

# Architectures, representations and processes of language production

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We present an overview of recent research conducted in the field of language production based on papers presented at the first edition of the *International Workshop on Language Production* (Marseille, France, September 2004). This article comprises two main parts. In the first part, consisting of three sections, we review the articles that are included in this Special Issue. These three sections deal with three different topics of general interest for models of language production: (A) the general organisational principles of the language production system, (B) several aspects of the lexical selection

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process and (C) the representations and processes used during syntactic encoding. In the second part, we discuss future directions for research in the field of language production, given the considerable developments that have occurred in recent years.

For many years, language production has been the least prominent member of the 'psycholinguistic trinity' (language comprehension, language acquisition, and language production). To be sure, some research threads within the field have a long history. Research of aphasic deficits in the ability to speak (or write, or both) can be traced back to early studies such as those conducted by Paul Broca (Broca, 1861). Other investigations of deviant performance (in normal speakers) led to the construction of early models of speech production based on speech errors (most prominently by Vicki Fromkin and Merrill Garrett: Fromkin, 1971; Garrett, 1975; see also Dell, 1986). In fact, for many years insights on the processes of language production came almost exclusively from investigations into these deviations from normal performance. However, experimental approaches developed during the 1980s. It is largely because of the publication in 1989 of Willem Levelt's seminal book (*Speaking*, Levelt, 1989) that the field of language production has become a theoretically and methodologically broad area of interdisciplinary investigation. The product of such research activities has been the development of theories and models informed by varied techniques, covering the whole range of cognitive processes required for producing language, from determining (pre-verbal) messages to be expressed, to retrieving words, to configuring them in sequences according to the rules of language, and finally to producing them in speech, sign, or print (e.g., Caramazza, 1997; Dell, 1986; Levelt, 1989; Levelt, Roelofs, & Meyer, 1999).

The articles presented in this special issue stem from talks presented at the *International Workshop on Language Production*, organised by the Laboratoire de Psychologie Cognitive (UMR 6146 CNRS and Université de Provence) in Marseille (France) in September 2004. This workshop was the first of a series of annual meetings. The conferences bring together researchers who specialise on different topics within the field of language production, who work in different disciplines and with different methodologies. Accordingly, the articles presented in this special issue of *Language and Cognitive Processes* cover a broad range of topics. They are organised into three sections: (A) the structure of the language production system, (B) lexical representations and their selection, and (C) syntactic processing. In the following, we provide a brief introduction to each of these areas. We then provide some discussion of possible directions that the investigation of language production might take from where it stands now, and of important issues that are not addressed in this Special Issue.

## THE STRUCTURE OF THE LANGUAGE PRODUCTION SYSTEM

The first series of articles deals with general issues about the structure of the language production system. The articles by Vigliocco and Kita (2006) and by Goldrick (2006) present different approaches and models addressing the issue of information propagation in the language production system. Vigliocco and Kita review a series of experiments that exploit cross-linguistic differences among Turkish, Japanese, and English to explore the links between the different levels of representation that are postulated in the system. For example, the authors discuss influences of language-specific lexicalisation patterns (Lehrer & Kittay, 1992) on conceptually driven gesture production (McNeill, 1992). They interpret these findings as evidence of information feedback between the lexical and conceptual levels.

In a complementary approach, Goldrick (2006) reviews studies and experiments conducted in a variety of languages (e.g., Dutch, German, Spanish, English). The goal of his review is to identify universal processes that characterise the propagation of activation in the speech production system, irrespective of the language being spoken. For example, Goldrick discusses in detail one widespread operationalisation of the issue of cascading activation in the lexical system: is there phonological activation and encoding for lexical items that are activated but not produced? Goldrick argues that results across experimental, neuropsychological, and computational studies suggest that activation in the lexical system proceeds interactively and he discusses in detail the quantitative aspects of this hypothesis (see Vigliocco & Hartsuiker, 2002, for similar conclusions; and see Levelt et al., 1999, for different conclusions).

Finally, Hartsuiker (2006) discusses an aspect of the architecture of language production which has received relatively less attention, namely the monitoring system – the processes by which language production is checked for accuracy and adequacy (Baars, Motley, & Mackay, 1975; Postma, 2000). His discussion directly relates to the two previous articles, because the monitoring system is often invoked as an alternative explanation of effects that appear to imply the existence of feedback within the production system (Levelt et al., 1999). Hartsuiker provides a thorough discussion about whether the monitor is a plausible theoretical construct to account for certain features of speech error patterns. He argues that the currently available evidence does not allow drawing strong conclusions on this issue, but his discussion clarifies the relationship between monitoring and the ‘central’ language production system.

## LEXICAL REPRESENTATIONS AND THEIR SELECTION

A second series of articles deals with how the message to be expressed is formed and how the corresponding word representations are selected. Nearly all models hypothesise that language production involves a mechanism that constructs a message and a mechanism that selects lexical representations appropriate for the message through some form of competitive process (for a discussion of alternative selection mechanisms, see Goldrick, in press). The articles by Kuipers, La Heij, and Costa (2006), Gumnior, Bólte, and Zwitserlood (2006), and Schiller and Caramazza (2006) are all empirical reports that address issues of lexical competition.

Kuipers et al. (2006) compare models that differ by the level – lexical or pre-lexical – at which they locate the competition process. To do so, they empirically examine various parameters that affect semantic facilitation or interference during word production tasks, including whether speakers name pictures at the basic or at the category level, whether they name pictures or translate words, or whether they name pictures with distractors presenting different types of semantic relationships. They discuss how their pattern of results constrains models of selection that include a conceptualisation stage in which the preverbal message is constructed. Their interpretation challenges a number of assumptions about lexical selection made on the basis of the popular picture-word interference paradigm (e.g., Roelofs, 1992; Costa, Alario, & Caramazza, 2005; Damian & Bowers, 2003).

Gumnior et al. (2006) used a translation task to investigate the representation of morphological information in the language production system. They report the intriguing finding that the semantic interference effect usually produced by distractor words is absent when morphologically complex distractors are used (in their study, German compound words). In fact, identical facilitation effects are reported for a given target (e.g., *Tasche*, ‘bag’) when transparent (e.g., *Handtasche*, ‘hand bag’) or opaque words (e.g., *Plaudertasche*, ‘chatterbox’) are used as distractors (see Dohmes, Zwitserlood, & Bolte, 2004, for similar findings in picture naming). The discussion of these findings provides valuable insights on the representation of morphological information in language production, a topic that has not been extensively investigated to this day (although see Allen & Badecker, 2000, for a review of neuropsychological studies, some of which describe deficits in morphological production).

Finally, Schiller and Caramazza (2006) report an investigation centered on the representation of grammatical gender in the lexical system. Grammatical gender is thought to be a property of lexical items (see

Corbett, 1991, for a linguistic discussion; and see Schriefers & Jescheniak, 1999, for a psycholinguistic discussion). Its investigation is informative about the processes of lexical selection, as well as about the processes of agreement that occur in contexts such as noun phrases (Schriefers, 1993). Schiller and Caramazza address two issues: the representation of grammatical gender for morphologically derived words (namely, Dutch diminutives), and the role played by this representation in the agreement-guided selection of other words in the noun phrase (namely, definite determiners). The authors interpret the results of two picture-word interference experiments as showing that the grammatical gender of base nouns is accessed automatically, without competition, when a derived word is accessed. By contrast, the selection of gender-marked determiner forms appears to be sensitive to interference effects and hence is presumably not automatic. This article extends previous findings bearing on the processes involved in noun phrase production and selection of determiner forms (for an overview, see for example Caramazza, Miozzo, Costa, Schiller, & Alario, 2001).

## SYNTACTIC PROCESSING

The last topic area includes two articles that report investigations of syntactic processing, on the basis of the well known phenomenon of syntactic priming. Syntactic priming (sometimes called structural priming or structural/syntactic persistence) refers to speakers' tendency to re-use recently experienced syntactic structures (Bock, 1986), and has provided one of the main ways to investigate the processes of syntactic encoding during sentence production. Articles by Branigan, Pickering, McLean, and Stewart (2006) and by Ferreira and Bock (2006) report investigations addressing different aspects of this phenomenon.

Branigan et al. (2006) investigate a linguistic property of the representations and processes involved in syntactic priming, namely whether these representations are sensitive to the hierarchical or recursive structure of language. They test the degree to which priming is sensitive (or not) to whether primed structures are embedded in longer sentences, in order to determine whether speakers use syntactic rules that are contextually specified or not. They report eight sentence-completion experiments (see Pickering & Branigan, 1998), which suggest that the representations primed in these experiments, which are thought to drive syntactic encoding, are not specified for context. This research contributes to our understanding of syntactic encoding by constraining the linguistic properties of the representations that it engages.

Ferreira and Bock (2006) review explanations of the functional basis of syntactic priming – what priming might be good for in everyday language

use (relatively independently of the specific representations or processes that are involved). They review several lines of evidence, including the performance of anterograde amnesic individuals. They conclude that syntactic priming primarily reflects an implicit learning mechanism responsible for learning to talk, but also that the repetition of linguistic features from utterance to utterance serves to promote successful communication.

## FUTURE AVENUES IN THE INVESTIGATION OF LANGUAGE PRODUCTION

Like all fields, research on language production operates by integrating past efforts with current innovations. This special issue represents well these traditions and future directions. In this context, we consider how the different research threads published in this volume represent perennial issues and future movements in the field.

We identify two issues of perennial importance to the field of language production, for which continued progress is imperative if we are to improve our understanding of the most fundamental aspects of linguistic and cognitive functioning. The first issue concerns the relationship between formal notions of linguistic structure and the psychological representations they correspond to (e.g., morphological structure, Gunnior et al., 2006; grammatical gender, Schiller & Caramazza, 2006; the context-free nature of syntactic knowledge, Branigan et al., 2006). Current research in language production makes use of ever-more-finely tuned linguistic materials when addressing issues of representation and processing. This continues to be a critical avenue of research, as it promises to synthesise insights from two independent research threads – those from formal linguistics, and those from psycholinguistics. The second issue concerns the dynamics of information flow during processing. The field has moved beyond the original strong dichotomy between ‘modular’ and ‘interactive’ distinctions, and has begun to investigate more thoroughly the computational and formal benefits of different patterns of information flow (Goldrick, 2006). This development includes a more sophisticated understanding of speech monitoring, which can be seen as a functionally interactive influence on production (Hartsuiker, 2006).

Recent work on production is characterised by the integration of previously separate research themes. One type of integration is between the systems that underlie language-processing proper and the systems responsible for learning (Ferreira & Bock, 2006), gesture (Vigliocco & Kita, 2006), categorisation and response selection (Kuipers et al., 2006), memory maintenance and retrieval (Martin & Freedman, 2001; Martin, Miller, & Vu, 2004), and eye-movement control (e.g., Griffin & Bock,

2000; Meyer, Sleiderink, & Levelt, 1998). Such integration continues the strong tradition of situating psycholinguistic research within the frameworks of cognitive psychology and cognitive neuroscience. Another type of integration involves the study of different languages and linguistic populations, including many who speak more than one language. The current issue includes work conducted in Belgium, Germany, the Netherlands, Spain, France, the USA, and the UK. This work investigates speakers of Dutch, English, German, Spanish, Japanese, and Turkish. These cross-linguistic and multilingual methodologies provide a powerful source of variation to gain scientific insights; the field of production is at the forefront of such efforts (for a review see Costa, Alario, & Sebastian-Gallés, *in press*). A third type of integration comes from a stronger recognition of the communicative functions of language production, bringing the domains of pragmatics and social psychology (among others) into contact with psycholinguistics. This is emphasised most in the current work by Hartsuiker's (2006) investigations of monitoring and Ferreira and Bock's (2006) review of structural priming: Monitoring is explicitly about determining the communicative efficacy of an utterance, and Ferreira and Bock discuss the influential alignment framework (Pickering & Garrod, 2004) that portrays structural priming as functioning to coordinate communicated meaning among interlocutors. Related research threads in production include increasing attention to pragmatics and language use (Clark, 1996; Schober & Brennan, 2003), and the possible tight relationship between production patterns and the distribution of information in the environment (a kind of Gibsonian approach to production; Brown-Schmidt & Tanenhaus, 2006).

The articles presented in this Special Issue are also representative of some of the 'biases' that have characterised the field of language production to this day. For example, almost every article in this issue deals with the production of speech, while other important modalities of language production such as the production of written language (spelling) or the production of sign language are not represented (although see Vigliocco & Kita, 2006, for an example of research using sign language to address general issues on language production). Some bias towards researching speech over writing and signing is not unreasonable; speech represents the primary means of linguistic communication, and spoken language users heavily outnumber sign language users. Nonetheless, psycholinguistic investigations should not overlook a valuable opportunity to gain fuller insights about language processing by exploiting these distinct linguistic modes. Interestingly, the bias towards speech is much less pronounced in aphasia research, where the investigation of written output deficits has provided a great number of insights (Tainturier & Rapp, 2001), from the description of mechanisms that are involved in spelling (e.g., the

graphemic buffer: Caramazza, Miceli, Villa, & Romani, 1987; Jonsdottir, Shallice, & Wise, 1996; Miceli & Capasso, 2006; Miceli, Silveri, & Caramazza, 1985; Tainturier & Rapp, 2004) to the study of modality-specific dissociations that are informative of the relationship between the speaking and writing systems (Alario & Cohen, 2004; Caramazza & Hillis, 1991; Miceli & Capasso, 1997). A full integration of speaking and writing models with the mechanisms of typical language production should be a high priority for the field (Bonin & Fayol, 2000; Cleland & Pickering, 2006; Hotopf, 1980; Kellog, 1988).

The study of the production of sign language is even more in its infancy than the study of writing. However, a strong programmatic effort investigating the neural and cognitive basis of sign-language production is acquiring increasing prominence, spearheaded by Karen Emmorey (Emmorey, 2002). Sign language production presents a valuable means of probing the nature of language representation and language production, including investigations of the modality dependence and the neural organisation of language, bilingualism (Emmorey et al., 2005; Thompson, Emmorey, & Gollan, 2005), and how atypical patterns of language exposure affect processing (Mayberry, Lock, & Kazmi, 2002).

Another major issue that is not represented in this Special Issue is the study of the neural basis of language production. Of course, the aphasic tradition and more recent studies have provided major insights about this (Kreisler et al., 2000). However, the use of electrophysiology and brain-imaging tools to inform language production models has been noticeably slower to develop than in other areas of psycholinguistic research, such as visual or auditory language perception. This delay could be due to methodological considerations. In principle, producing speech requires movement of the articulators, a constraint that appears to impose limits on the measures of brain activity. However, this methodological consideration should not limit the research. First, it has been found that it is possible to record the activity of speaking brains without major loss of signal to noise ratio, when comparing overt and covert production situations (Barch, Sabb, Carter, Braver, Noll, & Cohen, 1999; Birn, Bandettini, Cox, & Shaker, 1999; Rosen, Ojemann, Ollinger, & Petersen, 2000). Also, alternative production situations that avoid articulation have been used. For example, participants are sometimes asked to provide manual responses based on lexical access induced by pictures or other non-verbal stimuli or to produce verbal responses in a delayed fashion, etc. (e.g., Jescheniak, Schriefers, Garrett, & Friederici, 2002; van Turennout, Hagoort, & Brown, 1998). Furthermore, the area of language production can benefit greatly from a number of investigations whose main purpose was not the investigation of language production per se, but that used tasks recruiting some or all of the stages of language production (Indefrey &

Levelt, 2004). In recent years, investigations aimed directly at addressing the neural correlates of language production have become more and more common. Importantly, these investigations cover a wide range of language production processes: from syntactic processing (e.g., Heim, Opitz, & Friederici, 2002; Indefrey et al., 2001) to lexical selection (e.g., Damasio, Grabowski, Tranel, Hichwa, & Damasio, 1996; Maess, Friederici, Damian, Meyer, & Levelt, 2002) and issues of phonological encoding and articulation (e.g., Alario, Chainay, Lehericy, & Cohen, 2006; Riecker et al., 2000). Clearly, the integration and development of the existing research on spelling and signing, as well as the neurophysiology of producing language are central topics for the years to come.

## CONCLUSIONS

In closing, we note that the field of language production promises valuable and unprecedented insights into both the structure and the processing of linguistic systems more broadly. These insights stem from a number of features specific to production. First, to know a language is to speak it; this implies that real understanding of language acquisition and the nature of linguistic competence more generally must necessarily account for how we produce linguistic forms. Second, language comprehension of course takes as its subject of investigation exactly the products of language production; increasingly, theories of comprehension will need to account for how production works to explain how comprehension works. Finally, language production permits near-direct observation of the products of a language-processing system: What speakers say is necessarily a result of the operations of their production mechanisms, whereas how comprehenders press buttons, answer questions, or move their eyes only indirectly results from how they understand language. Investigations of language processing that exploit these features that are inherent to production will necessarily advance the field. Our aim with this special issue is to promote that advancement.

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