodologies: Can it actually inform linguistic/language acquisition theories and translate to evidence-based applications?* The authors first provide a critical assessment of twenty years of neurolinguistic research on language acquisition that uses

ERPs and fMRI. As to the former, they analyse the meaning of the different electrophysiological components for language development and phenomena such as the brain–behavior dissociation (the fact that ERP measures and behavioral measures of proficiency such as acceptability judgments often dissociate). In the second part of this position paper, the authors analyse the implications of neurolinguistic research for language acquisition theories. Finally, they deal with the issue of language instruction by interpreting the 'interface debate' (the possibility that explicitly acquired knowledge gets proceduralised over time) in terms of the declarative-procedural distinction. The authors seem to open up to the possibility that there can be a positive effect of instruction on how language is processed and on the rate at which language is learned. The presence of the so-called biphasic pattern (the shift between N400 and P600 components as response to violations as a learner's proficiency increases) in neurolinguistic studies could be a clue to the existence of an interface between (explicit) teaching of grammar rules and (implicit) acquisition.

The volume continues with two experimental papers. The first one is written by Stefanie Nickels and Karsten Steinhauer and is entitled, *Prosody-syntax integration in a second language: Contrasting event-related potentials from German and Chinese learners of English using linear mixed effects model.* The novelty of this experimental study is twofold. First, the study explores the role of prosodic information in second language processing and the interaction between prosodic information and variables such as L1, background and L2 proficiency. Prosody is the neglected part in ERP studies on SLA and this study makes an important exception. The results of this study – among other things – show that the prosodic profile of the L1 strongly affect learners' interpretation of garden-path sentences. One of the advantages of this study is that it utilizes the mixed effect linear regression analysis in order to treat L2 proficiency as a continuous variable. This methodological choice overcomes the traditional flaws of more traditional statistical methods (e.g. ANOVA) and allows assigning proficiency scores regardless of other grouping factors (e.g. 'classroom', see also Rastelli, 2017, in this issue). Based on the results of this study, the authors also suggest that classroom learners could profit from receiving explicit information and from undergoing practice on the prosodic profiles and characteristics of the target-language, especially when these profiles, prosodic differences and contrasts have syntactic relevance.

The second experimental paper is by Mandy Faretta-Stutenberg and Kara Morgan-Shorts and is entitled, *The interplay of individual differences and context of learning in behavioral and neurocognitive second language development*. This paper reports the result of two longitudinal ERP studies (with two different groups of L2 Spanish adult learners) aimed at identifying the roles of learning contexts ('study abroad' vs. 'at-home') and of individual differences (working memory – WM – and declarative/procedural cognitive abilities) in behavioural performance (acceptability judgments) and neurocognitive L2 processing. Regression analysis of ERP (changes in electrophysiological responses to stimuli over time) data with WM and cognitive scores as covariates shows that; (a) WM and procedural memory play a role in ERP responses, but only for study-abroad learners and not for at-home learners; (b) individual with higher scores in declarative memory show more success at earlier stages of acquisition, especially in at-home settings. In contrast, individuals with higher scores in procedural memory show more success at later stages of acquisition, especially in study-abroad contexts; (c) At-home learners show behavioural gains, but not processing gains over time. This study is also important because it paves the way for further research on the

possible correlation between learning contexts (at-home vs. abroad), the ways of teaching that characterize those contexts (respectively, explicit vs. implicit) and the cognitive abilities that are more actively engaged in those contexts (declarative vs. procedural memory). If such correlations can be established and if it is confirmed by other studies, there could be further consequences for teaching research and for teaching methodologies.

The last paper in this special issue is written by Stefano Rastelli and is entitled *Neurolinguistics and second language teaching: a view from the crossroads*. In this paper, the author addresses critically the link between research on the neurocognition of the teaching-acquisition interface and research on second language teaching. He analyses how neurolinguists have operationalised three aspects specifically related to second language teaching: (a) learners' proficiency; (b) the between-groups experimental design; (c) the implicit vs. explicit teaching dichotomy. He suggests that the degree of replicability of such neurolinguistics studies can be increased by adopting non-circular operational definitions. Such definitions should not be based on psycholinguistic or neurolinguistic metrics, but on standards that are commonly discussed in the literature on instructed second language acquisition, second language teaching, and assessment. Finally, the author also suggests that for future research, neurolinguists should consider the advantages of welcoming on board more developmental linguists and teachers.

In this Special Issue the guest editors first reviewed each paper. We sent the works out for double blind review once the authors incorporated our comments and feedback. We would like to thank all the anonymous reviewers for their time, insights, and attention to detail. Finally, we would especially like to thank our contributors for the outstanding quality of the work they produced.

References

Faretta-Stutenberg M and Morgan-Shorts K (2017) The interplay of individual differences and context of learning in behavioral and neurocognitive second language development. *Second Language Research* (pages forthcoming)
DOI: 10.1177/0267658316684903

Luck S and Kappenman ES (eds.) (2013) *The Oxford Handbook of Event-Related Potential Components*. Oxford and New York: Oxford University Press.

Nickels S and Steinhauer K (2017) Prosody-syntax integration in a second language: Contrasting event-related potentials from German and Chinese learners of English using linear mixed effects model. *Second Language Research* (pages forthcoming).
DOI: 10.1177/0267658316649998

Rastelli S (2017) *Second Language Research*: Neurolinguistics and second language teaching: a view from the crossroads. *Second Language Research* (pages forthcoming).
DOI: 10.1177/0267658316681377

Roberts L Alonso GG Pliatsikas C and Rothman J (2017) Evidence from neurolinguistic methodologies: Can it actually inform linguistic/language acquisition theories and translate to evidence-based applications? *Second Language Research* (pages forthcoming).
DOI: 10.1177/0267658316643125

Steinhauer K (2014) Event-related Potentials (ERPs) in Second Language Research: A Brief Introduction to the Technique, a Selected Review, and an Invitation to Reconsider Critical Periods in L2. *Applied Linguistics* 35(4): 393–417.

Ullman MT (2005) A cognitive neuroscience perspective on second language acquisition: The declarative/procedural model. In: Sanz C (ed.) *Mind and context in adult second language acquisition: Methods, theory and practice*. Washington, DC: Georgetown University Press, (pp. 141–78).

Ullman MT and Lovelett J (2017) Implications of the declarative/procedural model for improving second language learning: the role of memory enhancements techniques. *Second Language Research*: (pages forthcoming).
DOI: 10.1177/0267658316675195