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## INTRODUCTION

### Cross-linguistic psycholinguistics and its critical role in theory development: early beginnings and recent advances

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Recent years have seen a small but growing body of psycholinguistic research focused on typologically diverse languages. This represents an important development for the field, where theorising is still largely guided by the often implicit assumption of universality. This paper introduces a special issue of *Language, Cognition and Neuroscience* devoted to the topic of cross-linguistic and field-based approaches to the study of psycholinguistics. The papers in this issue draw on data from a variety of genetically and areally divergent languages, to address questions in the production and comprehension of phonology, morphology, words, and sentences. To contextualise these studies, we provide an overview of the field of cross-linguistic psycholinguistics, from its early beginnings to the present day, highlighting instances where cross-linguistic data have significantly contributed to psycholinguistic theorising.

**Keywords:** Cross-linguistic psycholinguistics; field-based psycholinguistics; language production; language comprehension; linguistic typology

In an article on the “Future Directions” of psycholinguistics, published in the first edition of *The Handbook of Psycholinguistics* in 1994, Alan Garnham wrote that:

like linguists before them, psycholinguists have gradually come to realize that, if they are to make universal claims, in this case about language processing mechanisms, they should not restrict themselves to the study of English. However, although there has been a growing number of cross-linguistic studies in all the domains of psycholinguistics, the full potential of such studies remains to be exploited. (1994, p. 1137; see also Hawkins, 2007)

Twenty years later, the cross-linguistic scope of language processing research has widened, but still falls far short of what is required to test the assumption of universality that underlies many psycholinguistic theories. While an important body of research now exists, and continues to grow, on languages other than English, the vast majority of these studies is based on a very small sample of the world’s languages, primarily Germanic and Romance, to a lesser extent Finnish, Hebrew, Chinese, Korean, and Japanese. For sentence production research, for example, a recent survey found that the predominant psycholinguistic accounts draw on data from – by the most generous of counts – about 0.6% of the world’s languages (Jaeger & Norcliffe, 2009), mostly from branches of the Indo-European language family.

Why does it matter that there are still huge gaps in our cross-linguistic coverage of psycholinguistic research? In the psychological and cognitive sciences more generally, there is an increasing recognition that generalisations based on data from a very thin slice of the human population (most typically, American or European undergraduate students) may not be applicable at the level of the species as a whole (Henrich, Heine, & Norenzayan, 2010). If the goal is to delineate the bounds of psychological universality, broader subject pools must therefore be tapped (see e.g. Kuperman & Van Dyke, 2011). For the language sciences in particular, the extent of linguistic diversity documented by field linguists serves as a pressing reminder that psycholinguistic theories are currently being evaluated against a typologically narrow empirical base (Evans & Levinson, 2009). Accordingly, the answers to some of the central questions in the field of psycholinguistics continue to lie beyond reach: what are the *universal* processing mechanisms that are general to the architecture of the human language processing system? To what extent, conversely, are language processing mechanisms “fine-tuned” to the language one speaks, exerting an influence on how that language is parsed and produced? It is by no means yet evident how we are to reconcile the remarkable diversity of human languages with the shared cognitive and neural bases that must presumably underlie speaking and understanding them.

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What is exciting, however, is that this picture is changing. Recent years have seen a small but growing body of psycholinguistic work focused on typologically diverse languages (for reviews, see e.g. Bornkessel-Schlesewsky & Schlesewsky, 2013; Hawkins, 2007, 2014; Jaeger & Norcliffe, 2009).<sup>1</sup> We are therefore excited to have the opportunity to introduce this special issue of *Language, Cognition and Neuroscience*, which showcases the important contributions such research can make to psycholinguistics. To contextualise these studies, we provide an overview of the field of cross-linguistic psycholinguistics, from its early beginnings to the present day, highlighting instances where theoretical debates have been affected by cross-linguistic data.

We begin in Section 2 with a brief historical survey of comparative/cross-linguistic studies of the psychology of language, turning first to the role that comparative language data have played in the study of child language acquisition. While developmental psycholinguistics is not the focus of this special issue, it serves as a useful departure point: by comparison with adult language processing, language acquisition research has had a sustained focus on typologically diverse languages practically since its genesis as a discipline. We then turn to adult language processing and consider how cross-linguistic perspectives have been adopted (or overlooked) across the decades. In Section 3 we present two case studies that demonstrate how cross-linguistic data have affected psycholinguistic theorising in recent years. The first focuses on syntactic complexity and comprehension difficulty, the second on incremental sentence production. In Section 4 we provide an overview of the papers featured in this special issue, highlighting their contributions to this rapidly growing field. We conclude in Section 5 with a brief discussion of the practical challenges of conducting field-based psycholinguistics.

### 1. A very brief history of comparative/cross-linguistic studies of the psychology of language

The birth of modern psycholinguistics is often dated to the 1950s, though, as charted in detail by Levelt (2013), the various roots of the discipline may be traced much further back to at least the late eighteenth century. On the linguistic side, the discovery of the Indo-European language family in the late 1700s gave rise to a new interest in the origins of language and the psychological basis for its emergence. Separately, this period also saw the beginnings of the scientific study of language in the brain as well as early forays into child language acquisition. By the latter part of the nineteenth century, a fourth root had taken hold, in the form of experimental and speech error approaches to the study of adult language production and perception. The foundation of Wilhelm Wundt's psychological laboratory in Leipzig in 1879, led for the first

time to an interest in coordinating these hitherto disparate threads, culminating in Wundt's grand two volume synthesis *Die Sprache* ("Language"), which is often regarded as marking the emergence of the psychology of language as a new science. Of these threads, it is the study of child language acquisition that has engaged most fully and directly with typologically diverse language data, throughout its evolution as a discipline.

#### 1.1. Child language acquisition

Language development first came to be studied in the late nineteenth century through the practice of diary keeping. By the turn of the century, researchers were collecting diary data from an impressive variety of languages, including Algonquian, Arabic, English, French, German, Hungarian, Iroquois, Italian, Polish, Russian, Spanish, as well as sign languages (see Levelt, 2013 for an overview). The general approach to cross-linguistic research during this period is captured by Clara and Wilhelm Stern in *Die Kindersprache* (1907; quoted in Slobin, 1985: 3):

Child language study can be more than the analysis of individual instances of language development, because it is possible to formulate laws of formation that are operative in every child language. This commonality is even international; therefore we will not need to limit our evidence solely to German children.

In other words, the value of studying various languages was to demonstrate commonalities, and data from any language could be taken to reflect general patterns.

In the twentieth century, acquisition research began to grapple with cross-linguistic data in new ways. Already by the turn of the century, we can find early speculations about the possibility that the particular properties of the language being learned could affect the learning process. Elemér Kenyeres (1927)'s work on the acquisition of Hungarian led him to conclude, for example, that:

The grammatical forms of different languages differ much with respect to the ease of their realization, as well as to their value, their use and their frequency. The appearance of such forms will therefore not necessarily coincide for two children at the same stage of development, but speaking different languages. (Levelt, 2013, p. 330)

As Levelt observes, this idea anticipates by some five decades the modern cross-linguistic approach to language acquisition, discussed in more detail below.

The systematic study of child language development began in earnest in the 1960s. This work was galvanised by Chomsky's searing critique of Behaviourism, with its notion that language learning involved little more than memorisation and surface generalisations. Chomsky argued instead that language learning requires internalising the set of abstract rules underlying sentence structure, and that this process is only made possible by inborn

knowledge of linguistic universals. In the wake of these proposals, the goal of child language studies became to uncover the universal features that defined the human capacity for language learning. Based on research largely on the acquisition of English and a limited number of other languages, hypotheses began to be formulated about possibly universal aspects of early child grammars (e.g. Slobin, 1968, 1970). However, further engagement with cross-linguistic data demonstrated the difficulty of coming up with tenable hypotheses. For example, one hypothesis held that children begin with a “rigid word order” (a fixed order of subject, object and verb, regardless of the nature of word order in the input language). Research on Finnish, however, a flexible word order language, found that Finnish children adopt the flexible word order at the outset (Aksu-Koç & Slobin, 1985; Bowerman, 1973).

As cross-linguistic research failed to uncover the set of early syntactic invariants (see Levelt, 1975 for discussion), some researchers began to look elsewhere for universals of language development. Dan Slobin, one of the pioneers of modern cross-linguistic language acquisition research, used language acquisition data from around 40 languages in order to try to uncover the general cognitive/perceptual tendencies that might underlie language learning. This approach led him to formulate a set of general OPERATING PRINCIPLES for language learning, arrived at inductively by comparing a diverse set of acquisition phenomena (e.g. “pay attention to the ends of words” – children learn post-positions more easily than prepositions; “pay attention to the order of words and morphemes” – children make very few ordering errors). The Operational Principles (OP) approach guided the development of the ambitious Berkeley Four-Language project, which investigated the acquisition of morphosyntax in four typologically divergent languages, English, Italian, Serbo-Croatian, and Turkish, using comparable child language data (Ammon & Slobin, 1979; Johnston & Slobin, 1979; Slobin & Bever, 1982). This, together with other seminal cross-linguistic work of the period (e.g. Bowerman, 1973; MacWhinney & Bates, 1978) yielded a number of important insights that would have been impossible to arrive at in the absence of language comparisons, for example, that children can learn to express grammatical relations equally well via case marking or word order (Slobin & Bever, 1982), or that fusional morphology (as found in Serbo-Croatian) is harder to acquire than agglutinative morphology (as found in Turkish; Slobin, 1977).

Slobin’s Operational Principles approach piqued an interest in cross-linguistic research among developmental psycholinguists worldwide, in the process generating a lot of important new work and theorising. Much of this was published in the 1980s and 1990s in the impressive five volume work *The Cross-Linguistic Study of Language Acquisition* (Slobin (Ed.) 1985–1997) which featured child language acquisition studies in over thirty languages,

spanning over twelve families and five continents. Developmental psycholinguistics has sustained its focus on cross-linguistic research since this period<sup>2</sup> (for recent surveys, see Berman, 2014; Bowerman, 2011; Stoll, 2009; Stoll & Lieven, 2014). While the Operational Principles approach is no longer actively employed (see Bowerman, 1985 for critical discussion), many of its empirical findings still stand.

It is notable that work in this area has vastly outpaced that of adult language processing. As we discuss below, research on adult language processing in the 1960s and 1970s saw little engagement with cross-linguistic data (for a notable exception, see MacWhinney & Bates, 1978). Contrast this with the strongly empiricist character of developmental psycholinguistics (at least within the OP and related frameworks), during that period and since, whose guiding principle could be summarised as follows (Bowerman, 2011, p. 598):

universals are not what you start out with as hypotheses to support deduction and hypothesis testing; rather, they are what you hope to end up with after careful analysis of data from a suitably large and diverse number of languages.

From the outset, language acquisition research has been far more oriented towards the development of methods for comparative data collection than its sister discipline, and towards the construction of substantial cross-linguistic databases (e.g. CHILDES). It has grappled with a much broader typological slice of languages and has covered a range of linguistic phenomena that have been barely or not at all yet addressed in adult processing research, for example, evidentiality (Aksu & Slobin, 1986; Fitneer & Matsui, 2009 and papers therein; Papafragou, Li, Choi & Han, 2007), ergativity (Allen, 1996; Bavin, 1992; Bavin & Stoll, 2013; Fortescue & Olsen, 1992; Imidadze & Tuite, 1992; Narasimhan, 2005; Ochs, 1982; Pye, 1990, 1992; Slobin, 1985, 1992; Van Valin, 1992), and serial verb constructions (Fung, 2011; Lee & Naigles, 2005).

## 1.2. *Adult language processing*

While cross-language research has been routine in developmental psycholinguistics for some decades, it has, until recently at least, rather been the exception in adult psycholinguistic research. Rewinding to the nineteenth century once more, we find little in the way of dedicated cross-linguistic work. Where it does make an appearance, it is mostly in contexts where the emerging discipline was rubbing shoulders with linguistics. For example, linguistics during this period witnessed an increasing interest in the comparative study of “exotic” languages (e.g. Bantu, Mayan, Finno-Ugric, Yeniseian, Turkic, Mongolian, Tungusic, families of the Caucasus, Semitic, Hamitic, Basque, Dravidian, and others; see Bleek, 1851; Law, 2013; Pedersen, 1962/1931). As nineteenth century



linguists began to document the grammars of non-Indo-European languages, scholars also came to consider for the first time the possible relationship between language “type” and biological and mental evolution. This resulted in the formulation of the now discredited ‘verticalist’ perspective on language, according to which there existed a natural hierarchy of languages (from isolating, to agglutinative to inflectional; e.g., Humboldt, 1963; Steinthal, 1871, 1881), Wundt also subscribed to the verticalist view (though he rejected the notion that languages evolve along a simple three-rung hierarchy), regarding different language types as reflecting different psychological evolutionary states in the minds of speakers. For Wundt, their comparative study was therefore a means of studying the laws of psychological development (Wundt, 1920; see discussion in Levelt, 2013).<sup>3</sup>

By the early twentieth century, verticalist perspectives had given way to a newly evolving horizontal perspective, espoused especially by American linguists and anthropologists (e.g., Franz Boas, Leonard Bloomfield, Edward Sapir and Benjamin Lee Whorf), according to which all languages were considered to be fully developed complex systems for the communication of thought. In this context, cross-linguistic differences now became interesting because of the proposed relationship between language and conceptual/perceptual experience. Sapir, and especially his student Whorf are associated with the theory of LINGUISTIC RELATIVITY, the hypothesis that the language one speaks affects, or even determines, the way one views the world. Initially, linguistic relativity was associated with anthropological research, but it also came to make an impact on the emerging cognitive psychology of the 1950s, finding a place on the agenda of the 1951 *Interdisciplinary Summer Seminar in Psychology and Linguistics*, an event that is widely regarded as kindling the birth of modern psycholinguistics (Levelt, 2013). One outcome of the seminar was the *Southwest Project in Comparative Psycholinguistics*, directed by John Carroll, which focused on testing the Whorf hypothesis through the cross-linguistic experimental study of speakers of various indigenous languages of the American Southwest (see Casagrande, 1960). This work is significant in the history of modern psycholinguistics in representing some of the earliest controlled experimental studies on indigenous languages.

With the rise of transformational generative grammar in linguistics in the late 1950s, the focus predominantly shifted to uncovering the universal aspects of language and cognition,<sup>4</sup> as Chomskyan linguistic theorising came to set the research agenda for psycholinguistic research. For most of the 1960s, empirical research in psycholinguistics was largely devoted to deriving the processing predictions of the grammatical models being developed. By the early 1970s, the domination of Chomskyan theorising on psycholinguistic research had waned as psycholinguistics

oriented itself more and more towards cognitive psychology. Nevertheless, the assumption of psycholinguistic universalism continued to remain largely unquestioned during this period (see Cutler, 2009). Indeed, it is possible to detect a kind of “language blindness” in some psycholinguistic studies in the 1970s: given that the basic goal was an account of the universal processing system, the specific language in which an experiment happened to be carried out was often regarded as inconsequential for the question under study. Cutler (1985, 2009) observes that during this time it was possible for an experiment carried out in one language to be followed up by an experiment in another language, without any discussion of the possible role of language differences. Cutler gives the example of the debate on “units of perception” (the units into which listeners initially segment speech; more on this below), in which empirical data were drawn from experiments conducted variously on English (Foss & Swinney, 1973; Healy & Cutting, 1976; Savin & Bever, 1970), French (e.g. Segui, Frauenfelder, & Mehler, 1981), and Portuguese (e.g. Morais, Cary, Algeria, & Bertelson, 1979), without the language under study being considered a relevant factor.

Possibly, the decoupling of psycholinguistics from linguistic theorising ultimately contributed to the lack of interest in cross-language research during this period. It is, at any rate, striking that the blossoming field of linguistic typology (e.g. Greenberg, 1963; Keenan & Comrie, 1977; Li & Thompson, 1976) did not foster much in the way of cross-linguistic psycholinguistic research at this time. Whatever the reason, although considerable advances were made in the modelling of language processing mechanisms since the 1960s, these advances were initially largely based on English and closely related languages – at least in the journals that were available in English and thus influencing theory development at the core of the discipline at that time.

Only in the 1980s did empirical investigations of adult language processing begin to systematically extend to other languages. By the mid-1980s, cross-linguistic oriented psycholinguistics had even developed to the point where it was possible to write a survey article on the topic; Anne Cutler’s overview, which appeared in 1985, refers to a contemporary “renaissance of cross-language psycholinguistics”, and documents a number of developments in the field, including a revival of interest in the linguistic relativity hypothesis, cross-linguistic approaches to research on reading, the question of universality vs. language-specificity of phonological rules governing word order preferences in fixed phrases, and comparative research on relative clause processing in English and French.

One area of study where cross-linguistic data began to have a particularly strong impact during this time was speech perception, as researchers discovered that certain critical typological differences affected processing routines (Cutler, Mehler, Norris, & Segui, 1983, 1986, 1989; Mehler

et al., 1993; Mehler, Dupoux, Nazzi, & Dehaene-Lambertz, 1996). Mehler, Domergues, Frauenfelder, and Segui (1981) had found evidence that French speakers segment speech into syllabic units prior to lexical access (in a syllable detection task, listeners responded faster when the target corresponded to the first syllable of the stimulus word, compared to segments that were longer or shorter than the first syllable). Crucially, however, Cutler et al. (1983) did not find such a syllable advantage effect for speakers of English. These cross-linguistic differences led Cutler, Mehler, Norris, and Segui (1986) to propose that speech is processed differently by speakers of languages with different rhythmic properties. Where a language has clear syllabic boundaries (as in French), listeners segment speech using a syllabic representation. For stress languages (like English), such a representation is not used. In short, this seminal work led to the idea that different processing routines may be used by speakers of different languages.

In the latter half of the 1980s, newly discovered cross-linguistic differences also came to have a profound effect on theorising in sentence comprehension research. Bever's (1970) discussion of temporarily ambiguous reduced relative clause constructions (such as the now famous sentence *The horse raced past the barn fell*) had helped to "spawn an entire subfield, sentence processing" (Sanz, Laka, & Tanenhaus, 2013, p. 85) by calling attention to syntactic ambiguity as a means of investigating information integration during comprehension. Subsequently, a series of models was developed to account for processing preferences during the resolution of syntactic ambiguities. The earliest models proposed universal parsing principles that prioritised syntax over semantics during initial processing of ambiguous sentences (e.g. Frazier's GARDEN PATH THEORY (1979, 1985, 1987; see also Frazier & Rayner, 1982). In 1988, Cuetos and Mitchell questioned the universality of the parser when they showed that speakers of Spanish and English differed in their processing routines. They investigated an attachment ambiguity, in which a relative clause can be attached to either of two preceding nouns (e.g. *psychiatrist* or *actress* in the sentence *The woman looked at the psychiatrist of the actress who was having a cup of coffee*). Cuetos and Mitchell found that speakers of English prefer to interpret the relative clause as modifying the second "low" noun phrase (*the actress*), whereas Spanish speakers prefer the interpretation in which the relative clause modifies the first "high" noun phrase (*the psychiatrist*).

This striking finding generated an interest in the possibility of cross-linguistic variation in parsing, and has led to the sustained investigation of ambiguities of this kind in a variety of languages ever since<sup>5</sup> as well as to the development of a number of theories of ambiguity resolution (and, more generally, models of parsing) that have differed according to how they handle the existence of cross-linguistic differences. While UNIVERSALIST models of

parsing (e.g. Abney, 1989; Crocker, 1996; Frazier & Clifton, 1996, 1997; Grillo & Costa, 2014; Weinberg, 1999) have continued to posit that the sentence processor is guided by universal process-generated principles, PARAMETERISED models (e.g. Gibson, Pearlmutter, Canseco-Gonzalez, & Hickok, 1996; Hawkins, 1994, 2004; Hemforth, Konieczny, Scheepers, & Strube, 1998; Mazuka & Lust, 1990) assume that parsing strategies vary across languages in accordance with specific grammatical properties. EXPERIENCE-BASED models (e.g. Cuetos & Mitchell, 1988; MacDonald, 1994; MacDonald, Pearlmutter, & Seidenberg, 1994; Mitchell & Brysbaert, 1998; Mitchell, Cuetos, Corley, & Brysbaert, 1995; Spivey-Knowlton, Trueswell, & Tanenhaus, 1993; Spivey-Knowlton & Sedivy, 1995; Trueswell, Tanenhaus, & Garnsey, 1994) assume that processing is statistically driven, and attachment preferences are determined by the frequency with which ambiguities have been resolved a certain way in the past. Thus, like parameterised models, these models assume language dependence, but due to cross-linguistic differences in the nature of prior linguistic exposure. We do not review the vast literature on these ongoing theoretical debates here, but rather emphasise the more general historical point that the marshalling of cross-linguistic data in the study of ambiguity resolution marked a pivotal shift in the theoretical discourse: parsing universals were no longer taken as an unquestioned theoretical assumption, but rather as a hypothesis to test empirically on the basis of cross-linguistic data.

Cross-linguistically oriented psycholinguistics received another boost in the 1980s, with the development of Bates and MacWhinney's COMPETITION MODEL (Bates & MacWhinney, 1982, 1987, 1989; see also Bates, McNew, MacWhinney, Devescovi, & Smith, 1982). The Competition Model is a predecessor to later experience-based accounts, incorporating many of their central ideas in a functionalist, interactive model of language learning and processing (Elman, Hare, & McRae, 2004; MacDonald & Seidenberg, 2006). According to the Competition Model, language is learned and processed probabilistically by means of competing "cues" that are weighed as a function of their effectiveness in prior comprehension events. Importantly, the model incorporated the idea that languages differ with respect to the relative "validity" of different cues, based on their availability and reliability (e.g. inflectional morphology vs. word order vs. intonation patterns, cf. MacWhinney, 1987, 2005). Quite uniquely for the period, it relied heavily on experimental data from typologically diverse languages. The collected volume *The Crosslinguistic Study of Sentence Processing* (edited by MacWhinney and Bates, 1989), featured a number of empirical studies of learning and processing within the framework of the Competition Model, covering data from French, Spanish, Hebrew, Hungarian, Warlpiri, English, Italian, German, and Japanese. While much of this work focused on first and second language acquisition, the

competition model also inspired cross-linguistic studies on language processing (e.g. McDonald & Heilenman, 1991; Sokolov, 1988; Taman, 1993).

Since the 1980s, cross-linguistic oriented research on language comprehension has continued to have an important place on the research agenda. Bornkessel-Schlesewsky and colleagues's work in the domain of "neurotypology" is an excellent example of a recent psycholinguistic research program with an explicitly cross-linguistic focus; see e.g., Bornkessel & Schlewsky, 2006, 2009; Bornkessel-Schlesewsky & Schlewsky, 2013; Bornkessel-Schlesewsky et al., 2011). For general reviews covering various theoretical and methodological approaches see Bates, Devescovi, & Wulfeck, 2001; Bornkessel & Schlewsky, 2006; Bornkessel-Schlesewsky & Schlewsky, 2009; Bornkessel-Schlesewsky et al., 2011; Lago, 2014; Thornton, MacDonald, & Gil, 1999. Perhaps inevitably, production research has lagged behind comprehension research in this regard. One reason for this is likely that, as a field of investigation, language production is relatively younger than its sister discipline. Another reason is to be found in the cost of language research: the collection and annotation of production data tends to be more time consuming than the collection of comprehension data to begin with and limited familiarity with the language of study tends to super-additively affect these efforts. With the flourishing of language production research in the 1990s and later, cross-linguistic data began to be of sustained relevance in theorising here too (see in particular, Hawkins, 1994, 2004), and has been brought to bear on many, if not all of the major areas of study, including phonetic and phonological encoding, lexical retrieval processes, sentence and message formulation (for reviews see Costa, Alario, & Sebastián-Gallés, 2007; Hawkins, 2007, 2014; Jaeger & Buz, accepted for publication; Jaeger & Norcliffe, 2009; Norcliffe & Konopka, 2015).

## 2. The relevance of cross-linguistic data for theorising: two case studies

Our brief tour through the history of psycholinguistics has provided us with a few examples of how cross-linguistic data can inform psycholinguistic theory development. More generally, we see two equally important ways in which cross-linguistic research is critically necessary in advancing our field (for discussion, see also Costa et al., 2007): (1) by empirical testing postulated general (universal) properties of processing (see, for instance, the research on relative clause attachment, summarised above) and (2) by pointing to gaps in our theoretical coverage and exploring unknown territory. For example, cross-linguistic variation can help disentangle the effect of multiple linguistic properties that are correlated in previously studied languages (cf. Hawkins, 2004, 2007 for discussion). Cross-linguistic research can also take advantage of

language-specific properties that make it possible to adjudicate between theories that cannot be contrasted in previously studied languages – simply because the relevant environment does not exist in those languages. Even if tests are possible on previously studied languages, cross-linguistic evidence can provide critical independent evidence. For example, whereas research on agreement processing in languages like English had to heavily rely on data from agreement *errors* – thereby being limited to studying the system at its breaking point – languages with optional plural marking (e.g. Yucatec Maya) provide alternative means of studying the same questions (Bohnemeyer, Butler, & Jaeger, in press; Butler, Bohnemeyer, & Jaeger, 2014). Cross-linguistic data can also contribute to theory development by providing instances of linguistic phenomena that lie beyond the explicit purview of current theories – for example, it is unclear how existing theories of sentence processing extend to languages with high degrees of morphological incorporation. To illustrate the potential value of cross-linguistic research, we now discuss in some more depth two examples of theoretical debates that have been strongly affected (not necessarily resolved) by cross-linguistic data.

### 2.1. Syntactic complexity and comprehension difficulty

It has been well documented that differential processing costs may arise from the comprehension of structures that are syntactically complex. Cross-linguistic data have been crucial for informing our understanding of this domain of sentence comprehension as well as generating new sets of theoretical questions.

Relative clauses (RCs) are a prime example of a syntactically complex structure and have played a prominent role in studies of syntactic complexity. One of the most studied aspects relates to processing asymmetries between subject-extracted and object-extracted transitive relative clauses, as in (1) below.

- (1a) The guest who pushed the waiter fled the restaurant (subject-extracted RC)
- (1b) The guest who the waiter pushed fled the restaurant (object-extracted RC)

It was in fact linguistic typologists who first drew attention to the possibility that such structures may be associated with different processing costs.<sup>6</sup> In their seminal typological study of relative clause formation, Keenan and Comrie (1977) showed that across languages, certain limitations apply to the syntactic positions that may be relativised on. The general pattern they discovered is referred to as the "Accessibility Hierarchy", an implicational scale of grammatical positions which places subjects higher than direct objects, and direct objects higher than indirect

objects and obliques. According to the hierarchy, if a language can relativise lower positions on the hierarchy, it can also relativise noun phrases at all positions higher on the hierarchy, but not vice-versa. Keenan and Comrie speculated that the Accessibility Hierarchy may have its roots in differential processing costs associated with different types of relative clauses, and therefore that subject relative clause may be universally easier to process than object relative clauses. In keeping with Keenan and Comrie's original proposal, a number of subsequent studies of English have found object-extracted RCs to be more difficult than subject-extracted RCs (Ford, 1983; Grodner & Gibson, 2005; Gordon, Hendrick, & Johnson, 2001; Keenan & Hawkins, 1987; King & Just, 1991; Traxler, Morris, & Seely, 2002; Wanner & Maratsos, 1978, *inter alia*).

Broadly, three classes of theories have been developed to account for this processing asymmetry. PHRASE STRUCTURE<sup>7</sup> theories explain the subject advantage in terms of syntactic factors, positing that subject RCs should be universally easier to process due to the higher structural position of the subject RC's extraction site, which is argued to make it more accessible than object positions (Lin & Bever, 2006; O'Grady, 1997). MEMORY-BASED theories instead rely on cognitive factors such as cognitive resources or integration constraints. According to these theories, longer dependencies are more costly on working memory, with cost defined either in terms of the burden of maintaining unintegrated dependents in short-term memory (Gibson, 1998; Grodner & Gibson, 2005; Wanner & Maratsos, 1978) or of retrieving dependents at the point where they must be integrated into the dependency (Gibson, 2000; Gordon, Hendrick, & Johnson, 2004; Lewis, Vasishth, & Van Dyke, 2006, *inter alia*; see also Hawkins, 1994, 2004, 2014). Memory-based theories predict that the processing of object RCs will be more costly than subject RCs in English because the distance between the head of the RC and the point where the dependency is resolved is shorter for subject RCs than for object RCs.<sup>8</sup> According to EXPECTATION-BASED theories, the key factor influencing processing difficulty is not memory but rather experience and/or generalisation (making them a type of experience-based theory): the more experience speakers have with a given structure, or the more easily they can infer its likelihood given their linguistic and world knowledge, the easier that structure will be to comprehend. A number of theories fall broadly under this rubric, including WORD ORDER FREQUENCY theories (Bever, 1970; MacDonald & Christiansen, 2002), which hold that surface word orders which are more frequent will be processed more easily and SURPRISAL theories (Hale, 2001; Levy, 2008) according to which the difficulty of processing some input decreases monotonically as the conditional probability of that input increases. For word

order frequency theories, the greater facility with which subject RCs are comprehended follows from their surface word order: Subject–Verb–Object (SVO) word order is much more frequent in English than the Object–Subject–Verb word order of object RCs. For surprisal theories, subject RCs are predicted to be easier than object RCs in English because (for transitive RCs whose head noun and embedded noun are both full, definite noun phrases), subject RCs are more probable than object RCs (Reali & Christiansen, 2007; Roland, Dick, & Elman, 2007), resulting in greater overall surprisal for object RCs.

All three sets of theories are, broadly, able to account for the subject/object processing asymmetry attested in English.<sup>9</sup> Their predictions diverge, however, with respect to relative clause processing difficulty in other languages. Cross-linguistic data thus have been crucial for adjudicating between the different theories. Phrase structure theories predict that subject RCs will always be processed more easily than object RCs, regardless of the language. By contrast, neither memory-based, nor expectation-based theories predict a universal processing advantage for subject relative clauses. For memory-based theories, the predicted direction of the processing asymmetry will differ depending on language-specific structural properties (e.g. the distance between the RC head and the relativiser and/or extraction site). For expectation-based theories, language-specific frequency distributions – rather than structural properties – determine the predicted relative difficulty of different kinds of RCs.

For example, one important cross-linguistic data point is offered by the typological contrast between pre-nominal and post-nominal relative clauses. In post-nominal relative clauses, the relative clause follows the head noun that it modifies, as is the case in relative clause constructions in English (see (1) above). Thus the “filler” (the head of the relative clause) precedes the “gap” (the extraction site) in such constructions. In pre-nominal relative clauses, where the relative clause precedes the head noun, the gap precedes the filler. This is shown in the Mandarin Chinese example in (2) below:

- (2) [RC \_\_\_<sub>i</sub> gōngjī yìyuán]-de jìzhě<sub>i</sub> chéngrén-le  
 attack senator-ADN reporter admit-PERF  
 cuòwù  
 error  
 The reporter who attacked the senator  
 admitted the error  
 (Kwon, Kluender, Kutas, & Polinsky, 2013, p. 33).

While phrase structure theories predict a processing advantage for subject RCs regardless of the relative clause type, memory-based theories predict that the direction of the processing asymmetry will depend on the position of the RC relative to the head noun. In the case of post-nominal RCs, the distance between the filler and the



gap is longer for object RCs than for subject RCs (compare the arrow lengths in (3a) and (3b); similar differences are seen in tree structures), leading to a predicted processing advantage for subject RCs. In languages with pre-nominal relative clauses, where the gap precedes its filler, dependency distance is calculated with respect to the point at which a missing argument is detected. This leads to a predicted processing advantage for object relative clauses. In Mandarin Chinese, for example, which has a basic SVO word order, the absence of a subject will first be detectable at the sentence initial verb (4a), while the absence of an object will be detectable at the clitic *-de* (which in RCs, marks the end of the RC) following the verb (4b).

- (3a) English post-nominal subject relative clause with filler-gap ordering

FILLER<-----> GAP

The reporter<sub>i</sub> [<sub>RC</sub> who \_\_\_<sub>i</sub> attacked the senator] admitted the error

- (3b) English post-nominal object relative clause with filler-gap ordering

FILLER<----->GAP

The reporter<sub>i</sub> [<sub>RC</sub> who the senator attacked \_\_\_<sub>i</sub>] admitted the error

- (4a) Chinese pre-nominal subject relative clause with gap-filler ordering

GAP <-----> FILLER

[<sub>RC</sub> \_\_\_<sub>i</sub> gōngjī yìyuán]-de jìzhě<sub>i</sub> chénggrén-le  
attack senator-ADN reporter admit-PERF

cuòwù  
error

- (4b) Chinese pre-nominal object relative clause with gap-filler ordering

GAP <-> FILLER

[<sub>RC</sub> yìyuán gōngjī \_\_\_<sub>i</sub>]-de jìzhě<sub>i</sub> chénggrén-le  
senator attack -ADN reporter admit-PERF

cuòwù  
error

Studies have confirmed the subject RC advantage for a number of post-nominal RC languages, consistent with the predictions of both phrase structure and memory-based theories. This includes data from Brazilian Portuguese (Gouvea, Phillips, & Poeppel, 2002), Dutch (Frazier, 1987; Mak, Vonk, & Schriefers, 2006), English (Ford, 1983; Gibson, Desmet, Grodner, Watson, & Ko, 2005; King & Just, 1991; King & Kutas, 1995; Traxler et al., 2002), French (Cohen & Mehler, 1996; Frauenfelder, Segui, & Mehler, 1980; Holmes & O'Regan, 1981), and German (Mecklinger, Schriefers, Steinhauer, & Friederici, 1995; Schriefers, Friederici, & Kuhn, 1995). For pre-nominal RC languages, however, the picture is more mixed. Some studies of Korean and Japanese, for example, have reported a subject processing advantage

(Kanno & Nakamura, 2001; Kwon, 2008; Kwon, Kluender, Kutas, & Polinsky, 2010; Kwon et al., 2013; Ishizuka, Nakatani, & Gibson, 2003; Miyamoto & Nakamura, 2003; Ueno & Garnsey, 2008), consistent with the predictions of phrase structure theories. On the other hand, research on Basque (Carreiras, Dunabeitia, Vergara, De La Cruz-Pavia, & Laka, 2010), as well as some (but not all) studies of Chinese have reported an object RC processing advantage (Chen, Ning, Bi, & Dunlap, 2008; Gibson & Wu, 2013; Hsiao & Gibson, 2003; Jäger, Chen, Li, Lin, & Vasishth, 2015; Lin & Garnsey, 2007; Qiao, Shen, & Forster, 2012, but see Lin & Bever, 2006, Vasishth, Chen, Li, & Guo, 2013), consistent with the predictions of memory-based theories (see also Özge, Marinis, & Zeyrek, 2015, for discussion). The fact that cross-linguistic evidence does not unilaterally point to a subject RC processing advantage calls into question phrase structure theories, which, on theoretical grounds, predict this processing advantage to be universal. However, the fact that not all evidence supports the predictions of memory-based theories also suggests that this class of theories cannot single-handedly account for the cross-linguistic facts either.

Where memory-based theories fall short, it has been observed that expectation-based theories often fare better. For example, the fact that a subject processing advantage has been consistently found in pre-nominal relative clauses in Korean is in keeping with the predictions of expectation-based theories, given that in Korean, as in English, corpus studies have shown subject relative clauses to be more frequent than object relative clauses (Kwon, 2008). Expectation-based theories can also account for the finding (predicted by neither phrase structure nor memory-based theories), that English object relative clauses in fact become easier to comprehend than subject relative clauses when the embedded noun is pronominal (e.g. *the barber that you admired*): this is consistent with the fact that pronominal object relative clauses with embedded pronominal noun phrases are more frequent than pronominal subject relatives with embedded pronominal noun phrases in English corpora (Real & Christiansen, 2007). On the other hand, expectation-based theories do not predict the finding of some studies of Chinese that object relatives are easier than subject relatives, given the lower frequency of object relative clauses (where head and embedded noun are both full, definite noun phrases).

How can such a mixed pattern of results be accounted for? As cross-linguistic coverage increases, it is becoming apparent that unitary accounts of processing difficulty are probably insufficient for capturing the empirical facts (cf. discussions in Boston, Hale, Vasishth, & Kliegl, 2011; Levy, Fedorenko, & Gibson, 2013; Levy & Gibson, 2013). This is a hard-won and important insight in a field with a strong bias towards simple, monocausal explanations. Supporting this possibility, some studies have

found evidence conforming to both memory-based and expectation-based predictions within the same language. Studies of German (Levy & Keller, 2013) and Russian (Levy et al., 2013), for example, have found both locality effects (where greater distances between arguments and heads increases processing difficulty) and so-called “anti-locality” effects, where greater dependency distances in fact facilitate processing. The former are predicted by memory-based theories, while the latter are predicted by expectation-based theories, as the context provided by more intervening material can strengthen the expectation of an upcoming word or structure (Grodner & Gibson, 2005; Konieczny, 2000; Levy, 2008; for alternative explanations within a more recent generation of memory-based accounts, see Lewis et al., 2006; Vasishth & Lewis, 2006).

Interestingly, there is also some evidence that different language *types* may more closely conform to the predictions of one or the other theory. Research to date suggests, for example, that verb-medial languages such as English tend to exhibit locality effects (consistent with memory-based theories), whereas verb-final languages such as Japanese, Hindi, or German tend to exhibit anti-locality effects (consistent with expectation-based theories; see, e.g. Konieczny, 1996, 2000; Konieczny & Döring, 2003; Nakatani & Gibson, 2008, Vasishth & Lewis, 2006). While there are some exceptions to this generalisation,<sup>10</sup> as Levy et al. (2013) observe, the possibility of this type of language dependency opens up new sets of research questions: which linguistic properties might determine particular patterns of processing difficulty (in keeping with the predictions of one or other theory)? More fundamentally, how might these kinds of language dependencies be accounted for? In other words, rather than using comparative language data as evidence for a single universal processing mechanism, the question now becomes: how do different kinds of language structures interface with postulated mechanisms?

Recently, the typological coverage of research on syntactic complexity and processing cost has extended to include ergative languages, a language type that has traditionally received little attention in the adult processing literature (Carreiras et al., 2010 for Basque; Polinsky, Gallo Gómez, Graff, & Kravtchenko, 2012 for Avar (Nakh-Dagestanian) and Clemens et al., 2015 for Ch’ol and Q’anjobal (Mayan); see also Bickel, Witzlack-Makarevich, Choudhary, Schlesewsky, & Bornkessel-Schlesewsky (2015) for a recent comprehension study of ergativity in simple clauses in Hindi). In ergative languages, subjects of intransitive verbs and objects of transitive verbs are morphologically indicated in the same way (receiving “absolutive” marking, often indicated by the absence of overt marking), and distinctly from subjects of transitive verbs (ergative marking). Investigating whether ergative languages also exhibit a subject RC advantage provides another perspective on the theoretical debates discussed above, though here, given the relative

paucity of studies so far, an entirely consistent pattern of results has not yet emerged. We briefly summarise these studies, as they serve to make a perhaps unwelcome but important point: even when cross-linguistic data sometimes *complicate* the picture, it is crucial for our field to face these data.

In a set of studies on Basque, a verb-final language with pre-nominal relative clauses, Carreiras et al. (2010) found a processing advantage for object relative clauses compared to transitive subject relatives. While this finding is consistent with memory-based theories, given that the object gap is temporally/linearly closer to its antecedent in the target structures, Carreiras et al. suggest an alternative possibility, namely that processing difficulty could correlate with morphological markedness: in Basque, ergative subjects are morphologically case-marked, while absolutive subjects/objects are unmarked. The authors speculate that what has previously been taken as evidence for a universal subject advantage, may actually be due to morphological markedness: only in ergative languages can the effects of morphological case marking and phrase structure prominence on parsing be studied independently and hence reveal these effects (in nominative-accusative languages all subjects are marked the same way). This serves as an example of hypothesis generation that arguably was facilitated by the language-specific properties of Basque, in contrast to previously studied languages.

Polinsky et al. (2012) suggest a different way in which morphological case patterns could affect processing difficulty in ergative languages. They explored the effects of ergative case marking on relative clause processing in Avar, which, like Basque, is a verb-final language with pre-nominal relative clauses. They compared the processing of object relative clauses (i.e. clauses with a gapped absolutive object), transitive subject relative clauses (clauses with a gapped ergative subject) and intransitive subject relative clauses (clauses with a gapped absolutive subject) and found a processing advantage for absolutive subject gaps over both ergative subject gaps and absolutive object gaps. Unlike the Basque results, they found no difference between ergative subject gaps and absolutive object gaps. Polinsky et al. suggest that this pattern of results reflects the combined effects of two distinct processing preferences, one morphologically based and the other syntactically based. First, in object relative clauses, the existence of an ergative case-marked subject in the relative clause serves as a strong cue to the downstream existence of an object gap (ergative subjects only occur in transitive clauses, and so therefore indicate the presence of an object). This morphological cue makes the parsing of object relative clauses easier, because the gap is predictable (this would be consistent with the predictions of expectation-based theories). On the other hand, a subject preference is also operative in Avar, which facilitates the processing of both intransitive and transitive subject

relative clauses. The two processing preferences cancel each other out in the case of transitive subject and object relative clauses, yielding the result that neither is parsed more easily than the other.

While further work will be necessary to reconcile the mixed pattern of results found in the Basque and Avar studies, taken together, they serve to reinforce the idea that language-specific properties (in this case, morphological alignment types) might have differential effects on processing difficulty. This point is further emphasised in Clemens et al. (2015) study of relative clause processing in Q'anjob'al and Ch'ol, two ergative Mayan languages in which ergative marking is expressed not by case markers, but rather by person-marking morphemes attached to the verb. This language type is referred to as "head marking" (grammatical relations are marked on the verb), rather than "dependent marking" (grammatical relations are marked on noun phrases). Clemens et al. found evidence for a subject processing advantage in both Ch'ol and Q'anjob'al, and, unlike Avar, no evidence of a cueing effect associated with the ergative agreement marker. Consequently, they conclude that dependent marking is a stronger morphological cue for parsing than head marking. In sum, this work raises the interesting possibility that different morphological expressions of ergativity may have different parsing consequences.

Overall, the body of cross-linguistic work in this area of sentence comprehension research has substantially advanced our understanding of syntactic complexity and processing. As observed by Levy et al. (2013), the patterns found in the data so far undoubtedly result from a combination of universal cognitive capacities and their interaction with language-specific properties. Expanding the typological scope of work in this area will be necessary to elucidate how these aspects interface with one another.

## 2.2. Incrementality and the time-course of sentence formulation

It is generally agreed that sentence formulation is an incremental process: speakers do not typically plan their entire utterance in advance before beginning to speak. Instead, presumably to maintain fluency, and ease memory load, sentence planning unfolds piece by piece (Ferreira & Swets, 2002; Kempen & Hoenkamp, 1987; Levelt, 1989). As soon as one piece of information becomes available at one level of processing, it is shunted on for processing at the next level in the system, from *conceptual* (or "message") formulation (the first stage of the production process), through to *linguistic encoding* (the second stage in the process, in which words are retrieved and integrated into a syntactic structure), and onwards to phonological encoding, in preparation for articulation.

While incrementality itself is not disputed as a general principle of production, there is less agreement with respect

to exactly *how* incremental the process is. What scope of planning do speakers use when preparing to speak? Data from typologically different languages have helped to inform this area of language production research (see also Hawkins, 2007). They have been relevant not only as a means of theory testing, but also, more recently, are being increasingly used to tackle the question of language specificity, that is, whether sentence formulation processes may be dependent on the language being spoken.

The question of planning scope is often addressed by studying how speakers begin their utterances (the question of *starting points*; Bock, Irwin, & Davidson, 2004; MacWhinney, 1977). This body of research has given rise to two different classes of theories of incrementality. WORD-DRIVEN (or "linear") INCREMENTALITY assumes that formulation begins with the lexical encoding of the most available concept in the message. On this view, the first increment planned before speech onset may be as small as a single word. Whichever word is retrieved first will then constrain the possible structural continuations of the sentence. STRUCTURE-DRIVEN INCREMENTALITY, by contrast, assumes that formulation begins by generating an abstract representation of the relational structure of the message as a whole (who did what to whom), which allows for the selection of a suitable structural sentence frame. The structure that is selected then guides the order in which words are retrieved. While purely word-driven incrementality is compatible with theories that assume that lexical items play a key role in the construction of sentences (Bock, 1982; Kempen & Hoenkamp, 1987; Levelt, 1989), purely structure-driven incrementality is consistent with theories that assume that structure-building and lexical operations are independent processes (Bock, 1990; Chang, Dell, & Bock, 2006; Christianson & Ferreira, 2005; Dell, 1986; Fisher, 2002; Konopka & Bock, 2009; Konopka & Meyer, 2014; Kuchinsky & Bock, 2010).

One important line of evidence that has been drawn on when discussing word and structure-based views comes from the role of accessibility on production choices (see Butler, Bohnemeyer, & Jaeger, 2015; Jaeger & Norcliffe, 2009, for cross-linguistic reviews). In recent years, visual world eye-tracking paradigms have also been employed to shed light on the nature of incremental sentence production by providing a fine-grained picture of the actual *time-course* of formulation. Eye-tracking methods complement standard approaches based on off-line measures such as structure choice because they yield a detailed measure of how utterance planning takes place in real time.

For English, some eye-tracking work lends support to word-driven incrementality. In an eye-tracked picture description task in which the perceptual salience of characters in the scenes was manipulated by means of a (subliminal) attentional cue, Gleitman, January, Nappa, and Trueswell (2007) found that speakers of English tended to fixate the cued character within 200 ms of picture onset, and then

preferred to start their sentence by mentioning this character first. Effects of this kind are compatible with linear incrementality, as they suggest a “greedy” process in which the most available concept (in this case, the most perceptually accessible) is the first to undergo lexically encoding. Other eye-tracking evidence has been interpreted as supporting the structure-driven view, however. Griffin and Bock (2000) found that it took English speakers around 400ms to preferentially fixate the character that they would mention first when describing depicted events. This relatively long initial time window, the authors suggest, is evidence that speakers start by generating a structural plan for the sentence, which guides their eyes to the referents in the order called for by that structure (see also Bock et al., 2004).

How are these conflicting interpretations to be accounted for? An increasing amount of evidence suggests that, (for English, at least), each of these possibilities may sometimes be correct, because the time-course of formulation is *flexible*: under different conditions, speakers may plan more or less information up front. Evidence from English (Kuchinsky, 2009; Kuchinsky & Bock, 2010) and Dutch (Konopka & Meyer, 2014; Van Velde, Meyer, & Konopka, 2014), for example, suggests that the relative ease of formulating a message plan can influence whether speakers choose to start with words or structures, the latter being more likely when the relational content of the message is easy to conceptualise (see also Bock & Ferreira, 2014 for discussion). Beyond conceptual processes, various extra-linguistic factors have been implicated in variability in planning scope in English, including differences in cognitive load (Wagner, Jescheniak, & Schiefers, 2010), time pressure (Ferreira & Swets, 2002) and working memory capacity (Swets, Jacovina, & Gerrig, 2014). Taken together, this body of work suggests that the time-course of sentence formulation is not rigid, and thus that there is no unitary strategy that speakers rely on when planning their utterances.

These within-language findings have theoretical implications for the nature of formulation processes *across* languages: if within-language evidence points to the existence of multiple formulation strategies, to what extent might reliance on different planning strategies be driven by the grammar of the language being spoken (see also Norcliffe & Konopka, 2015 for discussion)? As we summarise next, a small but growing body of research on sentence production in typologically diverse languages is starting to address this question.

While evidence suggests that, under different conditions, speakers of English and Dutch may adopt either word- or structure-driven formulation strategies, the grammars of other types of languages appear to impose more constraints on how sentence formulation may proceed. Evidence for this comes from eye-tracked attentional cueing studies. In a task modelled on Gleitman et al. (2007), Myachykov, Garrod, and Scheepers (2010) compared the effects of attentional cueing on structure choice in

English and Finnish. While in English, speakers were more likely to begin their sentence by mentioning the cued referent first (replicating Gleitman et al.’s earlier results), the authors failed to find any effect of attentional cueing in Finnish: although the attentional cue was successful in drawing speakers gaze to the cued referent, speakers consistently produced transitive SVO sentences, regardless of whether the agent or the patient in the scene was cued. Similarly, in a study comparing Korean and English, Hwang and Kaiser (2015) found that neither priming patient characters with semantic prime words (to enhance their conceptual accessibility) nor employing visual cues (to enhance their perceptual accessibility) had any influence on structure choice in Korean, while both did in English. Thus, while several eye-tracked attentional cueing studies support the idea that English speakers can adopt a word-driven formulation strategy, this tendency does not generalise to other languages using the same experimental task.

What kinds of linguistic properties could explain the divergent behaviour of Korean and Finnish by comparison with English? Myachykov et al. (2010) attribute the absence of attentional cueing effects on production choices in Finnish to the relative unavailability of passive structures in the language. Arguably, the strong structural bias towards active sentence structures in Finnish attenuates any reliance on word-driven formulation, instead inducing structural guidance during formulation. Further empirical support for this possibility comes from Slavic languages, where accessibility effects on structure choice (e.g. active vs. passive structures), while present, are reduced by comparison with English (see Gennari, Mirković, & MacDonald, 2012 for Serbian; Myachykov & Tomlin, 2008 for Russian). In Serbian and Russian (as in Finnish) passive structures are very rarely attested in corpora (Gennari et al., 2012; Myachykov, Thompson, Scheepers, & Garrod, 2011). Thus, cross-linguistic differences in production strategies may emerge from differences in how strongly specific structures are favoured in a given language (see MacDonald, 2013 for further discussion).

Alternatively, Hwang and Kaiser (2015) attribute the absence of cueing effects in Korean to the combination of its flexible word ordering and its case marking properties (Finnish and Russian, notably, are also case-marking languages with flexible word order). Because sentence-initial nouns in Korean can be either subjects or objects (with case markers indicating grammatical functions), adopting a word-driven formulation strategy implies that speakers are faced with a choice between alternative grammatical function assignments/alternative syntactic structures. Hwang and Kaiser suggest that if speakers experience competition between different structural options, word-driven formulation should be disfavoured in Korean, as it will hinder utterance formulation. In English, by contrast, because there is a stricter relationship between word order and grammatical function, and hence



no competition between structural alternatives, adopting a word-driven strategy can facilitate formulation, as it allows for the early assignment of the subject function to the first-selected noun lemma.

While further work will be necessary to tease these two sets of explanations apart, these examples serve to demonstrate how research on sentence production in typologically different languages has resulted in the development of new hypotheses relating to the connection between language-specific properties and sentence formulation processes. Recently, this line of research has been extended to a language type that has previously received little attention in sentence production research: verb-initial languages. Verb-initial languages offer an interesting test case for studying the effects of grammar on sentence formulation. In order to select a suitable sentence initial verb, information about the relational structure of the event presumably must be planned early, possibly earlier than in subject-initial languages. Comparing sentence formulation in the two language types offers a way of assessing the extent to which word order may influence message and sentence-level planning processes (Norcliffe, Konopka, Brown, & Levinson, 2015). Verbs in verb-initial languages also often have (rich) agreement morphology specifying information about their arguments, which occur only later in the sentence. Morphological dependencies of this scope are interesting for theories of incremental production, because they imply that speakers must engage in fairly extensive planning at the outset of planning. Sauppe, Norcliffe, Konopka, Van Valin, and Levinson (2013) tested this possibility for Tagalog, a verb-initial language with a typologically rare system of verbal agreement. In Tagalog, verbs obligatorily agree with the semantic role of the argument that has a syntactic status roughly comparable to the “subject” function in languages like English. In an eye-tracked picture description task, Sauppe et al. found an early effect of this morphological dependency on fixation patterns: within 0–600ms after picture onset, speakers briefly fixated the character in the event that was referenced morphologically on the verb. The authors interpret this pattern of fixations as reflecting the early assignment of a grammatical function to an argument of the verb, in order to be able to select the appropriate agreement marking on the sentence-initial verb. Thus, given its complex verbal morphology, the early stages of sentence formulation in Tagalog appear to require advance grammatical planning.

In sum, there is evidence to suggest that the formulation processes involved in producing sentences are, to a certain degree, language-dependent: the way speakers prioritise the encoding of different types of information during utterance planning may differ from language to language, depending on their grammatical properties. While some grammars facilitate lexical guidance at the outset of formulation, others are more supportive of structure-driven processes. Just as in sentence comprehension research, an

important goal in future work will be to determine how exactly general production biases interact with language-dependent ones.

### 3. The papers in this issue

The increasing interest in cross-linguistic psycholinguistics is reflected in the number of submissions we received to this special issue. We received a total of 69 abstract submissions, of which 17 were invited to submit a paper after review. This issue contains 13 of these papers (18% of the original submissions), thereof 6 regular articles and 7 brief reports. We are deeply indebted to the reviewers that made this special issue possible, including almost 200 abstract reviews and reviews for the 17 invited submissions. As evidenced also in the acknowledgements of several papers in this issue, many of our reviewers generously went beyond what is usually expected, providing auxiliary analyses and helping authors bridge the often inter-disciplinary literatures relevant to the topics discussed in this issue. A complete list of all reviewers that decided to disclose their identity is available at the end of this issue.

The papers in this issue address a variety of questions in the production and comprehension of phonology, morphology, words, and sentences. We introduce these papers, starting with those that address phonological issues, working our way to those that address issues in syntactic production and processing.

**LaCross (2014)** presents **artificial language learning studies of non-local phonological dependencies by native speakers of English and Khalkha Mongolian**. Research on English and French speakers has found that participants in artificial language learning studies easily learn local phonological dependencies, but fail to learn non-local dependencies or do so only after prolonged or more informative exposure. This contrast has been taken to speak to prior learning biases that guide language acquisition. LaCross points out that these biases might not be universal, but rather originate in the learner’s native language. Previous artificial language learning experiments on non-local dependency learning had been conducted with native speakers of languages *without* such dependencies. As LaCross points out, however, there are languages that exhibit such dependencies. This leads her to compare learners of English and Khalkha Mongolian, which exhibits vowel harmony, a form of non-local dependency. Vowel harmony is a phenomenon in which the realisation of vowels in surrounding syllables is restricted to vowels that are similar in a particular dimension; vowel harmony is a non-local assimilation. Given the same amount of exposure, native speakers of Mongolian are able to learn non-local dependencies (of a type somewhat different from those in their native language), whereas speakers of American English fail to learn them. This points to

strong influence from the learner's native language during artificial language learning (for discussion, see also Fedzechkina, Newport, and Jaeger, accepted for publication) and relativises what can be concluded about the universality of the bias against non-local dependencies.

**Wiener and Ito (2014)** investigate **the role of tone in word recognition in three Chinese dialects**. The importance of suprasegmental information in word recognition varies by language, and it is believed that tones play a more significant role in tone languages than stress does in other languages. The tone system of Cantonese is more complex than that of Mandarin, while the tones in Shanghai Chinese are largely predictable on the basis of syllable structure. Mono-dialectal Mandarin speakers, bi-dialectal Shanghai-Mandarin speakers, and bi-dialectal Cantonese-Mandarin speakers all show comparable off-line mouse-click responses. Tones affect off-line recognition of infrequent words more than that of frequent words. However, in online eye-tracking, mono-dialectal Mandarin speakers are better able to make use of probabilities of association of a tone and a segmental syllable. The study suggests that knowledge of a more complex or less complex tonal system in L1 does not contribute significantly to accuracy of word recognition in L2.

In another contribution on prosody, **Turnbull, Burdin, Clopper and Tonhauser (2015)** investigate **the effects of contextual predictability on the prosodic realisation of focus** in two languages, **American English and Paraguayan Guaraní (a Tupí-Guaraní language)**. It has been widely observed that predictable linguistic forms are more likely to be reduced than unpredictable forms, a fact which is captured by information-based theories of language production, which predict an inverse relationship between linguistic form and contextual predictability (e.g. Aylett & Turk, 2004; Jaeger, 2010). Using an interactive speech production task, Turnbull et al. test whether prosodic prominence is weakened when the location of focus in noun phrases (i.e. whether the focus is on the noun or the adjective) is predictable from visual context. They find that in both languages, prosodic prominence is weakened when the location of focus in the noun phrase is predictable, broadly in keeping with the predictions of information-based theories. Interestingly, however, the languages differ in the precise location of these effects: in English, it is the focused element in the noun phrase that is realised with weaker prosodic cues when the location of focus is predictable, while in Guaraní, the prosodic prominence of the noun phrase overall is weakened when the location of focus is predictable. The authors conclude that the interaction between contextual predictability and focus marking is language-dependent, a possibility that is not explicitly predicted by current theories of form reduction in production (for a review, see Jaeger & Buz, accepted).

Moving from prosody to lexical processing, **Pham and Baayen (2015)** investigate the **visual processing of bi-**

**syllabic compound words in Vietnamese**. They find a novel inhibitory, anti-frequency effect on processing: response latencies are longer for compounds whose constituents are highly frequent and belong to large morphological families. Pham and Baayen show that these effects are predicted by a Naive Discrimination Learning model of lexical processing trained on Vietnamese words. These results are striking given that the same learning model, when trained on English, predicts facilitation under the same conditions (as confirmed also in a number of prior empirical studies of English). Pham and Baayen suggest that the cross-linguistic difference resides in the distributional properties of the lexicons of Vietnamese and English. Specifically, Vietnamese compounds are created by recycling a small set of "syllabemes". This functional overloading causes difficulty in discriminating between the meanings of the constituent syllabemes and the meaning of the compounds as a whole. Another striking contribution of this paper is that one of its studies employs a *single* participant, providing **20,000 data points** (including processing data for all compounds in the language; a replication of the core findings with 33 participants is provided). Pham and Baayen suggest that such large-scale single participant studies have particular advantages, for example, for the study of languages with few speakers.

Another four papers in the current issue investigate the processing of morphologically complex words, focusing on derivation (rather than compound) morphology. **Ussishkin, Dawson, Wedel, and Schluter (2015)** draw on a unique property of **Maltese**, allowing them to **distinguish contributions of orthography from those of morphology to auditory lexical priming**. The unique root-and-pattern word structure of Semitic languages has made them an important empirical domain in research on morphological processing. Essentially, words are composed of non-continuous consonant sequences (roots) embedded in a fixed prosodic structure with vowels interspersed (patterns). This makes it possible to disentangle phonological and morphological influences in, for instance, priming paradigms. However, the writing systems of Semitic languages emphasise the root-and-pattern structure (e.g. vowels are often not written), making it impossible to distinguish effects of orthography and morphology. Maltese provides a way around this problem: it is the only Semitic language written in the Roman alphabet. Ussishkin et al. employ auditory priming paradigms to test root-and-pattern priming. They find only root (not pattern) priming. This confirms the cross-linguistic importance of the morphological root in lexical access.

A closely related issue is the role of root access in the processing of complex words that contain them. Research on this issue in Indo-European languages is confounded by the fact that what morphological relationships usually are confounded by form overlap (e.g. *near* – *nearness*). **Kgolo and Eisenbeiss (2015)** take advantage of a

phonological and orthographic property of **Setswana, a Bantu language widely spoken in southern Africa**, which allows them to **distinguish contributions of phonology or orthography from those of morphology**. While some roots can be found in the same form in their derivatives (as in the English example above), some Setswana noun classes use consonant mutation (e.g. *pits-o* “a call/meeting” from *bits-a* “to call, convene”), thus disrupting the form overlap between the root and the complex word derived from it. The authors find that complex words in which consonant mutation obscures the form overlap prime their root just as strongly as complex words without consonant mutations. This shows that morphology, even under reduced form overlap, plays a role in processing.

**Caballero and Kapatsinski (2014)** investigate the **processing of one kind of morphological redundancy, multiple exponence, in Rarámuri, a Uto-Aztecan language of Mexico**. Linguists have long observed that language is highly redundant, providing multiple cues to many parts of meaning. Multiple exponence is the marking of a feature more than once in a word. In their experiment, aural stimuli are partially hidden by “pink” noise. In Rarámuri, the markers of the causative and of the applicative may optionally be doubled, and the issue is whether double marking enhances the identifiability of the word in less than optimal conditions. The authors find that in the presence of noise, subjects do identify words more accurately with doubled marking. The functionality revealed by multiple exponence in this experiment provides a potential reason for why morphological redundancy may endure in a language.

**Lipski (2014)** explores **transfer in more or less bilingual speakers of Spanish and Palenquero, a Spanish-based creole spoken in Colombia that lacks the gender agreement that characterises Spanish**. Lipski compares three groups of bilingual speakers: L1-Palenquero L2-Spanish speakers, heritage Palenquero speakers, and L1-Spanish L2-Palenquero school-trained speakers. He finds that school-trained L2 speakers produce utterances with gender agreement in Palenquero much of the time in the way it would be used in Spanish. They frequently add gender in Palenquero in repetition tasks, and accept many Palenquero examples that erroneously have gender agreement. In contrast, traditional speakers make no production errors that would introduce gender, correct many of the erroneous examples containing gender, and find many instances of gender agreement ungrammatical. A third group, heritage speakers, are like traditional speakers in making no production errors, but they pattern closer to school-trained L2 speakers in terms of correcting gender agreement errors and in grammaticality judgements. These types of data illustrate a complex continuum of Spanish influences on Palenquero speakers with different degrees of exposure to both languages.

Another three papers in the current issue focus on sentence production. Most previous work on sentence production has focused on languages in which the encoding of sentence-level grammatical information (such as grammatical functions, agreement, etc.) is mostly carried by word order (see Jaeger & Norcliffe, 2009). To the extent that languages with morphologically richer grammatical systems have been investigated, these have typically been dependent-marking languages with relatively impoverished morpho-syntactic marking on the verb (e.g. German, Japanese, and Korean). All three papers on sentence production in this issue share a focus on languages with rich morphology on the verb.

**Ros, Santesteban Fukumura, and Laka (2014)** investigate the role of **grammatical weight (or “phrasal length”) in constituent ordering preferences in Basque**. Basque has a number of properties that make it an interesting comparison to previously studied languages. First, it has rich agreement morphology on the verb, which contains information about the verb’s arguments. This is particularly interesting as Basque also has case-marking. Second, although it is an Object-Verb (OV) language (resembling, e.g. Japanese and Korean), unlike previously studied languages of this type, it allows arguments to be realised post-verbally. Ros et al. draw on these properties to contrast the predictions of competing accounts of sentence production. They focus, in particular, on Hawkins’s proposal that speakers prefer constituent orders that minimise dependency lengths (Hawkins, 1994, 2004). In support of Hawkins’ proposal, Ros et al. find a strong long-before-short ordering preference. This finding extends results from experiments and corpus studies on other OV languages, and calls into question whether the short-before-long ordering in Verb-Object (VO) languages stems from a universal preference to order “available” material first (e.g. Arnold, Wasow, Losongco, & Ginstrom, 2000; Arnold, Wasow, Asudeh, & Alrenga, 2004; Wasow, 1997). Ros et al. also find the length-based ordering preferences seem to interact with the position of the verb in the sentence (which in Basque, unlike in Japanese or Korean, is somewhat flexible). They attribute this to the information that Basque verb morphology carries about its arguments. Their results thus provide a critical piece of evidence in understanding the factors that contribute to speakers’ production preferences.

Another investigation into Basque sentence production is provided by **Santesteban, Pickering, Laka and Branigan (2015)**. These authors draw on another property of **Basque** that distinguishes it from most previously studied languages: rather than having nominative-accusative case, Basque has ergative-absolutive case. In four spoken sentence production experiments, Santesteban et al. investigate **the types of information that structural priming is sensitive to**. In doing so, they test whether findings previously obtained for SVO languages extend to SOV

languages with ergative-absolutive case systems. They confirm, for example, that structural priming is observed in the latter type of language and that its magnitude increases when the verb is repeated between the prime and target sentence. This provides evidence that the verb plays a crucial role in the planning of sentences, even in SOV languages. Santesteban et al. further find that the repetition of the subject's case-marking between the prime and target sentences (mono-argumental intransitive sentences with absolutive or ergative case-marked subjects were used as primes) does *not* modulate the magnitude of structural priming, suggesting that case-marker selection is independent of constituent structure processing.

In an eye-tracked picture description study, **Norcliffe, Konopka, Brown, and Levinson (2015)** investigate the effects of word order variations on the time-course of sentence formulation in Dutch and Tzeltal, a Mayan language spoken in southern Mexico. Tzeltal, like Basque, is a language with complex verbal agreement morphology, which encodes information about both verbal arguments. Additionally, its basic word order is Verb-Object-Subject (VOS), a rare word order type that is only found in around 5% of the world's languages. The language also optionally permits SVO word order. This variability allows a within-language contrast of how sentence formulation might vary as a consequence of the linear position of subjects and (morphologically rich) verbs. Fixation patterns indicate that from the earliest time windows, verb placement has strong effects on formulation: when preparing to produce subject-initial sentences, Dutch and Tzeltal speakers prioritise the encoding of referent-specific information (pertaining to the first-to-be-mentioned noun); when preparing to produce verb-initial sentences, Tzeltal speakers prioritise the encoding of relational information (pertaining to the sentence initial verb). These results demonstrate that, from a very early stage of formulation, the word order that is under production strongly influences how speakers construct their sentences online. Given such tight parallels between fixation patterns and linguistic structure, Norcliffe *et al* conclude that there may be no strict temporal separation between processes related to conceptualisation and those related to linguistic formulation (contrary to standard assumptions of informational encapsulation of message formation from linguistic formulation, see e.g. Levelt, 1989).

The final two papers in the current issue focus on topics in sentence comprehension. **Yasunaga, Yano, Yasugi, and Koizumi (2015)** present an ERP study that investigates the universality of word order preferences against another Mayan language, **Kaqchikel, spoken in Guatemala**. Kaqchikel's basic or canonical word order is generally assumed to be VOS, though VSO and SVO orders are also grammatical. The authors draw on this word order flexibility to test whether the preference for subject-object word orders that

has been observed in other languages extends to a language where subjects canonically come last. They observe a P600 for SVO and VSO sentences compared to VOS sentences, which they interpret as evidence that VOS word order incurs a lower processing cost compared to the other word orders. This is particularly striking given that SVO, although being syntactically less basic, is in fact the most frequently produced word order in Kaqchikel. Koizumi et al. conclude that there is no universal preference during comprehension for subject before object structures; rather, the syntactic features of individual languages have differential effects on processing costs.

**Özge, Marinis, and Zeyrek (2015)** investigate the processing of relative clauses. As discussed above, this is a literature with relatively extensive, though sometimes conflicting, cross-linguistic coverage. Most of this research has focused on the acquisition of post-nominal relatives. Özge et al. investigate the **acquisition and adult online comprehension of pre-nominal relatives in Turkish**. Özge et al. set out to determine whether subject or object relatives are *consistently* harder to learn or process. Their findings suggest that, neither for children nor for adults, are subject or object relatives systematically harder to process. Rather the two clause types lead to differences in *where* processing difficulty occurs. Özge et al. interpret the results as inconsistent with PHRASE STRUCTURE accounts ("filler-gap" accounts). They suggest that many cues contribute to the processing of pre-nominal relative clauses in Turkish, in both children and adults.

#### 4. Conclusion and looking forward

The papers in this issue provide further evidence that cross-linguistic research on language production and comprehension can critically advance psycholinguistic theory building and empirical coverage. Of particular importance is research on languages with understudied structural properties and properties that allow psycholinguistics to distinguish between theories that are difficult or impossible to distinguish with data from previously studied languages.

This has several important consequences for our field. First, research on languages other than those best understood psycholinguistically typically *requires additional time and money*. Sometimes sufficient numbers of participants can only be obtained by moving the lab into the field (or at least out of the researcher's university; see Whalen & McDonough for 2015 for discussion). Sometimes cultural issues further slow down research (e.g. one might have to be introduced to community elders before one can set up shop). Additionally, some of the cheapest and easiest to use technologies (such as self-paced reading to study comprehension or picture-word interference paradigms to study production) cannot be used with



the target population (e.g. because there is no writing system for the language or because computers are not tolerated). Transcription and annotation might have to be conducted solely by one of the researchers because no research assistants who speak the target language are available. For psycholinguistic studies at field sites (i.e. away from labs), it might further be critical to have equipment that is portable (since it might have to be carried by the researcher over longer distances), durable (rain, heat) and powerable without an electricity source. This typically also comes with a higher price tag (including insurance in case of loss or theft of the equipment).

Second and relatedly, cross-linguistic research often requires *additional training*. The most obvious issue is that sufficient knowledge about the target language and culture is required. For psycholinguistics in the field, further training in preparation is required to deal with the large number of issues that can occur in field situations (e.g. cultural expectations, poisonous animals, diseases, etc.). This second issue weighs particularly heavily, as there are still very few departments in which student researchers have access to advisers with backgrounds in psycholinguistics, fieldwork, typology, as well as the specific target language.

In order to allow cross-linguistic research to advance research in psycholinguistics, it is important that these issues are recognised by readers, reviewers, editors, and funding agencies. For example, a graduate student who spends one year learning a new language, two visits of three months to familiarise herself with the dialect and culture at the field site, and another three to six months collecting data for two experiments, does not have the same amount of time to learn advanced statistics, read about psycholinguistics, and so on.

Beyond psycholinguistics, expanding the typological coverage of psycholinguistic research can inform our understanding of the proposed connection that is often drawn between processing and typological patterns (e.g. from functional typologists, e.g. Haspelmath, 2006, 2009; Hawkins, 1994, 2004, 2007, 2014; Sinnemäki, 2014, as well, more recently, from psycholinguistics and the cognitive sciences, e.g. Bornkessel-Schlesewsky, Choudhary, Witzlack-Makarevich, & Bickel, 2008; Christiansen & Chater, 2008; Jaeger & Tily, 2011; MacDonald, 2013; McDaniel, McKee, Cowart, & Garrett, 2015; see also Bever, 1970). Typology-processing links are often based on an implicit assumption that processing mechanisms are the same universally, though this of course remains to be empirically demonstrated (for encouraging progress, see, e.g. Bickel et al., 2015; Dediu & Ladd, 2007, Fedzechkina, Jaeger, & Newport, 2012; Fedzechkina, Newport, & Jaeger, submitted; Futrell, Mahowald, & Gibson 2015; Futrell, Mahowald, & Gibson, in press; Gildea & Temperley, 2010; Gildea & Jaeger, submitted, Graff & Jaeger, 2009; Piantadosi, Tily, & Gibon, 2011).

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## Notes

1. Growing interest in cross-linguistic psycholinguistics is also reflected in the increasing number of recent events dedicated to the topic. A panel held at the 2012 Annual Meeting of the Linguistic Society of America organised by Alice Harris drew attention to recent work focusing on the processing and acquisition of endangered languages, and at the same meeting Sandra Chung delivered her Presidential Address on psycholinguistic work done on endangered languages in the Pacific in collaboration with Manuel F. Borja and Matthew Wagers. The 2014 meeting of the American Association for the Advancement of Science featured a symposium “The Large Cognitive Implications of Small Languages”, organised by Douglas Whalen.
2. See, for example, the ongoing debate over whether nouns are universally learned before verbs, which has drawn on language data from English (Childers & Tomasello, 2006; Gentner, 1982), Japanese (Imai, Haryu, & Okada, 2005), Korean (Gopnik & Choi, 1995; Pae, 1993), Mandarin (Tardif, 1996; Tardif, Gelman, & Xu, 1999), Navajo (Gentner & Boroditsky, 2009), and Tzeltal (Brown, 1998).
3. See Levelt (2013) for a comprehensive treatment of the various manifestations of verticalist perspectives in nineteenth century thought, and their close connection to theories of biological evolution. We adopt the terms “verticalist” and “horizontal” from Levelt’s exposition.
4. This is not to say that there were not exceptions to this general trend. In a series of studies Forster (1966, 1968) and Forster and Clyne (1968), for example, compared English and Turkish in order to test the hypothesis that differences in syntactic branching direction would have differential processing consequences; see Cutler (1985) for discussion.
5. Including Dutch (Brysbaert & Mitchell, 1996), German (Konieczny & Hemforth, 2000), Greek (Papadopoulou & Clahsen, 2003), Italian (French-Mestre & Pynte, 2000; Grillo & Costa, 2014), Japanese (Kamide & Mitchell, 1997), Korean (Jun, 2003; Lee & Kweon, 2004), Russian (Sekerina, 2002, 2004; Fedorova & Yanovich, 2004, 2006) (all “high” attachment languages) and Basque (Gutierrez-Ziardegi et al., 2004), Brazilian Portuguese (Miyamoto, 1999), Chinese (Shen, 2006), Norwegian, Romanian and Swedish (Ehrlich, Fernández, Fodor, Stenshoel, & Vinereanu, 1999) (all “low” attachment languages).
6. We thank Tom Wasow (p.c.) for drawing our attention to this connection. It constitutes a classic example of how linguistic typology can serve to inform psycholinguistic theorising (see Hawkins, 2004, 2007 for detailed discussion of this point).

7. Our use of the term “Phrase Structure theories” is a label of convenience and is not meant to imply that all phrase structure grammars necessarily postulate a universal configurational subject position (thanks to Juergen Bohnemeyer (p.c.) for alerting us to this point).
8. Some memory-based theories also posit a competing mechanism, activation boosts with every retrieval, that can sometimes lead to facilitation with increasing distance (Lewis et al., 2006; Vasishth & Lewis, 2006). Here we simplify for the purpose of discussion and focus on strictly locality-based memory accounts (e.g. Gibson, 1998, 2000; Grodner & Gibson, 2005).
9. They do differ, however, in *where* exactly they predict the locus of processing difficulty to reside in object RCs (see discussions in Grodner and Gibson, 2005; Levy, 2008; Levy & Gibson, 2013).
10. Specifically, Levy and Keller (as noted above) found locality and anti-locality effects in German verb-final structures and Vasishth and Drenhaus (2011) found locality effects when memory costs were made high.

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