CHAPTEH 6

Sentence Production:
From Mind to Moutn

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1. TOWARD AN EXPLANATION OF LANGUAGE PRODUCTION

The study of sentence production is the study of how speakers turn messages into utterances. Messages are communicative intentions, the things a speaker means to convey. Utterances are verbal formulations. They may be complete sentences or fragments of sentences, well formed or errant, fluent or hesitant. To paraphrase a famous formulation of Chomsky's (1965, p. 3), a theory of sentence production is concerned with real speakers who are vulnerable to memory limitations, distractions, shifts of attention and interest, and errors (random or characteristic) in applying their knowledge of the language.

The goal of a theory of sentence production is to explain how speakers use linguistic knowledge in the production of utterances. This requires a specification of the knowledge that speakers have and a specification of the information processing system in which the knowledge is put to use. Linguistic knowledge is a component of the speaker's long-term memory. As a practical matter, descriptions of language structure from linguistics are often taken as best guesses about the organization of speakers' knowledge of their language (see Frazer, Chapter 1, this volume). The chief issues in production therefore center on information processing, and include how and when the processing system retrieves different kinds of linguistic...
knowledge, how the system uses the knowledge once it has been retrieved, how and when the system retrieves and uses nonlinguistic knowledge, and how the system is organized within and constrained by human cognitive capacities.

What is there to explain? Phenomenologically, talking is no harder. In a lecture delivered at the University of Illinois in 1909, Titchener claimed to be able to "read off what I have to say from a memory manuscript" (1909, p. 81), certainly caricaturing the usual experience, but perhaps not by much. Because of this apparent ease, the interesting problems of production are more readily appreciated, and most often studied, in terms of talk's typical failures.

The failures range widely. A psychologist reported a transient neurological episode in which he was able to form perfectly coherent messages, but could not express them:

The thoughts can only be described in sentence-like form, because they were as complex, detailed, and lengthy as a typical sentence. They were not sentences, however. The experience was not one of merely being unable to articulate a word currently held in consciousness. Instead, it was one of being fully aware of the target idea yet totally unable to accomplish what normally feels like the act of finding-and-saying-the-word... The idea... was complete and full as any idea one might have normally, but was not an unspoken mental sentence... It was the unusual "gap" in this usually seamless process [of sentence production], a process taken completely for granted in normal circumstances, that amazes me. (Ashcroft, 1993, pp. 49, 54)

William James described the tip-of-the-tongue experience, in which a single circumscribed meaning comes to mind but the corresponding word does not:

Suppose we try to recall a forgotten name. The state of our consciousness is peculiar. There is a gap therein: but no mere gap. It is a gap that is intensely active. A sort of writhing of the name is in it, beckoning us in a given direction, making us at moments tingle with the sense of our closeness, and then letting us sink back without the goal for term. If wrong names are proposed to us, this singularly definite gap acts immediately so as to negate them. They do not fit into its mould. And the gap of one word does not feel like the gap of another all empty of content as both might seem necessarily to be when described as gaps. (James, 1890, pp. 251–252)

A professor on leave from his university, and looking forward to his return, expressed the opposite sentiment

"I miss being out of touch with academia."

A radio-talk-show host, querying a guest about a government official who was reportedly having an affair with a female subordinate, questioned the propriety of the official being involved with someone who he works for."

A secretary, discussing the problems of home renovation and their depiction in a movie called "The Money Pit," said,

"Have you ever seen the movie, 'The Movie Pit'?

A lecturer, intending to make the point that verbs are inflected for number, said,

"The verb is inflected for number."

And finally, an umbrella-carrying colleague was asked,

"Is that your elevator?"

These cases and many others reveal that a lot can go wrong between the mind and the mouth. What a theory of sentence production has to explain, apart from such errors, is the course of events or those less notable but more frequent occasions when everything goes right.

When set against a backdrop of normal success in speech, failures of production hint at an information handling system of great complexity but considerable efficiency. Measurements of normal speech rates give average values of about 150 words/min (Machley & Ogood, 1959) or 5.65 syllables/s (Deese, 1984). Yet syntactic errors are surprisingly rare. In a tape-recorded corpus of nearly 15,000 utterances, Deese (1984) counted only 77 syntactic anomalies, roughly one in every 195 utterances. Heeschen (in press) reported a similarly low incidence of syntactic errors in spoken German. Errors of lexical selection are even less common, with attested rates averaging under one per thousand words (Bock & Levelt, 1994).

Dysfluency is more pervasive, as is the jabberwocky most prominently associated with the 41st president of the United States:

"No, we've taxed—"we're taking steps to fund it. Because I think when you create more export market—OPIC—and that's exactly what it does—you create more jobs in this country. In this sick and ailing country, which has had—incidentally grown for the last five audio technical difficulties[—]

Hey, just a minute. I haven't finished yet. (Remarks by George Bush in Collegeville, Pennsylvania, September 9, 1992)

Nerority aside, dysfluency and jabberwocky must be distinguished from outright error. First, they can be consequences of changes to or uncertainty in the message, rather than disruptions in production mechanisms themselves (Goldman-Eisler, 1968; Schachter, Christenfeld, Ravina, & Bilous, 1991). Message uncertainty is more akin to a thinking problem than a talking problem. Second, dysfluency and jabberwocky both seem to display local well-formedness: dysfluencies typically interrupt or punctuate syntactically and phonologically well-formed stretches of speech (Levelt, 1983),
and commonplace jabberwocky, like its literary namesake, is often syntactically well-formed at the same time that it is semantically or pragmatically incoherent.

This chapter surveys some contemporary views about the processes that produce the structural and lexical features of utterances, as well as errors and dysfluencies. The first section sketches a modal view of the processes of production as background for the second section, which highlights some current controversies. The third section looks at fluency and how it is linked to the information processing problems of production. The conclusion touches on some residual questions about the relationships between production and comprehension and between performance and competence.

The treatment of these things is too cursory to do them full justice. More comprehensive surveys and alternative analyses of some of the issues can be found in Levelt (1989) and Bock and Levelt (1994). Bock (1995) reviews the observational and experimental methods that are used in production research. For other topics, I offer directions to supplementary literature throughout the chapter.

II. AN ANALYSIS OF SENTENCE PRODUCTION

Behind most current work in language production there is a widely shared view about the broad outlines of the production system (for a divergent perspective, see McNeill, 1987). In this chapter I sketch those outlines, reserving until later a discussion of some of the disagreements that have developed within this framework.

Figure 1 gives an overview. It separates processing into three broad components, the message component, the grammatical component, and the phonological component. The vertical connections represent the staggered flow of information over time, with the message leading and phonological encoding trailing. The message captures features of the speaker’s intended meaning and communicative perspective (see Clark and Bly, Chapter 11, this volume). The phonological component spells out the sound structure of the utterance, both in terms of the phonological segments of word forms and the prosody of larger units (see Cutler, Chapter 4, and Fowler, Chapter 2, this volume). In between lies the grammatical component. This is the heart of language production, serving to build the bridge from meaning to sound.

A. The Grammatical Component: An Overview

The processes within the grammatical component subdivide into functional processing and positional processing. Functional processing associates message elements with grammatical functions on the one hand and with entries in the mental lexicon on the other. Positional processes associate grammatical functions and lexical entries with sentence structures and word forms. Each of these subcomponents thus includes mechanisms that specify words or morphemes (lexical mechanisms) and mechanisms that create word order (structural mechanisms).

In functional processing, the lexical mechanism is lexical selection, which involves the identification of lexical entries that are suitable for conveying the speaker’s meaning. These entries are often called lemmas in the production literature, and can be likened to the part of a dictionary entry that lists a word (i.e., indicates that an appropriate word exists) and gives its grammatical features. The structural mechanism is function assignment, which assigns and coordinates grammatical roles with features of lexical entries (ensuring, e.g., that the lexical entry destined to serve as the head of the subject phrase is a noun). Positional processing involves lexical retrieval (activating a schematic description of a word’s phonological features) and

- **FIGURE 1** The components of the language production system (adapted from Bock & Levelt, 1991). The links among the components are staggered from left to right to represent the flow of information over time.
the creation of a hierarchically structured, ordered set of word and morpheme slots (constituent assembly). In Dell's (1986) model, the lexical work is carried out in the lexical network and the structural work by tactic frames.

The grammatical component can be specified more concretely by going through the steps in generating a simple utterance and constructing problems or errors that might arise at each step. Suppose a speaker witnesses an event in which an unknown man gives a stick of licorice to a known boy. Later, in a conversation about the same boy, the speaker describes the event in this way: “A guy offered him some licorice.” After the speaker had decided which features of the event to talk about (to encode in a message), what was required in order to convey the remembered event into this utterance?

1. Functional Processing

A major step in functional processing is lexical selection. The speaker must determine that words with the appropriate meanings exist (i.e., find lemmas corresponding to the intended meanings) and mark the lemmas for inclusion in the utterance. This marking, which constitutes selection, makes available the grammatical information that is associated with the word (e.g., whether it is a noun or verb). Several things can go wrong in this selection process. One is that a word is selected whose meaning does not quite match the intended meaning. This produces a kind of speech error called a semantic substitution (Hotopf, 1980), illustrated by our hypothetical speaker saying “A guy offered him some celery.” Another possibility is that two words with closely related meanings may be selected in tandem, creating a blend (Bohler, 1961; MacKay, 1972) such as “A my offered him some celery” (my blending man and guy). A third problem is not strictly one of lexical selection, but offers some insight into its nature. Sometimes speakers select a word whose meaning they know but whose pronunciation eludes them. This yields a tip-of-the-tongue state (R. Brown & McNeill, 1966), which can be interpreted as successful lexical selection coupled with failed lexical retrieval or phonological encoding.

Another part of functional processing is function assignment, which determines what grammatical roles different phrases will play. It involves assigning syntactic roles such as nominative, accusative, dative, and so on to the rudiments of eventual phrases, for example, during the formulation of “A guy offered him some licorice,” provision must be made for associating with individual referents. The known boy, the unknown man, the stick of licorice, with a nominative noun phrase (a guy), an accusative noun phrase (some licorice), a dative noun phrase (him), and a verb that unites them in the intended way (offered). Problems in function assignment manifest themselves in phrase exchange errors such as “I got into this guy with a discussion” when “I got into a discussion with this guy” was intended (Garrett, 1980). In such errors, phrases surface in the wrong syntactic role. So, in the error “He wants us to do something else” (“We want him to do something else” was intended), a plural first-person pronoun seems to have been assigned the accusative instead of the nominative function, and a singular masculine pronoun was assigned to the nominative instead of the accusative function. Notice that these are not simple exchanges of word forms, since the attested error is not “He want we to do something else.” A switch in the function assignments in the example utterance, erroneously assigning the dative to a guy and the nominative to the masculine pronoun, would yield “He offered a guy some licorice.”

2. Positional Processing

The events of functional processing pave the way for positional processing, which retrieves certain specifications for the elements of the utterance and fixes their locations. Lexical retrieval consists of activating the lexical and grammatical morphemes that fill the slots in this structure. Lexical morphemes are customarily dubbed lexemes in the production literature, and they represent such word features as number of syllables, location of primary stress, and segmental (phonological) composition. For example, the lexeme for licorice might indicate that it has three syllables with stress on the first, along with a blueprint for its segmental phonology.

Common errors that can be traced to lexical retrieval are phonological word substitutions, in which a word that sounds the same as the intended word substitutes for it (Fay & Cutler, 1977). The intended utterance “make a funny face” turned into “make a fuzzy face” after a phonological substitution. These are sometimes called malapropisms. A hypothetical error of this sort in the example “A guy offered him some licorice” might yield “A guy offered him some I merick.” A second type of error that is arguably due to a malfunction in lexical retrieval involves the exchange of individual words, as in “You remember . . . our Cambridge in kitchen?” (where the target utterance was “You remember . . . our kitchen in Cambridge?”). Grammatical morphemes consist of inflections and closed-class words. So, to construct “A guy offered him some licorice,” the elements a, -ed, and some must be designated. Notably, these elements are rarely involved in errors like the substitutions and exchanges of lexemes (Garrett, 1982). Competing explanations for this apparent invulnerability to error fuel a controversy about whether these elements are retrieved in much the same way as lexemes (e.g., Stemmer, 1984) or are specified in a manner that, in effect, bypasses the need for lexical retrieval (Garrett, 1982).

The other subcomponent of positional processing is constituent assembly. This creates an implicit hierarchy for phrasal constituents and inflectional morphemes. The hierarchy controls the grouping and ordering of
words during production, encoding various dependencies among syntactic functions. For "A guy offered him some licorice," the hierarchy can be depicted in this way:

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     y
    / \   
  stem  affix
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This structure is largely predictable from the types of syntactic functions that have to be represented and from the syntactic features of the selected lemmas. There are few errors that can be unambiguously attributed to the formation of these structures, although certain agreement errors (Bock & Eberhard, 1993; Bock & Miller, 1991) and word deletions are potential candidates. For example, a football broadcaster intoned the commercial message, "Formby—No one woods as good" instead of "Formby—No one woods wood as good." Since the utterance contains a verb slot (its presence can be inferred from the verb inflection -s) but lacks a direct object slot, one interpretation of this error (albeit not the only one) is that the direct object occupied the verb's place. A similar error might yield "A guy nimmed some licorice." This sounds anormal even as a mistake, in testimony to the fact that structural errors are very rare at all levels. In phonological encoding, as well, the structure of syllables is seldom deformed from acceptable English patterns.

One error feature that is more directly traceable to constituent assembly is known as stranding (Garrett, 1982). Stranding occurs because inflections are bound to other words in speech but, in processing, can be divorced from them. So, the past-tense feature on the verb offered requires the retrieval or generation of the inflectional morpheme -ed. Stranding is illustrated in the utterance of a speaker who intended to say "The dog doesn't save any windows" and instead said, "The window doesn't have any doomes." In such errors, bound suffixes (here the plural -s) show up in their proper locations in the utterance but affixed to the wrong (often exchanged) word stems.

3. Monitoring

Not shown in Figure 1 is a component that has a major impact on ongoing speech. This is the monitor, which oversees the output of the production system and initiates self-repairs or redirects already-uttered speech. Levelt (1983, 1989) identified the monitor with the comprehension system, and constructed its input as fully formed products of the production system. These products may be either inner speech (the voice in which we silently talk to ourselves) or overt speech. Monitoring should be distinguished from the potential for unconscious modification of the products of processing prior to production (see: MacKay, 1987, chap. 9). The questions that have been asked about monitoring have to do with what speakers monitor, when they monitor, and how they repair their speech.

Levelt (1989, chap. 12) offers examples to suggest that speakers monitor every facet of speech for infelicity as well as outright error. Among clearly identifiable errors, there are differences in the likelihood of repair that may reveal something about where attention is directed during speech. Errors of word choice: (saying "hot" instead of "cold") are surprisingly unlikely to be noticed: two studies have shown correction rates hovering around 50% (Levelt, 1983; Nooteboom, 1980). Sound errors may be caught more reliably. In one observational study, they were corrected at a rate of 75% (Nooteboom, 1980).

Blackmer and Mitton (1991) examined the timing of self-repairs in the spontaneous speech of callers to a radio talk-show. These speakers interrupted themselves an average of once every 4.8 s, sometimes to repair speech errors. For speech errors, the speakers halted 426 ms after the error, overall, and initiated corrections an average 545 ms after the error. Revision (reparations for style or propriety of speech) took significantly longer, averaging 1126 ms between the original utterance and the change. Although they did not break down the production errors, Blackmer and Mitton observed that most of the fastest (under 150 ms) error-to-cutoff times involved the production of aberrant phonemes. This reinforces the suggestion that speakers carefully monitor their articulation as well as the conceptual and pragmatic content of their messages.

How speakers repair their speech depends in part on the kinds of errors they detect. Levelt (1983) found that speakers often acknowledged their errors with the use of editing terms before correcting them (62% of speech errors were so marked vs. only 28% of revisions). The most common editing expression, according to Levelt (1989), is "er": it exists in many languages with only minor phonetic variations, and in Levelt's 1983 study of self-repairs, accompanied 30% of all repairs.

III. SOME POINTS OF CONTENTION

The foregoing sketch of the production system can be used to anchor a set of ongoing arguments about how the grammatical component is organized. I will proceed through the questions roughly as they arise within the organization shown in Figure 1, going from top to bottom, although in some cases the issues apply to the architecture of the entire system.
A. From Message to Language

1. Message to Word

The first controversy arises in the transition from the message component to the selection of lemmas. The presupposition behind the transition is that there is some point in processing that is nonverbal, the message, and another that is verbal (cf. Butterworth & Hadar, 1989; vs. McNeill, 1989). One difficulty with this conception arises because languages differ in the kinds of notions that are grammaticalized, and therefore in the kinds of message information that will be relevant for grammatical encoding. For example, Chinese lacks the inflectional variation in noun number that is found in English, so there is no need for a Chinese speaker to represent number information in the message unless it is relevant to the communicative situation. English speakers have such choice, since the vast majority of English nouns indicate number in some way. In the face of these language-conditioned variations in what must be represented in the message, is it defensible to suppose that the message is truly nonlinguistic or, more generally, that there is an abstract thought code ("mentalese") that is completely divorced from language (J. A. Fodor, Bever & Garrett, 1974, chap. 7)? But a different way, is there any sense in which an utterance is meaningful on its own (Murphy, 1991) and supposing so, are there limits to that meaning?

One view of these matters is represented in Whorf's claim that the forms of thought are in thrall to the grammatical forms of individual languages (for a wide-ranging review and new evidence, see Lucy, 1992a, 1992b). A compromise can be found in Slobin's (in press) proposal that speakers engage in something that he calls "thinking for speaking," a kind of mental activity whose goal is to package messages in a way that can be verbalized in the target language. So, an English speaker must "think number" in order to speak; Chinese speakers need not. Levelt (1989) endorses a similar view, suggesting that an important component of language learning is the discovery of what features of mental states must be represented in messages. Levelt observed that once this learning is complete, there is no reason for the representation of the message to interact with the processes of grammatical encoding.

A related debate is over the format of mentalese, and specifically whether its elements, concepts, are wholes that are roughly isomorphic to the lexical vocabulary of language (J. A. Fodor, Garrett, Walker, & Parke, 1980; Roelofs, 1992) or more primitive features that can be independently combined and separated (Bierwisch & Schreuder, 1992; McNamara & Miller, 1989). These compositional and decompositional views have a variety of implications for lexical access in production. Levelt (1985, 1992) has worked some of them out in what he terms the hyperonym problem, which arises most clearly in a decompositional framework. The problem is that the semantic conditions for a superordinate term (e.g., dog) should be satisfied whenever a subordinate (e.g., poodle) is conceptually represented. The solution demands so nothing approximating a one-to-one relationship between concepts and lemmas, as in a compositional framework, or a requirement to use the most specific member of a set of satisfied lemmas (Levelt, 1992).

2. Message to Syntax

The mapping from messages to grammatical structures is equally poorly understood. It seems obvious that meanings and communicative functions somehow constrain the structures of utterances: languages have a tendency to group together syntactically things that belong together mentally (E. V. Clark & Clark, 1978), and speakers modify the structural organization of their utterances in response to subtle changes in the communicative context (Bock, 1977). However, it is unclear how message details serve to specify structural details in the course of normal processing and what the limits of these specifications are (for reviews of various perspectives, see Bates & MacWhinney, 1988; Bock, 1990; Newmeyer, 1992). Figure 2 recapitulates the leading possibilities in a Chinese-run format.

The columns in the figure contain the basic choices that must be made in a theory of the mapping from messages to grammatical structures. The theory must include a specification of form–function correspondences (select one from Column A) and a specification of the architecture of the processing system (select one from Column B). Regarding form–function correspondence in Column A, the first position is that the grammatical

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**FIGURE 2** Theoretical options for specifying the mapping from messages to grammatical forms in production. To build a production theory, combine one option from Column A (form–function correspondences) with one option from Column B (architecture of processing system). Iconicity implies a tight relationship between messages and linguistic forms; autonomy implies a minimal or irrelevant relationship. Modularity implies a production system that operates as a black box and is independent of message specifications; interaction implies a processing system that updates message specifications in light of ongoing processes.
structure of an utterance is heavily constrained by communicative functions and intentions, both developmentally and in ongoing language use. Newman (1992) terms this *aperture*, and Bates and MacWhinney (1989) call it level 4 functionalism. The alternative is *autonomy*, the position that the relationship between functions and structures is opaque or irrelevant to the explanation of form.

Moving to Column B, processing considerations are then factored into the theory. Because pronoun processing itself creates constraints, over and above message constraints, certain structural details may be modified in the course of utterance formulation. For example, structures may be organized to permit readily selectable words to be produced before inaccessible words (Bock, 1982; 1986a; 1987b) or to allow easily formulated structures to be produced in place of alternatives (Bock, 1986a; Bock & Kroch, 1989).

The degree to which a processing system imposes its own unique constraints on its product, it can be said to be modular. If the imposition of these constraints involves modifying or updating the message, the system is instead interactive. The result in either case is an utterance structure that may be a compromise between the demands of the message, the demands of the grammar, and the demands of efficient encoding in real time.

In practice, theories of language processing tend to draw their options from the same rows in Figure 2. Theories combine: iconic correspondence between form and function with interactive processing systems (e.g., Bates & MacWhinney, 1989), or combine autonomous grammatical components with modular processing systems (e.g., Frazier, 1987). In principle, however, a theory could combine iconicity with modularity (e.g., a categorial grammar like the one discussed by Steedman, 1991, could be implemented in a modular processing system), or autonomy with interactivity (MacDonald, Pearlmuter, & Scidenberg, in press, lean in this direction). Although the full range of positions is currently approached only in theories of language comprehension, the same options are available to production theories.

B. Debates about the Grammatical Component

1. Finding Words

Regarding the grammatical component itself, the central debates have to do with the discreteness of processing at each level. A strong case for these debates is the question of modularity (J. A. Fodor, 1983), particularly informational encapsulation. Informational encapsulation implies that specific cognitive processes are heavily restricted in the kinds of representations that are accessible to them. On one side there is the bias that encapsulation is a property that serves to keep production efficient by restricting the passage of irrelevant noise from one process to the next (Levett et al., 1991b). On the other side is the bias that the probabilistic sharing of different kinds of information can support efficient encoding through the use of redundancies (Dell & O’Sheaghdha, 1991, 1992). Two specific questions will illustrate how these biases play out.

The first question is whether processing is completed at each level of the production system before activity ensues at the next. This point could be argued at every level of the system, but the focus of current attention is on lexical selection (locating a word’s entry) and retrieval (getting sound information from the entry). Selection may be completed before retrieval commences (Butterworth, 1989; Levett et al., 1991, 1991b; Roelofs, 1992) or retrieval may be affected by partially activated but unselected lemmas (Dell & O’Sheaghdha, 1991; Harley, 1993; Peterson, Shim, & Savoy, 1993). Figure 3 illustrates the difference in a simplified way. Discrete activity, shown in (A), activates only the sounds /kat/ after selection of the lemma for cat, whereas cascaded activity in (B) results in partial activation of sounds that belong to words related to cat, like the /l/ of /rat/ and the /d/ of /dog/. The empirical focus of this debate is the mixed error effect. Mixed errors are word substitutions that resemble both the meanings and the sounds of an intended word (e.g., saying “rat” instead of “cat”). Mixed errors appear to be more probable than would be expected from a discrete system (Dell & Reich, 1981; Martin, Weisberg, & Saffran, 1989), lending support to the existence of cascaded activation.

The second question has to do with the existence of feedback between levels. A conservative view of production is that encoding proceeds in a strictly top-down fashion with no feedback from lower to higher levels (Garrett, 1976; Schriefers, Meyer, & Levett, 1990). The alternative, worked out most thoroughly by Dell (1986), is that lower-level activity may influence higher-level processing. In Figure 3B, for example, the bidirectional arrows symbolize a two-way flow of information. At stake empirically is the explanation of a word superiority effect, or lexical bias, for sound errors. Sound errors are more likely to result in real words than chance would predict (Dell, 1986; Dell & Reich, 1981). Dell’s explanation for this tendency involves the tuning created by interactive activation, which causes activity at lower levels to be modulated by rebounding activation from higher levels. In Figure 3, an erroneous /l/ is more likely to be retrieved than an erroneous /d/, although both sounds receive some activation from words related to cat. The /l/ reaps an additional benefit from the activation that rebounds from rat. This rebounding activation is a secondary consequence of the activation that feeds back from the /r/ and /t/ shared by cat and rat. Because only real words produce this secondary effect, real words are a more likely product of sound errors than chance would predict.

The alternative to the interactive activation account for such errors is an
creates a completely discrete, top-down processing system like the one in Figure 3A. Within this framework, the lexical bias in sound substitutions results from editorial bias. The editor may be more likely to accept real words than nonwords (see Baars, Motey, & MacKay, 1975, for supporting evidence). Mixed errors in word substitutions constitute a bigger challenge, so far not satisfactorily addressed.

2. Finding Places for Words

The preceding questions about grammatical encoding concern the “vertical” relationships in Figure 1. There is another set of questions, less well developed in the literature, that have to do with “horizontal” relationships between the lexical and structural processes at each level. Broadly stated, the problem is that words must find places within structures, and not just any place will do. Block (1967) called this the coordination problem. A common theoretical solution is a slot and filler mechanism (Dell, 1986; Garrett, 1988; Shattuck-Hufnagel, 1979) in which a structural frame provides slots into which words or sounds must be inserted, and the words and sounds carry information about the kinds of slots they require. Coordination is then a simple matter of fitting pieces into place. After the manner of Dell (1986), Figure 4 shows a simple slot and filler arrangement accompanying a lexical network.

Constraints on speech errors make this kind of mechanism plausible, because exchange errors of all kinds usually involve units of the same lin-
guistic type. However, the mechanisms can be notoriously unguaranteed. The features of the frames are stipulated rather than generated, information is multiply represented, and representations are sometimes taken apart only to be put back together again. For example, in Shattuck-Hufnagel's (1979) model, a word is retrieved from the lexicon with its sounds properly ordered, but the sounds are then copied, one by one, into an independently generated frame. The emergence of more elegant theoretical alternatives to the slot and filler approach (e.g., Dell, Juliano, & Govindjee, 1992) should serve to fuel interest in alternative processing mechanisms for solving various coordination problems in production. So far, however, these mechanisms do not go far enough on their own to solve the coordination problem for syntax (see Dell & C'Seagidh, 1993, for discussion).

a. Incrementality and Parallelism in Coordination

One issue that is latent in the coordination problem concerns incrementality (V. Ferreira, 1993) and, intimately related to it, the scope of planning units in encoding. Incrementality refers to the word-by-word character of speech. This creates a challenge for speakers, because there is a certain amount of parallelism in thinking and in messages: one can seemingly hold in mind all at once a complex idea or a rich visual image. To communicate the information, it may have to be dissected into proposition-like elements (Levett, 1981) and known concepts (Levett, 1992) and the pieces arrayed in time. The tension between parallelism and incrementality shows up in various speech errors. Certain kinds of blends, exchanges, and anticipation errors might be taken as reflections of simultaneity in the preparation of elements that are asynchronous in the spoken utterance.

Where is linearity imposed? The most common solution puts a hierarchical frame in control of the sequencing of terminal elements, and calls in some fashion on slot and filler mechanisms. The frames impose an order on elements (words, sounds, etc.) that may be available in parallel (Dell, 1986; Garrett, 1988). Because the scope of the frame becomes smaller as an utterance develops from a message to an articulatory plan, the sizes of the planning units change across the levels of Figure 1. Although there is no requirement in such models that the planning of high-level units be completed before work on lower-level units can begin (Garrett, 1976), there is typically no account of when or how the frames themselves are constructed.

A somewhat different solution ties incrementality to the order in which words (technically, lemmas) become accessible in the mental lexicon (Bock, 1982, 1987a; Bock & Warren, 1985; Kelly, Bock, & Kelt, 1988; Levett, 1989; McDonald, Bock, & Kelly, 1993) and builds sentence structures around the words as they are selected (V. Ferreira, 1993; Kempen & Hoenkamp, 1987). The structures that are created are drawn from the possibilities licensed by the language, but their assembly is opportunistic and carried out in ongoing time. For instance, a speaker might tend to say "The bird fed a worm to the nestling" if the word *worm* is selected earlier than *nestling*, but say "The bird fed the nestling a worm" if the lemma for *nestling* is selected first.

The attraction of this solution is that it accounts at once for the seriality of speech and for the intuitions that words normally emerge as they are retrieved, often without logjams or temporal chasms. Still, there must be mechanisms that implement grammatical constraints at the same time that they juggle words, and these mechanisms must be explicit within a production theory. The theory must also explain how word order in an utterance is negotiated with respect to the elements of a message, a problem with a long history: Levett (1989, p. 26) attributes to Wundt the view that "word order follows the successive apprehension of the parts of a total conception," and notes the difficulties that this hypothesis confronts when it is faced with word-order constraints in languages. Any general solution to the problem will require accounts of whether and how the dissection of messages is constrained so as to deliver chunks for grammatical encoding on a manageable schedule, whether and how choices among competing realizations are made in the (possibly frequent) event that several words are available at the same time, and whether and how information is buffered when it is delivered ahead of schedule. This leads directly to the issue of minimal units of preparation.

b. The Scope of Coordination

The contrast between incrementality and parallelism in coordination has obvious implications for utterance preparation. The larger the minimal units of coordination (e.g., word, phrase, clause), the wider the scope of planning must be, and the greater the simultaneity in processing. In slot and filler approaches, differences in the sizes of planning units at different processing levels are explicitly linked to differences in linguistic units. For example, Garrett (1988) suggested that the scope of functional planning is roughly two clauses, and that of positional planning roughly a phrase, as reflected, respectively, in the spans of word exchange errors and sound exchange errors. Other work has also pointed toward clause-like units of higher-level planning (Bock & Cutting, 1992; Ford, 1982; Ford & Holmes, 1978).

However, the scope of preparation need not be tied strictly to linguistically defined units. An alternative, one that is more consistent with lexically driven incrementality, envisions a flexible deployment of information processing capacity across linguistic levels (Bock, 1982; Hume, 1993; Levett, 1989). The presumption is that variatons in the construction and use of structural frames reflect changes in cognitive capacity and general constraints on the size or complexity of individual structural realizations (e.g., the length of an individual phrase or word), as well as hierarchically
defined variations in structural units. So, the scope of preparation might sometimes encompass an entire simple utterance (e.g., "here it is") and sometimes no more than one complicated word (e.g., "eponymously").

3. Positional Processing

a. Lexeme Retrieval

There are two hot spots in work on lexical retrieval in production, both of them related to the role of word frequency. One has to do with the precise locus of word-frequency effects in production, mirroring a related controversy in the study of reading (Balota & Chursby, 1985, 1990; Monsell, 1990, in press; Monsell, Doyle, & Haggard, 1989; Savage, Bradley, & Forster, 1990), but with a different set of concerns. There is evidence that the production of words in the course of naming pictures is affected by word frequency (Huttenlocher & Zubin, 1983; Oldfield & Wingfield, 1965), recently confirmed in detail by Jescheniak & Levelt (1994). Frequency also affects the likelihood of speech errors in words and sounds (Dell, 1990; del Visko, Igna, & Garcia-Albea, 1991; Kelly, 1986; Livett & Healy, 1985; Stemberger & MacWhinney, 1986), word order (Fisk-Orlitzky, 1989), the spoken durations of words (Wright, 1979), and word length (Landauer & Streeter, 1973).

The question is where the effects of frequency arise. One theoretical view links the impact of frequent use most tightly to those components of processing that require the retrieval of stored information rather than inference, construction, or application of grammatical rules (Pinker, 1991). A different answer, implicit in connectionist views of language processing, is that frequency affects everything (Seidenberg & McClelland, 1989). Although the question is far from settled, some observations (del Visko et al., 1991; Kelly, 1986) and experimental results (Jescheniak & Levelt, in press) favor lexeme retrieval as the locus of frequency effects. This makes sense from the standpoint that lexeme retrieval is, in fact, retrieval, whereas lemma selection may demand inference in order to abstract a message from the communicative context, disintegrate a sentence into meanings that can be lexicalized, and map meanings to lemmas (as in a meaning-postulates framework; J. D. Fodor, Fodor, & Garrett, 1975).

Other evidence, however, points indirectly toward the lemma as a source of frequency effects. Using an error-eliciting procedure, Dell (1990) found that sound errors were more likely to occur on low-frequency than on high-frequency words, and that the occurrence of errors involving homophones like by and buy was related to the combined frequency of the words. The homophone result showed that low-frequency homophones inherit the benefits of having a high-frequency twin. This implies a lexeme locus for the frequency effect, since homophones share the same lexeme but have different lemmas. Paradoxically, however, frequency did not reliably affect the strength of lexical bias; high-frequency words were not significantly more likely to be the byproducts of sound error than low-frequency words. The absence of this frequency difference is inconsistent with the lexeme hypothesis, if lexical bias results from rebounding activation between lemmas and segments. Simulating all of these effects, Dell found that the best account was given by an interactive activation model in which frequency is represented at the lemma level. The same model readily explained homophone inheritance in terms of interactions between lemmas and lexemes.

Frequency is also at the center of controversy over the closed-class vocabulary. As noted in Section II.2, the closed-class elements of utterances are sometimes accorded a special status in generation, with the view being that they are inserted by grammatical mechanisms rather than lexical ones. One aspect of this view is a claim for syntactic immutability (see Bock, 1989): the constituent tree carries features that may uniquely specify a particular element (e.g., if a slot calls for a determiner that is indefinite and singular English offers only one possibility). A second aspect is a claim for special access: rather than being retrieved from the general lexicon, these elements come from a special store. A variant of this is Levelt's (1989) indirect access hypothesis: closed-class words are recruited by way of the syntactic information stored with the lemmas for open-class words. The evidence for a special encoding route comes from several sources, prominently including the vulnerability of the closed class to disruption in aphasia and its relative invulnerability to normal error (Garrett, 1982, 1992; Lapointe & Dell, 1989). Although the supposed invulnerability to error has been challenged by evidence that error probabilities are highly sensitive to frequency (Dell, 1990; Stemberger, 1984), the evidence from aphasia remains troublesome. As Garrett (1982) notes, many aphasics disproportionately lose the elements of the closed class, which are among the most frequent: elements in the language. The paradox is that in the open-class vocabulary, the elements most likely to be lost are the infrequent ones.

b. Constituent Assembly

A different question about the effects of frequency arises with respect to constituent assembly. Bock (1986b, 1990; Bock, Loebell, & Morey, 1992) marshaled evidence that speakers tend to repeat constituent structures across successive utterances. For example, a speaker who employs a double-object dative in one utterance (perhaps, "The governor made the princess a pot of tea") is subsequently more likely to use a double-object dative than a prepositional dative, ever in a completely unrelated utterance (so, "The woman is showing a man a dress" becomes relatively more likely than "The woman is showing a dress to a man"). There is suggestive but still inconclusive evidence that this effect strengthens with the repeated use of a structure (Bock...
& Kroch, 1989), raising the possibility that the creation of sentence structures is a frequency-sensitive process. But since structural repetition does not appear to depend on the repetition of particular words (Bock, 1989) or thematic roles (Bock & Loeckl, 1990) or features of word meaning (Bock et al., 1992), its explanation rests on the transient enhancement of general structural procedures rather than the enhanced retrieval or use of specific stored information. If this is so, it becomes difficult to use frequency effects as symptoms of simple retrieval processes. More broadly, it points to mechanisms of syntactic performance that undergo continuous modification with use, counter to the standard view of syntax as something whose use is fixed beyond childhood.

IV. FLUENCY

One issue that has yet to attain a sure foothold in the contemporary study of production is the question of what supports fluency. Although considerable attention is paid to the absence of fluency in errors and hesitations (Garrett, 1982, reviews these literatures together), the mere absence of trouble does not explain fluent speech. H. H. Clark and Clark (1977, pp. 251–262) characterized a hypothetical ideal delivery as one in which “people know what they want to say and say it fluently,” with “most: types of clauses . . . executed in a single fluent speech train under one smooth intonation contour” and pauses restricted to grammatical junctures. This characterization emphasizes a regular speech rate with fluid prosody. The grounds for this ideal might be placed either in the wants and needs of the listener (H. H. Clark & Clark, 1977) or in the speaker’s own desire for proficient action. In either case, fluency is an ideal to which speakers aspire.

Two different explanatory traditions offer cognitive accounts of fluency. One emphasizes the salutary effects of an efficient mechanism, with efficiency achieved either by dint of an elegantly tailored architecture or by dint of practicing cognitive tasks. I will call these mental skill explanations. The other tradition stresses the role of attention or working memory resources in the creation of speech. I will call this a mental energy explanation. After reviewing some of the production work that falls into these two traditions, I briefly consider two other components of fluency that have so far gone mostly unmentioned, prosody and preparation.

A. Mental Skill and Mental Energy

Most current modes of production offer a skill-based explanation of fluency that emphasizes efficiencies of architecture. Although the modes differ over what creates an efficient architecture, whether it is something like informational encapsulation or the exploitation of informational recurrenci, there has been little consideration from either standpoint of how the system comes to have the form it does, or becomes as efficient as it is. Conceivably, the parser and production system are innate (Picier, 1984), but, just as conceivably, they organize themselves as the grammar is learned. There has likewise been little consideration on how the parameters of fluency (speed rate, prosody, preparation, etc.) change with experience, particularly across complete utterances (though see Wijnen, 1990). With the emergence of interest in developmental language performance problems (Gerken, 1991; Plunkett, 1993; Stemberger, 1989; Wijnen, 1990, 1992) and in production models that can change features of their organization with training, more emphasis may be laid on these issues.

A different, sometimes complementary tradition in cognitive explanation stresses mental capacity over the organization of mental skills. Some of the extensive research on hesitations in speech (filled and silent pauses) has been carried out in this framework. Garrett (1982; also see Goldman-Eisler, 1968) observed that hesitations may reflect normal advance planning and retrieval for an upcoming structural unit (Beattie, 1988; Boomer, 1965; Butterworth, 1980; Ford, 1982; Goldman-Eisler, 1972; Holmes, 1988; see Bock & Cutting, 1992, for review), or delay created by the momentary inaccessibility of a needed piece of information (Lounsbury, 1965; Smith & Clark, 1993), or transient increases in processing load. Garrett cubbed these three culprits “wait till the boat’s loaded,” “it’s the mail,” and “don’t bother me, I’m busy.” The last of these implies that changes in fluency can be traced to transient variations in cognitive capacity that may affect production globally or locally. Experimental efforts to create variations of this kind have examined the effects on speech and writing of situational anxiety (Mahl, 1987; Reynolds & Paivo, 1998), secondary task demands (J. S. Brown, McDonald, Brown, & Carr, 1988; Power, 1985, 1986), and individual differences in working memory capacity (Denneman & Green, 1986). Errors can be analyzed from a similar perspective (Fayol, Largy, & Lemaire, 1994).

One intriguing relationship that has emerged within the capacity limitations framework is a link between the duration of traditionally defined short-term memory traces and speech rate (Baddeley & Hitch, 1974; Schweickert & Bonnif, 1986). Beginning with Baddeley, Thomson, and Buchanan (1975), evidence began to appear that the measured capacity of short-term memory is sensitive to the amount of time required to articulate words. Generally, people can immediately recall about as many items as they can pronounce in two seconds. This interacts with differences among languages in the normal sizes of the lexical units employed in short-term memory tasks (Cheung & Kemper, 1993; N. C. Ellis & Henny, 1980; Hossain, 1982; Stigler, L., & Steverson, 1986; Zhang & Simon, 1985) and with developmental differences in speech rate (Hulme, Thomson, Muir, &
B. Prosody

Integral to the ideal delivery is a smooth intonation contour. To achieve this, English speakers must control their speech rate, the relative timing of stressed and unstressed syllables, changes in amplitude, and changes in fundamental frequency. The determinants of these factors are of many kinds. According to Cutler and Isard (1980), they fall into four main categories: the stress patterns of individual words, the location of the main accent in an utterance (sentence accent), syntactic structure, and various pragmatic factors (including discourse structure, speech acts, speaker's attitude, and so on).

Interest in the production of prosody has centered on two of these factors. The first is the role of syntactic structure in determining prosodic boundaries. There is obviously a relationship between syntactic structure and prosodic structure: with pauses, slowing of speech, and drops in amplitude and fundamental frequency tending to occur at major syntactic breaks (Cooper & Paccia-Cooper, 1980; Cooper & Sorensen, 1981; Steedman, 1991). A question has been raised about whether these prosodic features are under the direct control of syntactic structures, or are created instead by an intermediate representation that makes its own contribution to prosody.

F. Ferreira (1993) argues for the operation of an abstract prosodic structure, showing experimentally that changes in words and pauses that follow them can reflect prosodic boundaries that are different from syntactic boundaries. Ferreira also reported striking evidence that the prosodic representation is not dependent on an utterance's specific speech sounds. She found that the combined duration of a word and any pauses that followed it was not predictable from the segmental contents of the words; longer words were followed by correspondingly shorter pauses and vice versa. This suggests that a prosodic structure can be created without reference to the sounds that comprise individual words (though data from Meyer, in press, dispute this possibility).

A second, related factor in the production of prosody is lexical stress and how it is distributed throughout an utterance. In English, words differ regarding whether they typically bear stress and, if they bear it, where. Function words commonly lack stress, but among content words in natural speech, nearly 90% are monosyllabic (i.e., stress bearing) or have stress on the first syllable (Cutler & Carter, 1987). There is a long-standing view (e.g., Pike, 1945) that English speakers try to space these stresses relatively evenly over time. Although this appears to be far from accurate (see Levelt, 1989, chap. 10), a grosser kind of rhythmicity is created by a tendency to alternate strong and weakly stressed syllables. To achieve this, speakers subtly shift the stress pattern of words (Kelly, 1988; Kelly & Bock, 1988) or arrange words to avoid long sequences of weak or strongly stressed syllables (Kelly & Rubin, 1988).

Errors involving stress and intonation sometimes occur, and these, too, have been examined for what they reveal about the production of prosody. In line with the evidence for rhythmic alternation, Cutler (1980b) showed that syllable deletion errors (e.g., "Next we have this bici...rug") instead of "bic Tit" tend to improve the rhythm of utterances, as do erroneous movements of lexical stress ("we do think in Specific terms," instead of "spec ific"). Perhaps the best-known observation about prosody in speech errors is that sentence intonation tends to be preserved in the face of other errors: Garrett (1975) gives an example like: the error, "stop beating your brick against a head wall" (produced in place of "stop beating your head against a brick wall"). However, Cutler (1980b) contended that this holds only for open-class (content) words. When closed-class words move, they tend to carry sentence accent with them, if they bear it, as in, "you can turn it ON back now" (instead of "you can turn it back ON now"). Levelt (1989) interpreted these contrasting patterns as reflecting differences in when the accent-bearing elements actually move. Or this view, open-class movement errors occur during grammatical encoding, and do not change the syntactic structure over which prosody is calculated, whereas closed-class elements move after their metrical patterns are specified, during phonological encoding.

C. Preparation

Speakers engage in a certain amount of preparation before they begin to talk. They take longer to initiate long utterances than short ones, and fundamental frequency is higher at the beginning of long utterances than short ones (Cooper, Soares, & Reagan, 1985). Oddly, despite the considerable attention given to hesitation and other forms of dysfluency in connection with questions about speech planning, comparatively little is known about changes in fluency as a consequence of variations in preparation. An utterance that is fully prepared (phonologically encoded into inner speech) can probably be uttered more fluently than an utterance whose preparation falls short of this (see Sternberg, Knoll, Monsell, & Wright, 1988). However, most utterances undergo less than full preparation because of the limit on the amount of fully formulated material that can be held in immediate
memory, and because utterances can be launched before this limit is reached. Speakers often begin talking not too long after they formulate the first content word in the sentence (Huitema, 1993; Lindsley, 1975).

Between the extremes of maximal and minimal preparation, differences in the amount and type of preparation may have consequences for fluency. Huitema (1993) showed that about 95% of a set of simple descriptive utterances were produced fluently when speakers had a minimum of 550 ms of pure planning time, versus 60% when the minimum planning time was 600 ms. Huitema also found that complex subject noun phrases consume planning resources to the point that speakers hesitate or slow their speech after producing them, presumably to prepare the rest of the utterance. With regard to lexical planning, Butterworth (1980, 1989) argued that content words are produced more fluently (with fewer pauses) when their lemmas have already been selected than when both the lemma and the lexeme must be prepared. Similarly, Deese (1980) suggested that speech whose content (but not form) is planned in advance displays less disruptive hesitation patterns than completely extemporaneous speech.

Less explicit kinds of preparation come in the form of contextual priming and interference, caused either by one's own prior speech or that of an interlocutor. Relationships of similarity or identity across the elements of sentences may affect the speed with which utterances are initiated (Dell & O'Leary, 1992; Schriefers, 1992, 1993), the fluency with which they are produced (Bock & Loebell, 1990; Sevald & Dell, 1992; Sevald, Dell, & Cole, 1993), their word order (Bock, 1986a, 1987a; Bock & Irwin, 1980), their syntactic structure (Bock, 1980b, 1990), the case of lexical selection and phonological encoding (Meyer & Schriefers, 1991; Bock, 1992, 1993; Schriefers et al., 1990; Wheelan & Monsell, 1994), and the likelihood of error (Baars et al., 1975; Dell, 1984; Harley, 1990; Martin et al., 1989; Stermerger, 1985; Stermerger & MacWhinney, 1986a).

D. Summary

Because of the traditional emphasis on errors and dysfluency in production research, the positive components of fluency have received little direct attention. In some cases, explanations of error and dysfluency will help to shed light on their fluent speech counterparts. This seems particularly likely for hesitant speech, where fluency is the background against which hesitations are assessed. Likewise, the study of speech errors may help to disclose the joint architecture of normal language production. In other ways, however, fluency is more than the absence of dysfluency, and its explanation depends on characterizing how the disparate elements of language can be integrated into a smooth stream of speech.

V. CONCLUSION: THE PC PROBLEMS

From the broad standpoint of psycholinguistic theory, two overarching questions about language production have to do with how the processes of production (P₁) are related to the processes of comprehension (C₂), and how the processing theory of production (a performance theory, P₂) is related to a linguist’s theory of language knowledge (a competence theory, C₂). These are the PC problems.

A. Production and Comprehension

Views of the relationship between production and comprehension run the gamut from close identification of the performance systems (MacKay, 1987; MacKay, Wolp, Yin, & Abrams, 1993) to substantial dissociations of them (Frazier, 1982; Shallice, McLeod, & Lewis, 1985). Although it may turn out that production is simply “comprehension turned upside down,” in what follows I give some reasons for skepticism about this possibility. The main point is that differences in what a processing system has to do create differences in how the processing system works (Marr, 1982).

First, differences in the goals of the two systems make it reasonable to suppose that there may be differences in their normal functioning. The goal in comprehension is to create an interpretation of an utterance. In production, the speaker’s immediate goal is simply to create an utterance. The utterance should be adequate to convey the speaker’s meaning, but to do so, it must meet a range of constraints that are specified in the grammar of the language. This necessity gives the production problem a spin that Garrett put like this: “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). As a result, a general issue in a theory of production is to explain how speakers create linguistic structures at all levels. There can be no argument about whether syntax, for example, is “important” in production, because the speaker as a matter of course creates those features of utterances that we call their syntax. It is considerably less clear whether language comprehension requires that listeners reconstruct these features to the same level of detail.

Beyond this, differences in the starting points for production and comprehension also lead one to expect differences between them. Listeners must piece interpretations together from degraded and ambiguous input that arrives one syllable at a time. Speakers begin with an interpretation, in the form of a message. The message may be apprehended all at once, and without ambiguity. The hurdle is to assemble the linguistic pieces that convey the communicative intention.
Despite these differences, it is unlikely that the linguistic resources employed in comprehension are entirely independent of the resources for production. Communication is successful because words and their arrangements mean the same thing regardless of whether one's role is that of speaker or listener. One implication is that there is an important role in performance theories for general descriptions of the language knowledge that is called upon in comprehension and production. More controversial is the role that performance data can play in informing theories of linguistic knowledge.

B. Performance and Competence

One of the weightiest questions about the relationship between language knowledge and the systems that put that knowledge to use is whether the latter are in any important sense specialized for the implementation of the former (see Frazier, Chapter 1, this volume). The view that performance systems are linguistically neutral (and therefore linguistically uninteresting) is well entrenched in linguistics, inaugurated by Chomsky's (1965) famous formulation of the distinction between competence and performance. J. A. Fodor (1983) put forward a very different view, according to which the performance systems that subserve language are dedicated largely segregated from other cognitive and perceptual systems, and innate. Dedicated performance systems, in turn, may be distantly related to the grammar of the language or may transparently encode it (J. D. Fodor, 1981, 1989).

Underlying the view that performance systems transparently encode the grammar is the strong competence assumption, which says that a linguistic theory captures knowledge as the speaker actually represents it. In some quarters (e.g., Bresnan & Kaplan, 1984; J. D. Fodor, 1989) this motivates interest in language performance as one way of testing hypotheses about knowledge representation. On this view, when performance data diverge from the predictions of a linguistic theory, the data count against the theory.

In part because most psycholinguistic data reflect language comprehension, research on this has played a more substantial role than production research in informing competence theories. The undeniably linguistic nature of the input to comprehension also helps to drive interest: there is no need to grapple directly with the unknown commerce between language and thought. Moreover, the study of comprehension is closely tied to linguists' interest in language acquisition, insofar as the acquisition problem is the first instance seen as a problem of making sense of linguistic input.

For several reasons, production data merit comparable weight in developing theories of linguistic knowledge. First, speakers are, in a sense, the proximate cause of the features of language. They create linguistic structure whenever they talk. Second, although variation in a speaker's use of structures is often said to be a concern for making comprehension easier, it is likely that some variations serve only to make production easier (e.g., Brown & Dell, 1987; Dell & Brown, 1991; Keysar, 1994; Schober, 1993). This means that linguistic explanations that incorporate performance constraints (e.g., Hawkins, 1990) cannot overlook the problems faced by speakers, which may be different from those faced by comprehenders. Just as decisive is shaping the grammar. Third, questions about language acquisition motivate attention to production at least as much as attention to comprehension. Children's speech is the main source of current data about the course of language development, and because knowledge acquisition and skill acquisition are inextricably intertwined in this development, it is impossible to understand one without the other. Fourth, speaking is a cardinal fact of language ability; the commonsense test of skill in a language is not the ability to understand it, but the ability to speak it. And finally, production data can provide converging validation for competence explanations of comprehension evidence. This convergence is essential if linguistic theory is to be a theory of the knowledge that is used by all of the cognitive systems that perform language.

The problems of characterizing the conceptual input to production remain. However, with the advent of experimental methods that tap ongoing processes of production without changing a speaker's communicative intention (see Bock, 1995), it has become possible to temporarily bypass some of the thornier questions about relationships between language and thought. This makes the study of production more tractable and the prospects for satisfactory theoretical tests brighter.

One last cautionary point concerns the nature of the relationship between a production theory and linguistic theory (see Frazier, Chapter 1, this volume). There remains some quarters a tendency to regard language production as the animation of a linguistic theory. This is a vestige of the early days of transformational generative grammar, when the mathematical term "generative" was sometimes confused with the processes of generation that production requires. The basic constructs of transformational theories (rewrite rules, transformations), linking abstract structures to concrete linguistic details, also appeared to trace a route for production. Efforts to use linguistic theory as a performance theory encouraged these misleading equations (see J. A. Fodor & Garret, 1966, for review). It should be clear by now that production theory is a theory of using language, not an account of how language is represented, and that linguistic frameworks whose province is the static organization of language knowledge are unlikely to provide the theoretical machinery for explaining how that knowledge is deployed in time.
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Endnotes

1 There are important differences between the "gap" that James describes and the "gap" that Aschera describes. Aschera's gaps seem to contain propositions, the elements of what I am here calling messages. James's gaps contain concepts, the meanings behind single words.

2 This error was reported in a scrawled note along with the annotation "poor verb."

3 The division into functional and positional processing generally corresponds to the functional and positional levels in Garrett's theory (1975, 1988), to functional and constituent integration in Bock (1978a), and to the top two levels of the lexical network with their associated tactic frames in Dell's (1986) model. Collectively, Levelt (1989) terms the processes grammatical encoding.

4 A genuine error of this sort occurred in a request for "one of those sandy things" when the speaker meant to say "one of those litter boxes." These are rather rough, but the traditional roles of subject, direct object, and indirect object.

5 This conflation of the constituent assembly and the inflection processes discussed in Bock and Levelt (1994).

6 Because Blackmer and Milton (1991) included filled pauses and repetitions in their repair classifications, not all of these interruptions represented actual corrections. Only a small minority were repairs of speech errors (3% of the sample), suggesting that many of the dysfluencies may have been something else (e.g., planning delays).

7 An editor that operates only on the final output is equivalent to the monitor discussed above.

8 The coordination problem is a species of the finding problem that affects connectionist approaches to language (J. A. Fodor & Pylyshyn, 1988).

9 DeSmedt (1990) and Kempen and Kempen (1987) have developed computational models that satisfy these requirements but as yet there have been few tests of their psycholinguistic implications.

10 The fact that this choice comes in two allomorphic variants (a and an) is not relevant here, since the variants are phonologically conditioned.

References


Ferrucci, V. (1994). *It is better to give than to take? The consequences of syntactic flexibility in language production*. Manuscript submitted for publication.


