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A Dozen Competing-Plans Techniques for Inducing Predictable Slips in Speech and Action

Bernard J. Baars

INTRODUCTION

Psychologists have studied the inner workings of input processes like sensation, perception, and comprehension in great detail and with considerable success. Mediating processes like memory and thinking have also come under close scrutiny. But until recently, the mechanisms underlying *action* have been comparatively neglected. One of the main reasons for this neglect was apparently already known to Wilhelm Wundt (1862/1961): "It must be admitted that it is primarily the sensory side of psychic life which accords the widest prospect for experimental investigation" (p. 72). In perception and memory studies, the problem of *experimental control* is clearly solvable: one needs only to control the stimulus conditions. But it is much more difficult to manipulate the preconditions of spontaneous thought and action.

BERNARD J. BAARS • The Wright Institute, 2728 Durant Avenue, Berkeley, California 94704.

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In this chapter, we describe a family of techniques for eliciting predictable slips of speech and action, most of them developed over the last 15 years. These slips can apparently be induced at all levels in speech and action, from abstract plan representation to actual control of the muscular effectors; further, they are demonstrably involuntary; and they can be designed to meet (or violate) a host of preselected criteria. The family of elicitable slips includes spoonerisms, blends, word exchanges in sentences, syllable exchanges between words, and reversals of subject and object in a sentence, as well as nonverbal slips of typing, gestures, and object manipulation. All of the elicitation techniques appear to work by creating *competition* between alternative output plans (see Chapter 1). This fact has many implications, but methodologically it implies that the set of techniques is expandable, so that new slip inductions may be designed to test specific hypotheses (e.g., Chen & Baars, Chapter 9, this volume; Dell & Repka, Chapter 10, this volume; Baars & Mattson, 1981, and Chapter 11, this volume). In addition to plan competition, all of the techniques discussed here involve some time pressure, and the plan conflict is also likely to load the central limited-capacity system, at least momentarily. Thus, all induction methods fit the Competing-Plans Hypothesis discussed in Chapters 1 and 4.

Once we gain experimental control over lifelike slips in speech and action, a number of hypotheses become testable. A prominent example is the Freudian slip hypothesis, which has been the subject of widespread speculation since Freud's first book on the topic (1901/1938). Until recently, Freud's hypothesis was as untestable as it was famous, because any given spontaneous slip can be explained in many different ways. Having experimental control over the occurrence of slips puts us in a much better position to test the Freudian hypothesis (see Chapter 12). Later in this chapter, we will briefly discuss these substantive applications and implications of the slip induction techniques. Last, we will consider whether experimentally induced slips are "ecologically valid," that is, whether they are sufficiently lifelike to bridge the gap between laboratory findings and the real world.

Competing-Plans Techniques

Table 1 gives an overview of the slip techniques, which will be described one by one.

A number of researchers have attempted to replicate spontaneous slips in the laboratory. McKay (1971) attempted to simulate the conditions leading to spontaneous spoonerisms by having people repeat a syllable string in which only one syllable was to be stressed and reported that the stressed syllable tended to preenter in the sequence. MacKay and Soderberg (1971a,b) reported experimentally induced finger slips analogous to linguistic blends. Finally, errors of various kinds have been evoked as a by-product of other tasks (e.g., McKay, 1976).

Table 1
Competing Plans Tasks that Elicit Slips in Speech and Action

A. Tongue twisters: Phonological–motoric competition
   1. Overt tongue twisters (e.g., MacKay, 1971)
   2. Tongue twisters in inner speech (Dell, 1980; Dell & Repka, Chapter 10, this volume)
   3. Phonological fusion task (Laver, 1980)
B. Phonological bias techniques
   4. For spoonerisms (Baars & Motley, 1974; Motley & Baars, 1974)
   5. For word retrieval errors (Kimble & Perlmutter, 1970; Reason, Chapter 3, this volume)
C. Ordinal conflict techniques
   6. Spoonerisms (Baars & Mattson, 1976)
   7. Syllable switches (Baars & Mattson, & Cruickshank)
   8. Word exchanges between phrases in a sentence (Baars, 1977)
      a. Socially inappropriate
      b. Semantically anomalous
      c. Transformational errors (Chen & Baars, Chapter 9, this volume)
   9. Question-answering technique (Baars & Mattson, 1981)
   10. Typing errors (Mattson & Baars, 1985)
   11. "Simon Says" task (Mattson & Baars,)
   12. Table-setting task (Mattson & Baars, 1987)
D. Techniques that use competition between alternative words in memory
   13. Word blends (Baars, 1977) (See also B.5 above)
E. Techniques that use competition by deliberate transforms
   14. Irregular vs. regular verb competition (MacKay, 1976)
   15. Active–passive competition (Baars, 1977)

A. *Tongue Twisters: Phonological–Motoric Competition*

1. Overt Tongue Twisters. Tongue twisters have long been known to induce predictable errors. MacKay (1971) noted that they are characterized by successions of similar phonemes, which often pose some difficulty in pronunciation: one effective trick is to have alternating consonants that differ in only one feature in identical syllabic positions, such as "The Leith police dismisseth us." All the /th/'s can exchange with /s/'s, because they are all in the final syllabic consonant position. The fact that the two consonants differ only in one feature seems to be critical in ensuring a high rate of dysfluencies and errors.

The rapid alternation of phonemes differing in only one distinctive feature can easily be interpreted from a competing-plans perspective. Tongue twisters appear to involve competition for output under time pressure between two minimally different phonemes. Thus, at first glance, tongue twisters seem to satisfy at least two of the conditions for the competing-plans techniques: competition, time pressure, and perhaps momentary overloading of the limited-capacity system due to the speed of the task.

There has been a tendency at times to dismiss tongue twisters as merely motoric confusions. If by *motoric* one means "simple" or "merely physical," that view is clearly wrong. After all, we know well that phonemes are complex *classes* of physical events, not single events. Liberman, Cooper, Shankweiler, and Studdert-Kennedy (1967) pointed out, for example, that in different vowel contexts, different consonants are shaped differently, both acoustically and motorically. If the /b/ or "bad goof" migrates to the position of the /g/, the resulting error is shaped differently spectrographically and articulatorily. Thus, even in discussing phoneme exchanges, we are already addressing a fairly high level of abstraction.

In addition to tongue twisters, sheer speeded speaking can apparently induce errors (Cohen, 1973; MacKay, 1982; Nooteboom, 1969). Errors induced by a high speaking rate are not specifically predictable, however, unlike the other competing-plans tasks discussed in this chapter. In addition, it is difficult to know exactly what causes these errors because the exact items are rarely given in experimental reports. Thus, there may be a "tongue-twister component" in a speeded speaking task if similar phonemes alternate, or if they are difficult to pronounce. Further, speeded tasks are likely to overload the limited-capacity system, a factor that is also likely to contribute to errors (Chapter 1).

2. Tongue Twisters in Inner Speech. Dell (1980) and Dell and Repka (Chapter 10, this volume) have shown that tongue twisters in inner speech resemble those produced overtly. This finding—which is one of the few things we know about the very important modality of inner speech—also emphasizes the nonphysical nature of tongue twisters. After all, if tongue twisters were only physical events, they would not occur in inner speech, unaccompanied by any effector movements.

3. Phonological Fusion Task. Laver (1980) reported a procedure in which competition is induced between the vowels in /pUp/ (as in "poop") and /pip/ (as in "peep") by repeating these syllables in rapid alternation. Laver's monolingual English speakers sometimes produced the fused vowel /püp/—a vowel that does not exist in standard English, and that most English speakers cannot produce voluntarily (that is, the vowel /ü/ as in French *mur,* or in German *für).* This vowel is located precisely between /U/ and /i/ in the linguistic vowel circle. This may be taken as further evidence that tongue twisters involve phonemic output processes, which go beyond merely "low-level" motoric processes.

B. Phonemic Bias Techniques

4. Phonemically Induced Spoonerisms. Probably the best-known technique for eliciting slips is the phonemic biasing method for producing spontaneous spoonerisms (Baars & Motley, 1974; Motley & Baars, 1974). It works as follows. Subjects are shown a series of word pairs displayed for a duration of 1–2 seconds by means of a memory drum or a computer terminal.[1]

The instructions are as follows:

> This is an experiment to test your immediate memory for word pairs. Please
> 1. Pay careful attention to each word pair as it appears, so that you can recall it immediately afterward; and
> 2. When you see the cue RESPOND, say the preceding word pair out loud, as quickly as you can.

The reader is encouraged to try the task in Table 2 by cutting a small horizontal slit in a card and moving it down each column, exposing only one word pair at a time. (Table 2 does not contain a short practice list, filler items, and "false alarm" response cues, which were, of course, used in the experimental task to break up any predictable patterns.)

This simple task tends to create a readiness to say *each* word pair as it appears, so that the subject can say it rapidly afterward, if the response cue appears. The phonemic priming items resemble the desired slip as much as possible. (Notice that the biasing material resembles the slip not just in its initial phonemes, even though those are the phonemes that must exchange to create the spoonerisms.) This task reliably elicits a reasonable slip rate—perhaps 10–20% of trials—depending on many factors, including the exposure and interexposure interval, the verbal facility of the subjects, the kinds of linguistic materials used, and whether the slips are consistent with or violate any linguistic or social expectations (Chapter 11). Further, the degree of priming, the presence of a concurrent limited-capacity loading task (Chapter 1), and the like are apt to influence the error rate.

Table 2 can also be used to illustrate the ordinal conflict task for spoonerisms (Baars & MacKay, 1978; Baars & Motley, 1976). The reader needs only to use the same card with a horizontal slit, simply *reversing the order* of the last word pair that appeared, just before RESPOND. Imagine, for example, that the response cue is REVERSE instead of RESPOND. Now, even in the absence of phonemic priming, spoonerisms will be elicited at a reasonable rate. The same ordinal conflict effect also works to produce syllable exchanges, word exchanges in sentences, and action spoonerisms (see below).

5. Phonemically Induced Word Retrieval Slips. Phonemic bias can also trigger errors in word retrieval. The most famous example of this is the "poke-poke-poke" technique (Kimble & Perlmutter, 1970; Reason, Chapter 3, this volume). In this case, one merely asks the subject to repeat "poke, poke, poke" a number of times (about seven seems adequate) and then asks the subject to answer the question, "What do you call the white of an egg?" Re-

[1]Informal observation suggests that the rather loud, regular relay click of the memory drum may serve to pace the subjects's speech, thereby increasing the slip rate. This can be simulated on a microcomputer by a brief 0.1-second tone, sounded simultaneously with each change in the display.

TABLE 2
Demonstrating the Phonemic Bias and Ordinal Conflict Techniques for Eliciting Spoonerisms

bill deal	rack seal	sane foam
bark dog	read sale	sell phone
bang doll	real sick	seal fog
darn bore	soul rock	seem fine
		RESPOND
give book	take ball	
go back	tall box	cell roll
get boot	bail toss	same row
bad goof	RESPOND	sane rope
RESPOND		rafe sode
	gait bosh	RESPOND
ball doze	can't bowl	
bash door	cat boast	kid lot
bean deck	cad bossed	kicks log
bell dark	bet gashed	guess lock
darn bore	RESPOND	liss kong
		RESPOND
RESPOND	RESPOND	
		fail sun
RESPOND	key door	
	keen dog	ladle food
ripe log	deep cot	lake faint
real long	RESPOND	fate lame
long rice		RESPOND
RESPOND	cot bed	
	code bit	toe dead
big dutch	cod bait	code bit
bang doll	bought cat	tome dive
bill deal	RESPOND	doan tef
bark dog		RESPOND
dart board		
RESPOND		

markably, the wrong answer (the yolk) is obtained almost 100% of the time, if the subjects answer quickly enough. For those who are genuinely unfamiliar with the right answer (the egg white, or albumen), this is of course not a real slip because it does not violate their intention to say what they believe to be the right word; but those who do know the answer also make the error remarkably often. This technique will trigger slips at a higher rate than any other method discovered so far, so that it may be an optimal tool for exploring some aspects of the speech system (viz. Chapter 12).

"Priming" or "biasing" is of course a familiar tool for cognitive psychologists. It generally involves the conscious presentation of some stimulus that is closely related to the event to be tested (Baars, 1988). Priming works not just phonemically, but probably at every level of psycholinguistic control. For example, if one elicits a certain spoonerism such as "darn bore—barn door" at a

reasonable rate, one can add semantic primes (such as "farm gate"), which will significantly increase the rate of errors like "barn door" (Motley & Baars, 1976). Thus, different sources of priming or activation seem to be additive, providing they are all compatible with the same slip.

C. *Ordinal Conflict Techniques*

It is not clear that phonemic priming is likely to trigger errors in spontaneous speech. Baars and Motley (1976) argued that it is not, and that spoonerisms that can be evoked phonemically in the laboratory may be due to higher level problems in spontaneous speech. Specifically, order competition between two different lexical orders may serve to confuse the order of phonemes; thus, competition at one level may *propagate* to the next lower level to create a spoonerism. If that is so, then order competition between two words may cause phoneme exchanges (spoonerisms).

6. Spoonerisms. As predicted by the above argument, phonemic priming is not the only way to elicit spoonerisms. Baars and Motley (1976) showed that creating order competition within word pairs does indeed generate phoneme exchanges, as predicted. The reader may demonstrate this effect with the materials given in Table 2, using the second (REVERSE) method. Order competition can generate many other kinds of slips, as the following sections indicate.

7. Syllable Exchanges. Baars, Mattson, and Cruickshank (1985) showed that syllables can switch between two multisyllabic words if uncertainty is created about the order of the words. Notice that the target word pairs have parallel stress patterns and receptive syllabic and phonemic contexts—thus, "horrible miracle—*mir*able *hor*ricle," (Table 3). Pacing may need to be rather rapid in this demonstration.

8. Word Exchanges between Phrases in a Compound Sentence. Baars (1977) and Baars and MacKay (1978) have shown that this Ordinal Conflict Effect applies to phrases in a sentence as well, as demonstrated in Table 4. The two phrases are syntactically parallel, but the syntactic structure of the phrases can vary quite a bit. (In the examples below, the phrases themselves are in brackets [], and the switching words are underlined.) Thus:

1. [The infant's height is *good*] but [his weight is *moderate*].
2. He [*fixed* his trousers] and [*dropped* his watch].
3. The woman [worked *incessantly*] while the nun [waited *patiently*].
4. The housewife [*bought* the cat food] and [*obtained* the detergent].
5. The picky gourmet [*covered* his dinner] and [*threw up* his hands].

TABLE 3
Eliciting Syllabic Spoonerisms with the Ordinal Conflict Effect

recapturing discovery	discreditable pedestrian
REPEAT	REPEAT
distressing reflection	horrible miracle
REPEAT	REPEAT
recurrent dependence	interfering homophone
REPEAT	REVERSE
magnanimous regretfulness	interrupted undertaking
REPEAT	REPEAT
reporters discussants	underhanded takeover
REVERSE	REPEAT
guilty switches	intervening centuries
REPEAT	REPEAT
nullified syllable	cancerous mystery
REVERSE	REPEAT
orderly cardinal	dignified monastery
REVERSE	REVERSE

Evidently, the syntax can vary quite a bit, as long as some parallelism is maintained. Notice that nouns may switch in these sentences as well as verbs, adjectives, or adverbs. Indeed, in many of the slips obtained, it is difficult to be sure which elements have actually moved—assuming that the sentence frame has remained stable, so that we can talk about "movement" at all with respect to some stable string of words.

Some fairly complex syntactic and semantic accommodation seems to occur. In Sentence 5, the particle *up* tends to travel with its verb *throw*, whereas the other verbs move without any prepositions. If we were to present in Sentence 1 the adjectival phrases *good* and *only moderate, only* is likely to move along with *moderate* rather than produce the somewhat anomalous slip "The infant's height is *only good.*"

Once we can manipulate the content of a sentence, it is fairly easy to create sentential slips that meet or violate normal expectations. Thus, we can create slips that are:

1. Socially appropriate or inappropriate (Baars, 1977).
2. Semantically normal or anomalous (Baars, 1977).
3. Putative "transformational errors" (Chen & Baars, Chapter 9, this volume).
4. Sentences that are false as opposed to true (Baars & Mattson, 1981).
5. Slips that express emotional conflict (Baars, Chapter 12, this volume).

Examples 4 and 5 above also make an interesting contrast: 4 is essentially a switch in synonyms and therefore is not a semantic error at all. It is entirely correct at all purely linguistic levels, except possibly for stylistic preferences between the formal *obtained* and the less formal and more specific *bought*. In contrast, 5 involves a major change in meaning: "The gourmet *threw up* his

TABLE 4
Eliciting Word Exchanges between the Phrases of a Sentence by Means of the Ordinal Conflict Effect[a]

The woman [heard the melody] and [remembered the story].
REPEAT
The mother [tossed the ball] and [cuddled the baby].
REPEAT
The girl [caught the train] and [saw the show].
REVERSE
The maid [took the apple] and [ate the cake].
REPEAT
The watchman [ripped the letter] and [sent the signal].
REVERSE
He [dropped a watch] and [fixed his trousers].
REVERSE
She [touched her nose] and [picked a flower].
REVERSE
He [left his seat] and [kissed the girl].
REPEAT
My wife will [buy a puppy] and [nurse the baby].
REPEAT
We will [improve the cancer problem] and [intensify the research].
REVERSE
The housewife [helped the maids] and [stripped the beds].
REPEAT
The gourmet [smelled his food] and [ordered his bill].
REVERSE
He [scratched his chin] and [rubbed his nose].
REPEAT
She [covered the cheese] and [served the cake].
REVERSE

[a]Phrases to be reversed in order are shown in brackets [ ].

dinner and *covered* his hands." Experimental materials can be designed in which all factors except one are kept constant in the two comparison conditions, so that very good experimental control is maintained. As noted before, sentential slips can be designed to meet or violate a large number of semantic and pragmatic criteria, thereby allowing us to confront the speech production system with a real problem: Does it manage to avoid making the error overtly? In general, the answer seems to be that it does, most of the time, though not always (Baars, 1977; Baars & MacKay, 1978; Baars & Mattson, 1981). Possible mechanisms for maintaining this kind of output control are examined in Mattson and Baars (Chapter 11, this volume), and the Freudian slip issue is discussed in Baars, Cohen, Bower and Berry (Chapter 12, this volume).

9. Question-Answering Technique. How can uncertainty about the order of two phrases occur naturally? From the beginning of this research pro-

gram, we have been concerned with the issue of naturalness. Above, we argued that phonemic priming may not happen naturally but may be caused by order conflicts at the lexical level. Ordinal conflict seems much more natural because the fundamental task of speech production is to string words in the proper order, in one of many optional ways.

One case where conflict may happen naturally is the following. Suppose we are answering a question relating two clauses, and we wish to answer using the same vocabulary—perhaps because it is in short-term memory and therefore readily available. These conditions are satisfied by the task illustrated in Table 5. Notice that a subject in this task frequently has to choose between the order of the two clauses, as well as opposite adjectives like *above* and *below*. Baars and Mattson (1981) showed that this task does indeed lead to a variety of errors, including exchanges of words between the clauses. This must be one of quite a large number of cases in which the speech production system is faced with a reordering of known lexical units. The job of choosing a particular order among several possibilities may be quite a productive source of linguistic errors.

We can generalize the Ordinal Conflict Effect to other slips, including nonverbal actions. The need to order components is not limited to speech; it is part of any action that is extended over time. Thus, we have found that we can elicit typing errors using the ordinal conflict effect, as well as errors in the

TABLE 5
The Ordinal Conflict Effect Induced by Answering a Question[a]

1. Does the wet fall come before the cold winter?
2. Are the green hills below the snowy mountains?
3. Is the blue sky below the gray sea?
4. Is chilly Norway south of sandy Egypt?
5. Do you drink your soup before you start dessert?
6. Can you die happily before living peacefully?
7. Is chilly Norway north of sandy Egypt?
8. Are the leafy tree branches below the intricate roots?
9. Are the green hills above the lush mountains?
10. Can you die quickly after living vigorously?
11. Is our friend Canada north of our neighbor Mexico?
12. Is a fast car smaller than a racing bicycle?
13. Can you eat a light lunch after a big dinner?
14. Does the wet fall come after the cold winter?

[a]Subjects are required to answer *with the same words* used in the question. "No" answers therefore always involve phrase reversals. Thus, the correct answer for Question 3 is "No, the gray sea is *below* the blue sky." Several types of slips are possible, including a false answer using a correct preposition, and a switch of adjectives or nouns between the phrases. A complete list of instructions, questions, and sample slips is given in Baars and Mattson (1981).

so-called "Simon Says" task, and in a table-setting task (Mattson, 1987; Mattson & Baars, 1985).

10. Typing Errors. Although the relationship between hands and finger strokes is not the same as the relationship between words and phonemes, creating order competition between two hand orders (right-left vs. left-right) also tended to trigger simple finger-stroke errors. However, complete exchanges of finger strokes between the two hands were rare. (See also MacKay & Soderberg, 1971b.)

11. "Simon Says" Task. This task is named after the children's game in which the leader calls out "Simon says do this!" followed by some action. One tends to become so primed to the act of following the leader, that when the leader simply calls out, "Do this!" the followers have a tendency to move, even though the crucial words "Simon says" have been omitted. We have used an analogous follow-the-leader task, in which the subjects imitate a videotaped action, followed by a cue that signals the subject to copy the action either in order or in reverse order.

12. Table-Setting Task. Mattson (1987) chose the task of setting a table as a socially well-defined action and induced errors by means of order competition. As expected, components of the task were executed out of order or even exchanged, in much the way phonemes are exchanged to create spoonerisms. (See Mattson & Baars, Chapter 11, this volume.)

D. Creating Competition in Deliberate Memory Retrieval

13. Word Blends. It has been known for many years that word blends often seem to fuse two equally likely synonyms. It is easy to evoke such blends in the laboratory. For example, Baars (1977) gave subjects a list of similar-sounding synonym pairs to remember and instructed them to say one synonym whenever the other was presented. Thus, whenever *ghastly* appeared, the subject was to say *grizzly,* and vice versa. Table 6 provides a number of synonym pairs to memorize (Column 1) followed by individual words that serve as cues for their synonymous associates (Column 2). With reasonable pacing, the second column will evoke some blends between the paired synonyms.

E. Creating Competition by Deliberate Transforms

14. Irregular versus Regular Verb Competition. In a study on the speed of regular versus irregular past-tense formation, MacKay (1976) obtained such incorrect past tenses in a task in which the subjects were given the

TABLE 6
Eliciting Blends between Two Related Words

Paired associates to memorize	Task: given one associate, quickly say the other
ghastly—grizzly	muggy
	grizzly
shout—yell	scary
	hugged
scary—screaming	touch
	plucked
good—fine	yell
	small
slick—slippery	buy
	shady
muggy—sweaty	shout
	good
stop—halt	wish
	sweaty
kissed—hugged	picked
	get
checked—fixed	need
	feel
feel—touch	screaming
	checked
picked—plucked	fine
	ghastly
low—small	stop
	need
buy—get	cool
	picked
need—wish	slick
	low
cool—shady	slippery

present-tense forms and were asked to provide the past tenses as rapidly as possible.

15. Active–Passive Competition. It is easy to show subjects the relationship between active and passive versions of the same sentence. If they are asked to make active versus passive transformations as quickly as possible, would we find blends or more complex combinations of the two sentences? Baars (1977) showed that some of these errors are indeed induced.

In sum, these are the fourteen slip induction techniques, all understandable in the framework of competing plans, that are now available to psycholinguists for further exploring speech and action control.

Common Principles of the Slip Induction Techniques

A few major principles underlie all the slip induction techniques developed so far:

1. *Competition between alternative speech plans.* Competition can be induced by means of a misleading preparatory set, by asking people to reverse unexpectedly the order of two units, by creating competition in memory retrieval, or by asking people to rapidly transform difficult input voluntarily.

2. *Time pressure.* In addition to competition, all of our slip techniques demand a quick response from the subjects. We suspect that the time pressure keeps subjects from "sorting out" the competing plans and from editing out some anomalies.

3. *Momentary overloading of limited capacity.* As we argued in Chapter 1, any task in which different goals or plans are contending for access to the conscious/limited-capacity system is likely to overload this system at least momentarily. This is indeed likely to happen even if the task is not particularly designed to overload limited capacity. Overloading of the conscious/limited-capacity system may block effective monitoring, editing, and repair during a critical phase in the production of speech or action (Baars, 1988). In this chapter, we focus primarily on a more easily observable level: the application of the competing-plans techniques in the induction of a great variety of slips (Baars, 1980). It is important, however, to keep in mind that several other factors may be operating at the same time.

SUBSTANTIVE IMPLICATIONS OF THE TECHNIQUES

What can we learn from the techniques themselves about the control of speech and action? First of all, they support the idea that competition between different speech plans may be a general source of problems in planning and control. One continuing theme is that many—perhaps all—slips seem to emerge from choice points in the control of speech and action. Indeed, a principled argument can be made that competition between alternative plans is to an output system what ambiguity is to input: it defines a choice point between alternative paths in the flow of processing. Such choice points are obviously of critical importance in any comprehensive theory of action (see Freud, 1901/1938; MacKay, 1987; Norman, 1981).

Competition between alternative plans probably occurs naturally in spontaneous speech (see Chapter 1). We have pointed out that there are often many ways to express a thought or to carry out any single purpose. This implies that, starting from an abstract intention to say or do something, the system must make choices between alternative ways of realizing the abstract plan. This need to choose between alternatives can be a source of competition between speech plans, and one can easily imagine other sources as well. To give some idea of the generality of this problem, consider some points made by Greene (1972):

> A person can perform the same action in many different ways; for example, he can write with his arm held high or low or loaded with a weight, or even with a pencil held in his teeth, and although his muscles move differently in each, the same handwriting always results. An infinity of motions can lead to a single result. . . . Surely [the] brain does not store . . . all the possible configurations of all his hand muscles. . . . The nervous system avoids this storage through a style of motor control whereby subsystems having many degrees of freedom are governed by a central control system having a few degrees of freedom. . . . The highest control center selects an appropriate combination that almost fits what it wants to do, and transformations at lower levels shape these combinations into a better approximation of the desired action. (p. 304)

It appears, therefore, that choice points are often desirable in control systems—and that they can also lead to real difficulties.

It is very clear that most details of speech articulation are not normally under voluntary control. Indeed, one of the dramatic facts about speaking is how much of it is left to unconscious mechanisms: we are not aware of the syntactic rules we use, of the details of lexical search, or of the detailed movements of the mouth. Moreover, movements of the articulatory organs—the tongue, lips, jaw, glottis, velum, and vocal cords—have enormous variability and flexibility. We can speak in an understandable way even if some of those articulators are obstructed by large wads of chewing gum, head colds, or laryngitis. Thus, it makes sense to suppose that many details of speech are controlled by subsystems that are not under immediate voluntary control. The fact that highly rule-governed, involuntary errors are made overtly at all suggests that subsystems occasionally escape from executive control (see Table 1 in Chapter 1).

We can draw further substantive implications. For example, the success of the priming technique for inducing slips supports the idea that action systems are prepared before execution by mean of "feedforward" from an abstract action plan (e.g., Gel'fand, Gurfinkel, Fomin, & Tsetlin, 1971; Greene, 1972; Norman, 1981). There are a number of functional arguments in favor of this position. The idea of preparatory feedforward is made even more plausible by the empirical effectiveness of phonetic and semantic *priming* in inducing slips. In terms of the ideomotor theory developed in Chapter 4, such priming may correspond to conscious goals or goal fragments, which are believed in that theory to recruit the unconscious subgoals and effectors that carry out the ultimate action.

Finally, the Ordinal Conflict Effect (OCE) has interesting implications for a comprehensive theory of action. Here, we find that an order conflict at the level of words shows up as an error in phoneme and syllable sequencing, that an order conflict of phrases shows up in word sequencing, and that in a typing task, an order conflict of hands shows up as a slip in finger sequencing. Conflicts of order between higher level units seem to cause a switch of subordinate units. The OCE may in fact be a general property of the organization of serial action. It clearly involves an interaction between different levels of control.

One could imagine a number of scenarios to explain this interaction. One scenario was proposed by Baars and Motley (1976), who suggested that sometimes a speaker may want to insert a word into a planned sentence after the sentence has already been partly executed. This desire may create a conflict of order between two words in the sentence, which may lead to the activation of initial phonemes out of order. For instance, in the case of a slip such as "bad good—gad boof," the speaker may have started to say, "I really made a goof," and decided to insert the adjective *bad* after beginning to say the word *goof.* Thus the initial phoneme /g/ of *goof* might already be activated when one inserts the initial phoneme /b/ of *bad.* The highest activations are then /g/ and /b/; however, phoneme sequencing constraints rule out a combination such as /gb/, and syntactic constraints prohibit /goof bad/, leaving the system with only one viable plan, "gad boof." This is only one possible scenario; others can be devised rather easily. Further work needs to be done to test different explanations of this apparently quite general effect.

Using Experimental Slips to Study the Control of Speech and Action

In consequence of these new techniques, we have been able to test a set of substantive hypotheses about speech production, some of which were previously resistant to experimental investigation. These include the problem of anticipatory control of errors in speech planning, the issue of "Freudian slips," and some aspects of the organization of serial action (Baars, 1977; Baars, Motley, & MacKay, 1975; Motley & Baars, 1976; Motley, Baars, & Camden, 1979). We have also begun to focus with one of these techniques on the issue of intentionality in the control of speech and action (Baars & Mattson, 1981; Mattson, 1987).

Specifically;

1. The effect of multiple levels of priming. For example, a slip like "barn door" is increased in frequency with a preceding semantic prime like "farm gate."
2. Studying the interaction between "units" and "integration mechanisms" in speech and action (see Chapter 1).
3. Error-minimizing mechanisms, such as anticipatory editing of speech plans prior to articulation (see Chapter 11).
4. The question of Freudian slips (see Chapter 12).
5. Limited-capacity overload and the Competing-Plans Hypothesis (see Chapter 1).

Are Induced Slips "Artificial"?

Are our experimentally induced slips like those observed outside of the laboratory? Any experimental technique is useful if it gives insight into normal conditions; for this purpose, it is not always necessary to reproduce the exact

phenomena found in nature. For example, there are extensive research literature on reaction time, on subliminal perception, and on lexical decision tasks, even without a guarantee that such tasks are naturalistically important. Presumably, then, if the slip induction techniques yield insight into the mysteries of speech and action production, their naturalistic status would be of secondary importance. Scientific yield is the major criterion for judging any experimental task. Nevertheless, it is still useful to clarify the relationships between the experimental and naturalistic slips, because a great literature has emerged on the latter phenomena.

Naturalness of Induced Slips

Do induced slips resemble spontaneous slips? Because we are speaking of a *family* of slip techniques, the answer is not a simple yes or no. In general it would seem that, *to the extent we can plausibly simulate the triggering conditions of natural slips* in the laboratory, and *to the extent that we find similar error patterns in consequence,* we can claim a successful simulation of natural slips. We now have a growing body of evidence that some of the causal conditions of real-world slips can be closely simulated in the laboratory (see Dell, 1980; Stemberger, Chapter 8, this volume).

Controversy over the naturalness of experimental slips has emerged in one case so far. Baars *et al.* (1975) found that experimentally elicited lexical spoonerisms are made several times more often than matched spoonerisms that are nonlexical. This result has been replicated directly (Dell, 1980). However, there has been some disagreement over whether the lexical-slip-rate advantage exists in spontaneous slips. Fromkin (1980) found that, in the UCLA corpus of speech errors, nonsense slips occurred about 60% of the time compared to 40% lexical slips and suggested that the results of Baars *et al.* (1975) therefore do not apply to spontaneous speech. Unfortunately, she did not suggest a null hypothesis with which to compare this observed rate of lexical slips, so that the logic of her argument raises difficulties. No one would claim that there are simply *more* lexical than nonsense spoonerisms; most of the time, creating spoonerisms between neighboring words is going to create nonsense. The argument is rather that one observes more lexical slips than would be expected *by chance.* MacKay (1970) and others have pointed to the necessity of comparing observed rates of naturalistic slips with some plausible null hypothesis before any firm conclusion can be drawn. And indeed, an informal analysis of the published UCLA corpus comparing lexical with nonsense errors suggests that lexical errors occur much more often than would be expected by chance.

Garrett (1975) calculated such a null hypothesis based on random phoneme exchanges in a *Playboy* interview and found, on this basis, that slips in the MIT corpus do not show a lexical preference. However, Dell (1980) took the more conservative approach of finding his null hypothesis *in the error corpus itself,* and he found that, indeed, there is now reliable evidence for a lexical bias

in spontaneous slips. This result has now been replicated several times (see Stemberger, Chapter 8, this volume).

It is also worth pointing out that numerous effects analogous to the results of Baars *et al.* (1975) have been found, as discussed in Chapter 11: with spoonerisms, syntactically correct slips are made several times as often as nonsyntactic ones (Motley, Baars, & Camden, 1981); further, socially acceptable spoonerisms are made more often than taboo spoonerisms (Motley, Baars, & Camden, 1979); and in the case of word exchange slips, we have found similar effects with semantically normal versus anomalous slips, true versus false slips, pronounceable versus hard-to-pronounce slips, socially acceptable versus unacceptable slips, and so on. Again, it is difficult to believe that this highly consistent pattern of results—replicated with different techniques in several laboratories over a period of years, with more than a thousand subjects—has no reflection in nature.

On more general considerations, it would be very surprising indeed if there were *no* lexical preference in slips, given the major lexical bias that has traditionally been found in studies of lexical versus nonsense items in memory and perception (e.g., Miller, 1956; Rumelhart & McClelland, 1982). Indeed, it is difficult to find any evidence for the *similarity* of lexical and nonsense materials, and most psycholinguistic theories of the lexicon aim to take account of such a very general and reliable fact.

It would be senseless to claim that all experimental slip techniques replicate natural conditions *under all circumstances.* Surely, the speech control system has many operating modes; for example, from merely shadowing or reading speech, to the careful and purposeful crafting of an entirely new sentence. Thus, slips in such different conditions, if they are to be simulated in the laboratory, must reflect the different conditions. Hence, the idea that all experimental slips replicate all natural conditions is not even desirable. Further, in some sense, Garrett (1975) must be correct in believing that experimental spoonerisms differ from spontaneous ones; the question is whether this difference is *essential* or *incidental* to the hypothesis being tested. If one experimental technique is not appropriate for testing some particular hypothesis, one could develop another technique, using the flexible and powerful principles outlined here. For example, the question-answering technique used by Baars and Mattson (1981) was motivated in part by an effort to find a natural example in which conversational interactions would produce competition of the order of two phrases in a compound sentence (see Table 5).

Too often in the past, psychologists have embarked on experiments that had no noticeable connection with real life. The solution, however, is not to give up experiments. In the case of slips, experimental work gives us an opportunity to elicit very predictable and meaningful slips that we could never observe naturalistically. Spontaneous slips are far too rare and too variable to let us test the Freudian hypothesis naturalistically. The solution, then, is to do experiments that sample the real world, not crudely but in its essence. And the only way to define the essence of a real phenomenon is to use appropriate theory. Thus, theory, experiment, and ecological validity

compose a triad of interacting values, mutually supportive if we approach them properly. If one or two of the members of this triad are missing, our research will ultimately be sterile. But if we can respect natural phenomena, perform careful experiments, and develop imaginative theory, we stand a better chance today than ever before of gaining scientific insight into the human condition.

There is always a trade-off between the pros and cons of experimental and naturalistic work. We should be very much aware of the richness of naturalistic data, and of their usefulness. Equally, psycholinguists working with naturalistic slip corpora should be aware of the advantages of experimental techniques for testing causal hypotheses about the control of speech and action. What is needed is a close marriage between the two methodologies, so that each one can make up for the limitations of the other.

We believe there is good reason to think that experimental slip techniques represent the essentials of some situations that produce spontaneous slips. Although some arguments have been made to the contrary, these arguments appear to be based on shaky evidence. Following are some reasons for holding this position:

1. *Experimental slips closely resemble spontaneous ones.* On the surface at least, it is difficult to tell the difference between a spoonerism elicited in the laboratory and one made spontaneously. We have induced spoonerisms more frequently than any other slip, and particularly spoonerisms that involve initial consonant switches between two single-syllable words or nonsense syllables. Since 1973, we have run thousands of subjects in spoonerisms tasks, and in general, the slips we obtain conform to the descriptions given in naturalistic corpora (MacKay, 1981). A spoonerism in the laboratory, like those found in the real world, always turns out to be a "phonetically possible noise" (Wells, 1951). Further, with the word-reordering technique described above we do not experimentally control the particular phoneme that will switch, and in this case, initial consonants always switch with other initial consonants, final consonants with other final consonants, and vowels, of course, switch only with other vowels, just as they do in nature. The subjects are often surprised at their own slips, just as they are in real life, so that in the laboratory we can measure significant changes in the galvanic skin response (GSR) for slips, but not for correct responses (Motley, Baars, & Camden, 1979). Furthermore, people will often correct themselves if they have the opportunity to do so (Baars & Mattson, 1981).

All this is different from spoonerisms that are made deliberately. One can explain to naive subjects what a spoonerism is and ask them to produce spoonerisms voluntarily, on demand—this is a critical test in many ways—and it shows clearly that deliberate spoonerisms are not sensitive to many of the subtle rules of English to which unnatural and experimentally induced spoonerisms conform. For example, we have asked people to create spoonerisms from a word pair like "Freudian slip." Many subjects say, "Sreudian flip," which violates phonological rules because the initial /sr/ is not permissible in English. This impermissible sequence of phonemes is never found in spontaneous slips (Fromkin, 1973), nor have we observed it in experimentally induced slips. And of course, deliberate slips are not surprising to the speaker, nor are they self-corrected.

It may seem curious that deliberate "slips" are more likely to violate the rules of English than unintentional slips, but on reflection, it will be clear that this result is really quite general. It is only when we think *consciously* about doing some skilled act that we are likely to lose the smooth, subtle, automatic control that characterizes normal, proficient action.

2. *The conditions that give rise to experimental slips have plausible counterparts in ordinary speech and action.* There are more reasons to think that experimental slips reflect important aspects of spontaneous speech and action. We have pointed out that competition between alternative plans may be common in ordinary speech and action, and that biasing techniques simulate the kind of preparatory feedforward of action subsystems that many researchers have postulated. The very effectiveness of our slip induction techniques suggests that we are manipulating properties of the system that are powerful enough to be an important part of normal control. Indeed, it would be strange if some strong pattern of experimental results were entirely unrelated to the identical pattern in nature.

3. *Because there is an expandable family of techniques, one can develop the most natural possible analogue of any spontaneous type of slip one wishes to study.* We have done this at several points. After developing the phonetic biasing technique for spoonerisms, we felt that phonetic bias was unlikely to be the proximate cause of spoonerisms; it seemed more natural to think that phonetic bias itself was triggered by higher level processes. This line of thinking led us to suppose that order conflicts at the lexical level might create phonetic bias toward the wrong initial phoneme, and that this incorrect choice might be resolved by creating a complete spoonerism (Baars & Motley, 1976). More recently, we have felt that the phrase-reordering technique for inducing word exchange slips was somewhat unnatural and hence evolved a question-answering technique that elicits the identical slip, but under a set of conditions that simulate natural speech more closely. No doubt much more could be done along the line of marrying the laboratory work to the real world.

Summary and Conclusions

We have described in this chapter a research program aimed (1) at developing experimental control over high-level, predictable, and demonstrably unintentional speech and action; (2) at exploring the substantive implications of the techniques themselves; and (3) at using the resulting techniques to investigate substantive questions about speech production.

The first part of this research program has been quite effective, so that, if anything, we are now faced with an embarrassment of riches. There are so many new techniques for eliciting different kinds of slips that we have been able to investigate only a few in depth.

Second, slip induction techniques themselves have substantive implications for understanding speech and action control. The effectiveness of priming techniques may be due to the fact that, in normal voluntary action, conscious goal images may recruit and trigger unconscious effectors that control the action in all its details. The success of the Ordinal Conflict Effect in triggering spoonerisms, syllable exchanges, word exchanges, and slips of action suggests that competition between different goals and plans for the limited-capacity component of the nervous system may be quite common in spontaneous speech and action.

Third, we briefly listed ways in which slip induction techniques have been used to investigate new, and often otherwise untestable, questions (e.g., Chapters 11 and 12). And finally, we considered the criticism that induced slips may be artificial. Thus far, there is more evidence for convergence than for the divergence of induced and spontaneous slips. Further, there are numerous laboratory techniques in psychology that do not have an immediate and obvious parallel in the natural world, but that are believed to be scientifically very informative. Naturalness in induced slips is often desirable, however, and we can often use the competing-plans strategy to make the slip induction technique as lifelike as possible.

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7

Laboratory Induction of Nonspeech Action Errors

Mark E. Mattson and Bernard J. Baars

Introduction

There is a continuum of views on the uniqueness of language as a cognitive function, ranging from the linguist's view that language involves a special-purpose "mental organ," to the behaviorist's view that the same principles shape all behavior. Clearly, there are both similarities and differences between speech production and other actions, such as typing, manipulating objects, and driving a car. An intermediate view is that different action systems have unique, domain-specific constraints, but all action systems are influenced by certain general processing constraints.

One piece of evidence that is relevant to the question of general processing constraints on action systems is the fact that similar types of errors occur across a wide range of different types of action. For example, a common type of speech error is the spoonerism, named for an Oxford don noted for errors such as:

1. You have wasted the whole term. →
   You have *t*asted the whole *w*orm.

MARK E. MATTSON • Social Sciences Division LL 916, Fordham University, New York, New York 10023. **BERNARD J. BAARS** • The Wright Institute, 2728 Durant Avenue, Berkeley, California 94704.

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