

Syntactically Speaking

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Abstract

Syntax is a construction project. It fills the conceptual holes and builds the conceptual bridges among words during ventures that speakers undertake in virtually every episode of talking. This chapter focuses on hypotheses and evidence about what speakers do and how they do it. The topics range over how construction proceeds from the draft of an idea through the creating of structural frames, the assembling of words, and the scheduling that brings words and frames together.

Key Words: syntax, sentence processing, structural frames

What you are reading is a product of language production. It contains sentences, clauses, phrases, and words that we are making up while we keep you, the reader, in mind. As you read, you might become aware of a faint echo of real speech in your head, a wraith of spoken language. You know the voice is only registering what you are reading (otherwise, please seek help). If everything is going as we intend, you also understand the ideas that we are trying to convey. To some unknown extent, we have made our thoughts into yours.

Suppose you exchange places with us. Imagine that you are the one with something to say, perhaps in reaction to the strange word *wraith*. Right here, right now, how do you turn your reaction to *wraith* into a comment that conveys your puzzlement, your sense of surprise, maybe the feeling that your reading stopped in its tracks? What arrangement of words would tell us what you experienced? That is, how could you use language to turn your thoughts into ours?

Questions like these are at the heart of research on syntax in language production. In more than 1,500 upcoming sentences, you will find more than 18,000 words that we put together with an aim to

explain what kinds of answers these questions call for. Some of the ideas behind the arrangements of words are our best guesses about what the answers are, drawn from what we have learned about language production during the hundreds of thousands of years that people have been talking.

Why Bother?

Most psycholinguistic research on language production focuses on producing single words (often object names) and the sounds of words. The production processes that support these abilities are fundamental to an explanation of talking, because words are building blocks of what people say. They are recurring, recognizable bits of language with sounds and meanings that are stable enough to be listed in dictionaries. They present interesting challenges: starting from nothing, they accumulate into the tens of thousands of words that adults can produce. Revealingly, they sometimes fall apart to disclose an intricate meshing of different kinds of information bound together in what looks like an individual word, inspiring important studies of single-word speech errors (see Dell & Reich, 1981, for a good example).

Yet almost all the words that people say occur in fluent strings with more than one word, unless the speaker is younger than about 3. Most of the connected strings of words that people utter will not be found in dictionaries, because there are too many of them, in fact an unlimited number. What speakers use to put the strings of words together is a set of abstract mechanisms collectively known as syntax. These syntactic mechanisms make sequences of words with structures that systematically convey sensible meanings. Because there are countless sequences with countless structures capable of conveying countless understandable meanings, speakers cannot memorize the strings and retrieve them from memory. Instead, they have to build syntax on the fly, virtually every time they talk. Single words are part of this process, but without the framework of syntax their communicative value is negligible.

The communicative limitations of single-word speech help to show why syntax is central to human language (and why the transition beyond one-word speech during the language development of toddlers is so significant). On its own, a word expresses too little or too much.

Sink.

Sink is a perfectly acceptable English word, and you know what it means, but if it comes out of the blue, as it did above, it is a mystery. You do not know if it is supposed to be the noun *sink* or the verb *sink*, which mean very different things. You might guess that there was a printing error. If the word comes from a speaker older than 3, you might wonder if you missed a question, since questions provide contexts in which single-word utterances *do* make sense. Questions, like the syntax of sentences, can supply the conceptual relationship between a single word and other things.

Conceptual relations are the heart of communication: communication is *about* things, *aboutness* being its very stuff. The linguistic vehicle of aboutness is syntax. Syntax identifies what a particular string of words is about (an “about-ee,” roughly a topic that in English serves as a sentence’s subject) and at the same time clarifies and enriches the aboutee with features from an “about-er” (a modifier of the aboutee that in English serves as a sentence’s predicate). Without syntax, communication in language would be a shambles, heaps of words with baffling connections. So, to understand how people convey meaning when they talk, we have to explain how they make sentence structures with syntax. Let us look at what a speaker has to do to make this happen during a single fleeting episode of sentence production.

Building Structure with Syntax

Figure 1 illustrates a simple working hypothesis about the components of syntactic structure-building and their connections. From top to bottom, the components are arranged to broadly depict the flow of information from a speaker’s *notion* (a hunk of thought, sometimes called a communicative intention) down to a rudimentary structure that corresponds to a syntactic *frame*. By *frame*, we mean a mental representation of relationships that can, as they fill in and fill out, guide the ordering of elements. In essence, a frame is a short-lived mental ensemble that transiently symbolizes how a sentence’s separate parts are related and ordered with respect to each other. In more technical terms, a frame is a virtual cognitive instantiation of hierarchical structure.

If construction goes well, the ensuing frame will convey what went together in a speaker’s notion, encoding aboutness links among disparate and sometimes distant pieces of an utterance. This is a definition of syntax that is known as Behaghel’s First Law (Vennemann, 1973): syntax ties together linguistically what belongs together mentally, even when the things that belong together mentally lie far apart in a sentence.

Figure 1 breaks syntactic frame construction down into hypothesized processes that consist of *message formation*, *structural scaffolding*, *lexical identification*, *structural assembly*, and *morphological specification*. This chapter’s focus is on structural scaffolding and structural assembly. Still, the

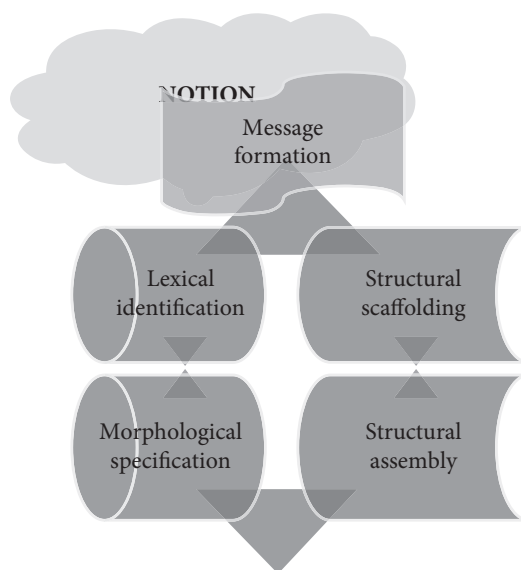


Figure 1. Basic components of sentence formation.

processes of message formation, lexical identification, and morphological specification are an integral and inescapable part of a sentence's history. They come up often in what follows, especially with respect to their links with structural scaffolding and structural assembly. In the discussions of these links we point to chapters in this volume that deal in more detail with messages (Konopka & Brown-Schmidt); words (Dell, Nozari, & Oppenheim; Race & Hillis; Caramazza & Leshinskaya; Vinson, Andrews, & Vigliocco); and morphology (Blevins).

We begin with the first link, the one between thought and the beginnings of linguistic structure, because it is the essential one that ideas must forge in order to become speech. This is the transition from message formation to sentence scaffolding.

Notions, Message Formation, and Structural Scaffolding

In a general account of cognitive processing, we place notions in the realm of *mentalese* (Fodor, 1975) or *mental models* (Johnson-Laird, 1983). Leaving conjectures about the layout of the information to braver souls, we define a notion simply as what a person has in mind when he or she is inclined to become a speaker. It is what a speaker intends to communicate.

A notion is embedded in ongoing mental activity from which it is set apart, because not everything that one has in mind when a notion arises is going to be worth saying. Someone who announces "It's time to feed the cat" is likely to be cognizant (even if not fully aware) of the listener, as well as an individual feline with a particular size, shape, color, and name, in a predictable state of agitation, in a particular place, at a particular time of day. Details about the cat food, the location of the cat food, and the feeding routine will also be on the threshold of awareness. In short, information is accessible at a level of unwieldy specificity, going far beyond what is situationally and communicatively viable or necessary. In this unfolding pageant of ideas, speakers have to spotlight what the situation requires to achieve a goal, calling on context, what they want the listener to do, and common ground, the knowledge that they believe they share with the addressee (Clark, 1996 and this volume).

As a focal point within an immediate perceptual, conceptual, emotional, social, and physical context, notions channel intended referents and relations in a nonlinguistic format. They are by definition nonlinguistic, because they need not be converted into or conveyed in language. Sometimes gestures are

better, or at least suffice for communication, given the setting. Other nonlinguistic devices work, too. But if language is the modality of choice, notions have to assume a form that is suitable for linguistic expression. For this to happen, a notion has to undergo on-the-fly categorization, the classification of notional elements (referents and relations among them) in terms of known concepts or ad hoc categories (Murphy, 2002). The product is a *message*.

Message Formation

Messages are analogous to locutionary forces in an analysis of speech acts (Searle, 1969), enveloped in illocutionary forces like questioning, asserting, commanding, and so on. The contents of messages are sometimes treated as *propositions*. Symbolically, propositions have a predicate (an aboutee, often expressed with a verb and other modifiers that qualify aboutees) and arguments (one of which is the aboutee that the predicate modifies). In the sentences (a) *Dogs chase mailmen* and (b) *Mailmen are chased by dogs*, the predicate is *chase*. *Chase* puts two arguments (*dogs* and *mailmen*) that respectively perform and undergo chasing.

Unfortunately, a treatment of messages as propositions has drawbacks. Among other problems, propositional notation does not lend itself to representing the kinds of pragmatic information that sentences must convey. From a more practical standpoint, it leads to ambiguity in the treatment of syntax in language production. Propositional subjects sometimes are and sometimes are not sentence subjects: In *Dogs chase mailmen* and *Mailmen are chased by dogs*, the propositional subject argument is always *dogs*, while the grammatical subjects differ, corresponding to *dogs* and *mailmen*, respectively. To skirt this confusion, we avoid propositional terminology and instead talk about messages in terms of aboutness and the products of categorization, the *concepts* that play various aboutness roles. The message, then, is a prelinguistic representation of aboutness relations among concepts.

In the framework we adopt here, messages are the beginnings of syntax. Little is known about how transitions from messages to the formulation of syntax proceed, and even less about the timing and interaction of these processes. For now, this makes it risky to specify what is in a message before structural and lexical mechanisms come to the fore, despite the many empirical and theoretical efforts to pin answers down (e.g., Ford, 1982; Ford & Holmes, 1978; Osgood, 1971; see Levelt, 1989 for extended treatment).

A safe conjecture is that speakers do not always formulate complete messages before the mechanisms of language production get into gear (Brown-Schmidt & Tanenhaus, 2006; Brown-Schmidt & Konopka, 2008; Konopka, 2012; Lindsley, 1975). Even after speech begins, messages may undergo reformulation. This makes message formation and reformulation a culprit in the most pervasive disruptions of discourse, the disfluencies that punctuate almost all spontaneous speech (Barch & Berenbaum, 1997; Clark & Fox Tree, 2002; Deese, 1984; Goldman-Eisler, 1968; Maclay & Osgood, 1959). Disfluency is so common that as much as 50% of speaking time can be taken up by *umms* and *uhhs* and silent pauses (estimate from Goldman-Eisler, 1968). Message formation is hard.

Because symptoms of message formation show up in disfluency, the distributions of pauses and hesitations should be valuable clues to how message creation works. The drawback of using hesitations for this purpose is that more than a half-century of research has failed to find unambiguous signals of alternative sources of hesitation. Message-rooted hesitations can be hard to distinguish from language-rooted hesitations. This could mean that there is no distinction to be made, that the thinking part of speaking actually flows seamlessly into the speaking part of speaking.

Fortunately, there is another kind of speech problem that is enlightening about both the etiology of hesitations (Garrett, 1982) and the transition from meaning to language. These are overt errors in saying sounds, words, and sentences. The properties of these errors hint that there is a buffer between message-making and structure-building. Because of this buffer, some of the problems of readying messages may have few direct consequences for the processes of readying language. We turn to this transition in the next section.

From Messages to Linguistic Structure

In the transition from a message to the structural domains of language processing, messages provide information relevant to assembling words and syntactic relations. This information is essential for conveying what the speaker has in mind, and at least some of it, at least briefly, has to be maintained in memory. In contemporary accounts of language production, the constraints from message contents must span cognitive chasms of sorts. The chasms have inspired terminology like *rift* (Levelt, 1993) in word retrieval and *syntactic cleft* (Bock, Loebell, & Morey, 1992) in structure-building. Figure 1

implies that the chasms differ, if only in the sense that what lies on the other side of the message is in one case a vocabulary or *mental lexicon*, and in the other the syntactic mechanisms for constructing sentences.

For the purposes of theoretically justifying a separation between the creation of notions and messages on the one side and the workings of syntax on the other, what is important is evidence for a qualitative dissociation. Separation presupposes a fundamental, natural discontinuity between thinking and speaking, and its tenability for language production is far from obvious or generally accepted (e.g., Boroditsky, 2001; Whorf, 1956), even among proponents of modularity (Fodor, 1983).

We think the assumption of discontinuity is not only tenable but unavoidable for explaining syntactic processes. In linguistics, the discontinuity is captured in the hard-to-dispute idea that language symbols (and here we include both the concrete lexical ones and the abstract structural ones) are to various degrees arbitrary with respect to human cognition. This holds even though the cognitive processes that motivate communication may be pretty much the same in format and content for speakers of different languages (e.g. Barner, Li, & Snedeker, 2010; Bock, Carreiras, & Meseguer, 2012; Iwasaki, Vinson, & Vigliocco, 2010).

The implication is that the products of a universal human ability to think are expressible with systems of symbols—languages—that bear no necessary relationship to underlying notions. The symbol systems vary in all the ways that languages around the world exhibit. At the same time, the lexical and structural constraints that languages impose on their human users have to be tightly organized. How tight we do not know, but tight enough to allow humans, within a couple of seconds or less, to retrieve suitable words and build suitable syntax for one of countless utterances to convey one of countless thoughts on any one of countless occasions throughout most of their lifetimes.

The consequences of a cognitive discontinuity between processes of thought and language are unveiled in research on the production of both words and structures. In word retrieval, clues come from sources that include research on familiar phenomena like tip-of-the-tongue states (Badecker, Miozzo, & Zanuttini, 1995; Vigliocco, Vinson, Martin, & Garrett, 1999), where the sense of discontinuity can be almost palpable (James, 1890), as well as the timing and accuracy of word production in controlled and natural settings (see chapters in

the *Speaking* section of this volume). In the formulation of sentence structure, many of the clues come from analyses of speech errors.

Speech Error Analysis

With respect to structural processes, the discontinuities in language production were first disclosed in painstaking analyses of observed speech errors by Fromkin (1971), Garrett (1975, 1980, 1988), and others. By and large, these analyses encouraged the conclusion that when people make errors, the errors occur within well-formed structures. Even when words and their locations in utterances seem wrong, their syntax is right.

What makes them wrong? The fault lies in the havoc that errors can play with intended messages and the possibility of communicating them. A speaker who said that something was “costing the money more state” had a message in mind that is poorly communicated by the utterance. Nonetheless, the syntax of the error is impeccable. Likewise, “everyone expects high hopes of you,” “I’ve got the whole thing wrapped around my arms,” and “I enjoyed talking with these things about you” are perfectly fine examples of English syntax, but mishmashes of what the speakers intended (we leave it to you to figure out what those intentions were). Even “use the loose of her feet,” which reverses an intended noun and verb, has a grammatical outcome (for reasons explained in Ferreira & Humphreys, 2001; Wardlow Lane & Ferreira, 2010).

Surprisingly, even the errors that analysts categorize as syntactic (excluding the rarefied minutiae of “school grammar”) tend to be structurally well formed. These errors typically involve the abstract parts of whole-sentences frames, from phrases to whole sentences and syntactic relations. Among reported syntactic errors, one informal survey found 0.3% that contained clear structural violations (Bock, 2011). Note that this rate of ill-formedness is found *within* a type of speech error that is itself extremely rare: in large collections, syntactic errors constitute only about 2% of all the errors recorded (Fay, 1982; Stemberger, 1982). Disfluency aside, speech errors themselves are uncommon (Deese, 1984). This is not because of an irrevocable human ability to put words together in acceptable ways; attempts to speak languages that one knows poorly readily reveal how difficult it is to create consistent sentence structures. Speakers exhibit remarkably reliable production of syntax in their mother tongues.

These characteristics make it hard to resist the conclusion that the structural machinery of

language continues to work when good messages go bad. This is the backbone of speech error analyses. It allows error properties to illuminate structural components of formulation like those in Figure 1, and strengthens the assumption of discontinuity between the activities of meaning and speaking.

The disparity between message preservation and syntax preservation also suggests that messages lose control of the formulation process, but the formulation process does not lose control of syntax. When speakers start thinking about what to say next, a current message can, and perhaps must, abandon its oversight of production. When structure-building takes control, it has its own priorities. Merrill Garrett summed up the operating principle with haiku-like austerity: “The production system must get the details of form “right” in every instance, whether those details are germane to sentence meaning or not” (1980, p. 216).

Putting a Sentence’s Show on the Road

Even if there is some kind of qualitative transition between messages and sentence structure, something has to happen to bridge the gap. This “something” was the centerpiece of one of the longest, most heated debates about language production in the history of psycholinguistics (Blumenthal, 1970). The positions in the debate can be sketched like this: (a) Language production begins with an incremental concept-by-concept catapulting of message material into the lexicon, allowing concepts to identify corresponding words that arrange themselves one-by-one into phrase and sentence frames (Paul, 1886/1970); versus (b) Language production begins with a schematic, holistic configuration of message elements in aboutness relations. The relations serve as struts for a temporary bridge to linguistic-structural scaffolding and the lexicon. The bridge may give priority to salient or important elements, but only within the holistic framework (Wundt, 1912; see Levelt, 2012, chapter 6 for an unprecedented, lucid treatment of Wundt’s views of language production). In line with the wellsprings of virtually all debates in cognitive psychology, one view (Paul’s) emphasizes elements and the other (Wundt’s) emphasizes the relationships among them.

Figures 2 and 3 (from Konopka and Bock, 2009; Kuchinsky & Bock, 2010) caricature the different accounts in terms of an experienced event that leads to structure-building. In both figures, the same experience gives rise to a message about one person shooting another. Figure 2 depicts a transition to language in which one part of the event and message

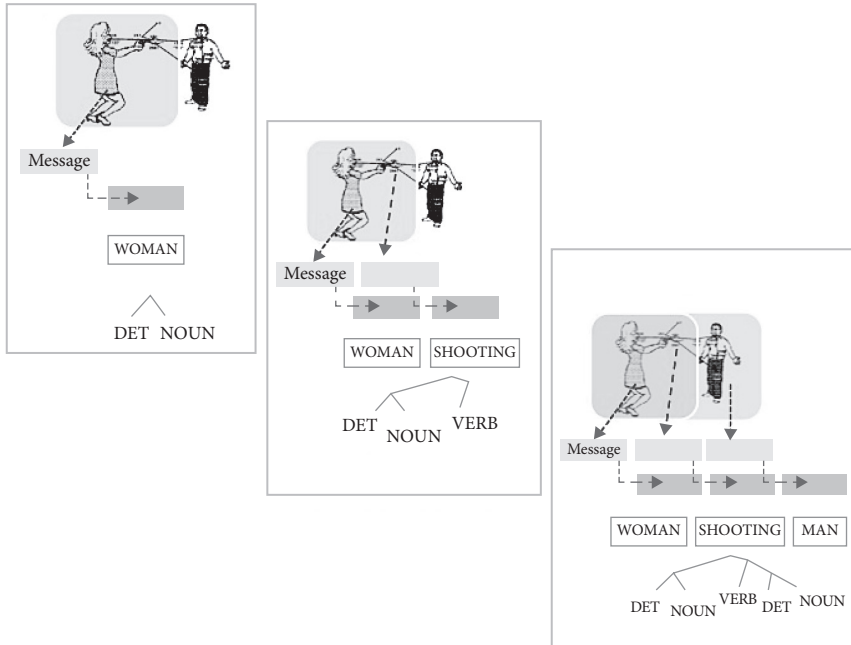


Figure 2. Word-driven development of utterance from attentional focus through structural assembly.

and then another drive formulation successively, each one serving to identify relevant message concepts and appropriate words for expressing them. The words in turn arrange themselves into sentences. As shorthand, we call this *word-driven* sentence production (more precisely, production driven by the words that head initial phrases). Figure 3 depicts

structure-driven sentence production, in which relationships in the event (what is going on? what's it about?) dominate the transition to language, where the first order of business is building a structure that can eventually arrange words.

A fundamental property that word-driven and structure-driven production share is *incrementality*.

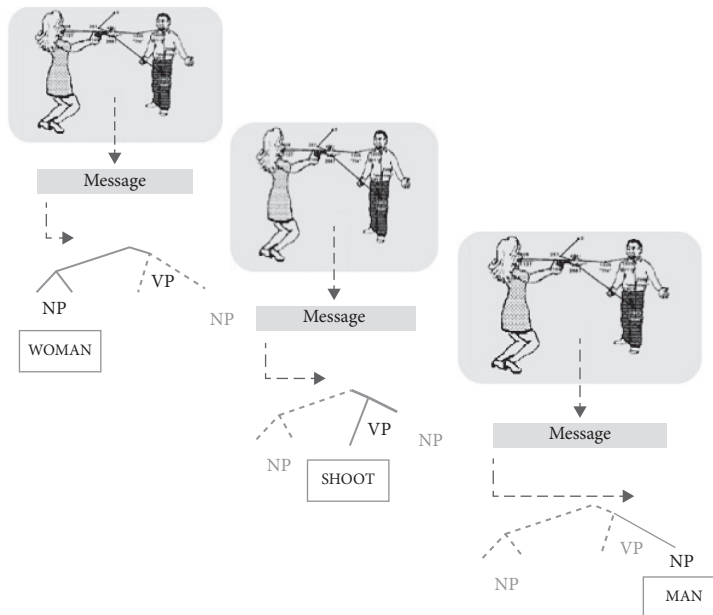


Figure 3. Structure-driven development of utterance from apprehension through structural assembly.

Sentences are not formulated as wholes or all at once, but as parts that are progressively linked to one another, and this incrementality is essential to an explanation of production. However, they are incremental in different ways. Word-driven production is *linearly incremental*: a sentence is built *up* from separate concepts in a message. Structure-driven production is *hierarchically incremental*: a sentence is built *out* from large structural joints that reflect relationships in a message.

Word- and structure-driven sentence formulation are far from mutually exclusive, and as we will see, they both play essential parts. Words and structures both have to be engaged, together or in succession, and integrated in the course of production. What is at issue here is the nature of the transition from messages to language. It could be that there is only one sort of steering that can lead off the structure-building process, with consequences for what happens later. Alternatively, it could be that either kind of steering can achieve the transition, as circumstances permit or demand. With that as background, let us look at the evidence for how language unfolds from messages.

Word-Driven Sentence Production

The word-driven view is in such good intuitive agreement with our sense of how we talk—one word at a time—that its rightness tends to be taken for granted. So, the typical question is not about whether the word-first approach is right, but about the factors that determine what the first word, the starting point, will be. A common answer to the starting-point question goes back at least to the ancient Greeks: speakers begin with the concept that is most important in the message.

Definitions of importance vary widely across the large literature dedicated to demonstrating word-driven ordering, and the results might best be taken as illustrating the many ways in which something can be important. Something can be important because it is perceptually salient, conceptually salient, personally significant, momentarily prominent in consciousness or attention, a topic of conversation, or a transient focus of shared interest (for reviews and discussion see Bock, 1982; Bock, Irwin, & Davidson, 2004; Levelt, 1989; MacWhinney, 1977). A different kind of importance, in terms of a speaker's priorities, is easiness: when possible, speakers begin with easy-to-use concepts, ones that are animate, concrete, familiar, frequent, simple, prototypical, at a basic level of categorization, and so on (e.g., Bock & Warren, 1985; Christianson

& Ferreira, 2005; Kelly, Bock, & Keil, 1986; McDonald, Bock, & Kelly, 1993; Onishi, Murphy, & Bock, 2008; Prat-Sala & Branigan, 2000). The easiness that matters most for speakers is not easiness for listeners, but easiness for themselves (Brown & Dell, 1987; Ferreira, 2008).

Oddly enough for something that seems so self-evident, research on word-driven language production has a long history of outcomes that would leave a skeptic unconvinced (see Bock, Irwin et al. 2004 for discussion). Fortunately, there is persuasive evidence from experiments by Gleitman, January, Nappa, and Trueswell (2007). The experiments manipulated the salience of alternative actors in pictured events using a subtle, almost imperceptible attentional cue (sidestepping a common problem in previous studies). The manipulation was accompanied by an assessment of eye fixations, to ensure that participants actually looked at the supposed salient object (remedying a source of circularity in earlier work). Gleitman et al. found a clear impact of attentional cuing on the choice of an initial phrase, often the subject phrase, of a sentence: cued referents were more likely to be mentioned first.

As an example, consider an event in which a woman is standing in front of a group of men, perhaps singing to them. Cueing the woman increased the probability of utterances along the lines of *The woman is performing for the men*, whereas cueing the men increased the probability of *The men are watching the woman*, mentioning the men first. This is credible support for a word-driven view of the transition between messages and utterances.

The structure-driven hypothesis that is depicted in Figure 3 is harder to assess for several reasons. First, the factors relevant to structural effects remain poorly understood. Second, there is no unambiguous link between the abstract components of sentence structure (whatever they might be) and potential manifestations of structural effects during production (e.g., prosody, latency, duration). Third, the suites of measures needed to converge on structural processes are far from obvious. Keeping these limitations in mind, there are several results that are consistent with initiation of formulation from a message-derived structural representation whose scope is broader than a word.

One of these results highlights what structure-driven sentence production looks like and at the same time provides illuminating counterpoint to Gleitman et al.'s (2007) work. The findings come from experiments that used the Gleitman et al. attention-cuing paradigm with eye-movement monitoring (Kuchinsky,

2009; Kuchinsky & Bock, 2010). As in Gleitman et al., speakers recounted pictured events in which alternative actors were covertly cued, and the impact of cuing on the choice of a sentence starting point was assessed. The major departure from the Gleitman et al. method was in the range of pictured events that speakers saw and described.

The events in Kuchinsky's experiments included those used by Gleitman et al. but went beyond them in an important way. The critical additions were events that varied in codability (Figure 4). Highly codable events are straightforwardly interpretable in terms of the relationship between two actors (e.g., the hitting that relates the ambulance to the car). In less codable events, the relationship between actors is ambiguous and hard to construe (e.g., a woman on an elevated surface being eyed by a group of men). Out of necessity, many of the Gleitman et al. materials had the latter kind of ambiguity, because their aim was to elicit verbs that offer different perspectives on the same event (e.g., *perform/watch; buy/sell, eat/feed*).

With less-codable pictures, Kuchinsky replicated the Gleitman et al. result that cued actors tended to be mentioned earlier than uncued actors. For the readily interpreted events, though, the results were different: attentional cuing had little effect on early mention. This was not due to failure to perceive or to use the cues, because the cues were highly effective in drawing the eyes: speakers consistently looked first at the actor that was cued, regardless of whether the event was more or less codable. But only for the less codable events was the cued actor likely to be used earlier in sentences than uncued actors. In other words, when events were hard to interpret, early attention to an object in the event elicited a word-driven production pattern, but in easy-to-interpret events, the cue had no consistent impact on the starting point.

What made codable events less susceptible to cuing? Putting together the results from several experiments, the account that stood up best in Kuchinsky's

data was the fast emergence of structure, at least rudimentary structure, during the transition from a message to an utterance. This rudimentary structure (a *scaffold*) flags a suitable subject from referents represented in the message, projecting a tentative assignment on the basis of *accessible conceptual relations*. For this to happen, the relationship between actors in an event must be easily apprehended (categorized), for instance in terms of causality or intentionality, construed in terms of what the event is about. This construal allows subject selection.

When relational information is readily conceptualized, as it is in codable events, the relation can take precedence over momentary variations in attention to single referents. For example, a brief (500 milliseconds or less) glimpse of an event like the collision in Figure 4 can be enough for the general nature of the event to be apprehended and for an aboutee to come to the fore (Griffin & Bock, 2000; Schyns & Oliva, 1994).

Let us say that the aboutee is the car. With this construal in hand, there may be little inclination to construct an alternative interpretation provoked by a transient shift of attention to something else in the event. This is especially the case when a scene does not change during an eye movement. If the scene is the same, the event-world remains the same perceptually (unsurprisingly, because the stability of the visual world across eye movements is a classic phenomenon of vision; Irwin, 1991, 1996). In stable visual environments, efforts at recalibration are an extravagance; consider the effort required to discover alternative interpretations of newly encountered ambiguous figures. So, notwithstanding the movement of the eyes to the car, a speaker's initial construal of the car's centrality to the event is likely to remain in place and surface in an utterance like *The car is being hit by an ambulance*.

The findings of Kuchinsky and others (Brehm & Bock, 2011; Bock, Irwin, Davidson, & Levelt, 2003; Bock, Irwin et al. 2004; Griffin & Bock,

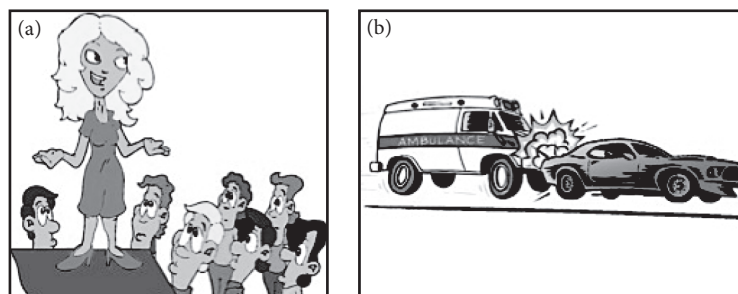


Figure 4. Events that are hard to interpret and easy to interpret.

2000; Konopka, 2012) imply that abstract structural relations *can* drive sentence production. What is harder to assess is how common structure-driven formulation occurs relative to word-driven formulation, or how common the circumstances are that promote one or the other.

The honest answer is that we do not know. Even so, it is worth keeping in mind that when people want to talk, they usually know what they want to talk *about*. (We all know people who blather on without discernible attention to aboutness, but they are rare enough to be distinctly annoying.) Speakers are often in possession of relational information before they start to talk, because what they are venturing to say starts out as a notion of their very own. Perhaps it is chiefly or only in situations like play-by-play announcing or pressured speech where speakers willingly start talking about something or someone that has an unknown role in an unknown event.

Structural Scaffolding and Structural Assembly

Regardless of whether a sentence is constructed in a word- or structure-driven way, structural relations arise at some point. So far, our only question has been whether a structure can emerge early, before lexical identification, as well as later. Now we have to get more explicit about what kind of structure we mean, what it contains, and how it gets there. We call it a *structural scaffold*.

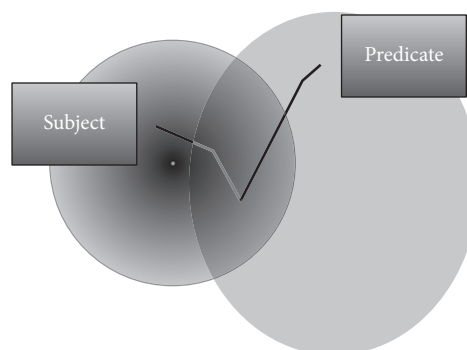
Structural Scaffolding

A structural scaffold is the product of a mapping (the struts of the bridge in our earlier metaphor) between a message's conceptual instantiation of particular referents and a linguistic framing of particular words and syntactic relations. Syntactic relations are so far from receiving a satisfactory treatment, either linguistically or psycholinguistically, that Chang, Dell, and Bock (2006) resorted to the labels X, Y, and Z.

What we settle for here is a rough-and-ready characterization that combines the message terminology of *aboutness* with familiar, traditional grammatical-role labels. This yields an aboutee and an abouter, respectively the syntactic subject and its predicate. Predicates turn into verbs and other relations that can further specify (modify) an aboutee, including relations realized as the direct and indirect objects of verbs. Other relations may be expressed eventually in prepositional phrases, subordinate clauses, adverbs, and adjectives. These other relations (which we call *complements*, without

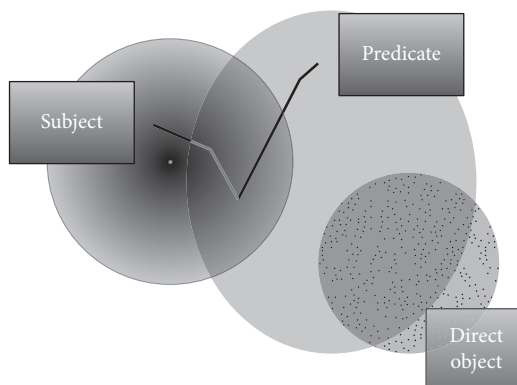
distinguishing among them) provide even greater precision for conveying aboutness.

A simple structural scaffold contains a subject-predicate relation. Subjects and predicates are really just one relationship looked at from opposite perspectives, predicates representing the abouters of subjects and subjects representing the aboutees of predicates. Accordingly, the terms *subject* and *predicate* each presuppose a subject-predicate relation, because they automatically implicate each other. In this way, a rudimentary or latent structure emerges as soon as a subject, the aboutee from the message, is flagged. If we had to depict a subject relation, we would sketch it something like this:



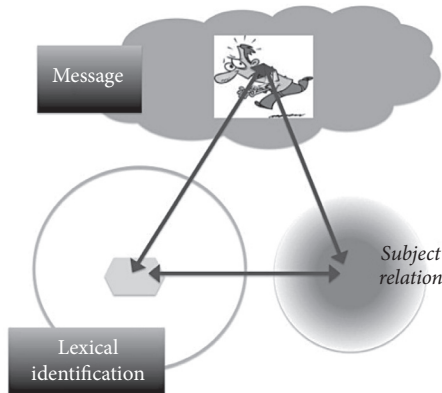
A direct object relation, if one emerges, intersects with the predicate, like this:

Other relations create other intersections, unions, and so on.



Each of the syntactic relations in a scaffold also has to have been rooted in the components of the message. The syntactic relations must likewise be bound to appropriate words, and going full circle, the words must be rooted in the same message components as their bound syntactic relations. For the subject relation shown below, the lexical binding

is to a lexical entry and the message source is a referent-based concept:



This is a sentence-production analogy of pulling off a triple play in baseball (ignoring the fact that baseball's triple plays are rare, while a syntactic relation's triple plays have to be the rule). Take Figure 4's collision event. In it, the message representation of the car (the initial tag for the triple play) can be linked to the subject relation (another tag in the play) and to the word identified to denote the car (completing the triple play). An essential feature in this configuration is that, given the message element and its link to the subject, the word identified for the scaffold had better be *car*, not *ambulance*. If it were *ambulance*, the resulting utterance could be *An ambulance is being hit by a car*, and that's not the right notion. Instead, it is a kind of error in which syntactic relations reverse.

Thus, for an accurate description of the collision in Figure 4, it is essential for the subject relation and an appropriate word to be rooted in the same component of the message. The creation of this small network in a referential-relational-lexical triple play is called *binding*, and it is a keystone of communication in language. Like a real triple play, the tagging of targets in the three-way binding may occur in any order, but some transitions will be more frequent and effective than others. Also like a real triple play, binding has to be fast-paced and short-lived, because successive messages have new elements that need binding to the same syntactic relations with different words. Unlike a real triple play, though, some or all of the bindings in a scaffold might arise simultaneously.

Triple-play binding means that in structure-driven formulation, where syntactic relations emerge before lexical identification, there is a strong lexical constraint: if the AMBULANCE concept

in a message is bound to a particular relation, the same relation must be bound to words that are capable of denoting the AMBULANCE concept. Conversely, in word-driven formulation, if the concept AMBULANCE is lexically identified as the noun *ambulance*, the noun must bind to a syntactic relation that is also linked to the AMBULANCE part of the message. Two possible options are to bind *ambulance* to the subject (*An ambulance is hitting a car*) or to an object in a passive sentence (*A car is being hit by an ambulance*). If message representations can be more or less ambiguous or neutral with respect to aboutness, either of these structures could convey the speaker's notion.

The constraint of triple-play binding, and the various ways in which it might be satisfied, lead directly to the topic of syntactic flexibility. Even if a triple-play constraint *can* be logically satisfied in one of several ways, it does not mean that language production mechanisms are configured in a way that allows options. The next section takes up the evidence for flexibility in production, which is a primary consideration in how words and structures work together.

Coordinating Words and Syntax

The prospect for flexibility in lexical and syntactic coordination raises questions with far-reaching implications for theories about the flow of information in language production (Bock, 1982; 1987b). The simplest and strongest claim about production comes from accounts in which formulation proceeds from a message through a defined sequence of encoding operations (Levelt et al., 1991). In such a framework, there is no natural accommodation for disruptions or failures in coordination. If trouble occurs or the circumstances that lead to trouble arise, failure at any point should instigate efforts at message recasting in order to resume speaking, perhaps with symptoms like disfluency. If adaptive mechanisms are present, however, they provide a recourse against brewing threats to utterances that avoids the revision of the original message.

A known source of trouble in sentence formulation comes from the need to identify suitable words. Links from messages to the lexicon may serve to automatically activate words, but sometimes too weakly for identification, sometimes too many at the same time (Cutting & Ferreira, 1999), and sometimes none at all (Burke, MacKay, Worthley, & Wade, 1991). Problems like these can stall production for an uncomfortably long time, or bring it to a complete halt. Like message formation, hitches

in word retrieval are a culprit in disfluencies, particularly the disfluencies whose contexts of occurrence implicate upcoming content words (Clark & Wasow, 1998). Content words differ widely in ease of selection and retrieval that are attributable to variations in learning, experience, and circumstances of use (Griffin & Ferreira, 2006). They vary in the age at which they are learned, their objective frequency and subjective familiarity, their recency of occurrence, their contextual distinctiveness, their abstractness, their length, and so on. Variations like these can create roadblocks to ongoing but unfinished sentence formulation (Ferreira & Pashler, 2002), regardless of whether formulation is lexically or structurally driven.

To see how a roadblock could arise in the course of production, imagine that the AMBULANCE concept for Figure 4's collision event has been linked to the subject relation. Because the concept is a nonverbal conceptual categorization, it also has to activate and identify a specific word, optimally *ambulance*. However, *ambulance* is a complicated, infrequent word that could be hard to dredge up, interfering with launching the utterance. Had the other vehicle-concept in the message been designated as the subject and sought in the lexicon, the excellent and easy word could get things underway much faster. But with the ambulance-actor already occupying the subject relation, a different direction for the triple play has to be set up.

In a fully top-down formulation system, the only backup for lexical retrieval breakdowns is adjustment of the message. Perhaps, though, production processes are able to adapt to variability in retrieval without beginning a message anew (Bock, 1982). The feasibility of such adaptation in the internal mechanisms of structural and lexical processes gains considerable credence from the behavior of speech errors: when overt errors arise, they reliably come with any changes that are needed to make their structural contexts well formed, though with distortions to the message. It is a small step to the hypothesis that structural adaptation is possible without serious damage to a speaker's intended meaning.

This alternative gets support from another result of Kuchinsky (2009; Kuchinsky & Bock, 2010). Recall that speakers in Kuchinsky's experiments described events like those in Figure 4 after their attention was drawn to one or the other actor by an imperceptible cue. Although cuing had little impact on how speakers began utterances that recounted easy-to-interpret, codable events (suggesting fast

scaffolding that guided the identification of words), less codable events behaved differently.

In the less codable events, cuing was more effective in eliciting early mention of the cued actor. However, only a subset of the hard events showed this pattern. In these events, cued actors most often occurred early when they were *also* easy to name. This is an impact of lexical accessibility. It was measurable because the nameability of actors was manipulated in all of the events, both more and less codable, so that half of the events contained one hard-to-name actor (e.g., ambulance, audience) and one easy-to-name actor (car, woman). The other half was split into events in which both of the actors were easy or hard to name, providing controls for nameability effects.

When a cue targeted an easy-to-name actor in a less-codable event, the tendency to start with it was substantial. Since these events were less codable, though, speakers were unlikely to have a structure prepared. There was also no way to anticipate the cue, since the speakers were not even aware of it. But if words have the capacity to build their own scaffolds, instead of simply binding a directly message-controlled scaffold, another way to start off quickly is to use an accessible word to begin the scaffold. This is what the speakers in Kuchinsky's experiments seemed to be doing.

The difference between this apparent word-driven adaptation and message revision can be seen in what speakers did when the cue targeted a hard-to-name actor. In these cases, the cuing effect unexpectedly reversed: the tendency was to begin with the *uncued* object and to do so even when the uncued object was also hard to name. Apparently, the inaccessibility of words for referring to the cued object prompted speakers to shift attention to the other object and begin with it, as a sort of last-gasp effort. In contrast to what happened when cued actors were easily named, this looks like rethinking with message reformulation. In line with this conjecture, uncodable events in which the cues fell on hard-to-name actors also tended to be accompanied by eye-movements to the uncued actor.

The adjustments in sentence formulation that accommodate variations in event codability and lexical accessibility illustrate the intricate collaboration that is necessary between structural scaffolding and lexical identification. The triangular "bridge over the chasm" in Figure 1 represents this collaboration, allowing either lexical or structural initiation as circumstances require. For codable events, the commitment to a particular scaffold of syntactic

relations may withstand variability in lexical identification (presumably within limits). With less codable events, pulling off the triple play against constraints from messages, syntactic relations, and words is less straightforward, requiring information to combine in ways that a strict sequence of production operations cannot easily accommodate. We turn to this with a discussion of word- and structure-driven coordination.

Word-Driven and Structure-Driven Coordination

Word-Driven Coordination

One way for sentence production to be resilient against lexical variability is to allow words to directly guide structural scaffolding. The results of Gleitman et al. (2007) taken together with those of Kuchinsky (2009; Kuchinsky & Bock, 2010) testify to the existence of a process of this kind and the circumstances that allow it to work. In fact, there is a substantial amount of converging evidence for word-driven formulation and the lexical opportunism that it signifies (Bock & Irwin, 1980; Bock, 1982; Bock, 1986a, 1987a; Ferreira & Dell, 2000; Ferreira & Firato, 2002; Kelly, 1986; Levelt & Maassen, 1981).

To work smoothly, word-driven formulation must proceed from messages through words into scaffolding, structural assembly, and morphological specification. This means that words have to take responsibility for constructing a set of grammatical relations. If they do not or cannot, effects of lexical accessibility could show up mostly as errors like word exchanges, errors along the lines of “costing the money more state” rather than *costing the state more money*. In fact, word exchanges and other word errors have a slight tendency to put more accessible words ahead of less accessible ones and to substitute more for less accessible words (Bock, 1987b; Dell & Reich, 1981; Stemberger, 1984). If speakers are to sidestep these errors, words have to know something about syntax.

Fortunately, it appears that they do. A lexically driven process can work because words come with built-in information about their structural privileges (Melinger & Dobel, 2005). In some languages, verbs are particularly rich in syntactic detail, but other words have it, too. The entries in the lexicon that make this kind of information available are often called *lemmas* (Kempen & Huijbers, 1983; for an explicit model of lemma access, see Levelt, Roelofs, & Meyer, 1999).

Lemmas work roughly like this. Suppose that the message for Figure 4’s collision retrieves lemmas for

the noun *car* and a verb like *hit*. *Car* can be a subject, but it requires a verb to build the subject-predicate scaffold. *Hit* serves this purpose. The verb *hit* also makes possible something more, additional “aboutness” information that indicates more specifically what happened to the car. This generates another relation to add to the predicate in the scaffold. *Ambulance* supplies the necessary noun, filling out a scaffold that is suited to the transitive verb *hit* (subject[predicate(complement)]).

Lexical Accessibility with Structure-Driven Formulation

Sometimes, though, lexical accessibility may affect sentence structure when a structural scaffold is already underway. If some words are accessible for binding to a scaffold when others are not, the smart way to proceed is with an opportunistic grab-and-go process. With adjustments to the in-progress scaffold, structural assembly can proceed. Without adjustments, though, errors can appear in which words show up in the wrong structural relations. To avoid error, structure-driven opportunism requires scaffold adaptation.

Structure-driven opportunism, structural steering, comes about when a message creates the beginnings of a scaffold before adequate words are identified (analogous to how lexical steering begins with a message identifying words before a structural scaffold is built). This makes it the structural parallel of easy lexical retrieval. For it to happen, opportunism in a developing scaffold would sometimes lead to an adjustment of structural relations to accommodate accessible words. That is, if a structural relation cannot bind a word that suits it (i.e., the word spoils the triple play), the scaffold may reorganize its relation-to-message mapping in a manner that allows it to exploit a readily accessible, already identified word. To do this, it must be supple enough to adjust how its relations are linked to message referents so as to parallel the message referents that are linked to accessible words. Objects may have to become subjects and subjects may have to become objects. In short, for an existing scaffold to accommodate words, a revision of structural relations may be necessary.

The simplest way for an existing scaffold to accommodate lexical variability is in effect the inverse of how accessible words build scaffolds by calling on the structural options they possess. Ongoing construction of a scaffold should proceed more smoothly if it binds an accessible word that has the ability to adapt to the scaffold’s developing relational configuration. This is in effect the

reverse of Kuchinsky's finding, where an accessible word exploited its option to create a subject relation.

The benefits to structure-building from flexible words are illustrated in the outcomes of experiments by Ferreira (1996). Ferreira examined the effects of lexical flexibility with an anagram-style task in which speakers built sentences from sets of words. The sets of words differed only in that some contained a verb with more structural options than a corresponding set. The verbs had similar meanings, like the dative verbs *give* and *donate*, but one of them offers more structural flexibility. To illustrate, the options for *give* include *give some money to the church* as well as *give the church some money*, whereas *donate* offers only one, *donate some money to the church* (*donate the church some money* is unworkable for most English speakers).

With such verbs, there are two ways in which the coordination between a scaffold and lexical identification could proceed, one of them lexically driven and the other structurally driven. Suppose that just one of the possible dative scaffolds is under construction before the verb is selected, and the selected (in fact, provided) verb is *give*. Regardless of which dative scaffold is underway, it can continue to unfold regardless of its relational scheme given that there is a form of the verb that is consistent with either scheme. Now, imagine that the same scaffold is in progress, but the verb selected is *donate*. If the in-progress scaffold happens to be one with relations incompatible with *donate's* only option, coordination could grind to a halt. In this scaffold-first, structure-driven scenario, the prediction is that *give* should be easier than *donate*.

The word-driven coordination account makes a different prediction. If the selected verb is what builds the scaffold, *give* demands that a choice in structure be made. This adds uncertainty to the process, along with the possibility of slowing formulation. With *donate* as the driver of formulation, however, there is no choice and no uncertainty. Now, the prediction is that *give* will be harder.

The result was that verbs with more options (like *give*) were easier, implying that the ability of the scaffold to bind a verb with different options was beneficial. Thus, a scaffold that was underway could proceed with the selected verb regardless of the relations under construction; a scaffold incompatible with an inflexible verb required time-taking adaptation. This result is consistent with the possibility of scaffolds selecting their words, capitalizing on lexical flexibility.

Another way to exploit lexical accessibility is when scaffolds contain relations that require multiple words. Common instances of this are conjoined structures (*car and ambulance; ambulance and car*). Here, the scaffold has the option of fairly free word ordering, naturally accommodating differences in the accessibility of words and the ease of binding them to relations. There is broad support for accessibility effects of this kind from research in the laboratory and in the wild (Cooper & Ross, 1975; Onishi et al., 2008; Kelly et al., 1986; Fenk-Oczlon, 1989).

Miscalculation in structure-driven coordination can create specific sorts of errors, just as miscalculations in word-driven coordination create word exchanges. Structure-driven errors show up on occasions when whole phrases seem to be linked to the wrong referents. Errors like these, apparent failures in the adjustment of structural scaffolds, show up in some intriguing mistakes that Garrett (1980) called functional errors. To keep our terminology consistent, we call them relational errors.

Table 1 lists some examples. The very first example, taken from Garrett (1980), illustrates why relational errors differ from single-word exchanges. The error looks like a mere reversal of pronouns. The flaw in that impression is that the speaker did not replace *He offends her* sense of how the world should be with *Her offends he* sense of how the world should be, but with *She offends his* sense of how the world should be." The pronouns and syntactic relations are linked to opposite things in the message.

Let us look in more detail at the nature of this anomalous linkage. In traditional grammatical terminology, the intended and produced pronouns represent different cases (like nominative, accusative, genitive) that overtly signal syntactic relations. In the first error, the speaker's intention suggests that the male in the message was linked to the subject (nominative) relation and the female to a possessive (genitive). In the lexicon, the expected linkage would be to lemmas for masculine and feminine pronouns. If the subject binds the wrong lemma (the one for a feminine pronoun), the pronoun shows up in a form appropriate for a subject, the nominative *she*. This leaves the possessive relation to the male, yielding *his*.

Relational errors again illuminate the cornerstone of flexible interaction between lexical identification and structural scaffolding. For meaning to be preserved, it has to be possible to adjust existing mappings to message elements. In general, without remapping, scaffolds can exploit lexical accessibility

only at the risk of creating meaning-changing errors (like the pronoun error), for the same reason that word-driven variations in lexical accessibility must revise the relations in scaffolds to prevent simple word exchanges like “costing the money more state.”

Parallelism in Building Structural Scaffolds

The covert juggling that is needed to prevent message-changing errors, without changing the messages themselves, clearly requires deft coordination of lexical identification and structural scaffolding. Lexical and structural steering represent different ways of proceeding in the face of asynchronies in lexical and structural formulation. Together, they present at least one more option for coordination: Perhaps alternative scaffolds emerge simultaneously. Within a production system that is both word- and structure-driven, each route might yield a scaffold that then competes with the other. In effect, this is parallel word- and structure-driven formulation.

An argument for parallelism comes out of yet another kind of syntactic error that is shown in Table 1, *blends* (Butterworth, 1982; Coppock, 2010; Cutting & Bock, 1997). A unique feature of blends is that they combine two structurally and lexically different ways of expressing a notion, sometimes in ways that yield logical contradictions: “I miss being out of touch with academia” says exactly the opposite of what the speaker intended. Not all blends create contradictions, but many do, perhaps as many as half (45% in one estimate; Bock, 2011). Blends in general look suspiciously like a merger of separate scaffolds with different sources, one source biased to express the message in one way and the other in a different way. Oddly, even these convolutions look like all syntactic errors in having regular structural properties (Coppock, 2010). Odd or not, this is what we would expect from a system that is vastly better at creating well-formed than ill-formed utterances, semantic anomaly be damned.

Evaluating Word-Driven and Structure-Driven Coordination

There have been a few efforts to evaluate the consequences of word- and structure-driven formulation for lexical-structural coordination. One tactic for getting at their hypothesized differences compares the effects of lexical accessibility in structures where the accommodations to accessibility variations require smaller or larger changes in syntax with only subtle changes in message content. Examples of small changes include word order in

conjunctions (e.g., *Herb and Eve/Eve and Herb*) and equative sentences (*Herb and Eve are the current and former Mitglieder/The current and former Mitglieder are Herb and Eve*). The role of accessibility in creating more substantial changes in syntactic relations has been examined with structures that include active and passive sentences (e.g., *Tania's intellect awed Herb and Eve/Herb and Eve were awed by Tania's intellect*) and dative sentences like the ones mentioned above.

There are provocative but somewhat mixed results from using this tactic to get at whether and how structural flexibility and lexical accessibility interact. The most suggestive findings point to a difference in the kinds of lexical and conceptual dimensions involved in word order changes (e.g., in conjunctions) compared with those that can change syntactic relations and the order in which they are expressed. Some of the conceptual factors that affect assignment and ordering of relations, such as animacy, concreteness, and givenness, have less consistent effects on word order (Bock & Warren, 1985; Kelly et al. 1986; McDonald et al. 1993; Onishi et al. 2008; Tanaka, Branigan, McLean, & Pickering, 2011). Conversely, factors that affect word order (including word length and prototypicality) less consistently affect the assignment and expression of syntactic relations.

An appealing account of these differences is in terms of a property called *predicability* (Keil, 1979; see Bock, Irwin et al. 2004 for a review of the relevant literature). *Predicability* (not to be confused with superficially similar but semantically different word *predictability*) refers to the relative ease of categorizing notional referents and their aboutness connections, as abouters and aboutees. It reflects differences in the aboutness possibilities of concepts in terms of the richness and simplicity of the relational possibilities they offer. Relations among animate referents are easier to categorize than those among inanimates; relations among concrete referents are easier to categorize than those among abstract referents; and relations to previously categorized referents (given information) are easier to categorize than relations to not-yet-categorized referents (new information). *Predicability* has additional consequences for scaffolding, in forging the three-way connection among concepts, lemmas, and structural relations. Thus, *predicability* affects the formation of aboutness in messages on the one hand (via the ease of conceptually categorizing relations among notional elements) and the translation into language on the other (via the ease of

Table 1. Production Errors Involving Abstract Syntactic Structures

Error type	What was intended	What was said
Relational		
1.	He offends her sense of how the world should be	“She offends his sense of how the world should be”
2.	They’re going to set their dog on you	“They’re going to set your dog on them”
3.	You’re staying with her	“She’s staying with you”
4.	I enjoyed talking with you about these things	“I enjoyed talking with these things about you”
Blends		
5.	I’m not going to solely blame all of climate change on man’s activities/I’m not going to solely blame all changes in climate on man’s activities	“I’m not going to solely blame all of man’s activities on changes in climate”
6.	I think this is something that this movie might help/I think this is something that this movie might help him along with	“I think this is something that this movie might help him along”
7.	When a car seat is misused.../When a car seat is used improperly	“When a car seat is misused improperly”
8.	I miss academia/I’m out of touch with academia	“I miss being out of touch with academia”
Attraction		
9.	How much correction of syntactic errors <i>is</i> there, anyway?	“How much correction of syntactic errors <i>are</i> there, anyway?”
10.	Dr. Bock’s research on the processes of speech production ranks among the most important contributions to modern cognitive psychology	“Dr. Bock’s research on the processes of speech production rank among the most important contributions to modern cognitive psychology”
11.	Processing of semantic selection errors was accompanied by a classical N400 effect	“Processing of semantic selection errors were accompanied by a classical N400 effect”
12.	The validity of some of the experimental paradigms was questioned	“The validity of some of the experimental paradigms were questioned”

converting aboutness relations into structural relations). These are the two sides of *conceptual accessibility* in the transition from notions to linguistic expression (Bock, 1987a; Christianson & Ferreira, 2005), and its effects may be observable in scaffolding, lexical identification, or both at once.

Predicability is fundamentally a property of conceptual relations. There can also be differences in the ease of putting particular message concepts into words, due to conceptual prototypicality, transient activation, familiarity, frequency, morphological complexity, and so on. Factors like these may create *lexical accessibility* in the absence of relational accessibility, affecting mainly the identification

of words, the speed of binding them to scaffolds, and their morphological specification. Differences in lexical accessibility should be more apparent in how speakers exploit the possibilities for ordering words or phrases where options exists, in structural incrementation, compared with how options in the creation of structural relations are exercised.

Regardless of the dynamics, what emerges from lexical-structural coordination is a representation of structural relations that includes bindings to lexical entries. It may be generally the case that the representation’s lexical and structural components become incrementally available in the transition to structural assembly. The question we address in the

next section is whether structural relations and lemmas are inextricably bound before they are assembled into a structural frame. The alternative is that they remain divisible parts of a transient lexical-relational binding, not yet fully integrated in the way that they must be for utterances to become speakable. What has to happen for this to be possible occurs during structural assembly. That is our remaining topic.

From Structural Scaffolding to Structural Assembly

As its label implies, a structural scaffold serves to support the construction of a frame (as in Figure 1) for grouping and ordering words. Frame construction has to be fluid and capable of proceeding incrementally, with some parts built earlier than others to enable speech to start before frame construction stops. Incrementation may be comparatively slow or comparatively fast and fluent, reflecting combinations of message difficulty, formulation events, and tactics for starting to talk (Ferreira & Swets, 2002). Because the details of frames need not be fully spelled out before speaking begins, there can be variability in frame construction due to the ease or speed of binding during lexical-structural coordination (Ferreira & Dell, 2000; Ferreira & Firato, 2002), and to the accessibility or viability of alternative procedures for assembling a frame.

One focus of current research on structural assembly can be thought of in terms of the question raised above about the triple-play binding among messages, words, and structural relations. By the time that frame construction begins, the links to a message are unlikely to remain. Empirically, this follows from the indifference of speech errors to message contents. Pragmatically, it follows from the improbability of a production process in which messages have to remain in place until they are expressed. Message formation is attention demanding (Ericsson & Simon, 1980), so when speakers turn their attention to the formation of new messages or other processes, the nuts-and-bolts of language production must proceed on their own.

This leaves the binding between words and structural relations as the major player in frame assembly. Against this background, a major debate about frame assembly centers on another division between word- and structure-driven mechanisms. Perhaps sentence frames issue from a tight binding between words and abstract structures in which lexical properties play the dominant role in frame assembly, making sentence frames the product of the specific words they contain. Alternatively, structural

constraints on assembly might dominate, proceeding in part independently of the particular words destined to appear in the frame. A structural assembly process like this would give rise to the abstract constancies of speech errors, orderly structure with disorderly words (Bock, 1990).

In this further opposition between word- and structure-driven language production, the theoretical and empirical debates play out on a field shaped by research on structural priming and persistence. In the next section we look at what priming and persistence are, and then turn to the findings that dominate the debate.

Structural Priming and Structural Persistence

Speakers have a tendency to recreate and reuse surprisingly subtle relational features of utterances when they talk (Bock, 1986b). We call this *structural persistence*, the persistence of structural features from one sentence into another. On the assumption that the features represent basic properties of sentence frames, considerable effort has gone into exploring the factors that are responsible for the recreation and reuse of sentence structure. If the factors behind structural persistence themselves reflect properties of structural assembly, the findings from this research are important to how speakers group and order the words that they eventually produce.

To distinguish the phenomenon of structural persistence from the conditions that create it, we use the term *structural priming* for circumstances that evoke structural persistence. Accordingly, *structural priming* encompasses events that (adventitiously or intentionally) evoke later use of similar frames at greater-than-chance levels. The priming event is the structural prime, and a sentence in which the effect of priming can be observed is called the target. The increased tendency to use a frame is *structural persistence*.

Structural persistence can be observed over a wide range of conditions, over a wide range of ages, in a variety of languages, outside of awareness, within and between input and output processing modalities, using different kinds of exposure, tasks, structural forms, and measures. It persists across time, extraneous events, and changes in tasks, despite differences between primes and targets in content words, function words, bound morphology, and thematic roles. It is observable in the absence of discourse context, but also in the presence of discourse context, including conversation, ordinary speech, and writing. It has been found in different languages from different

language families. It occurs *across* the languages of bilingual speakers (see Pickering & Ferreira, 2008, for review.) It occurs when primes lack linguistic meaning but have the requisite structural properties (Scheepers et al., 2011). Most important, it goes away when prime and target sentences are superficially similar in word order and metrical properties, but have different structural frames (Bock & Loebell, 1990, Experiment 3).

Many of the key properties of structural persistence have been observed in experiments using a structurally primed event-description paradigm. The features of the paradigm circumvent an array of objections to the hypothesis that structural persistence is indeed structural, and not a byproduct of speakers' intentions or nonstructural relationships between sentences. This makes it worth describing the method in some detail.

The procedure requires participants to do two things. One is a memory task, a standby of laboratory psychology, presented as the primary task in an experiment ostensibly directed at memory processes. The secondary task serves as a supposed aid to memory, requiring speakers to produce an utterance in response to an event on each trial. It is this secondary task that elicits the responses of interest.

The trials consist of a long, random-seeming sequence of unrelated sentences and pictures. The order of sentences and pictures looks haphazard, with only occasional cases in which sentences precede pictures. A few of these cases constitute structural priming trials that proceed no differently from

other trials. For instance, on one trial a participant might hear and repeat the dative sentence

The governess poured a cup of tea for the princess.
On the next trial, a picture like this appears:



The participant says what is happening in his or her own words.

The covert relationship between the sentence and event is in the structure of the sentences produced. A sentence produced aloud as *The governess poured a cup of tea for the princess* may be followed by an event that can be described as either “The boy is giving an apple to the teacher” or “The boy is giving the teacher an apple.” Other participants see the same event, but preceded by the sentence *The governess poured the princess a cup of tea*.

What happens as a result of this procedure is that the probability of the primed structure increases. *The governess poured a cup of tea for the princess* is a prepositional dative that raises the probability of the prepositional dative in the target description, “The boy is giving an apple to the teacher.” Likewise, the participants who receive a double-object version of the prime *The governess poured the princess a cup of tea* exhibit an increased tendency to produce a double-object target, “The boy is giving the teacher an apple.”

This task is simple for participants, despite its methodological complexity. It also has important advantages, especially in creating priming episodes that are incidental and noncoercive. The manipulation is covert, camouflaged by the pseudorandom arrangement of lexically and topically disjointed events, most of which are filler sentences and



pictures representing a variety of other structures and event types. Speakers virtually never notice the structural properties of what they hear and say, nor do they suspect that the point of the experiment is how they describe the pictured events. Even the artificiality of the procedure serves a purpose, minimizing the syntactically influential pragmatic pressures of conversations. As a result, what participants say is unforced. When a prime's structure persists in a target sentence, the structure arises in extemporaneous speech that is constrained only by the pictured event.

Despite its importance, the spontaneity of structural formulation in this task has a major disadvantage: Some responses have to be discounted because relevant structural features are absent. Fortunately, other methods have been developed to circumvent this limitation. Though they tend to reduce the covertness of the manipulation and the spontaneity of speaking, they have complementary strengths that help to establish the generality of the phenomenon. In fact, there is good evidence for structural persistence in corpora of spontaneous speech, confirming its presence in everyday language use.

The findings from all of this work illuminate the circumstances in which structural persistence arises. In fact, mere exposure to a structure can suffice, with no intention or even explicit capacity to remember the structure on the part of eventual speakers. Striking evidence comes from individuals ~~suffering from~~ anterograde amnesia (Ferreira, Bock, Wilson, & Cohen, 2008). Amnesic patients and normal control subjects were tested for structural persistence at different intervals after priming occurred, from immediately after priming up to as many as 10 unrelated events later. Persistence was observed at all intervals for the normal and amnesic speakers, and to statistically similar degrees.

What makes this remarkable is the nature of anterograde amnesia. People with the disorder are typically unable to successfully probe the contents of their memories, even at short intervals after an experience. Consistent with this, the amnesic individuals in the priming experiment exhibited structural persistence even when their ability to recognize the priming sentences that they had just heard was profoundly impaired. Nonetheless, the levels of persistence were the same as in control speakers. This preservation of performance in the face of severe memory impairment is a well attested property of anterograde amnesia. In several domains, the ability to learn skills implicitly remains unimpaired, and even improves with practice, in the face of

inability to recall performing the same task ever before (Cohen & Squire, 1980).

So, structural persistence is pervasive and durable. Though its effects tend to be subtle and small, they have been observed in so many circumstances that its contributions to first and second language learning, to structural acceptability, to language change, to social bonding, and more, have become topics of research, speculation, and discussion (Bock & Kroch, 1989; Loebell & Bock, 2003; Luka & Barsalou, 2005; Pickering & Garrod, 2004). Nonetheless, much remains uncertain about its mechanisms and limitations, and we come to that problem now.

Structure-Driven and Word-Driven Assembly of Frames

The persistence of structure in the absence of more salient kinds of similarity implies that ordinary sentences undergo an assembly process of the kind disclosed in speech errors. Here, though, the product of frame assembly successfully conveys what a speaker means, albeit without support in the speaker's message for all of the details of the sentence frame. The implication is that structural persistence can be exploited in finding out how frames are built. However, something more is needed to uncover the specific mechanisms of structural assembly, to shed light on the factors that support and inhibit frame construction.

One valuable approach to this problem puts a provocative spin on structural priming. The implicit strategy is to look at what happens when factors that *can* be decoupled from structural persistence (disclosing its abstract structural sources) are instead *recoupled* with it. Pickering and Branigan (1998) took this fruitful tack in experiments that combined structural priming with repeated-word priming in constrained sentence-completion tasks. This research sparked a line of investigation that reintroduced pragmatic variables (Branigan, Pickering, & Cleland, 2000), phonological variables (Cleland & Pickering, 2003; Santesteban, Pickering, & McLean, 2010), information-structure variables (Bernolet, Hartsuiker, & Pickering, 2009), and more.

The general outcome of increasing similarity and increasing pragmatic constraint is an increase, sometimes a massive increase, in the probability of the kinds and forms of sentences that are elicited, relative to the rate seen with structural priming in the absence of lexical and contextual support. The only major exception may be phonological relatedness, which is ineffective in increasing persistence

in the absence of full phonological repetition between homophonic words (compare Cleland & Pickering, 2003, with Santesteban et al., 2010). What has emerged from this research is a theoretical debate that centers on the mechanisms behind the increased effectiveness of priming.

The bulk of the debate is about whether the impact of repeated words (often but not always verbs) occurs within a lexically or structurally driven framing process. Because the repetition of words across primes and target sentences raises the probability of structural persistence, the increase has come to be called the *lexical boost*. To distinguish lexically boosted performance from the persistence that arises in the absence of repeated words, we call the latter *abstract structural persistence*. In simple terms, the debate is about where the lexical boost comes from and whether its origin is in the same mechanisms that yield abstract structural persistence.

To tie the lexical boost to structural priming, Pickering and Branigan (1998) proposed a lexically based model for sentence production, with the further aim of explaining abstract structural persistence in the same framework. In the model, the lexicon consists of a network of lemmas through which activation spreads during the retrieval of words for production (Roelofs, 1992, 1993). Lemma activation makes schematic information available about the syntactic contexts or structural privileges of specific words. In the Pickering and Branigan account of structural persistence, the words in a prime activate their lemma representations, including the specific structural contexts in which the words appeared. So, when the verb *show* occurs in a sentence with a direct and an indirect object (*showed the painting to the gallery owner*), the representation of this structural context becomes more activated than an alternative that allows *show* to appear with two objects (*showed the gallery owner the painting*). If a subsequent sentence also contains the verb *show*, continued activation of *show*'s structural-context information predisposes the reuse of the verb in the same structure (e.g., *showed the hammer to the builder*).

The model's explanation for abstract structural persistence rests on the assumption that syntactic privileges of lemmas are themselves part of a network that captures similarities in the structural schemas for different lemmas. For instance, the verbs *show* and *give* share certain structural privileges that may be linked to each other. As a result, when prime and target sentences contain different verbs, structural

persistence can still occur. The persistence is weaker than with word repetition, because the direct connection between a specific lemma and its structural privileges is missing. Nonetheless, because of the lingering activation in the structural information associated with a word from a priming sentence, a word with the same structural privileges can tap into and exhibit effects from residual structural activation. That is, verbs like *show* and *give* that share an activated representation of a particular structure may both become temporarily inclined toward the use of that structure. The result is a secondary form of structural persistence that is a reflection of lexical representation and retrieval, rather than structural formulation processes.

A structure-driven account treats the lexical boost as an incidental but influential byproduct of identifying and binding a suitable word to a structure (finding-and-binding). Ordinarily, when a primed structure finds and binds a word, structural assembly proceeds with an inclination to recreate the same structure, yielding persistence. However, when the word that a primed structure finds and binds repeats a word that occurred in the priming sentence, there is an additional facilitation in the binding process. The consequences of facilitation include support for structural operations that result from immediate repetition of the same binding within the same procedures. This arises over and above the facilitation from abstract structural priming.

The competing predictions about the lexical boost that follow from these broad accounts reflect the primary versus secondary roles of structural processes in structural and lexical steering. The major prediction from the lexical perspective is that lexical repetition and other kinds of lexical facilitation should increase structural priming. This prediction has been amply confirmed. The structural hypothesis instead focuses on the duration of structural persistence and the conundrum this poses for a model in which words are viewed as the portal to structural information. To account for the extended time-course of abstract structural persistence attested in several experiments (Bock & Griffin, 2000; Bock, Dell, Chang, & Onishi, 2007; Ferreira et al., 2008; Kaschak, Kutta, & Schatschneider, 2011) the lexical hypothesis has to predict that the lexical boost should have a similarly long time-course. That is, the amount of persistence should be magnified when a target sentence contains a repeated word, even if the target occurs well after the prime.

Tests of this prediction have yielded results that run counter to it: the lexical boost is brief, disappearing within one or two sentences after a prime (Hartsuiker, Bernolet, Schoonbaert, Speybroeck, & Vanderelst, 2008; Konopka & Bock, 2005). When the boost disappears, what remains is the amount of structural persistence that tends to be observed when words are not repeated.

The differences in time course suggest that distinct mechanisms are responsible for the abstract form of structural persistence and lexically enhanced persistence. In a structurally driven formulation process, the distinct mechanisms are binding and structure building. Because binding is transient, the lexical boost also is transient. The problem for the lexical account is the idea that a word's links to structural representations are the underpinnings of syntactic processing. The effects of these links cannot be transient if they are to account for the duration of structural persistence, but they cannot be long lasting without predicting a lexical boost that endures as much as does abstract persistence.

The syntax-driven alternative to the lexical account places the source of persistence in a procedural system that instantiates the abstract mechanisms of structural assembly (Chang et al., 2006). One of the noteworthy features of the model is that it accounts for the abstractness of structural priming and for its durability in a system that implicitly learns how to build sentence structures. Learning occurs throughout the lifespan, tuning the structural operations that formulate utterances every time they are used. The model accounts for the abstractness in the relationship between prime and target sentences, because the structural operations do not depend on the properties or repetition of specific words. It accounts for observed levels of priming in a wide range of experiments and for the duration of persistence in normal and amnesic speakers. Perhaps most intriguing is that the model's learning mechanisms are rooted in language comprehension rather than production, predicting the cross-modality and modality-general effects that have been observed. A strong prediction, recently confirmed, is that priming within comprehension and priming within production should exhibit similar changes in the probability of persistence (Tooley & Bock, 2012).

Structural Assembly and Morphological Specification

Morphological specification during sentence production has a lot to do with grammatical inflection

(e.g., making words singular or plural). It comes together with structural assembly most saliently in the processes of grammatical agreement. There are several important kinds of agreement (e.g., subjects and verbs, pronouns and antecedents, and determiners and nouns) and features of agreement (e.g., number, person, natural and grammatical gender agreement). In English, agreement is familiar in the morphological variations that flag subject-verb number agreement: singular subjects occur with singular verbs (*The girl sings; The mother was proud*) and plural subjects appear with plural verbs (*The girls sing; The mothers were proud*). Subject-verb agreement is a fundamental part of morphological specification in sentence production, and a target of active research (see Bock & Middleton, 2011, for details).

Perhaps the most important thing to note about grammatical agreement, as a process of actual, everyday language production, is that its implementation calls on information from the notion on down: it depends on much more than morphology. Messages have to represent information about the construed one-or-more-than-oneness of things (*notional number*). This information has obvious consequences for lexical identification (whether a word will be singular or plural). Its consequences for scaffolding are less obvious but at least as important: the scaffold has to have information about whether the notional number of the subject's referent is one or more than one, separately from information about whether the subject noun is singular or plural.

Among the many reasons for why this must be, the most transparent is that the details of sentence formulation unfold in a way that varies with notional number, even when grammatical number stays the same. Take a subject like *her brother and best friend*. Appearances to the contrary, *her brother and best friend* can be either one person or more than one. When *brother and best friend* are separate individuals, a notional plural, speakers will produce a plural verb (*Her brother and best friend are coming to the wedding*) but if one and the same individual is both *brother and best friend* (a notional singular) the agreeing verb will be singular (*Her brother and best friend is coming to the wedding*).

Most people's awareness of subject-verb agreement is limited to a few forgettable lessons and occasional withering remarks about standards in contemporary grammar. Ironically, agreement is more appropriately cast as something that is unexciting (to most people) but complicated and important in its purpose, like a linguistic version of the

pancreas. It is one of the most basic devices for doing what syntax does: tying together linguistically what belongs together mentally, even when the linguistic pieces are far apart. A sizeable majority of languages in the world have it. English-speaking children learn it and use it, mostly correctly, long before they start school. English speaking adults use it, mostly correctly, more than once every five seconds in running speech.

Once again, there are two components of agreement that have to be coordinated, a lexical part and a structural part. The grammatical number of a word can be different from the notional number of its referent: In English, the word *scissors* is plural (unlike other languages) even when the word refers to a single implement (i.e., the notional number is singular). However, when a single scissors-categorized referent in the message is about to become the sentence subject, it is not plural. This conflict has to be reconciled in order for agreement to occur, and the grammatical number of the word typically (though not always) wins. This is another lexical/structural coordination problem that has to be worked out in the scaffold. In turn, it has consequences for structural assembly and morphological specification, where agreement unfolds (for models of these processes, see Eberhard, Cutting, & Bock, 2005; Franck, Lassi, Frauenfelder, & Rizzi, 2006; Franck, Soare, Frauenfelder, & Rizzi, 2010; Franck, Vigliocco, Antón-Méndez, Collina, & Frauenfelder, 2008).

Fittingly, there are lexically and structurally driven accounts of agreement. Lexical accounts (Vigliocco, Butterworth, & Garrett, 1996; Vigliocco, Hartsuiker, Jarema, & Kolk, 1996) build on linguistic approaches that make the lexicon and morphology the center of grammar in general and agreement in particular (e.g., Pollard & Sag, 1994). In these frameworks, notional number variations drive variations in agreement morphology, not only noun number but also verb number. For example, on this view the abstract lexical representations behind the singular and plural forms of the verb *sing* (*sings* and *sing*) reflect a notional difference between individual and multiple instances of singing. A structural approach places the responsibility for verb number with the sentence subject, whose own number determines the number of the verb during structural assembly: verb inflection is not a consequence of lexical identification, but of structural relations.

Evidence for the structural view and against the lexical view comes from experimental comparisons of verb and pronoun number agreement. Pronoun

number is in large part notionally determined, originating in a lexical identification process in which a singular or plural pronoun is selected from the lexicon. Because this is exactly the same kind of process hypothesized for verb agreement in lexical accounts, verb and pronoun number should have similar patterns of occurrence when pronoun antecedents and sentence subjects have the same referent. Contradicting this prediction, the distributions are strikingly different. While pronouns are extremely sensitive to notional number, verbs carry only weak vestiges (Bock et al., 2006; Bock, Nicol, & Cutting, 1999; Bock, Eberhard, & Cutting, 2004). These differences are well accounted for in the Eberhard et al. (2005) model of verb and pronoun agreement.

Likewise consistent with the structural account is a type of syntactic error called *attraction*. In a prototypical attraction error, verb number agrees not with the number of the subject, but with the grammatical number of another noun phrase in the sentence. So, in the first author's favorite attraction error ("Dr. Bock's research on the processes of speech production rank among the most important contributions to modern cognitive psychology"; #10 in Table 1), there is a singular subject noun (*research*) but a plural verb (*rank*), seemingly a reflection of a nearby plural noun (*processes*).

Attraction errors have two significant features that make their source more likely to be structural than lexical. The first is that the grammatical number of an attractor, not its notional number, is responsible for attraction. This indicates that the notional number of the referent of the attractor does not determine the number of the number of the affected verb (Bock & Eberhard, 1993; Bock, Eberhard, Cutting, Meyer, & Schriefers, 2001; Bock, Eberhard et al. 2004; Deutsch & Dank, 2009). Analogous effects are found in gender agreement, when the gender of an attractor creates a gender error: grammatical gender creates attraction, but notional (biological) gender does not (Deutsch & Dank, 2009; Vigliocco & Franck, 2001).

Where notional number does matter is in the formulation of sentence-subject number itself, throughout message formation, lexical identification, and structural scaffolding. Notional effects on agreement can then be explained as another facet of lexical and structural coordination that becomes observable in the interaction between morphological specification and structural assembly. When notional number gives a sentence subject an abstract plural feature, subjects take on a property that can

show up in number agreement, even when it does not surface on a noun. They do. Beyond the variations in verb agreement with conjunctions that were mentioned earlier, there are well-attested cases of plural agreement with subject noun phrases that are grammatically but not notionally singular, in particular collective and distributive subjects.

Collective subjects for the most part take singular verbs in American English (e.g., *The jury is deadlocked*), though they refer to multiple people at the same time. They are nonetheless more prone to plural verb agreement than a subject noun like *judge* (Bock et al. 1999; Bock, Eberhard et al. 2004). Distributive subjects make a subtler but more convincing case. Like collectives, distributive phrases can be singular subjects that represent multiple referents in singular subjects: the phrase *the picture on the postcards* implicates multiple instances of a singular picture, one per postcard. Even though *picture* is singular, when phrases like these serve as sentence subjects, they show up with plural verbs more often than would be predicted by the rates of plural attraction alone. This has been observed in English (Eberhard, 1999) and other languages including Spanish, Dutch, French, and Italian (Vigliocco, Hartsuiker et al., 1996).

Significantly, harking back to the “chasm” between language and thought, effects like these can be the same in magnitude in different languages from different language families (Bock et al., 2012). If notional properties affect grammatical agreement in similar ways crosslinguistically, agreement falls squarely into the realm of devices that tie together linguistically what belongs together mentally. Like other structural devices in language, agreement plays an important part in what syntax does for human communication.

Conclusions

There are a few broadly important points about the production of syntax that deserve a reprise. A central one is a property that sets a psycholinguistic account of language apart from linguistic approaches. This property is the situatedness of sentence production in the circumstances of communication. Speakers have to do a whole lot more than create grammatically acceptable sentences. They have to create acceptable sentences that make sense. This means that they have to convey *particular* notions to *particular* people in *particular* circumstances in a *particular* language.

Getting the particulars right means that speakers cannot use any old words with any old structures at any old place and time, at least if they intend to

communicate. They have to use words that fit their notions, selected from a vocabulary with upward of 40,000 items. They have to use structures that fit their notions, created from an incalculable number of possibilities. They have to fit the words and structures together. They have to do these things flexibly and opportunistically, in a fashion that can accommodate the vicissitudes of memory, perception, attention, and thinking, without neglecting muscles (i.e., the articulatory system, which has been said to encompass more working parts than any other human ability; Fink, 1986). Speakers have to accomplish all of this rapidly, at least fast enough to approximate a normal and socially tolerable speech rate, in the neighborhood of four words per second. Astonishingly, they *do* get the forms of utterances right, with surprisingly few exceptions, coping with disfluency as they go. Successful communication seems to be more the rule than the exception.

Out of this fundamental property of situatedness comes the problem that we see as the central one for explaining syntax in language production. The problem is explaining the nuts and bolts and gears of coordination, the mechanisms needed to turn notions into language (how speakers find pieces of language to start with, undertaking the heavy lifting needed to recruit words and syntax); explaining how words and syntax follow from linguistic starting points (in the opportunistic ways reflected in accessibility effects and structural persistence, as well as in lexical and syntactic errors); explaining how structural assembly and morphological specification forge linguistic links that flag what goes together mentally (as in the workings of grammatical agreement); and to achieve a grand union with sounds and speech.

Much of current research on language production goes after the components of coordination separately, with optimism that the pieces of the puzzle will eventually fit together. The puzzle in which all of the pieces fit will show how speakers create syntax from the interlocking components of coordination. It is not easy. But beguilingly, it feels easy enough that we will risk it one more time. The upcoming string of words was formulated from our here-and-now conscious contents, built with the intention to afford similar conscious contents to you, wherever you may be in time and space:

This is the end.

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