

## SLIPS OF THE TONGUE: THE FACTS AND A STRATIFICATIONAL MODEL

*by Gary S. Dell and Peter A. Reich*

One of the best ways of finding out how a system is constructed is to observe what happens when that system breaks down, when it fails to operate perfectly. Suppose you regularly receive a check from a small company. The check may be generated by a human being, or it may be produced by a computer. So long as everything operates perfectly, it would be impossible to determine which. But you may get clues if a mistake occurs, because computers and human beings make different types of errors. If you get a check for \$0.00, it is likely to be a computer error. If you get a check for \$517.00 when you are owed \$571.00, it is likely to be a human error, because human beings often transpose digits. Similarly, if your goal is to find out what the system is like that underlies language, it can be very useful to look at what happens when things go wrong.

This is the issue to which this paper is addressed. We shall review one class of language errors—slips of the tongue—to explore the implications this phenomenon has toward understanding in general how language processing works in human beings. We shall argue that stratificational grammar may be on the right track as a model of language behavior, because a modified version of it can be designed that makes very humanlike errors.

### THE FACTS

Slips of the tongue as a linguistic phenomenon have been known about and studied since before the time of Freud. But in the last fifteen years especially a large number of researchers have been collecting detailed information not only as to what sorts of slips happen, but how often they occur and what factors affect their likelihood of appearance. Before we describe the model we shall review these findings.

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### The basic types

One can categorize the majority of slips into seven basic types (Wells 1951; Hockett 1967; Fromkin 1971). For each we shall give a sample target (T), which is the utterance intended, and a possible slip (S), which might be said in place of what was intended.

(1) *Anticipations*. A unit in the stream of speech appears too soon, possibly replacing the unit that should have appeared.

T: Bad sack.

S: Sad sack.

(2) *Perseverations*. A unit that has already occurred in the stream of speech recurs later, possibly replacing the unit that should have occurred.

T: Bad sack.

S: Bad back.

(3) *Transpositions*. Two units in the stream of speech are produced, each where the other one should have been.

T: Bad sack.

S: Sad back.

(4) *Substitutions*. Some unit replaces another unit, but the origin of the unit that actually appears is unknown.

T: Bad sack.

S: Bad lack.

(5) *Blends*. When two words are both possible at a particular position in the stream of speech, occasionally a blend of the two words will appear instead of either.

T<sub>1</sub>: Don't yell so loud. T<sub>2</sub>: Don't shout so loud.

S: Don't shell so loud.

(6) *Counterblends*. This relatively rare phenomenon was noted by Hockett (1967). After a person produces a blend, he or she may, on a second attempt to produce the intended utterance, produce a second blend that uses the elements left over from the first blend.

T<sub>1</sub>: Can we afford it? T<sub>2</sub>: Can we avoid it?

S: Can we avord it? I mean, Can we affoid it?

(7) *Haplologies*. Also noted by Hockett (1967), this phenomenon involves skipping part of the target utterance.

T: Listened to Dorothy's story with attention.

S: Listened to Dory with attention.

### Different levels

The various types of slips described above can happen to units in language that vary in size from phonological feature to at least phrase, if not larger (Fromkin 1971). Specifically, units of eight different types have been observed to slip.

(1) *Phonological feature*. As pointed out by Fromkin (1971), many slips

that take place involve the replacement of a phoneme by one that differs from it by just one phonological feature. The clearest cases of this occur when the result is a phoneme that otherwise does not occur in the speech stream.

T: Scatterbrain.

S: Spattergrain.

In this slip one can say that there was a transposition of place of articulation without a transposition of voice or manner of articulation.

(2) *Phoneme*. Certainly a very common type of slip is that of an entire phoneme being involved.

T: Bad sack.

S: Bad back.

(3) *Cluster*. A cluster of phonemes may as a group appear out of order in the speech stream.

T: Snow flakes.

S: Flow snakes.

(4) *Syllable*. Occasionally a whole syllable will appear out of the intended order, or two syllables will be transposed.

T: Pack the cigarettes.

S: Sig the packarettes.

(5) *Morpheme*. Sometimes a whole morpheme will replace another one.

T: And so in conclusion.

S: And so in concludement.

(6) *Word*. Whole words, consisting of more than one morpheme, can mistakenly appear or be transposed.

T: The anticipation of her replacement.

S: The replacement of her anticipation.

(7) *Semantic feature*. Although the notion that words are made up of bundles of semantic features is a questionable one, one often finds slips involving the insertion of words into the speech stream that differ from the intended words by a single semantic feature.

T: Look in the top drawer.

S: Look in the bottom drawer.

(8) *Phrase*. Occasionally units larger than words become transposed.

T: The room over the garage has a carpet on the floor.

S: The carpet on the floor has a room over the garage.

## Frequency

The frequency with which slips of various types occur is known to vary because of a number of factors. Fifteen different frequency effects will be described here.

(1) *The type effect*. Anticipation slips of the tongue are more common than perseveration slips.

(2) *The location effect*. Slips involving initial phonemes are known to

occur more frequently than slips involving final phonemes (MacKay 1970).

(3) *The stress effect.* Slips involving stressed syllables appear to be more frequent than slips involving unstressed syllables (Boomer and Laver 1968).

(4) *The distance effect.* In those slips involving the interaction of two units in the speech stream—anticipation, perseveration, and transposition—the number of slips between two units is inversely correlated to the distance between the two elements. That is, the farther apart two elements are from one another, the less likely it is that there will be a slip between them.

(5) *The distance-type effect.* The distance between interacting units in transposition slips is less than the distance between interacting units in anticipation slips, on the average (Cohen 1973).

(6) *The location similarity effect.* Slips most often occur between two units that have the same location in their respective higher level units. Initial phonemes are most likely to slip with other initial phonemes; phonemes in stressed syllables are most likely to slip with phonemes in other stressed syllables, words that are the heads of prepositional phrases are most likely to slip with other words that are also heads of prepositional phrases, and so on.

(7) *The item similarity effect.* Phonemes that are similar to one another are more likely to slip with one another than phonemes that are dissimilar. Thus [p] and [b] are more likely to slip with one another than [p] and [d], for example. At the word level, two words that are similar in sound, meaning, or syntactic class are more likely to slip with one another than two dissimilar words. This is true of word substitution errors and blends. Thus *I caught a pike* is more likely to slip to *I caught a perch* than it is to slip to *I caught a mackerel*. Similarly, *I caught a perk* is more likely than *I caught a mikeral*.

(8) *The context similarity effect.* Two phonemes that appear in words in which the immediately preceding or following phonemes are identical are more likely to slip with one another than the same phonemes in words in which their immediate neighbors are dissimilar (MacKay 1970). For example, *bad cat* is more likely to slip to *cad cat* than *bad cup* is to slip to *cad cup*, because in the former example the two words share a phoneme (the [æ]), while in the latter example they do not.

(9) *The phoneme frequency effect.* All other things being equal, an infrequent phoneme is more likely to slip to a frequent phoneme than the reverse. Thus *far back* is more likely to slip to *bar back* than *bar fact* is to slip to *far fact*, because [b] is more frequent than [f].

(10) *The phoneme combinations frequency effect.* Slips are less likely to occur if the resulting sequence of phonemes is a low frequency combination than if it is a high frequency combination. Thus *banished sling* is more likely to become *blanished sling* than *vanished sling* is to become *vlanished sling*, since [bl] is a more frequent combination than [vl] (Wells 1951; Fromkin 1971).

(11) *The lexical editing effect.* The probability that a potential slip will

occur if the resulting phonological combination is a word is greater than if it is a non-word. This effect was demonstrated in an experiment by Baars, Motley, and MacKay (1975). Subjects were required to articulate two-word phrases in situations where they were confused about the order to the words. Many anticipations, perseverations, and transpositions of phonemes resulted. The errors were much more likely if the slip created a word or a pair of words, however, as happened when *darn bore* was spoken as *barn door*, than when the error created non-words, such as *dart board* slipping to *bart doard*.

(12) *The lexical expectation effect.* In an experimental situation if the subject expects to be saying nonsense syllables, he or she is more likely to make slips resulting in non-words than if he or she is expecting to be saying words. Thus the lexical editing effect seems able to be turned off (Baars, Motley, and MacKay 1975).

(13) *The semantic editing effect.* If a potential slip results in semantically appropriate text, it is more likely to occur than if it results in semantically inappropriate text (Motley and Baars 1976). Thus if the target utterance is *My rifle fell in the water so I need to get one*, the slip to *My rifle fell in the water so I need to wet gun* is semantically appropriate. On the other hand, if the target is *My waffle fell in the water so I need to get one*, the slip to *My waffle fell in the water so I need to wet gun* is not semantically appropriate. The semantic editing effect refers to the fact that slips of the former type are more probable, all other things being equal, than slips of the latter type.

(14) *Freudian slip.* If you are thinking about something, and a slip is possible that would express these thoughts, you are more likely to make the slip than if you were not thinking about that topic. Although everyone knows about Freudian slips, it is only recently that they have been experimentally verified. Subjects were wired to an electrical device and told that they might receive a shock. They were then asked to repeat nonsense phrases rapidly. When asked to produce *shad bock*, they were more likely to say *bad shock* than other subjects who had not been wired up (Motley and Baars 1977).

(15) *The speaking rate effect.* The faster people talk, the more slips they tend to make (MacKay 1970).

In addition to the fifteen different effects involving frequency of slips, there is one that does not involve frequency but is nevertheless quite interesting theoretically:

*The morphophonemic adjustment effect.* If a slip is made that otherwise would result in the use of the wrong allomorph of a particular morpheme, an additional change takes place in the text so that the appropriate allomorph is used. Thus if the target is *an ailing pal*, but the [p] is anticipated, the appropriate form of the morpheme /a~an/ is used to give *a pailing pal* (Fromkin 1971).

The listing above constitutes most of the major findings to date. One can see that the slips-of-the-tongue phenomenon under careful scrutiny breaks

down into a sizable number of different specific effects. The wealth and complexity of these findings constitute a substantial challenge to those wishing to build a model of the speech production process.

#### THE MODEL

The system on which our model of speech production is based is stratificational grammar. Specifically, the system is conceived as being organized much as in Lamb (1966) or Lockwood (1972). Two aspects of the structural organization of stratificational grammar and one of the process of production are particularly appealing for a person trying to model slips of the tongue. One is that the structure of language is seen within the stratificational framework as essentially similar at different levels. There is not one notational system for syntax and an entirely different one for phonology. This is desirable because similar types of slips seem to occur at different levels of processing. The second aspect is that in stratificational grammar, units that have features in common actually share part of their network structure, or at least are multiply connected to one another. This is very useful for accounting for the various similarity effects. The other aspect of stratificational theory that is appealing for our purposes is the notion of producing speech by means of a system of signals that flow through the relational network. The particular system closest to the one we are about to describe is that of Reich (1970), though ours is significantly different from that model. Superimposed upon the system of signals previously developed is a general system of *spreading activation*. This system involves the addition of eleven principles of signal processing.

Principle 1: *Activation*. In Reich (1970) the system of signals that produced speech used *all* or *none* signals. They were either present or absent. Such a system in theory produced only the speech that was desired; there was no way it could simulate human errors. The system we now propose is a significant generalization of the earlier system. In it signals have associated with them a positive value, which varies over a range of values. In the earlier model, each node had associated with it an indicator marking the state it was in. How a node behaved in response to signal inputs depended on both the node type and the state of that node at that time. In the model we now propose, in addition to the properties noted above, each node will have associated with it a number representing the degree of activation of that node. In other words, it makes sense to ask not only whether or not a node is activated, but also to what extent it is activated.

Principle 2: *Decay*. At each time step the activation of each node will decay to a set fraction of its previous value.

Principle 3: *Spreading*. During each time step, a set fraction of the activation of a node will spread from that node to all nodes directly connected with it. In general, activation will spread in all directions, but it will spread more in some directions than others, depending upon the type of node and the state



that it is in.

Principle 4: *Noise*. During each time step the total amount of activation on a node will be decreased or increased by a random amount considered to be a result of "noise" in the system.

Principle 5: *Summation*. The degree of activation of each node at any particular time will be determined by summing the values of the activation coming in all the input wires at that point with the decayed previous activation and the noise.

Principle 6: *Threshold*. There exists a threshold value such that whenever the total activation on a node falls below that value, the activation value of that node is set to zero.

Principle 7: *Signaling*. When it is time for a construction to be generated, a signal is sent to the concatenation (ordered AND) node heading that construction, which in turn sends a signal down the wire that realizes the first unit of the construction to be generated. This does not differ from previous system designs. In addition, however, an anticipatory signal of lesser value is sent down to the construction to be generated next. The signal that is a part of the normal production signaling system is not distinct from the activation; it is simply added to it.

Principle 8: *Satisfaction*. When a construction functions as output, a second type of signal travels up through the system. When it hits the first wire of a concatenation node, that node is signaled to send a production signal out the second wire to produce the next item to be produced, and an anticipation signal to the construction to be produced after that. When a satisfaction signal hits the final wire of a concatenation node, this indicates that the entire construction headed by that node has functioned as output. In this case the activation value on that node is set to zero, and the satisfaction signal continues up to the next higher node.

Principle 9: *Competition*. This is the principle governing the disjunction (unordered OR) node. When it is time for one of a set of possible constructions to be produced, each construction will be represented by a wire coming out of a disjunction node that defines the set. Each wire will be coming from a node that has a certain amount of activation on it. The competition principle states that *the construction having the highest activation is produced*. Thus a signal coming down into a disjunction node will continue down the most highly activated wire.

Principle 10: *Rate*. The rate of speech production varies independently of the rate at which production signals can be sent through the system.

Principle 11: *Conservation*. Although the amount of activation in the system will vary from time step to time step, over the long run the total amount of activation in the system must remain relatively constant. This is accomplished by balancing the amount of signaling and spreading against the amount of decay and satisfaction.

## SIMULATING THE MODEL

The model proposed involves the complex interaction of a number of factors, and a large number of parameters to set. The parameters include the degree of decay per time step, the value of the threshold, the fraction of activation that spreads, the amount of noise, the strength of anticipatory signals, and the speaking rate. Thus the only reasonable way of determining whether such a system will behave properly is to simulate it on a computer, setting the parameters to different values to see whether there are combinations of settings that lead to behavior comparable to human behavior.

Thus a small portion of a relational network was simulated to test the usefulness of the model. Figure 1 shows the network used. It encompasses ten words and their connection to a simple syllable phonology. The phonology indicates five possible initial consonants, followed by five possible vowels, followed by five possible final consonants. It should be noted that initial consonants and final consonants are kept separate in this proposed phonology. This is a deviation from the usual representation proposed for stratificational phonology, but it can be independently justified on the basis that initial and final consonants are often allophonically distinct—initial /t/ is [t<sup>h</sup>], while final /t/ is [t<sup>ɰ</sup>] for example. The phonology can generate  $5 \times 5 \times 5 = 125$  different syllables. Of these 125 possibilities, only ten are defined as words in the network; the remaining 115 are phonologically acceptable nonsense syllables in the system.

The program is run by assigning values to the parameters and initial values of activation to the nodes. The program randomly selects words from its vocabulary and attempts to say them until instructed to stop. The output is printed out, and can be scanned for slips.

## SIMULATION RESULTS

Of the many facts about slips discussed above, the simulation model is able to mimic a number successfully. In this section we shall explain briefly how the simulation is able to fit the data—that is, why the model works.

(1) *The basic error types.* The errors generated by the simulation fit very nicely into the known types of slips of the tongue. Phoneme anticipation errors, such as *bop deck* being realized as *dop deck*, are common in the simulation's "speech." These occur when the activation level of the initial /d/ node exceeds that of the /b/ node at the time when the phonotactics is selecting an initial consonant. This choice could be due to random noise in the system, or, interestingly, due to previous repeated use of an initial /d/. It is known that repeated use of a particular sound will increase the tendency to slip to that sound, and yet such a tendency is not built into the simulation. When a node has been satisfied, it is set to zero. Nevertheless, the phenomenon does occur in the simulation. When a phoneme is used repeatedly, it will, indeed, be more likely



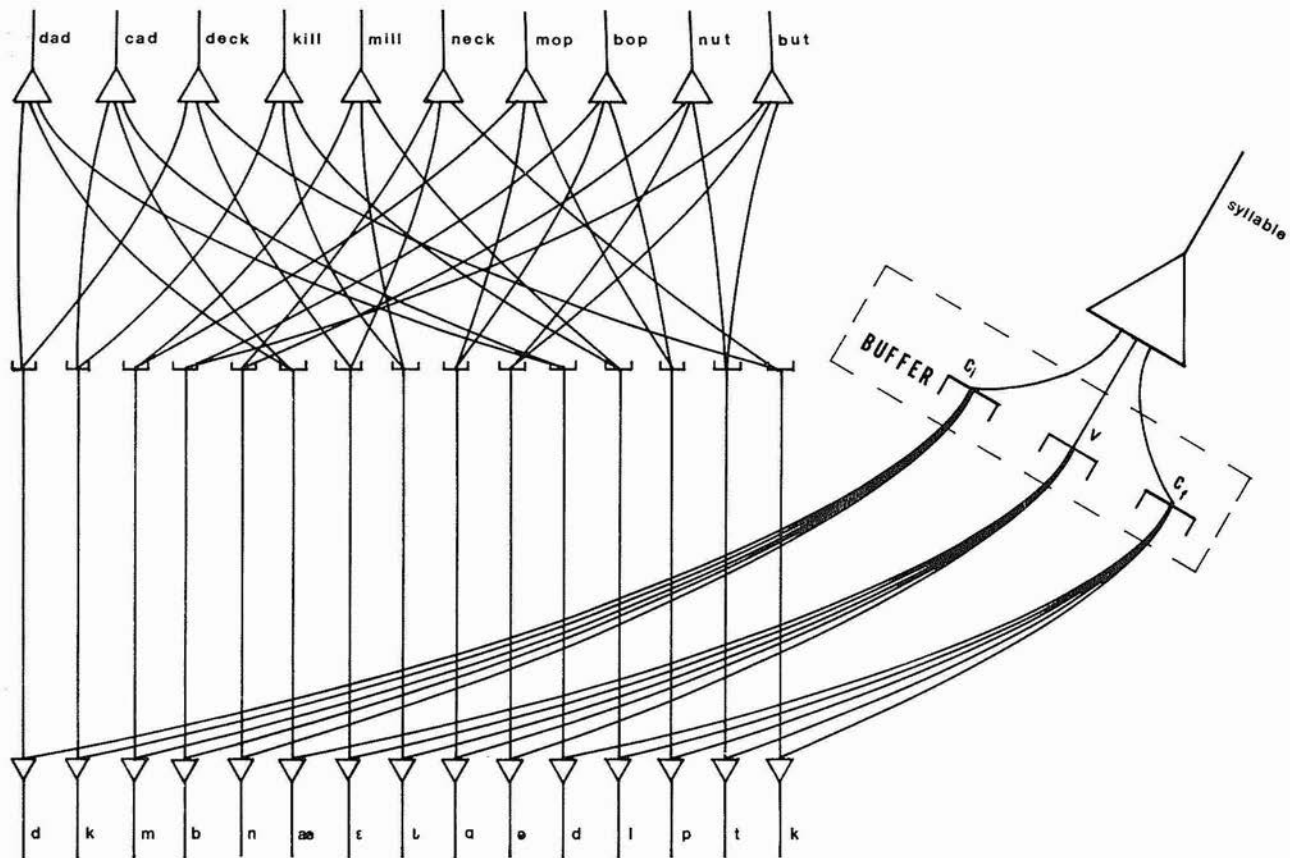


FIG. 1. FRAGMENT OF GRAMMAR USED IN COMPUTER SIMULATION OF MODEL.

that there will be a slip to that phoneme. This is because although the appropriate node will be zeroed out, it previously had been highly activated, and so a high amount of activation remains in the immediate neighborhood of the node. Some of that activation flows back into the node, so its activation will tend for a while to be higher than average. Repeated activation of the node will cause continued buildup of activation, increasing the likelihood of a slip to that construction. Similarly, phoneme perseverations result—*bop deck* being realized as *bop beck*, for example—when there is a relatively high activation level of the first phoneme—/b/ in this example. Furthermore, if an anticipation occurs, sometimes the simulation follows by completing the phrase with a perseveration, yielding a transposition error. Thus *bop deck* gets realized as *dop beck*. The reason for this is that when, in the example, the /d/ comes out too soon, it gets satisfied (set to zero), while the /b/, which was supposed to come out, does not, and so remains highly activated. This greatly increases its likelihood of coming out at the start of the next syllable. Such an explanation can also account for counterblends. In addition to these phonemic errors, the simulation also creates various types of word errors, including word substitutions, blends, and word level anticipations, perseverations, and transpositions. These are caused by variations in the activation levels of the word nodes. The simulation is not able to generate errors involving features, clusters, or syllables for the simple reason that these units are not represented in the small network chosen to illustrate the theory. In principle, however, errors involving these other units would happen if the grammar chosen had been more extensive in scope.

(2) *Lexical editing effects.* One of the most striking features of the errors made by the simulation is that they tend to be words. Thus *deck nut* is much more likely to slip to *neck nut* than *deck mill* is to slip to *meck mill*, simply because *neck* is a word and has a node corresponding to it in the network. This bias toward words is a direct consequence of the spreading of activation between word and phoneme nodes. In order to understand this mechanism it is best to consider an example and follow the flow of activation step-by-step. Assume that the speaker (the simulation) intends to say *deck*. First, the word node corresponding to *deck* is activated from higher level strata. Because the node has become activated, it sends activation to those nodes connected to it, in this case, the nodes corresponding to /d/, /ε/, and /k/. When these nodes become activated, they, as well, send out activation to the nodes connected to them. In this case, a large amount of the activation sent by /d/, /ε/, and /k/ will end up right back on *deck*, giving it even more activation than it had to begin with. In this way, the activation flowing between a word and its phonemes creates a reverberatory loop, with each continuously re-activating the other. (Activation would grow without bound in such a system, unless a counteracting influence is added. This is the reason for adding decay to the system.) The reverberation continues until the phonotactic rules operate to select out the

most highly activated phonemes. In this case /d/, /e/, and /k/ would be selected, assuming that competition from other phonemes is minimal. Next consider the case where *deck* is again the intended word, but for some reason the phoneme node corresponding to initial /m/ is highly activated, perhaps because words beginning with /m/ are being planned or have just been said or both. It is possible that the /m/ might be selected by the phonotactics instead of /d/, creating a slip to *meck*. But because *meck* is not a word, the reverberatory flow of activation between words and phonemes will tend to alter the relative activation levels of each of the various phonemes. Gradually the activation of /m/ will die away and the level of /d/ will increase, thus "editing" the speech stream. It turns out that only certain phoneme combinations, those corresponding to words or near-words, create stable patterns of activation, because of this reverberatory process. If the /m/ in the above example had been /n/, the outcome would have been different. If *deck* is planned, but /n/ is highly activated for some reason, then the activated phonemes /n/, /e/, and /k/ would create a stable reverberatory loop with the word node for *neck*, and so the error to this word would be a distinct possibility. Because *neck* is a word, it is not edited out. In this way the simulation can account for the lexical editing experiment of Baars, Motley, and MacKay. We have actually fit the data from this experiment by directing the simulation to "say" two-word utterances, where an initial consonant transposition would create either two unintended words or two unintended non-words. We found, as did Baars, Motley, and MacKay, that the slips creating the words were about three times more likely than those creating non-words. We also found that this tendency is somewhat stronger for transposition errors than for anticipations or perseverations.

(3) *The phoneme combinations frequency effect.* The simulation tends to create errors with high frequency phoneme combinations, and to avoid errors with rare combinations. That is, just as the simulation is biased to create words, it is biased to create wordlike non-words, and this is accomplished by reverberatory spreading in exactly the same way that lexical editing effects are created.

There are two types of phoneme and phoneme combination frequency. One involves a count of the occurrence of phonemes and their combinations in samples of natural text; the other a count of their occurrence in the lexicon, without taking into account the frequency of the lexical items. Our simulation is affected by the second type of frequency. Frequency studies of natural slips have not been conducted with enough accuracy to determine whether natural slips are affected by the first or the second type of frequency.

(4) *Context similarity effects.* When two words that share a phoneme are to be said consecutively by the simulation, there is a greater likelihood of an error. Thus it is more likely that *neck nut* will slip to *nuck net* because they share the phoneme /n/. This happens because the initial /n/ of *neck* and *nut*

is represented by the same node in the network. When *neck* and *nut* are activated to be spoken in that order, some of the activation from the more highly activated first word, *neck*, spreads to the less highly activated second word, *nut*, by way of the shared node. Thus the occurrence of the repeated sound tends to equalize the activation levels of the two words, when normally the intended first word would possess a much higher level. Because *neck* and *nut* are fairly close in degree of activation, their distinguishing phonemes, / $\epsilon$ / versus / $\text{a}$ / and / $t$ / versus / $k$ /, will also tend to be activated to a similar amount. This increases the chance that a phoneme from the intended second word will be selected before it should, creating an anticipation or transposition error.

(5) *Item similarity effects.* One of the item similarity effects is that word substitutions and word blends in natural speech usually involve words that are similar in sound. This happens in the simulation as well. From the point of view of the simulation, similar sounding words are words that share a number of phonemes. When a given word is activated, words similar in sound to it also become activated by the spreading of activation in the same fashion as that described in (4) above. These activated, similar sounding words then can either completely replace the intended word, giving a substitution error, or partially replace it, giving a word blending error.

(6) *Speaking rate effects.* When the simulation speaks rapidly, relatively few time steps occur between words. Under this condition it is extremely error prone. This can be seen in figure 2, where error percentage is plotted as a function of both speaking rate and noise level in the network. Note that when there is no noise the simulation can achieve error-free performance at certain speaking rates. The mechanism for the effect of speaking rate is simple. At fast rates, there is very little opportunity for the spreading of activation. As we have demonstrated, spreading leads to the creation of reverberatory loops, which act as editors. With no time available for these loops to become established, many errors are produced.

#### PREDICTIONS FROM THE MODEL

So far we have shown how our model can account for a variety of speech error phenomena. The computer simulation of part of the model generated slips of the tongue that were sensitive to many lexical and phonological considerations that are known to affect natural speech errors. In addition to accounting for existing data, the model is also able to make new testable predictions. In this section we shall review some of these predictions.

(1) *Non-adjacent context similarity effects.* We have shown how the simulation accounts for the tendency for repeated phonemes to facilitate errors in their neighboring phonemes, how because of / $n$ / in both words of *neck nut* the / $\epsilon$ / and / $\text{a}$ / are more likely to replace one another. This repeated phoneme effect is also accounted for by two other theories of speech pro-

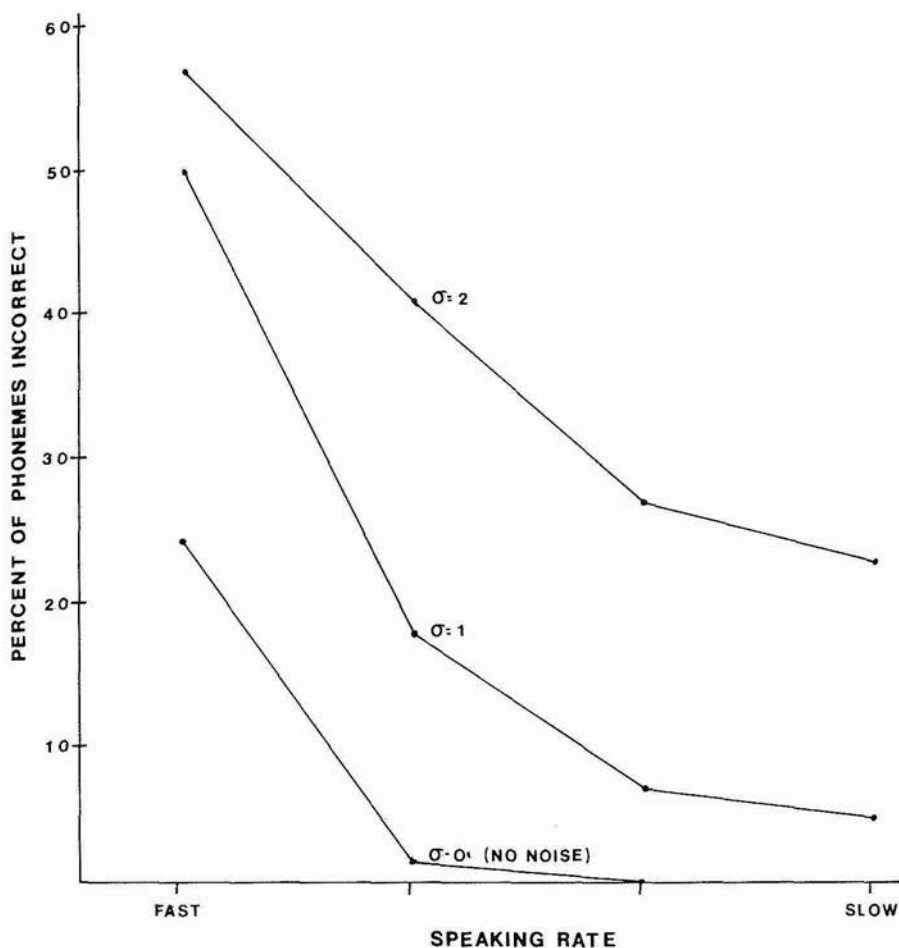


FIG. 2. SIMULATED INFLUENCE OF SPEAKING RATE AND NOISE.

duction: those of Wickelgren (1969), and MacKay (1970). Both of these theories assume that the cause of this effect is the relationship between the repeated and neighboring phonemes. According to these theories, there is an association between /n/ and /ε/ and between /n/ and /ə/. Because /n/ is associated with both /ε/ and /ə/, it is possible that an ordering confusion can result, creating a transposition, anticipation, or perseveration. Our model accounts for the effect of repeated phonemes very differently. The effect occurs because the repeated phoneme equalizes the activation levels of the two words to be spoken. This leads to the prediction that not only should the phonemes adjacent to the repeated ones slip—/ε/ and /ə/—but it is also possible that non-adjacent ones—/k/ and /t/—slip more frequently as well. The theories

of MacKay and Wickelgren would not make this prediction. On the basis of an extensive analysis of over 300 initial consonant anticipations, perseverations, and transpositions, we have determined that these errors are associated with repeated phonemes not only adjacent to the error, but also with repeated phonemes one and two phonemes away from the error. For example, one reported slip (Fromkin 1973) was that *take my bike* slipped to *bake my bike*. This is an anticipation slip of the initial consonant, which is made more likely by a repeated phoneme not adjacent to the phoneme that slipped, but one phoneme away from it. Thus our model makes a prediction not suspected by people using other models, and when checked against the data, the prediction made by our model was confirmed.

(2) *Lexical editing at various speech rates.* We mentioned earlier that editing has a greater effect at slow speaking rates for the simulation. In particular, lexical editing, the tendency to create words, should occur at slow rates more than at fast ones. This can be seen in figure 3, where percentage errors from the simulation are plotted as a function of the speaking rate, and whether the error makes a word or a non-word. Clearly, the lexical editor operates more efficiently at slower rates. Although this is the pattern of results from the

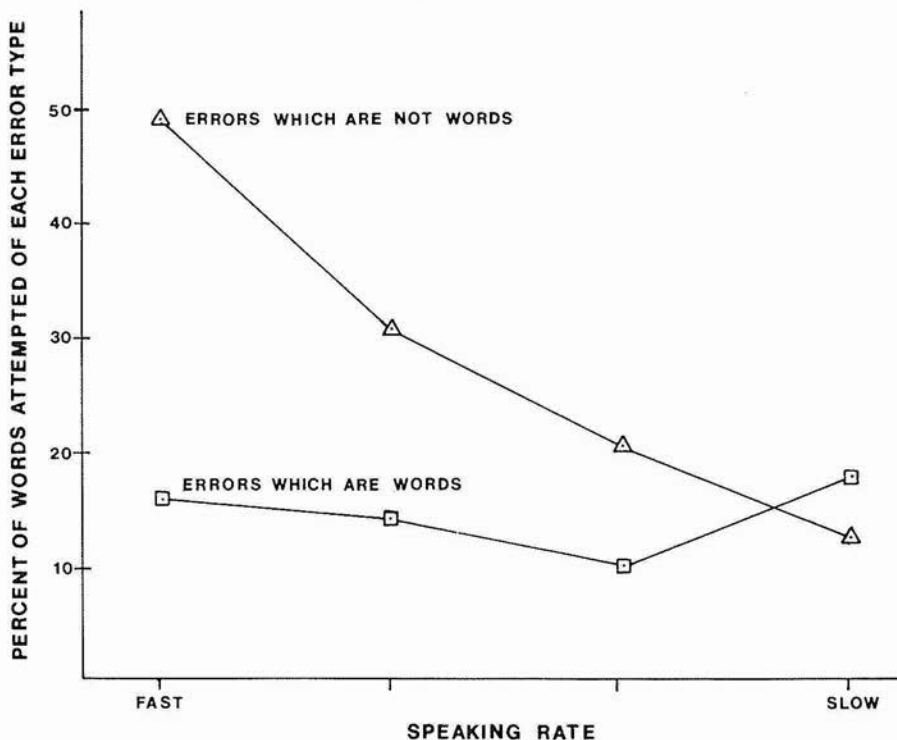


FIG. 3. OUTPUT OF SIMULATION SHOWING LEXICAL EDITING.



simulation, this effect has yet to be tested in an experimental setting, and as such constitutes a prediction from the theory.

(3) *Semantic and phonological factors in word substitutions.* We have shown how the simulation results in word substitution errors where the intended and substituted words are similar in sound. It is also known that the intended and substituted words are often semantically related. This could not be observed in the simulation because we did not include a semantic stratum. Had we done so, an interesting result would have been obtained. Because of the spreading of activation, semantic and phonological properties of words would interact, resulting in a disproportionately large number of word substitutions and blends between words that have both similar sound and similar meaning. Although this is hardly surprising, it is contrary to current linguistic views on speech production (e.g., Fromkin 1971), where it is asserted that word substitution errors are caused by interference from either similar sounding words or similar meaning words, but these influences are independent of one another. A given slip is either one or the other but not both. In our model, however, both semantic and phonological influences jointly determine whether or not two words will slip. This notion is not unlike Freud's (1901) discussion of errors. According to Freud, there is never a single cause for a lapse; rather a number of influences act together in an additive fashion. If it could be demonstrated that those word slips which involve similar meaning words also involve similar sounding words, then our model (and Freud's beliefs) would be supported over the current linguistic models.

#### CONCLUSION

We have seen that in the slips-of-the-tongue phenomenon what we have, in fact, is a large and very complex set of facts to account for. The model we have proposed is itself somewhat complex, though in fact little more than a generalization of previously proposed models of production in the stratificational framework. It appears that we can tune the model so that it not only produces the various varieties of slips, but produces them with the same frequencies as are found empirically. In addition, our model leads to new testable predictions about slips, and thus can provide a framework for further research into one of the most interesting aspects of language behavior.

#### REFERENCES CITED

- Baars, Bernard J., Michael T. Motley, and Donald G. MacKay. 1975. Output editing for lexical status from artificially elicited slips of the tongue. *Journal of Verbal Learning and Verbal Behavior* 14:382-391.
- Boomer, Donald S. and John D. M. Laver. 1968. Slips of the tongue. *British Journal of Disorders of Communication* 3(1):1-12.

- Cohen, Antonie. 1973. Errors of speech and their implication for understanding the strategy of language users. *In* Fromkin (1973:88-92), q.v.
- Freud, Sigmund. 1901. *Psychopathology of everyday life*. Translated by A. A. Brill. New York: New American Library, Mentor, 1958. Excerpt on slips of the tongue reprinted *in* Fromkin (1973:44-81), q.v.
- Fromkin, Victoria A. 1971. The non-anomalous nature of anomalous utterances. *Language* 47:27-52.
- , ed. 1973. *Speech Errors as Linguistic Evidence*. The Hague: Mouton.
- Hockett, Charles F. 1967. Where the tongue slips, there slip I. *In* To Honor Roman Jakobson, pp. 910-936. The Hague: Mouton.
- Lamb, Sydney M. 1966. *Outline of Stratificational Grammar*. Washington, D.C.: Georgetown University Press.
- Lockwood, David M. 1972. *Introduction to Stratificational Linguistics*. New York: Harcourt Brace Jovanovich.
- MacKay, Donald G. 1970. Spoonerisms: The structure of errors in the serial order of speech. *Neuropsychologia* 8:323-350.
- Motley, Michael T. and Bernard J. Baars. 1976. Semantic bias effects on the outcome of verbal slips. *Cognition* 4:177-187.
- . 1977. Semantic influences upon the outcome of speech errors: A laboratory verification of 'Freudian slips.' To appear in V. A. Fromkin, ed., *Slips of the Tongue, Ear, Pen, and Hand*. New York: Academic Press, in press.
- Reich, Peter A. 1970. Relational networks. *Canadian Journal of Linguistics* 15:95-110.
- Wells, Rulon. 1951. Predicting slips of the tongue. *Yale Scientific Magazine* 26(3):9-30.
- Wickelgren, Wayne A. 1969. Context-sensitive coding, associative memory, and serial order in (speech) behavior. *Psychological Review* 76:1-15.