Lexicogrammar and the brain, in theory and in practice

Jennifer Hughes and Andrew Hardie
Lancaster University

In this presentation, we aim both to provide an overview of, and to contextualise, an ongoing research project at Lancaster University into the neurophysiology of collocation and formulaicity. First, we will present the methods, and summarise the results, of a series of electroencephalography (EEG) experiments undertaken from 2014 to 2018. Next, we will attempt to draw out what these results mean for the theoretical understanding of how the human language system actually *works*, and in particular the support they lend specifically to network models of lexicogrammatical processing. Third, we will present current work to extend the methodological paradigm to deal with a more comprehensive range of collocational phenomena. Finally, we explore the implications of this work for linguistics (including, but not only, corpus linguistics) as a field.

Research and results

In corpus-based analysis, collocation is a broad phenomenon, but such an amorphous entity is not amenable to observation via EEG: a more precisely defined object of study was required. We thus looked first at collocational bigrams: directly adjacent word-pairs where the second word is highly likely to follow the first word (as identified via statistical analysis of large corpora of natural language). Bigrams were an obvious target of inquiry for the first phase of research, as designing a controlled experiment with a collocation that contains a single transition between a single pair of words is more straightforward than designing such an experiment with a collocation consisting of multiple transitions, or a collocation whose components appear in varying relative positions – because there are fewer variables to be considered.

Thus, an experimental paradigm has been developed wherein the collocational bigrams, as well as matched non-collocational bigrams, are presented in corpus-derived sentence contexts to adult participants. While the participants are reading the stimuli, their cerebral activity is directly recorded via scalp electrodes. The cerebral activity is then analysed using what is known as the event-related potential (ERP) technique in order to establish (a) whether there exist any neurophysiological correlates of the difference between the processing of the collocational and non-collocational linguistic units, and (b) what form such neurophysiological correlates take. A repeated finding of these various experiments (see Hughes and Hardie in press) is that *transitions within collocational bigrams are processed with less cognitive effort than transitions within equivalent bigrams that lack the collocational link*.

From experiment to theory

This empirical research provides neurophysiological evidence for a view of the nature of language in the brain common to a number of theoretical frameworks including, *inter alia*, Construction Grammar (Goldberg 2003) and Lexical Priming (Hoey 2005). These assorted models propose the processing of language as a single lexicogrammatical system – rather than as separate systems for grammar and for the lexicon (the latter including idiomatic and formulaic multiword units). This single system takes the form of a probabilistic network of linguistic items, where nodes corresponding to words, collocations, or constructions (depending on the theory

adopted) are interconnected via weighted links. Comprehension and production processes are conceptualized as the following of a path through the network, from node to node, through these interconnections. The sequence of nodes thus traversed corresponds to the sequence of linguistic units observable in spoken or written input/output.

As what we might call the *locus of processing* moves through the network, nodes become more or less activated; *mental activation* is defined in this context as a "state of memory traces that determines both the speed and the probability of access to a memory trace" (Anderson 2005:455). While the node at the locus of processing is highly activated, activation *spreads* between nodes via their interconnections; the more heavily weighted the link, the more readily activation spreads along it, so that a node may become activated *in advance* of the locus of processing moving to it. In consequence, paths through the network most easily follow heavily weighted node-to-node transitions. Speakers are more likely to produce, and in comprehension to anticipate, sequences that follow such paths. It is this prediction of network models of processing that has been borne out by our empirical work. Specifically, pre-activation of the node representing the *second* word of a bigram is a result of activation spreading in the network upon perception and retrieval of the *first* word. Thus, in theory, retrieval of the linguistic representation of the second word should be much easier to process. The neurophysiological evidence shows that this is indeed generally the case. The implications for the adequacy of network-model theories of the nature of the human language faculty are obvious.

Beyond bigrams: a new methodological paradigm

Bigrams are just one of the many types of collocation and formulaic/idiomatic language. As noted above, in corpus linguistics, pairs of regularly co-occurring words are considered to form collocations, even if they are not adjacent and even if they do not always occur in the same order. The current phase of our research thus seeks to work out the methodological issues involved in accounting for (some of) the additional variables relevant to such collocations, in preparation for a subsequent phase taking *multiple* kinds of collocation into account. Aspects of this methodological work worthy of note include: the issue of the syntactic relationship between a collocate pair; difficulties in balancing the statistical properties of items in a collocational and non-collocational pair that are not fixed bigrams; techniques both for the extraction of relevant corpus examples, and for devising suitable stimulus sentences on the basis of these examples; and refining the notion of the *transition* – critical to a network model of lexicogrammar – to encompass nonadjacency.

What does this mean for the field?

We are at pains to emphasise that we do not wish to propose any novel theory of language. Rather, we propose that neuroimaging techniques such as EEG/ERP present a path to deciding among competing theories of the nature of language on the basis of *how the brain/mind actually works* rather than merely on the basis of the model's descriptive or explanatory adequacy (or, worse, subjective aesthetic criteria such as *elegance*). To the extent that our programme of research continues to confirm the general picture implied by the results to date, models of language which treat lexis and grammar as independent entities must be relegated to the status of *handy tools for linguists' thinking* as opposed to *genuine characterisations of how language actually works in the real human brain*. This in turn suggests that a specifically lexicogrammatical framework must become a *sine qua non* of research into the operation of language system.

Conversely, the requirement in neurophysiological experiment design for the phenomenon under study to be defined with extreme precision may have a salutary effect on how we theorise about lexicogrammar. It will become necessary, we may predict, for the field to be much more precise about many aspects of these network models – such as the precise definition of what may or may not be a node in the network (just words?); how transitions other than direct-adjacency actually work; the differences between production and perception; implications of the network model for methodological issues in corpus-based analysis such as selection of collocation statistic(s); the differences between transitions within fixed versus semi-fixed formulae; and the possibility of reconciling a model of transitions within a network with the almost axiomatic notion of the linguistic *choice* in a substantial fraction of *all* linguistic research on language-in-use, including stylistics, text linguistics, and discourse analysis. However, while we *will* present our speculations on these major issues, we should underline that despite significant progress to date, much, much more remains to be done in this area of research.

References

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Bios

Jennifer Hughes is a Postdoctoral Fellow at the ESRC Centre for Corpus Approaches to Social Science, Lancaster University. Her main research interest is the application of neuroimaging techniques to collocation and other corpus phenomena. She completed her PhD in 2018, entitled *The Psychological Validity of Collocation: Evidence from Event-Related Brain Potentials*.

Andrew Hardie is Reader in Linguistics at Lancaster University. His main research interests are the methodology of corpus linguistics; the descriptive and theoretical study of grammar using corpus data; the languages of Asia; and applications of corpus methods in the humanities and social sciences. He is one of the lead developers of the *Corpus Workbench* analysis software, and the creator of its online interface, CQPweb. He is co-author, with Tony McEnery, of the book *Corpus Linguistics: Method, Theory and Practice* (2012).