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Publication Date
1978-08-01
Tip of the Tongue and Slip of the Ear
Implications for Language Processing
Catherine P. Brown
Tip of the Tongue and Slip of the Ear:
Implications for Language Processing

Catherine P. Browman

UCLA Working Papers in Phonetics
July 1978
University of California, Los Angeles
This work is dedicated
to
Montana,
a state of mind
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ACKNOWLEDGMENTS

The present endeavor reflects the influences of a lifetime: indebtedness begins in childhood.

My thanks to Judy Hanson Holbrook for keeping my imagination alive long past its scheduled demise, to Jay Lash Ross for sharing in the first bewildered gropings after things of the spirit and the mind, and to Suzanne Francisco Madden for helping to continue that search with fierce determination. And to Cecil Coker, Jim Planagan, Marion Orr Harris, Martha Claggett Johnson, Steve Johnson and Noriko Umeda for stimulation and nurturing; to Max Mathews and Lillian Schwartz for providing me with heroes long past the age of heroes. My especial thanks to F. Richard Moore for helping me know what I wanted in life.

There would have been no dissertation without the overwhelming warmth and support and stimulation and sharing of crazy ideas and jogging on the beach and arguing till 3 a.m. of the members of the UCLA Phonetics Lab, past and present. Thanks especially to Pat Coady, Vanna Condax, Linda Galloway, Jack Gandour, Jean-Marie Hombert, Volker Huss, Leon Jacobson, Tom Morarre, Roger Remington, Diana Van Lancker, Tricia Wood, Eric Zee; and to Ava Berinstein for enthusiasm, Ron Carlson for space, Sandy Ferrari Disner for presence, Steve Greenberg for ears, Richard Harshman for beauty, Ian Maddieson for words, George Papcun for questions, and Lloyd Rice for computalk. Steve Anderson, Merrill Garrett, John Gilbert, Vimal Graham, Ed Keenan, Willie Martin, Anna Meyers, Bob Stockwell, Renee Wellin, Ed Carterette, Breyne Moskowitz, Sandy Thompson, Alan Timberlake, Tom Wickens, and especially Vicki and Jack Fromkin in many ways provided stimulation and support. Thanks to those whose friendship has brightened the hours of drudgery: Rosanne Hesse DeBats, Don DeBats, Peter Fonda-Bonardi, Anne Friend, Bob and Sandi and Michele and Allegra Lundy, Marina McIntire, Sande Pruzansky, Ronnie Wilbur, and Wendy Wilkins.

The National Science Foundation and the National Institute of Health provided financial support. I am grateful to the Digital Equipment Corporation for healing the computer just frequently enough to keep sucking me into using it.

Peter and Jenny Ladefoged have supported me in every way in the path through graduate school. Andrew and Audra Elizabeth and David Browman taught me to tolerate and even enjoy violent disagreement and kept me always reaching to live up to their mystique. Audra and Ludwig Browman provided me with the guts to stick it out, a commitment to thoroughness, a respect for data, and an invaluable intellectual perspective.

And finally, there are three where words fail: AE and Michael, with whom life is clear, and Louis, who has shared it all.
ABSTRACT OF THE DISSERTATION

Tip of the Tongue and Slip of the Ear:
Implications for Language Processing

by

Catherine P. Browman

Doctor of Philosophy in Linguistics
University of California, Los Angeles 1978
Professor Peter Ladefoged, Chairman

Lexical retrieval errors (the tip-of-the-tongue phenomenon or TOT) and perceptual errors (slips of the ear or SLOE) occurring during casual conversation were analyzed and compared to each other.

Chapter one includes a general description of the TOT data as well as analyses of the role of unit size, within-unit position and stress. The lexical errors consist primarily of errors of segment order and secondarily of errors in segment identity. Recall is most accurate at three points of prominence within the word: at the beginning, at the end, and at the beginning of the stressed syllable. The segments tend to be recalled in small groups: consonant clusters, vowel plus clusters, or entire syllables. Vowels in particular are generally recalled in combination with the immediately adjacent consonants; they combine as often with preceding consonants as with following consonants. Consonants in final position in the syllable rarely are recalled alone; they are almost always combined with the vowel.
Consonants in the initial position of the syllable on the other hand, are recalled without the vowel much more frequently. The rhythmic pattern of the lexical item is generally recalled accurately regardless of whether the segments are accurately recalled. The initial consonant(s) of the stressed syllable are generally accurately recalled; however, they are recalled as stressed (rather than unstressed) only if the rhythmic pattern of the lexical item is also correctly recalled. Stress facilitates recall only for the initial portion of the stressed syllable, not for the vowel or final portion.

Chapter two includes a general description of the SLOE data as well as an analysis of the role of the word in perceptual errors. The majority of the errors occur within one word. There is no evidence that any particular portion of the word triggers the misperception. There is a very slight tendency for words to be perceived as shorter, either by perceiving two short words instead of a single long word, or by failing to perceive some portion of the word. A misperception of word structure (two short words perceived as one long word, or vice versa) is associated with more segmental errors and more serious segmental errors (multiple feature changes).

Chapter three continues the investigation of perceptual errors with analyses of the distribution of perceptual errors within the word. Two sources of perceptual errors are posited: a low-level acoustic misanalysis, and interference from higher (lexical) levels. Errors attributable to a low-level acoustic misanalysis occur most frequently at the beginning of the word and of the syllable, and least frequently at the end of the word and the syllable. On the other hand, errors attributable to high
level interference occur least frequently at the beginning and end of the word, and most frequently in the middle of the word.

Chapter four compares the lexical errors and the perceptual errors to each other and to the information present in the acoustic signal. On the basis of this comparison, a mechanism common to both lexical and perceptual errors is proposed. The common mechanism focuses attention on the beginning and end of the word, and also on the initial portion of the stressed syllable. It is suggested that the pattern of lexical errors is a function of this mechanism operating during retrieval, rather than a function of storage. It is further proposed that the pattern of perceptual errors is a function of this mechanism operating on the output of a duration-based low level acoustic analyzer.
CHAPTER 1

Internal Word Structure:
Evidence from the TOT Phenomenon

"It's on the tip of my tongue"

The tip of the tongue (TOT) phenomenon refers to the situation in which a person is trying to recall a word but cannot quite recall it correctly. Frequently, however, the person knows something about the word (besides of course its meaning or referent)—they may know its stress pattern, its initial segment, and may even be able to approximate the desired word with another similar word. This partial knowledge can provide revealing insights into the fine structure of recall. In particular, questions of the relevance of various linguistic descriptions to the process of recall can be provisionally answered. For example, various sizes of linguistic units have been proposed—words, syllables, and phonemes, among others. By investigating the TOT phenomenon in greater detail, the role of these units in recall may begin to be determined.

Note that the recall of portions of a word prior to recall of the entire item may reflect either the structure of storage or the structure of retrieval. In the former case, parts of the word may be stored more strongly or more clearly, and hence be more readily recalled. In the latter case, all portions of the word may be stored equally strongly, but the process of retrieval might accentuate certain portions. If one describes the process of incomplete recall as an attempt to recall vague information seen as if "through a glass darkly," then the storage model would be as if certain portions of the word were more brightly stored and hence more easily seen, while the retrieval model would have all portions equally dimly stored, but the process of retrieval would be as if a light were shined on portions of the word, which would then be more clearly seen. In the present chapter, the term 'recall' will be used to cover both models; the two models will be discussed in greater detail in chapters three and four.

The TOT phenomenon has been discussed by a number of scholars under a variety of rubrics—TOT, verbal evocation, searching for names, feeling of knowing, response blockage. Dwight Bolinger (1961) provided a number of anecdotal examples of what he called 'verbal evocation.' In one case, while trying to recall the name of Al Capp's heroine, he could only think of 'Lulu Belle' until several days later. While musing on the pleasures of bicycle riding in the long 'days of May,' he recalled correctly 'Daisy Mae.' Freud (1955), James (1950), Woodworth & Schlosberg (1954), and Wenzl
(1932, 1936) also discussed the phenomenon in earlier works. The seminal paper in recent years, however, was that of Brown and McNeill (1966). They used an experimental paradigm to elicit the TOT phenomenon, by providing definitions of low frequency words and requesting subjects to respond with the word. In about 13% of the instances the subjects were not sure of the correct word and hence were in a TOT state. In these cases subjects attempted to record the initial letter and number of syllables of the word for which they were searching, as well as any words similar in either sound or meaning that occurred in the TOT state. Brown and McNeill concluded that the subjects tended to correctly recall the number of syllables, the position of the stress, and the beginnings and ends of the words (especially the initial letter), and that grammatical suffixes were also important in the recall process.

These findings have been replicated by several authors. Koriat & Lieblich (1974) found, using a similar paradigm, that subjects tended to recall correctly the first and last letters and the number of syllables of the target word. Rubin (1975) modified the Brown and McNeill paradigm, using more subjects and only the four most productive target items from the Brown & McNeill study, and requesting the subjects to record any letters from the target that they could as well as the number of syllables and similar words. All of Brown & McNeill's findings were replicated. Varmey (1973) followed the Brown & McNeill paradigm but used photographs of public personages instead of definitions to induce the TOT state. Again, the initial letters of the name and the number of syllables were frequently recalled. Freedman and Landauer (1966) and Horowitz, White, and Atwood (1968) both found that providing the initial letter or letters improved recall of the target item; in addition Horowitz, White and Atwood found that the final letters, when used as a cue, improved recall of the target word.

Fay & Cutler (1977) studied a related problem. They analyzed naturally occurring malapropisms, in which the target word in speech was replaced by a semantically unrelated word that sounded similar to the target word. For example 'equivalent' in 'if these two vectors are equivalent, then...' was replaced by 'equivocal.' They found the target and the replacement generally agreed in number of syllables and stress placement; moreover the target and replacement generally agreed in syntactic category. They also found that vowels in the first syllable of the target and replacement were more frequently in agreement than those in the stressed syllable. Aitchison (1977) analyzed malapropisms collected from children and adults through responses to a newspaper advertisement. She found, for adults, that the malapropisms were most similar to their corresponding target words for initial and final consonants, and less similar for
number of syllables, stress pattern and stressed vowel. For children, on the other hand, she found most similarity for number of syllables, stress pattern, and stressed vowel, and less similarity for initial and final consonants.

The studies to date have been limited by a number of factors. In particular, only Koriat & Lieblich (1974) attempted to compare their results to any kind of chance level. The other authors simply presented the frequency of correct recall for the data. For some results this is not a problem. For example, the frequency of recall of the initial letter is so high that careful comparison to chance level is unnecessary. For the number of syllables and position of stress, however, the lack of comparison to chance level is a problem. The number of syllables and position of stress are accurate much of the time; however, since most American English words are two or three syllables, the number of syllables could be accurately guessed much of the time. Again, the stress placement in American English has a high degree of predictability, particularly once the form class and number of syllables of the word are known. Hence one would expect high accuracy of stress placement by chance alone.

In general, only the broadest types of structures have been investigated thus far in TOT research. Word-initial and final effects have been suggested, but the role of word-medial segments has not been determined. Retention of correct order of segments has been proposed for grammatical suffixes, but order elsewhere, particularly word-medially, has not been investigated. The role of smaller units, except for suffixes, has been neglected. Except for Fay & Cutler and Aitchison, all the analyses have involved letters, not phonemes. And the interaction of stress with segment recall, for example whether segments were in stressed or unstressed syllables, has been only lightly touched, again in the malapropism studies.

The present study, then, uses TOT data to investigate the structure of recall in finer detail; it also compares the results to chance. Naturally occurring TOT data, and in particular only those instances in which another word is produced as an approximation to the correct target word, are used. This approach permits the greatest amount of information to be gleaned from the data. The investigation is not limited to those facts about the target item which the subject is specifically invited to record, but rather includes all available information about the target item. Moreover, some kinds of information may be used by the subjects in attempting to recall the target items, but may not be separately reportable. Such information will also be retrieved in the present analysis.

Real-world data, as opposed to data elicited under experimental conditions, is frequently avoided because of the complexities involved in its analysis. It has, however,
several clearly desirable aspects. First, the ultimate goal of psycholinguistic research is to understand real-world language behavior, not behavior in the laboratory. Data collected under natural conditions provides a direct window on real-world language behavior. Second, the complexity of real-world data means a finer-detailed and more encompassing description of the behavior under investigation (provided always the complexity can be unraveled!). The mechanisms involved in the behavior can then be tested under the rigor of experimental conditions.

The major disadvantages of real-world data are the lack of control of certain variables and the difficulties of statistical analysis. Not all apparent lack of control is detrimental. In the present study, which uses real-world data, the subject population is similar to that used in most psychological experiments. The fact that the stimuli are initially chosen by the subjects rather than the researcher potentially provides additional clues into the process of recall, and avoids experimental artifacts. However, the researcher ultimately selects the particular stimuli to be recorded and analyzed, and it is here that a potential source of bias arises. It is all too easy to selectively record the data, and hence bias the results. The only recourse is to attempt to record all cases that arise, which was the goal in the present study. An additional difficulty is the fragmentary nature of real-world data, which makes statistical analysis challenging. In the present study, the results of the data analysis are compared to chance level in order to determine statistical significance. As Koriat & Lieblich (1974) pointed out, subsets of words can differ from each other in certain characteristics, particularly the expected frequency of occurrence of the segments. The expected or chance level for the present study was determined directly for the population of words involved, thereby maximizing the similarity between chance results and the data results.

The goal of the present study, then, is to determine in greater detail which aspects of the item in memory are known prior to complete recall of the item. The subjects' explicit knowledge is bypassed; instead their implicit knowledge is utilized to maximize the information available, by analyzing only responses which are whole-word approximations to the desired target. Those attributes of the target that are better recalled should also appear as attributes of the approximations—hence by comparing what the target and approximation have in common, and by always relating this to chance level, it is possible to determine the important characteristics of the word during recall.
Description of the Data

Samples of the tip-of-tongue (TOT) phenomena occurring in everyday conversation were collected by the author, or were reported to the author by friends. The samples included TOT's experienced by the author and friends, as well as TOT's experienced by others in the presence either of the author or of someone well known to the author. Often the search for the desired target item resulted in a complete blank—a 'don't know' state. Other times bits and pieces of information were retrieved—the first letter, perhaps. In order to investigate the process of recall as completely as possible, those TOT samples in which only partial information was reported were not used. Instead, each sample consisted of a target item (the item being searched for) and an approximation item (an item recalled in place of the target item). For example, the approximation 'waterweeds' was produced while searching for the target 'iceplants.' A total of 484 such target-approximation pairs were analyzed. Seventy-three different individuals, most of them college educated, contributed 415 of the 484 pairs to the corpus. Of these individuals, fifty-three contributed five or fewer TOT pairs, eleven contributed between six and fifteen pairs, eight people contributed between sixteen and twenty-seven pairs, and one person (the author) sixty-three pairs. The identity of the contributors of the rest of the pairs was unknown, since it was not recorded at the time. The contributors resided in a variety of places—New Jersey, Seattle, Los Angeles, Cincinnati, Vancouver—and were involved in various professions—linguistics, computer science, library science, philosophy.

The pairs are listed in Appendices A & B. Appendix A contains the orthographic representation of the target and approximation, the searcher's initials (where known), and whatever comments or elucidations the searcher added, or that the author thought might clarify the relationship. Wherever possible, the searcher provided the spelling. Otherwise, the author's spelling, as corroborated by a past College Bowl contestant and (in questionable cases) Webster's Second International Dictionary (1959), served as an easy and hopefully accurate approximation to commonly accepted usage. Appendix B contains the phonetic representation of the target and approximation (in ARPAAbet). Again, whenever possible, the searcher provided the pronunciation of the items. For most of the pairs, however, a four part system of transcription was employed. First, if the item was entered in Kenyon & Knott (1953), the first transcription provided the segmental description, primary stress, initial syllable boundary for stressed syllables, and occasional additional syllable boundaries. Second, if the item was not entered in Kenyon & Knott, but could easily
be approximated by combining several entries from Kenyon & Knott, then the author combined the entries to provide the basic information. For example, 'Bauerman' was transcribed as a combination of 'bower' plus the suffix '-man.' Third, if the item was too bizarre (4% of the items), a general idea of its stress pattern and pronunciation was obtained from Webster's Second, if possible. Otherwise the author (sometimes after consultation with friends) provided the general stress pattern and pronunciation. In both cases, the author then provided the phonetic transcription, proceeding according to the principles used by Kenyon & Knott. Thus, while the phonetic transcriptions did not necessarily reflect the researcher's dialect, nevertheless both target and approximation were transcribed using the same rules, which is an important consideration when comparing two sets of data. Finally, complete syllabification was added by the author, using the following simple principles, where a principle listed earlier supercedes a principle listed later:

1) $VC^2_1 \not\approx SC(C)V$

2) $VC^2_0 \not\approx C_1\{j\}V$, where $C_1 \neq j, r, w$

3) $VC^3_0 \not\approx CV$ otherwise

The principles were superceded completely whenever Kenyon & Knott assigned syllable boundaries (especially at the beginning of stressed syllables), at morph boundaries, and in a few other cases where it seemed a clear relation between the target and the approximation would be missed by rigid adherence to the rules, eg, #25 T: Cor $\not\approx$ inth A: Cor $\not\approx$ inth (instead of 'Co $\not\approx$ rinth'). Fewer than 1% of the items were affected by syllabification irregularities ascribable to morph boundaries and subjective decisions. (In the subsequent analyses, intervocalic consonants were treated separately from true syllable-initial consonants.) Although the items were double-checked, in four cases the syllabification rules were violated in the transcription by mistake.

In the rest of this section, the data will be described in general terms in order to provide the reader with a feel for its characteristics. The generalities pointed out here will not be discussed in detail. Seventy-five percent of the targets were nouns—about one half proper nouns, eg, 'Quine,' and one fourth common nouns, eg, 'confetti.' Fourteen percent were adjectives, nine percent verbs, and two percent phrases, eg, 'conflict of interest.' In about ninety percent of the TOT pairs, the approximation retained
the syntactic class of the target. Adjectives, however, retained their syntactic class only about 60% of the time. Thirty-four percent of the target adjectives had nominal approximations. However, the nominal approximations frequently retained the same phonological ending as the adjective. For example, the target 'arbitrary' was approximated by 'artificiality.'

In each pair, the target and approximation were usually (but not always) semantically related. For example, consider the following typical pairs:

<table>
<thead>
<tr>
<th>Target</th>
<th>Approximation</th>
<th>Relatedness</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Montana</td>
<td>Madison</td>
<td>place names</td>
</tr>
<tr>
<td>14. Hokusai</td>
<td>Hokkaido</td>
<td>Eastern culture</td>
</tr>
<tr>
<td>48. Pompeii</td>
<td>Ptolemy</td>
<td>Classical culture</td>
</tr>
<tr>
<td>30. Bobbitt</td>
<td>Beckett</td>
<td>person's name</td>
</tr>
<tr>
<td>53. chrysanthemum</td>
<td>carnation</td>
<td>flowers</td>
</tr>
</tbody>
</table>

Sometimes the relation between the target and approximation depended heavily on the specific individual or situation, eg:

<table>
<thead>
<tr>
<th>Target</th>
<th>Approximation</th>
<th>Relatedness</th>
</tr>
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<tr>
<td>152. Watonopa</td>
<td>Topanga</td>
<td>both Indian names, well known to searcher</td>
</tr>
<tr>
<td>35. imprecate</td>
<td>Rinaldi</td>
<td>searcher had just driven down Rinaldi street</td>
</tr>
<tr>
<td>309. Corfam</td>
<td>Fortran</td>
<td>searcher is a computer programmer</td>
</tr>
</tbody>
</table>

Sometimes there was little apparent semantic or experiential relationship between the target and approximation, but primarily an orthographic or phonological similarity, eg:

<table>
<thead>
<tr>
<th>Target</th>
<th>Approximation</th>
<th>Relatedness</th>
</tr>
</thead>
<tbody>
<tr>
<td>41. paradigm</td>
<td>diaphragm</td>
<td>Same letters in different order</td>
</tr>
<tr>
<td>54. manzanita</td>
<td>Modigliani</td>
<td>Same initial letter and stress</td>
</tr>
<tr>
<td>225. cigar</td>
<td>guitar</td>
<td>Same rhythmic pattern, final segments and initial vowel; 'g' in prominent syllable (stressed/initial)</td>
</tr>
</tbody>
</table>
But most of the target-approximation pairs had some semantic similarity, and some formal (orthographic or phonological) similarity. There being no principled reason to do otherwise, all the pairs were analyzed as one group.

The approximations were occasionally non-words, eg, 'empitology' for 'etymology' (#137). Occasionally, too, the approximations were incorrect in some other way. For example, 'Heidinger' was an approximation to the target 'Heisenberg' (#21), where probably 'Heidegger' was the intended approximation. Approximations were occasionally misspelled, as in 'Bollinger' (instead of 'Bolinger') for 'Bressler' (#51), or mispronounced, as 'Perséus' (instead of 'Péreus') for 'Pompeii' (#18). In all such cases of incorrect approximations, the searcher's own spelling or pronunciation was used. It is not clear in these cases whether the approximations were stored with the incorrect information, or whether, more interestingly, the errors were introduced in the process of retrieval. If the latter were true, then the nasal may have been introduced into 'Heidegger' because of the nasal in the corresponding position in the target 'Heisenberg'; the 'l' in 'Bolinger' may have been doubled under the influence of the double 's' in 'Bressler'; and the stress in 'Perseus' may have been changed to correspond to the stress in 'Pompeii.' Thus it is possible that the errors reveal even more clearly the structure of the retrieval process.

Eighty-two target items, excluding 'brush off,' had double letters, eg, 'Jennifer.' About forty percent of the corresponding approximations also had double letters, eg, the target 'Jennifer' was approximated by 'Jessica' (#50). Half of these approximations had the same double letters as the target, eg, target 'parried' with approximation 'quarried' (#393). Several of the cases in which doubling was not retained in the approximation were particularly suggestive. In a target such as 'immovable,' the double 'm' is the result of a variant on the prefix 'in-,' governed by the following segment. The approximation 'indecisive' (#228) retained the prefix 'in-' rather than the variant. Similar pairs were:

<table>
<thead>
<tr>
<th>Target</th>
<th>Approximation</th>
</tr>
</thead>
<tbody>
<tr>
<td>33. communicate</td>
<td>contribute</td>
</tr>
<tr>
<td>88. syllogism</td>
<td>synergy</td>
</tr>
<tr>
<td>216. opportunist</td>
<td>obsolescent</td>
</tr>
</tbody>
</table>

It is possible that doubling is effective only in case it is not a variant.
Analysis of the Data

The general approach to the analysis of the data was to compare the target and the approximation of each pair to see in what ways they were similar, and hence to establish what is known about a target being searched for prior to the complete recall of the target. The analysis included number and position within the item of phones in common, number and position within the item of letters in common, position of stress, number of syllables, effect of stress on number of phones in common, and number of sub-units in common (syllables and parts of syllables). Now for each of these comparisons, a certain number of similarities between target and approximations would be expected by chance. In order to determine whether similarities within the data were large enough to be significant, it was necessary to somehow determine the chance level of similarities. To most accurately reflect the chance level associated with the sorts of items in the corpus, it was decided (following a suggestion of Richard Harshman) to determine chance level using the corpus itself. The same target items and approximation items were used, but were randomly rematched. Thus, in the data the target 'vivid' was matched with the approximation 'vital' (#37); after random rematching T: 'vivid' might be matched with A: 'suppository.' One hundred different random rematchings of the targets and approximations were performed to enable chance level to be established directly. Thus on the first randomization T: 'vivid' might be matched to A: 'suppository,' on the second to A: 'anachronism,' and so on to the hundredth randomization.

Then the same analyses were performed on the original data set and on each of the hundred different randomizations. The analyses of the hundred different randomizations were averaged to arrive at a more accurate estimate of chance level. Generally a data analysis was compared with this random average, using chi square, to determine the significance of the results. A significance level $p > .20$ was taken to mean the results were definitely not significant; lower $p$ values are indicated in the text. Most analyses of the data were performed by a series of Fortran programs written by the author for use on the PDP-12 computer in the UCLA Phonetics Lab. Those performed by hand are so noted in the text.

1. Rhythm

The first hypothesis to be tested concerned the rhythm of the items. Was it the case that searchers knew the number of syllables and/or the position of the stress; that is, were more approximations identical to their corresponding targets with respect to number of syllables and stress placement for the data than would be expected by chance, as determined by
comparison with the random average?

Generally speaking, the searchers did know the number of syllables of the target. 269 of the 484 data pairs had the same number of syllables for both target and approximation, compared to 124 of the averaged randomized pairs of items, a difference significant at the .001 level. (See Figure 1)

Identity of stress placement was determined in several ways. For the items in which the target and approximation had the same number of syllables, identity of stress placement was trivial to determine. For these items, the data had a significantly higher proportion of items with identical stress placement in target and approximation (221 of 269: 82%) than the random average (70 of 124: 56%) (p < .001) as illustrated in Figure 2.

For the items in which the target and approximation had a different number of syllables, identity of stress placement was determined with respect both to the beginning and to the end of the item. Thus T: 'scatological' and A: 'scurrilous' (#177) had identical stress placement counting from the end; T: 'category' A: 'caterwauled' (#69) identical stress placement counting from the beginning. For the target and approximation data items with different numbers of syllables, there was no significant difference between identity of stress placement counted from the beginning and counted from the end (when compared to the same distribution for the random average). Therefore the data from the two groups was collapsed into one group. Figure 3 shows that for items with different numbers of syllables in the target and approximation, there was also a significant difference between the proportion of items with identical stress placement in the data (162 of 215: 75%) and in the random average (209 of 360: 58%) (p < .001).

2. Segment Identity

The second hypothesis to be tested concerned the identity of the letters and phones. Was it the case that the searchers knew phones and/or letters throughout the target? For this analysis only identity of segments (letters or phones) was considered. The segments were matched left to right by a computer program, proceeding from the beginning of the target item until no more matches were found. Thus the letters in the target 'paradigm' were matched to the letters in the approximation 'diaphragm' (#41) as follows:

T: paradigm
A: diaphragm
Figure 3: Equal stress for pairs with an unequal number of syllables
The phones for the same pair were matched as follows

T: p a r e d a m
A: d a i e f r a m

The number of pairs of items with no phones in common between target and approximation, 1 phone in common, 2 phones, and 3 or more phones in common were determined both for the data and for the random average. (Those item-initial segments that were identical for target and approximation were not included in these counts, to avoid inflating the results. As will be shown, segments at the beginning of the item were very often identical for target and approximation.) Then the distribution of number of phones in common for the data was compared to that for the random (See Figure 4). The data had far fewer pairs with no phones in common than the chance level or random average, and far more pairs with 2, 3, and more phones in common than the chance level or random average for both consonants and vowels (p < .001 for both). Thus there were more phones in common between target and approximation than would be expected by chance. The same analysis was performed on the number of letters in common between the target and approximation (See Figure 5) with similar results (p < .001 for consonants and vowels). Thus more letters were also in common between target and approximation than would be expected by chance. (In these analyses, the letters 'y' and 'w' were considered always to be consonants.)

One of the more striking attributes of the data was the effect of terminal segments, especially the initial segment of the item. 51% of the initial phones and 58% of the initial letters were identical for corresponding target and approximations in the data, compared to 6% initial phones and 6% initial letters for the random average. But the terminal effect was not limited just to the initial segment. Several segments, in the correct order, were frequently common at both the beginning and end of the word, eg, T: 'croquet' A: 'crochet' (#105). As shown in Figure 6, 19% of the items had two or more identical phones in the correct order at the beginning of the item; 30% of the items had two or more identical letters in the correct order at the beginning of the item. (The counting for figures 6 and 7 was hand-done.) Moreover, a total of 35% of the items had at least one identical phone at the end of the item, with 19% having two or more identical phones in the correct order. 37% of the items had at least one identical letter at the end of the item, with 24% having two or more identical letters in the correct order. Nor were these terminal effects limited to morphological (prefix and suffix) effects, eg, T: col+loqui+al
A: col+loid+al (#252) (See Figure 7). Two or more identical segments in the correct order at the beginning of
Figure 4: Phones in common
Figure 6: Terminal identical segments
Figure 7: Terminal identical segments due to morphological affixes
the item could be ascribed to morphological prefixes in only 7% of the items for phones and 10% for letters. One or more identical segments at the end of the item could be ascribed to morphological suffixes in only 18% of the cases for phones and 17% for letters.

In order to determine, then, if the similarity between target and approximation was due primarily to the effect of the identical terminal segments, these identical terminal segments were stripped from the items and the remaining segments compared. The same procedure was followed as for the comparison with all the segments present, that is, the distribution of the number of segments in common was compared for the data and the random average. Figure 8 displays the comparison between data and random average for the number of phones in common between target and approximation. For both consonants and vowels, the data had more phones in common than the random average (p < .001 for both).

Figure 9 displays the comparison between data and random average for the number of letters in common. For both consonants and vowels, the data had more letters in common than the random average (p < .001 for both). Thus, for both letters and phones, the number of segments in common between target and approximation was significant even after the identical ordered terminal segments were removed.

3. Orthographic vs Phonetic Coding

Since letters and phones are alternative methods of encoding the same information, it is not surprising that where one method provided more segments in common than expected by chance, the other did also. But there is by no means a one-to-one relationship between the phonetic code and the orthographic code. A particular sound may be represented in a number of ways orthographically. Consider the well-known spelling of 'fish' /'fɪʃ/ , for example, as 'ghoti': 'gh' as in 'enough,' 'o' as in 'women,' and 'ti' as in 'nation.' On the other hand, a particular letter may be associated with a number of different pronunciations, particularly when combined with other letters. Thus 'g' may be pronounced /g/ as in 'get,' /dʒ/ as 'gym,' /f/ in combination with 'h' as in 'enough,' /v/ in combination with 'n' as in 'sing.' Did the searchers prefer, then, one form of coding over another when recalling an item?

The analysis performed to answer this question used the same matching technique for the segments as in the second analysis. Then the total number of segments in common for the entire data corpus (excluding identical item-initial segments) was determined using both orthographic coding and phonetic coding. Since there are 26 letters and 42 phones (as used in this study), there should
Figure 8: Phones in common (identical terminal phones removed)
be, by chance alone, more letters in common between target and approximation than phones. Therefore, in order to estimate the chance level, the total number of segments in common for both codings was determined from the random average set of items. Then the relation between the two codings for the observed data was compared to the relation between the two codings for the random average (See Figure 10). For consonants, there was no significant difference between orthographic coding and phonetic coding— that is, the relation between the two codes was about the same for the data as for the random average. For vowels, however, phonetic coding was preferred over orthographic coding for the data (p < .05).

Because of the strong initial segment effect, the single initial segments were analyzed separately. As expected, somewhat more initial segments were in common between target and approximation when coded orthographically than when coded phonetically (282 to 248). But since the same relationship held for the random average (31 to 28), the difference was not significant. However, most of the initial segments in fact displayed a one-to-one correspondence between the orthographic and phonetic codings. The few pairs in which this was not the case were therefore analyzed by hand to determine which coding was chosen, eg, T: 'Pompeii' A: 'Ptolemy' (#48), but T: 'singled' A: 'centered' (#190). There were 17 such pairs, in which the initial segment was identical between target and approximation for either the orthographic coding, or the phonetic coding, but not both. (Items such as T: 'expediency' A: 'existentialist' (#92), where the phonetic mismatch was probably allophonic, were not included in the 17 pairs.) Of these 17 pairs, 13 were identical orthographically but not phonetically (eg, T: 'consequences' A: 'circumstances' (#82), T: 'Sherry' A: 'Sylvia' (#267), T: 'Phyllis' A: 'Peg' (#285)) and 4 were identical phonetically but not orthographically (T: 'Feynman' A: 'Venneman' (#247), T: 'Cathe' A: 'Karen' (#355), T: 'cypress' A: 'sycamore' (#383)). Thus in the key initial cases, apparently orthographic coding was used in preference to phonetic coding.

The same type of hand analysis was performed on those cases in which the single final segment was identical either phonetically or orthographically, but not both, eg, T: 'Cornish' A: 'Corinth' (#25) but T: 'perseverance' A: 'tenacious' (#90). There were 18 such cases (those items in which identity was due to identical morphological endings were not included, eg, T: 'singled' A: 'picked' (#195)). Ten of the pairs were identical only phonetically, eg, T: 'carrots' A: 'lettuce' (#145), while eight were identical only orthographically, eg, T: 'Louise' A: 'Lucille' (#384). Thus only in initial position were letters preferred over phones. It is of
interest to note that six of the eight final orthographic identities were due to a mute '-e,' as in the last example cited above.

4. Segment Order

Some of the letters and phones were known by the searchers prior to complete retrieval; this was true regardless of the position of the segment within the item. But we have seen that those segments at the beginning and ends of the item were frequently known in their correct order. Sometimes segments in the middle of the item were also in the correct order, at least relative to each other. Consider, for example, T: 'acronym' A: 'anachronism' (#61). Here the 'c,' 'r,' 'o,' and 'n' are in the same order, relative to each other. On the other hand, sometimes the segments, while identical between target and approximation, did not share the identical order. Consider for example, T: 'etymology' A: 'emtology' (#140), T: 'Heisenberg' A: 'Honegger' (#20), or particularly T: 'paradigm' A: 'diaphragm' (#41). Was it the case, then, that segments internal to the item generally retained their correct order, at least relative to each other?

First the identical terminal segments were stripped from both target and approximation, eg,

61. T: 'acronym' A: 'anachronism'
   ↓
   'crony'
   ↓
   'nachronis'

Then the remaining segments were matched (where identity of segments constituted a match) proceeding from left to right within the target as before. This pass, however, utilized a different algorithm than previous analyses in order to maximize the similarity of order between segments in target and approximation. In the case of two or more possible matches for any target segment, the leftmost match in the approximation that was also to the right of the immediately previous match was chosen. The algorithm thus maximized both the contiguity and the order of the matches for any two successive target segments. Note, for example,

61 T: crony
   A: nachronis

in which the 'n' from the target is matched to the first 'n' following the immediately previous match to 'o' in the approximation, rather than to the leftmost 'n' in the
approximation. The matching algorithm was applied to phones and letters in the data; the same algorithm was applied (again for phones and letters) to each of the hundred randomized sets, and the random average then computed.

The distribution of phones in order is shown for consonants and vowels separately, in Figure 11, for those pairs of items that had two phones in common (there were not enough with three or more phones in common to consider). Only one phone in the correct order means effectively that the phones were not ordered correctly at all (e.g., T: XY A: YX, would have one phone (X) in correct order, according to the algorithm; as would T: XYZ A: ZYX). The distribution was not significantly different from that expected by chance for either consonants or vowels. Figure 12 shows the distribution for letters for those pairs of items with two letters in common and those with three letters in common (there weren't enough items with four or more letters in common to test significance). The distribution was strikingly similar to that expected by chance for both consonants and vowels. Thus when considered segment by segment, and when consonants and vowels were separated into two separate 'streams,' the approximations did not retain item-medial order information, even though the segments were frequently accurately retrieved.

5. Units

So far only individual segments have been considered—their identity and their order. But clearly in some cases larger units were shared between target and approximation. For example:

<table>
<thead>
<tr>
<th>Target</th>
<th>Approximation</th>
<th>Unit Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>104. Goldman Eisler</td>
<td>Goldwin Meyer</td>
<td>Syllable</td>
</tr>
<tr>
<td>353. Betsy</td>
<td>Becky</td>
<td>Sub-syllable:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>initial ($C_3^1V$)</td>
</tr>
<tr>
<td>309. Corfam</td>
<td>Fortran</td>
<td>Sub-syllable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>final ($C_3^1S$)</td>
</tr>
<tr>
<td>266. prestor</td>
<td>preacher</td>
<td>consonant cluster</td>
</tr>
<tr>
<td></td>
<td></td>
<td>initial ($C_1^3$)</td>
</tr>
<tr>
<td>12. Princeton</td>
<td>Georgetown</td>
<td>consonant cluster</td>
</tr>
<tr>
<td></td>
<td></td>
<td>final ($C_3^1S$)</td>
</tr>
</tbody>
</table>
Figure 11: Order of phones (identical terminal phones removed)
The question is then, whether these larger units were shared by target and approximation more often than would be expected by chance, and, if so, whether there was a preference for one size unit over another.

The interaction between larger units and orthographic coding is extremely difficult to sort out. Questions of the definition of syllable using letters, for example, are nearly insuperable--one must define syllabic 'letters' such as the 'm' in algorithm. Therefore only phonetic coding was used in the rest of the analyses. Matching proceeded from the largest unit first down to the smallest unit. That is, first syllables in common between target and approximation were determined. These syllables (both target and approximation) were in effect removed from the items prior to the next pass which determined initial and final sub-syllable units in common (initial sub-syllable defined as $C_1^3V_\bar{S}_C_1^3S$; final sub-syllable defined as $VC_1^3/S_C_1^3_\bar{S}$. Thus only if the target syllable 1) had both initial and final consonants and 2) was not matched to an approximation syllable, would the initial or final portion of that syllable be considered for a match on the sub-syllable level. Stress identity was retained when possible: the stressed target syllable (or sub-syllable) was matched to an unstressed approximation syllable (or sub-syllable) only in case there was no match with the stressed approximation syllable (or sub-syllable). Next unstressed target units were matched; again, they were matched with stressed approximation units only if there were no unstressed match. Matching proceeded from left to right within the target; if there were a choice of matches in the approximation after all constraints were met (ie stress identity preferred), then the leftmost match was chosen.

The next pass matched consonant clusters, both syllable initial ($C_1^3V_\bar{S}_C_1^3V$) and syllable final ($C_1^3/V_\bar{S}$). Both target and approximation syllable and sub-syllable units were removed from consideration in this pass--that is, only clusters which were not part of a larger unit that was previously matched were considered here. In this pass within-syllable position (ie syllable initial or syllable final) was maximized first, and then stress identity. That is, if a target cluster matched two different approximation clusters, one with the same within-syllable position but different stress, and the other with the same stress but different within-syllable position, then the match with the same within-syllable position would be chosen. Matching proceeded from left to right within the target; if there were a choice of matches in the approximation after all constraints were met (ie, within syllable position maximized preferentially over stress identity maximization) then the leftmost approximation match was chosen.
The last pass matched individual phones, both vowels and consonants. Vowels were matched only if they had not participated in a higher unit match (for both target and approximation). Stress identity was optimized, first for stressed targets and then for unstressed targets. Matching proceeded from left to right within the target; the leftmost approximation was chosen if there were a choice left after the application of constraints. Individual consonants were matched only if they had not participated in a larger unit match (for both target and approximation). Within-syllable position (i.e., syllable initial or syllable final) was maximized preferentially over stress identity. Generally matching did not proceed from left to right within the target; all the examples of a particular consonant in the target, and all the examples of that consonant in the approximation, were selected, and matches made over the entire group in order to maximize within-syllable position preferentially over stress identity. Only in case several consonants matched several approximations equally well, was the leftmost target matched to the leftmost approximation.

5.1 Size of Units

The number of units that were identical between target and approximation was determined, both for the data and, as before, for one hundred different random rearrangements. The results for the data were compared to the random average to determine significance. In general, each size unit was significantly in common between target and approximation. (See Table 1) However initial and final clusters and individual consonants (GC and C6) were significantly in common only if their within-syllable position was retained, i.e., T: GC matched to A: GC and T: C6 matched to A: C6. In the further analysis, therefore, only clusters and consonants matched to the same within-syllable position were considered. Recall, when interpreting cluster and consonant results, that a cluster is herein defined as all consonants in the syllable preceding the vowel, regardless of number, whereas individual consonants refer to a portion of a cluster. That is, if only one consonant precedes the vowel, it is included with the cluster results. Individual consonants refer to the consonants in a cluster of two or more, where at least one consonant of the cluster was not matched.

Next the various sizes of units were compared to each other to determine an order of preference (if any) for the various sized units. In comparing the various sizes it was necessary to transform the numbers first, for several reasons. First the total number of units
<table>
<thead>
<tr>
<th></th>
<th>DATA</th>
<th>RANDOM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Matches</td>
<td>Total</td>
</tr>
<tr>
<td><strong>UNIT</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Syllables</td>
<td>181</td>
<td>1407</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subsyllables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial</td>
<td>44</td>
<td>1102</td>
</tr>
<tr>
<td>Final</td>
<td>49</td>
<td>572</td>
</tr>
<tr>
<td>Clusters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial-Initial</td>
<td>242</td>
<td>1070</td>
</tr>
<tr>
<td>Initial-Final</td>
<td>39</td>
<td>ns</td>
</tr>
<tr>
<td>Final-Initial</td>
<td>52</td>
<td>525</td>
</tr>
<tr>
<td>Final-Final</td>
<td>62</td>
<td>.02</td>
</tr>
<tr>
<td>Consonants</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial-Initial</td>
<td>116</td>
<td>936</td>
</tr>
<tr>
<td>Initial-Final</td>
<td>36</td>
<td>ns</td>
</tr>
<tr>
<td>Final-Initial</td>
<td>35</td>
<td>ns</td>
</tr>
<tr>
<td>Final-Final</td>
<td>51</td>
<td>497</td>
</tr>
<tr>
<td>Vowels</td>
<td>365</td>
<td>1170</td>
</tr>
</tbody>
</table>

Table 1: Number of matches for different size units.
being considered at each level differed because matches at a higher level were removed from consideration at lower levels and because, for consonants, the larger sized units frequently contributed several consonants. Second, the total number of units being considered at any one level (except the syllable level) differed for the random and for the data, since in general the data had more matches at any one level than the random, thereby removing more units from consideration in the next lower level. In order to permit comparison across levels, then, the total number of units on any one level was equalized for the random average and the data by taking the average of the two totals. Then the number of matches was adjusted to the new total, maintaining the original proportion:

$$\text{Transformed number of matches} = \frac{\text{Total number of matches}}{\text{Average total}} = \frac{\text{Number of data matches}}{2} \times \frac{\text{Number of random matches}}{\text{Total}}$$

Thus $$\frac{\text{transformed number of matches}}{\text{averaged total}} = \frac{\text{number of matches}}{\text{total}}$$

In this way, since the average total was the same for both the data and the random average, it was possible to compare the data and average, and further, by looking at the differences in patterning between the random average and the data, to compare across levels.

There was a significant order of preference ($p < .001$ overall) that corresponded to an order of decreasing size of the units. (See Figure 13). There were proportionately more syllables in common for the data than for the random average, then sub-syllable units, then clusters, and finally individual consonants and vowels. (Recall that only clusters and consonants that retain the same within-syllable position are being considered from here on in.) The order of preference retained a .001 significance level when the syllables were removed from consideration. Order of preference was then determined after breaking the units up into within-syllable position, i.e., initial and final sub-syllables, clusters, and consonants. (See Figure 14). Again there was a general ranking in terms of decreasing size of units (overall $p < .001$), but there was also an interaction with within-syllable position. Initial clusters were preferred over final clusters ($p < .05$); final sub-syllables tended to be preferred over initial sub-syllables, although the difference was not statistically
Figure 13: Comparison of size of units

Ratio: number of matches
data/random

15 12 9 6 3

Syllable Sub-syllable Cluster Consonant Vowel
Figure 14: Comparison of size of units including within-syllable position.
significant; initial and final consonants did not differ in preference. Initial clusters grouped with the sub-syllable, while final clusters, consonants and vowels grouped together. That is, the pattern in the data for the sub-syllables and initial clusters did not differ significantly from the pattern in the random average; the data pattern for final clusters, consonants and vowels did not differ significantly from the expected pattern; but the overall data pattern differed from chance (p < .001). The ranking, therefore was syllables, sub-syllables and initial clusters, and final clusters, consonants, and vowels.

5.2 Stress

Next the effect of stress on the number of matches was determined for the various sized units. That is, did the presence or absence of stress affect the number of matches? For this analysis, untransformed data was used. All unstressed units, except for initial individual consonants, were matched more frequently in the data than in the random average. (See Table 2) This was not true for stressed units. (See Table 3) Only stressed syllables, initial sub-syllables, initial clusters, initial consonants, and perhaps final sub-syllables were matched more frequently in the data than in the random average. Final clusters, final consonants, and vowels, when stressed, were matched no more often than would be expected by chance. The order of preference for various units was then determined using transformed data as before. As shown in Figure 15, for unstressed units the same order in terms of decreasing size was obtained as before. There were, however, fewer significant divisions than previously: the sub-syllables, clusters and individual consonants fell together, yielding syllable, sub-syllable and cluster and final consonant, and vowel. Figure 16 shows the same rank ordering for stressed units. Here there were only two significant divisions: syllables vs sub-syllables, initial clusters, and initial consonant. (The second group differed slightly (p < .20)).

Both unstressed and stressed units generally were matched more often than would be expected by chance. Presence or absence of stress might, however, affect the number of unit matches differentially. The next test then, was a direct comparison of the number of matches for stressed and unstressed units to see if the ratio of (transformed) data matches to random average matches differed for unstressed units and for stressed. Only for initial units was there a difference. Stressed initial clusters and initial consonants were matched significantly more often than the unstressed initial units when compared
<table>
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<tr>
<th>UNIT</th>
<th>DATA (Matches)</th>
<th>Total</th>
<th>RANDOM (Matches)</th>
<th>Total</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
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<td></td>
</tr>
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<td>13</td>
<td>421</td>
<td>.001</td>
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<td>Consonants</td>
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<td></td>
</tr>
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</tr>
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<td>Vowels</td>
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<td>.01</td>
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Table 2: Number of matches for different size unstressed units.
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<th>RANDOM Matches</th>
<th>RANDOM Total</th>
<th>Sig.</th>
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<td></td>
<td></td>
<td></td>
</tr>
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</table>

Table 3: Number of matches for different size stressed units
Figure 16: Comparison of size of stressed units
to the random ($p < .01$ and $p < .10$, respectively). Stressed initial sub-syllables were matched marginally more often than unstressed ($p < .20$). Thus the presence of stress facilitated unit retrieval only in certain instances.

The next analysis tested whether stress or lack of stress was retained. That is, was it the case that stressed target units were matched to stressed approximation units, and unstressed to unstressed more often in the data than would be expected by chance? Given the matching algorithm used, it was generally true for both the random and the data that stress matched stress and unstress matched unstress. Unstressed clusters (both initial and final) showed some increased tendency to match with unstressed clusters when compared to the random average (untransformed data). (Table 4 shows the results for this analysis in the middle column.) Stressed initial clusters, stressed vowels, and perhaps stressed initial consonants retained their stress significantly. So few sub-syllables, stressed final consonants, and stressed syllables were matched in the random average that it was impossible to adequately determine stress retention, although they appeared to retain their stress when compared to the random average, whereas the unstressed did not. The rest of the unstressed units (syllables, vowels, and consonants) and stressed final clusters did not retain their stress more often than was expected by chance. The stress effects so far are summarized in Table 4.

Recall that an earlier analysis had shown that the position of the stressed syllable in the item was known. The next analysis then determined if there was an interaction between positioning of stress and recall of stressed units. If there were a strong correlation between the two, then stressed units in the target would be matched to stressed units in the approximation (i.e., stress would be retained) if and only if the stress was positioned on the same syllable in the target and in the approximation (recall that stress placement was determined by counting the number of syllables from the item boundaries). This was not the case. While it was true that if at least one stressed target unit (syllable, sub-syllable, cluster, consonant, or vowel) was matched to a stressed approximation unit, then the stress placement was the same for both ($p < .001$ overall); it was also true that if no stressed target units were matched to stressed approximation units, the stress placement was still the same for both ($p < .001$). In all cases the items were hand-counted and compared to an estimated random average derived from the proportions of stress retention and correct placement of stress.) That is, regardless of whether or not stress was retained, the stress placement was correct. On the other hand, if the
<table>
<thead>
<tr>
<th>UNIT</th>
<th>UNIT MATCHED</th>
<th>STRESS MATCHED</th>
<th>STRESS RETAINED</th>
<th>STRESS UNIT MATCHED MORE THAN UNSTRESSED UNIT</th>
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</thead>
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<td>UNSTRESS</td>
<td>STRESS</td>
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<td>.001</td>
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<td>ns</td>
<td>.02</td>
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</tbody>
</table>

--- means significance not determinable

Table 4. Summary of stress effects in terms of significance levels
stress was not correctly placed, then the stressed target units were matched to stressed approximation units only as often as would be expected by chance; that is, stress was not retained above chance level. If the stress was correctly placed, then stressed units were matched to a corresponding stressed approximation unit (p < .001 overall). This effect appeared primarily in units containing an initial cluster. In fact, all of the syllables and 94% of the initial clusters that retained stress also had the correct stress placement.

To summarize then, stress was correctly placed regardless of the units' stress retention; when stress was correctly placed the units tended to also retain correct stress; but when stress was not correctly placed, stress retention was no different from chance.

5.3 Position within the Item

In the initial description of the data, it was noted that there was an apparent effect due to position in the item, especially initial and final position. This question was explored more thoroughly in the next analysis. All the initial syllables from two or more syllable items were combined in one group; the final syllables from two or more syllable items were combined into another group; and all the syllables that were neither initial nor final from three or more syllable items were combined in the group called medial. The untransformed data was then compared to the random average.

For initial position in the item, syllables and the initial units (sub-syllable, cluster, and single consonant) were matched more frequently than would be expected by chance (See Table 5). Final consonants were marginally better than chance; all the other units were no different from the random average. As shown in Figure 17, the units were then ranked in terms of order of preference (using transformed data). As usual, the units were ranked in terms of order of decreasing size, with, however, only two significant divisions, into syllable and initial sub-syllable and initial cluster on the one hand, and consonants on the other hand.

For medial position, syllable, initial and final clusters, initial consonants and vowels were matched better than chance (untransformed data). The ranking of the transformed data was in terms of unit size interacting with initial vs final (See Figure 18), with only one significant division: syllables vs initial cluster, initial consonant, final cluster, and vowels.

Final position, not surprisingly, produced a somewhat different array of significant units: the syllable, final and initial sub-syllables, and final consonant (untrans-
<table>
<thead>
<tr>
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<th>INITIAL</th>
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<th>MEDIAL</th>
<th>RANDOM</th>
<th>FINAL</th>
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<td>MATCHES</td>
<td>TOTAL</td>
<td>MATCHES</td>
<td>TOTAL</td>
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<td>Initial-Initial</td>
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</tr>
<tr>
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<td>.20</td>
<td></td>
</tr>
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<td>106</td>
<td>449</td>
<td>ns</td>
<td></td>
</tr>
</tbody>
</table>

*Reverse direction, i.e. data < random.

Table 5. Number of matches for different size units in each syllable position of the word.
Figure 18: Comparison of units in item-medial position
formed data). Initial consonants were also significantly different from the random average, but in the opposite direction; that is, there were significantly fewer initial consonants in item-final syllables matched than would be expected by chance. The transformed data was then rank ordered (See Figure 19); the ordering was as usual in terms of unit size. There were three significant groupings: syllables and final sub-syllables, initial sub-syllables and final consonants, and initial consonants.

The effect of position within the item was determined in another way as well. Consider, for example, syllable-initial clusters. These were matched more often than chance level in initial and medial syllables, but not in final syllables. The question tested in the next analysis, then, was whether or not each size unit significantly changed its matching pattern in different item positions. The data was transformed as usual, and then, for each size unit, the number of matches in item-initial, -medial, and -final positions was compared to the number of matches for the random average to determine if the data pattern significantly differed from chance level. For syllables, final clusters and final consonants, and vowels the pattern was that expected by chance. Syllables were matched comparatively often regardless of their position in the item; final clusters, final consonants, and vowels were matched least often of the units, again regardless of their position in the item. However, initial units (clusters, consonants and sub-syllables) and final sub-syllables varied their pattern of matching over the item.

The pattern of matching for initial clusters and individual consonants was higher item-initially, and decreased throughout the item, when compared to the random average ($p < .001$). This effect was due almost exclusively, however, to the unstressed units. Initial clusters and consonants from stressed syllables were matched relatively frequently, regardless of their position relative to the item. The unstressed initial clusters and consonants were matched about as often as the stressed initial clusters and consonants in the initial position of the item; by final position these unstressed units were matched only at chance level (or for single consonants, less than chance level), while their stressed counterparts were still matched significantly often.

The pattern for initial sub-syllables differed somewhat from that for the initial clusters and consonants, in that it was higher initially and finally, and decreased medially ($p < .10$) to chance level. Both unstressed and stressed sub-syllables appeared to follow the same pattern (there were too few to determine significance).
Figure 19: Comparison of units in item-final position

Ratio of number of matches
data random avg.
The final sub-syllable pattern completely reversed the pattern for initial clusters and consonants. Initially the final subsyllables were matched at chance level; the amount of matching increased throughout the item \( p < .01 \). As with the initial clusters and consonants, the effect was due almost exclusively to the unstressed units.

5.4 Position within the Syllable

There has been an apparent difference between syllable-initial and syllable-final units throughout the analyses. The last question to be tested, then, is whether initial units were matched more (or less) often than the analogous final units. The transformed data was compared, as usual, with the random average to determine significance. For neither sub-syllable units nor single consonant units was there a significant difference between number of matches syllable-initially and syllable-finally, with one exception. Syllable-final unstressed single consonants were matched significantly more often than their syllable-initial counterparts in the final syllable of the item \( p < .01 \). Syllable-initial clusters, on the other hand, were matched significantly more often than syllable-final clusters \( p < .05 \). This was true particularly for stressed syllables \( p < .01 \), item-initial syllables \( p < .01 \), and stressed item-initial syllables \( p < .001 \).

It is possible that, in comparing syllable-initial and syllable-final units, the results may differ if the syllable-initial group were separated into its two constituent elements. For medial and final unstressed syllables, the syllable-initial group included intervocalic consonants. To test for a possible difference, these were separated from the rest of the initials and matched to either initial, intervocalic, or final consonants. There was no significant difference between the intervocalic units and the rest of the syllable-initial units (subsyllables, clusters, consonants in unstressed non-initial position) except for initial sub-syllables in item-final position, which had mostly intervocalic segments.

Discussion

One of the major questions asked in this study concerned the size of the chunk involved in recall. The results show that this question was too simplistic. There was little evidence for well-defined units being involved in the tip-of-the-tongue process. Instead, there was a tendency for segments immediately adjacent to be more or less loosely attached to each other—more an open marriage than a monogamous relationship. Extended families were preferred over bachelorhood or nuclear families—a consonant
in a syllable-initial cluster combined with other segments to form a syllable, or the initial portion of the syllable with or without the vowel, much more often than it stood alone. On the other hand, the relationships among the various families was not, in general, determined. That is, the order in which the various groups appeared differed between target and approximation (except word-terminally).

Some of the segments showed much more affinity for grouping. Syllable-final consonants, for example, rarely occurred without the preceding vowel. Only in syllables within the word (non-terminal) did this dependency show signs of breaking down. Vowels rarely occurred alone, but rather in combination with either initial or final consonants (or both). Note that these affinities do not imply the existence of absolute sub-syllable units. It was not the case, for example, that syllables split into C + VC sub-units. Both CV and VC sub-units occurred, and about equally often. That is, the vowel displayed as much affinity for combining with initial C's as with final C's--vowels are the swingers of the phonetic world. There were, however, different degrees and types of dependencies. All segments tended to co-occur with other segments; vowels in particular depended on the occurrence of a consonant, and final consonants on the occurrence of a vowel.

The largest unit of the item being retrieved of course played an important role, in particular with respect to its boundaries. The beginning and end of the item act as points of prominence: those segments closest to them were recalled more often than internal segments. Thus at the beginning of the item, syllables and initial units (sub-syllables, clusters) were recalled better than final units and vowels, while at the end of the item, final units were better recalled. This pattern was particularly prominent for two units, syllable-initial clusters and final sub-syllables. Initial clusters were recalled much more often at the beginning of the item than at the end, while final sub-syllables portrayed the opposite pattern. This was true whether or not the item contained a morphological suffix. Thus two tendencies interacted on the level of the item--points of prominence at the boundaries, and the dependency of final consonant on the vowel.

There was another point of prominence--the initial boundary of the stressed syllable. Again, those segments closest to the beginning of the stressed syllable were recalled more often than those later in the stressed syllable. This was particularly true for initial clusters. In general, stressed units were not recalled more often than unstressed units--the prominence was confined to a syllable-initial vs syllable-final effect. However, stressed syllable-initial clusters were recalled more
often than unstressed initial clusters. Thus the stress point of prominence was most closely associated with the initial cluster. It is apparent that the points of prominence at which recall is improved are places which have definite boundaries--the beginning and the end of the item, and the beginning of the stressed syllable. Unstressed syllables frequently do not have definite boundaries; hence the points of prominence do not include the fuzzy unstressed boundaries.

Stress played a part in the rhythmic pattern as well. Both the number of syllables and the position of the stressed syllable were usually accurately recalled. That is, the rhythmic pattern was recalled correctly. The realization of the rhythmic pattern, however, may be one of two types. The position of the stress may be accurately recalled because stress is marked on the units, like a phonemic feature. Or the position of the stress may be accurately recalled because there is a separate rhythmic pattern, with stress not indicated on the units. (There may also, of course, be a combination of the two, but first things first.)

Suppose the former hypothesis were true, that stress is marked on the units (and unstress is left free). Then stressed units would be correctly recalled as stressed units (and unstressed units would be recalled as either). This was in fact the case, at least for initial units, especially initial clusters. Further, we know that (item-internally) there was no ordering of units. Therefore the stressed units could be recalled in any order and hence occupy any position, not necessarily the correct one, in the item. But this contradicts another portion of the data, namely that stress position was accurately known. Therefore there must be a separate rhythmic pattern.

Suppose only the second hypothesis holds, namely that there is a separate rhythmic pattern but stress is not indicated on the units. Then stressed units would be recalled incorrectly as unstressed as often as stressed. But this was not the case--stressed units (especially initial) were correctly recalled as stressed. Therefore there must be both a separate rhythmic pattern and some method of marking units as stressed. Suppose further then that the rhythmic pattern and the stressed units were either completely independent of or completely dependent on each other. In the first case stressed units would be correctly recalled as stressed regardless of the correctness of stress placement. But this was not true; stressed units retained their stress only in case the stress placement was correct. Suppose then the second case is accurate, that stressed units will be recalled correctly if and only if the stress placement is correct, and stress placement will be correct if and only if stressed units are correct.
Again, this was not true. Stress placement was correct regardless of whether or not the unit stress was retained. Therefore, the rhythmic pattern and the stressed units must be loosely associated, as in the following Skyhook Theory.

Recall that the prominence of stressed syllables resides mainly in the initial cluster. Suppose then that the rhythmic pattern operates as if it has a skyhook that latches onto the initial stressed cluster. If the skyhook works properly, then both the rhythmic pattern and the stressed unit will be correctly recalled. But the skyhook does not always latch properly—then the rhythmic pattern will be correct but the initial cluster of the stressed syllable will not be recalled as stressed. Suppose the rhythmic structure is not recalled. Then the skyhook fails to operate and the stressed cluster will be correct only by chance.

Note that the skyhook latches onto the entire cluster. Therefore, not only will the cluster be correctly recalled as stressed, but the cluster itself will also be correctly recalled. Since the rhythmic pattern is generally recalled, then stressed initial clusters will be recalled more often than unstressed clusters. The skyhook latches onto the initial cluster only, but, because segments are gregarious, frequently the adjacent segments accompany the initial cluster. In these cases the stress of initial sub-syllables and syllables will also be recalled correctly. Thus the Skyhook Theory adequately accounts for the distribution of correctly recollected stressed units.

The other major issue in this study, of orthographic vs phonetic coding in the lexicon, has not been adequately settled. The use of either phonetic or orthographic coding could account equally well for the data, with two exceptions. Phonetic coding is apparently more important for vowels, while orthographic coding is more important for item-initial segments. Phonetic coding may be more important for vowels because of the many alternate ways of spelling a single vowel sound; orthographic coding may be preferred for item-initial segments because beginnings of words are clearly marked by spaces on the printed page.

In sum, recall of a lexical item involves recognizing points of prominence at boundaries (item-initial, item-final, and beginning of stressed syllable) and also the rhythmic pattern. The rhythmic pattern latches onto the initial cluster of the stressed syllable; recall is enhanced in general close to points of prominence. Segments are generally gregarious and are recalled in small groups; final clusters have a particular affinity for vowels, and vowels for consonants in general. Recall of the order of the item-internal segments and groups is separate from recall of their identity. Failure to recall a lexical
item consists primarily of the failure to order the internal segments correctly, and secondarily of a failure to retrieve the identity of the internal segments accurately.
CHAPTER 2

Slips of the Ear—Description and Implications
for the Role of the Word in Perception

The ear has slipped when it (or the mind above it) hears that there are 'known purple consequences' when in fact 'no empirical consequences' were being talked about. Such misperceptions can reveal much about the perceptual processes.

Perceptual errors or slips of the ear occurring in everyday conversation have been but little examined. A few were included in Meringer's production error corpus (1908:142-3). The only scholars to study English perceptual errors in any detail are Celce-Murcia (1977) and Garnes & Bond (1975, 1976, 1977a, 1977b), Bond (1973). Garnes & Bond reported a wide variety of errors occurring in casual speech. Individual phonemes were deleted, inserted, or replaced with another phoneme. Syllables and words were inserted or deleted, frequently due to syntactic motivations. Word boundaries were deleted, inserted, or shifted. In general they found that the misperceptions were semantically dissimilar but syntactically similar to the productions.

The present study provides another corpus of perceptual errors, collected by different individuals in different parts of the country. Agreement between the two sets of data would provide confirmation that the results have not been skewed by geographical area or inadvertent bias on the part of the collectors. Areas of disagreement would suggest directions for further examination of the data.

While the Garnes and Bond studies provided insights into the perceptual process, there are many areas still untouched. This paper focuses on two of these areas: what role does word boundary information in the acoustic signal play in perceptual errors, and what kinds of mechanisms are involved in perceptual errors?

Lehiste (1960) observed that initial word boundaries were characterized by lengthened consonants (when compared to non phrase-final consonants), aspiration of voiceless stop consonants, allophonic differences (in the formants) for /r/ and /l/, and for vowels, laryngealization, increased intensity, and some formant differences. She further observed that final word boundaries were characterized by lengthened vowels with decaying energy.

Lehiste's results for consonant initial word boundaries have been repeatedly confirmed. Oller (1973) found initial consonant lengthening in a variety of environments. Klatt (1976) also found lengthening of initial consonants. Umeda and Coker (1974) and Umeda (1977)
found both increased length and increased aspiration for
word-initial consonants.

Lehiste's final word boundary cues have aroused some
disagreement. A later study by Lehiste (1972), using
derivationally related words in an experimental paradigm,
showed some instances of segment lengthening before word
boundaries as opposed to morph boundaries, tangential
support at best. Oller (1973) found marked syllable
lengthening in a variety of conditions for nonsense words,
for both stressed and unstressed syllables. Umeda (1975)
also found lengthening of vowels in final syllables for
unstressed syllables; the situation for stressed final
syllables and monosyllables was less clear. Seven of
eleven vowels showed final syllable lengthening for both
individuals reading 20-minute selections; /e/ showed final
syllable shortening; and three vowels showed opposite re-
sults for the two speakers. Nakatani and Schaffer (1978),
on the other hand, found very small amounts of lengthening
on final stressed and unstressed syllables, with more on
monosyllables (using reiterant speech with a 3 syllable
phrase).

Two studies have looked closely at which cues are
used to perceive word boundaries. Nakatani and Dukes
(1977) showed that, in two-word hybrid phrases, the strong-
est word boundary cues were initial, including laryngeal-
ization for the initial vowel and variations in the /r/
and /l/ allophones. (This study involved simply a segment-
al shift, eg, 'buy zinc' vs 'buys ink' and hence is not
necessarily applicable to cases involving presence or
absence of word boundary. That is, although the initial
segment provided most of the clue as to where the word
boundary was, it did not necessarily provide most of the
information about whether there was a word boundary or
not.) Using the reiterant speech paradigm, Nakatani and
Schaffer (1978) suggested that placement of a word bound-
ary (given a binary choice) in terms of syllable depended
primarily on monosyllable lengthening and perhaps also
initial consonant lengthening. Again, this does not
necessarily imply these cues are used to determine the
presence of a word boundary, since the question was one
of location of a word boundary known to be present.

The production data shows, then, that word boundar-
ies are marked by word-initial allophonic cues and length-
ened consonants, and probably also word-final syllable
lengthening. The perceptual experiments show that this
information can be used to accurately place a boundary
once its existence is known, but do not establish that
this information is used to determine the presence of a
boundary, nor (assuming that in fact it is) the relative
importance of the various cues for perceptual processing
and hence for perceptual errors. The first goal of the
analysis, in this paper, then, will be to help determine
the role that word boundaries play in perceptual errors.

The mechanisms associated with perceptual errors are likewise not known. Three possibilities seem most likely:
1) that all errors are initially caused by failures of the low level acoustic processor;
2) that some errors are caused by lexical decision; and
3) that errors are related to the structure of the acoustic signal; ie, that a misperception of one portion of the acoustic signal is the triggering mechanism for perceptual errors.

1. A failure of the low-level acoustic analyzer could be caused by not enough information in the acoustic signal for an adequate analysis, or by a breakdown of the analyzer itself. The second possibility is unlikely, given that perceptual errors frequently involve several syllables. A breakdown of a low level acoustic analyzer would involve at most several segments. The first option is possible, given that the amplitude of the production was not controlled. This implies that, for a certain portion of the acoustic signal, there is a disruptive signal-to-noise ratio. The amount of information available from the acoustic signal would vary in different portions of the signal; because not all the information necessary would be present or correctly interpreted, often the wrong lexical item would be chosen. Thus this option leads to:

2. Errors would be introduced by lexical decision in case the acoustic signal was not attended to or there was generally a poor S/N ratio, or in case the predisposition for a certain set of lexical decisions was very high. Certain expectations about the speech signal are current at any point in time. For example, based on the previous syntax, a subset of syntactic forms would be expected. Based on the topic being discussed, a certain semantic category (or set thereof) would be expected. A preoccupation with, say, sex would cause sexual topics and words to be current in consciousness. If these expectations were very high, or if attention lapsed from the acoustic signal, then an internally generated lexical decision would override the information available in the acoustic signal.
Thus, given "I have but one life to give for my [noise]," the expectations for the noun "country" would be very high, and "country" would be perceived via lexical decision rather than from acoustic information. Given casual conversation, it is unlikely the acoustic signal would be ignored completely; hence lowering of attention would act like noise or low amplitude in the acoustic signal to provide a poor S/N ratio. Thus some of the information in the signal would be accurately perceived, even in the case where internal expectations were high, and both would guide the lexical decision.
3. The speech signal has a certain structure in that, for example, some portions have greater amplitude and duration, eg, stressed portions, some portions have greater duration, eg, word final, and some portions have aspiration, eg, word initial. Consequently the misperception of one particular part of the signal might be the cause of the perceptual error. Word-initial consonants, for example, are well-defined in the acoustic signal and are likely to be important to perception. If the low-level acoustic analyzer were to fail briefly on an initial consonant, the perceptual process might be more disrupted than if a medial consonant were incorrectly analyzed. Hence perceptual errors might tend to be triggered by a low-level misperception of an initial consonant, or some other salient portion of the speech signal.

Thus the second goal of the present study is to further elucidate the mechanisms involved in perceptual errors. In addition to determining the triggering mechanism (if any), the analysis will explore the possibility that there is a preference in perceptual errors for either shorter or longer units.

Description of the Data

The corpus includes misperceptions occurring in casual speech recorded by the author and friends in Los Angeles, California, by Garnes & Bond in Columbus, Ohio, and by Stefanie Shattuck-Hufnagel in Boston, Massachusetts. Most of the individuals involved in both production and perception were academics; the errors were recorded by linguists. A total of 222 misperceptions were analyzed (See Appendix C for orthographic transcription, D for phonetic transcription). The perceptual errors were generally semantically anomalous, eg, 'Freudian slip' was perceived as 'accordian slip.' This does not necessarily imply that perceptual errors do not occur in cases where semantic relatedness is retained; it does suggest that only those errors which are seriously disruptive of communication are noticed and reported. Thus the errors in this corpus probably comprise a particular subset of all possible perceptual errors occurring in spontaneous speech.

About 75% of the perceptual errors involved single words--50% nouns, 15% adjectives, 10% verbs, pronouns, etc. Most of the remaining errors involved nouns in phrases--adjective plus noun, prepositional phrase, noun phrase plus prepositional phrase. For example,

Utterance: I'll see you after colloquium

Perception: I'll see you about four then
About 10% included verbs, with as many combining with subjects as with objects. For example,

U: Are you **going to paint** your ruler?

P: Are you **using paint remover**?

In about 40% of the cases, particularly in those involving several words, the perceived sentence differed in syntactic structure from the spoken utterance. For example:

U: I'm going to have **clean teeth** by tonight.

P: I'm going to have **my tea butter knife**.

where the underlined portions could be analyzed thus:

U: 
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P: 
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Only a few misperceptions yielded non-lexical terms, eg,

U: real hypocrite

P: /rehupratʃat /

This again is quite likely due to a reporting bias; most nonsense misperceptions probably elicit a what!? response, and are therefore not reported as misperceptions per se.

The misperceptions varied considerably in complexity. Sometimes only a single feature differed between the utterance and the perception, eg:

U: the _Garrett_ paper

P: the _carrot_ paper

Other times several features differed for several segments, eg:

U: _Barcelona_

P: _carcinoma_

Nor was the word structure always retained. In about 12% of the cases a word boundary was deleted in the perception--
that is, where two words were produced, only one word was perceived. For example:

U: I talked **his ear off**

P: I talked to zero

The word boundary was deleted prior to a stressed syllable about 31% of the time.

A word boundary was inserted during perception 14% of the time. On these occasions one produced word was perceived as two words:

U: You won't have to put **apples** down.

P: You won't have to put **up with** down.

The boundary was inserted before a stressed syllable 28% of the time.

Very occasionally a syllable was shifted from one word to another, eg:

U: San **Xavier**

P: Santa **Vier**

In case the perception and the production had different numbers of syllables, they were considered to have no word boundary change so long as the matched syllables that were in a single word in the utterance were also in a single word in the perception, eg:

U: **no empirical consequences**

P: **known purple** consequences

Note that word boundary changes are defined in terms of the nucleus or vowel of the syllable rather than the consonants. Thus, in the example given, there was not considered to be a word boundary change although the second nasal consonant in the utterance was at the end of the first word in the misperception, instead of in the first syllable of the second word.

Words, syllables, and phonemes were both deleted and inserted in the misperceptions. Table 6 shows the relative frequencies of deletions and insertion for those cases that had no word boundary changes (ie, no deleted, inserted, or shifted word boundaries). The deleted words were usually grammatical function words; the deleted syllables were nearly always unstressed (3 exceptions), and were reduced vowels about 1/3 of the time, frequently in the
<table>
<thead>
<tr>
<th></th>
<th>Only insertion</th>
<th>Only deletion</th>
<th>Both insertion and deletion at different portions</th>
</tr>
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<tbody>
<tr>
<td>At least 1 word</td>
<td>7 (4%)</td>
<td>8 (5%)</td>
<td>1 (1%)</td>
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<tr>
<td>At least 1 syllable</td>
<td>14 (9%)</td>
<td>19 (6%)</td>
<td>-</td>
</tr>
<tr>
<td>At least 1 phone</td>
<td>38 (24%)</td>
<td>36 (22%)</td>
<td>10 (6%)</td>
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Table 6. Number of cases (161 total) and frequencies of deletion and insertion for pairs with no word boundary changes.
environment of a nasal or liquid. (A syllable was defined as deleted if and only if the nucleus or vowel was not present in the perception.) For example:

U: **bizarre trailing** of a poem
P: car **broke down**

Inserted words were likewise generally grammatical function words, and 80% of the inserted syllables were reduced vowels:

U: **just saving** files
P: seeing **if it compiles**

Also,

U: book on learning
P: book on **alerting**

All types of consonants were both inserted and deleted:

U: You ought to check occasionally.
P: You **got to check** occasionally.

U: do you want something to **read**?
P: do you want something to eat?

Unstressed consonants were deleted slightly more often than stressed ones (18% to 11%), and were inserted slightly less often than stressed (11% to 17%). Syllable-final consonants were deleted slightly more often than syllable-initial (15% to 10%).

It should be noted that the transcriptions of the productions and frequently the perceptions are not precise. The productions were not tape-recorded; thus it is possible that some apparent perceptual errors in fact accurately reflect the production. This is probable only for such simple errors as 'van' → (perceived as) 'fan.' The more complicated errors, such as 'ratatouille' → 'on the wheel,' are very unlikely to be caused by production slips. Both the production and the perception were frequently transcribed by the speaker or an on-the-spot observer and the hearer. When this was not so, the author provided the transcription using the set of segments listed in the beginning of Appendix D. (The set of segments,
especially the vowels, was restricted to enable single key entry of the segments into a computer. Similarity of the production and perception was maximized whenever possible on the assumption that the perception was based on the production and hence differed minimally from the production. In other words, an attempt was made to ensure that only the clearest differences between perception and production were analyzed. This was particularly true for vowels and for syllabification. It is often difficult to identify syllables in the case of syllabic consonants (nasals and liquids). Hence maximal similarity between perception and production was used to decide ambiguous cases. For example, 'burl' was transcribed with two syllables because it was perceived with two syllables ('burro').

Analysis

The analyses were performed on a computer. A combination of hand and computer matching was used to relate the words, syllables, and phones in the utterance to those in the perception (See Appendix E for a full description of the algorithms used). The basic approach to matching the perceptual errors differed radically from that for matching lexical errors (TOT), due to the different natures of the errors, and the different null hypotheses. The null hypothesis for the TOT errors stated there was no similarity between the target and approximation, while the null hypothesis for perceptual errors stated there was no difference between the utterances and the misperceptions. For this reason, an almost completely arbitrary left-to-right matching algorithm was used for the TOT errors, since there was no reason to match the linear order more closely than initial to initial. For the SLOE errors, however, every attempt was made to equate the order of the utterance and the perception, since the perception was directly related to the utterance. Again, matching for the TOT errors included only identity, and in any position (except where order was being tested). This was the most conservative approach; that is, this approach granted the best chance of not artificially inflating the significance of the results. The perceptual errors, on the other hand, were matches for similarity as well as identity, and a limited distance between matches was of paramount importance.

1. Span of Errors

A perceptual error encompasses a certain portion of the speech signal— that is, it has a certain span. This span may be similar in some respect from error to error. The span may be defined in several ways however. It may be the case that the speech signal is incorrectly
perceived throughout the entire span. It may also
be the case that the signal is incorrectly perceived only
at the ends of the span. Or it may be the case that the
span provides merely the maximum bounds to the misper-
ception. The first question, then, was to determine if
there were a general span for the perceptual errors; the
second was to determine the kind of span.

The possible spans were defined in terms of kinds
and numbers of units in this study—segments, syllables,
words, and phrases. Since practically all the errors
involved more than one segment, the first unit to be
considered was the syllable. Those cases in which the
units, in particular the words, were similarly defined
in both the production and perception were considered
first. Three quarters of the errors met this criterion
of no word boundary changes.

A majority of these errors (60%) occurred within
one syllable. A total of 85% occurred within one or two
syllables, and 95% within one, two, or three syllables.
(See Figure 20) Therefore either two or three syllables
could be considered the span for the errors. An alter-
nate description of the span could obtain, however. Given
that 90% of all American English words are three or fewer
syllables (Roberts 1965), the span might well be one word
instead. Indeed, Figure 20 shows 80% of the errors to be
in one word. The two alternatives can be tested using
errors involving two or more syllables, since one
syllabic errors are trivially within one word. Poly-
syllabic errors, however, might on the one hand range over
more than one word, in which case two or three syllables
would better describe the span; and on the other hand
might be confined to one word, in which case the word
would better describe the span.

Suppose the span were defined in terms of several
syllables, without regard to words. Then a certain amount
of the time the span would fall into one word by chance.
To determine this chance level, the probability that
several contiguous syllables would occur in the same word
was determined on the basis of the distribution of various
length words in the corpus. 31% of the words were mono-
syllables, 38% had two syllables, 22% had three syllables,
and 8% had four syllables. (This distribution did not
differ significantly from that obtained by Roberts for
American English as a whole.)

Consider then the case of two contiguous syllables.
Each two syllable word contributes one chance for two
contiguous syllables to be in the same word; each three
syllable word contributes two chances for two contiguous
syllables to be in the same word; and each four syllable
word contributes three chances. Then the probability that
two contiguous syllables will be in the same word is:
\[
p (1 \text{ word} \mid 2 \text{ syllables}) = \frac{\sum_{k=2}^{4} (k-1) \cdot p(k-\text{syllable word})}{\sum_{j=1}^{4} j \cdot p(j-\text{syllable word})}
\]

where the numerator is the number of chances for two contiguous syllables to be in one word, and the denominator is approximately equal to the total number of samples of two contiguous syllables in the corpus. Proceeding similarly for three and four contiguous syllables, it was determined that two, three, or four contiguous syllables would fall into one word about 35% of the time by chance. Since in the data the polysyllabic errors were in one word 60% of the time, apparently polysyllabic errors were better described in terms of a span of one word than in terms of a polysyllabic span (\(p < .01\) by chi square). (See Figure 21)

While one word was the single best descriptor of the span, it was nevertheless not completely adequate. Twenty percent of the errors (and forty percent of the polysyllabic errors) encompassed more than one word. Half of these larger errors involved phrases—nominal and prepositional. The others included verb phrases or sentences. Very few errors split syntactic groupings unnaturally. Thus the phrase or sentence provided a very nearly absolute maximum bound to the span of perceptual errors.

The word also acted as a maximum bound to the span of perceptual errors. It was not the case that errors tended to occur throughout the word. Figure 22 shows that only about 40% of the time were all the syllables of the word involved in an error.

That subset of the errors that involved insertion of word boundaries of course all had two or more syllables. Here again about 60% of the errors involved one word productions. The portion of the data that involved deletion of word boundaries all had two or more words in the production, by definition. For this 15% of the errors, the word as the span clearly did not apply.

2. Distribution of Errors

The next question concerned the distribution of errors within the words, to determine if any portion of the word were a likely candidate for triggering the errors. Those cases with no word boundary change were again considered first.

There was no preference for segment errors (here "segment error" is being strictly defined as changes of segments in the production that were neither deleted nor inserted) to occur on any particular syllable of the word. Figure 23 shows the frequency of at least one segment error occurring in a syllable, for each syllable in the
Figure 21: Span of errors with two or more syllables
Figure 23: Frequency of occurrence of at least 1 error per syllable for different syllable positions.
word. Nor was there a dependency relation among the syllables. An error occurred on any one syllable regardless of whether another syllable was in error. Table 7 shows the dependencies for two syllable words; three and four syllable words showed similar distributions.

Neither deleted syllables (syllabic nuclei) nor deleted segments (consonants) showed a preference for any portion of the word. Syllables in each position of the word were deleted about 10% of the time, as were segments in each syllable in the different word-positions (See Figure 24).

Insertions did show a position effect. Sixty-five percent of all inserted syllables were inserted prior to the beginning of the word as produced. Moreover, in almost every case in which a syllable was inserted preceding a produced word, the initial syllable of the produced word was stressed. Seventy percent of all inserted segments were inserted in or preceding the initial syllable of the produced word, and 20% in or following the final syllable.

For those errors in which word boundaries were deleted or inserted, another type of distribution of errors is possible. The errors may be associated with the inserted or deleted word boundaries. This was not the case for segmental errors. There was some tendency for segments and syllables to be deleted prior to deleted word boundaries rather than following them (75% prior to deleted word boundaries, 25% following them). Inserted segments occurred more frequently at inserted word boundaries than elsewhere (72%); two-thirds of these occurred prior to the boundary.

3. Shorter vs Longer

The next question concerns the possible bias for shorter or longer words. Here the errors with word boundaries inserted or deleted become crucially important.

Since word boundaries were deleted about as often as they were inserted (12% to 14%), there was no apparent preference for shortening or lengthening words by this means. The other major method of changing word size was by inserting or deleting syllables. Figure 25 shows the preferences for all three types of errors. Only in the word boundary deleted class was the preference for shortening words marginally significant (p < .10). However it should be noted that in all cases there was a very slight preference for shortening words, whether by deleting syllables or inserting word boundaries.
<table>
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<th></th>
<th>1st Syllable</th>
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<tbody>
<tr>
<td></td>
<td>no error</td>
<td></td>
<td>error</td>
</tr>
<tr>
<td>2nd syllable</td>
<td>no error</td>
<td>11</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>error</td>
<td>15</td>
<td>15</td>
</tr>
</tbody>
</table>

Table 7. Distribution of errors on syllables for 2 syllable word.
Type and position of deletions within word

Figure 24: Syllable and segment deletions for different syllable positions
Figure 25: Number of syllables in perceived words as compared to number of syllables in produced words.
4. Difference among Classes

Some errors have, besides segmental and syllabic errors, an additional kind of error. In these classes, the word boundary was incorrectly perceived. Do these classes show more or more severe errors in other ways as well?

In general, errors with misperceived word boundaries did show more severe errors in other ways as well. Figure 26 shows that both word boundary change classes had more segmental errors than the no change class (overall p < .05). In addition, they had somewhat more complicated errors, where complication is measured in terms of number of features in error (overall p < .10). This was particularly true for the word boundary inserted class. Figure 27 shows that the most segments (including both vowels and consonants) were deleted in the word boundary deleted class, and the fewest in the word boundary inserted class (overall p < .01). Finally, Figure 28 shows that more segments (consonants and vowels) were inserted in the word boundary inserted class than in the others (overall p < .02).

Discussion

The results show that word boundaries in the production played an important role in perceptual errors. In those cases in which the word boundary was correctly perceived, the errors tended to be restricted to the portion of the speech signal between the boundaries, that is, within one word. On the other hand, incorrect perception of word boundaries and greater disruption of the perceptual process in other ways generally co-occurred (causality or directionality is not clear). There were more segmental errors when word boundaries were incorrectly perceived, and these errors were more severe (larger number of features changed). When the word boundary was deleted during perception, more segments were deleted. And when a word boundary was inserted during perception, more segments were inserted. Moreover, these deletions and insertions tended to cluster around the misperceived word boundary: deleted segments tended to occur just before a deleted word boundary and inserted segments tended to occur just before an inserted word boundary.

It is not possible to determine, in the case of misperceived word boundaries, what the triggering mechanism for the errors was (at least in the present study). Consider the cases in which the word boundary was deleted. If the preceding segment(s) were deleted, then much of the information about the boundary would be lost and the word boundary in effect deleted. This would be particularly true if both vowel and consonant were deleted, and
Figure 26: Total errors and single-feature errors for classes
Figure 27: Deletions for classes
Figure 28: Insertions for classes
indeed this tended to be the case. On the other hand, if the information about the word boundary was not perceived, the segments would not necessarily be lost. However, the syllable preceding the deleted word boundary would now be a medial syllable in the lexical decision process; since medial syllables tend not to have final consonants, the lexical item chosen on the basis of the misperceived signal would likely not have a final consonant in the medial syllable, and hence in effect the segments immediately preceding the deleted word boundary would be perceived as deleted. Neither of these possibilities need be correct of course—there could be a general lack of attention to the speech signal that resulted in overall higher error and deletion rates.

Similar reasoning applies in the bases with inserted word boundaries. An inserted segment would tend to result in a word boundary being perceived, again because medial syllables end in consonants less often than final syllables. The problem here is that it is difficult to imagine a segment being conjured up from nowhere and inserted; an inserted segment is likelier to be introduced by the lexical decision process. On the other hand, word boundaries could be perceived as inserted by a simple misinterpretation of length or other cues. Here again the perception of a word boundary could induce a segment to be introduced during the lexical decision process. Finally, a general lack of attention to the speech signal could result in a higher error (and insertion) rate. In the case of inserted word boundaries, however, it seems probable that the error was not triggered by an inserted segment.

In the cases where the word boundary was correctly perceived, no particular syllable position in the word seemed to trigger the misperception. It is interesting to note, however, that whenever a syllable was inserted at the beginning of the word, the word as produced always had the first syllable stressed. This suggests that the lexical decision process weighed the factor of stress more heavily than the factor of initial position.

There was a very slight overall tendency for words to be shortened, both by inserting word boundaries and by deleting syllables. However, this result is apparently at odds with that obtained by Garnes and Bond (1975), who reported "word boundary deletions dominate our data." Since at the time of their report, both data sets were equally small (about 200 pairs), this question must await the resolution of a larger data set or an experimental test.

The only other apparent area of conflict involved the retention of syntactic structure. Garnes and Bond (1975) report that "the basic phrase structure remains unaffected by the misperception," whereas the present study shows
difference in syntactic structure for forty percent of the cases. Probably the conflict lies in a different definition of syntactic structure used in the two studies. If the present study relied on a more fully expanded description of phrase structure, then it would incorporate differences ignored by the Garnes & Bond study. The criterion for syntactic similarity was in fact quite strict in the present study--any syntactic differences at all between the misperception and the utterance were counted as different syntactic structures. However, even if the conflict can be explained away in this manner (which is not clear), the degree of syntactic similarity between utterance and misperception will not be known until a reasonable basis for judgment can be determined.
CHAPTER 3
Perceptual Processing:
Evidence from Slips of the Ear

In the previous chapter, the relevance of auditory word boundary information to perceptual errors was discussed. It was shown that most of the perceptual errors occurred within one word. Apparently then the unit of the word plays a particularly important role in perceptual errors, and hence in perceptual processing.

The word can be discussed, in perception, from several viewpoints. It clearly is a lexical unit, with its associated lexical structure. The word also has a certain structure associated with it in the acoustic signal. The word in perceptual processing must serve to mediate between the lexical unit and the acoustic unit; additional primarily perceptual structures may also be associated with the unit of the word. The purpose of the present chapter is to examine in detail the interaction of the higher level lexical unit with the lower level acoustic unit, by relating patterns of segmental misperceptions to the internal structure of words.

The same body of data and the same matching techniques as in the previous chapter were used.

1. Word Structure and Segment Errors:
Distribution of Errors

In order to test the effect of word structure on segmental errors, a composite of words was created by summing over all the words in the corpus. The monosyllabic words were summed separately from the polysyllabic (two or more syllables). For monosyllabic words, the total number of word-initial consonants, vowels, and word-final consonants were each counted. Then the number of word-initial consonants, vowels, and word-final consonants that were perceived incorrectly were counted to determine the number of errors for monosyllabic words. A similar strategy was followed for polysyllabic words. The polysyllabic composite consisted of three syllables: initial, medial, and final, where medial syllables were defined as all non-initial and non-final syllables from words with three or more syllables. In order to test the effect of stress, each composite syllable was a sum either of all stressed syllables in that position in the word, or of all unstressed syllables in that position of the word. For each syllable, the total number of segments and the number of misperceived segments was counted for syllable-initial consonants, vowels, and syllable-final consonants. Ambi-
syllabic consonants were counted as syllable-initial. If the misperception extended over more than one word, each word contributed individually to the composite. For example, 'popping really slow' \(\rightarrow\)'prodigal son' contributed two words ('popping' and 'really') to the polysyllabic composite and one word ('slow') to the monosyllabic composite. A total of 164 words were summed to form the polysyllabic composite, and 182 words for the monosyllabic composite.

Errors were defined only as segmental changes on substitutions: segment deletions and insertions were not included in the study. The "error rate" as used herein is defined as the number of segmental errors in any one position, divided by the number of segments in that position. The overall error rate for the entire corpus is meaningless; only the distributions of errors can provide us with any information about the structure of the word. Given the meaningfulness of the overall error rate and the concomitant near impossibility of determining the expected error rate, significance figures have not been determined for the analyses.

Figure 29 shows the distribution of errors for each position of the polysyllabic and monosyllabic composites, considering stressed and unstressed syllables separately (See Appendix E for a discussion of the methods used to match the utterances and misperceptions on the segmental level). Consider first the distributions of errors for unstressed syllables in polysyllabic words, the top left figure. There was a definite word position effect, with the error rate progressively decreasing towards the end of the word. Within each syllable, there was a higher error rate for consonants than for vowels (except for the final consonant in initial syllable). Moreover, syllable-initial consonants had more errors than the corresponding syllable-final consonants. Notice these generalizations were not true for the unstressed monosyllables shown in the top right figure; the error rate seems about the same for consonants and vowels, and for initial and final consonants. In fact, the unstressed monosyllables shared the distributional properties of stressed monosyllables.

Consider now the stressed composites in the lower portion of Figure 29. The word position effect was apparently neutralized, with approximately the same error rate across the word. Moreover, within each syllable the vowels and consonants had about the same error rate (again with the exception of markedly fewer errors in the final consonants of the initial syllable). There was still a slight within-syllable effect with syllable-initial consonants having a somewhat higher error rate than syllable-final consonants. The stressed monosyllables, shown in the lower right of the figure, displayed the same error...
Figure 29: Overall error rates by position within composite
rates as in the stressed polysyllables, with perhaps a slight reversal of the within-syllable consonant effect.

Comparing the upper and lower portions of Figure 29, we see that monosyllables (whether stressed or unstressed) and stressed syllables (whether part of a polysyllabic or a monosyllabic word) had remarkable uniform error rates: regardless of word position, about 30% of the segments were in error. (Remember the absolute figures are meaningless.) For unstressed syllables, and to a lesser extent stressed syllables, the syllable-final consonant was less in error than the syllable-initial consonant, especially for initial syllables. This effect was nullified or slightly reversed for monosyllables. The consonants in unstressed syllables from polysyllabic words were much more frequently misperceived than their stressed counterparts; curiously the opposite was apparently true for vowels. Probably, however, the stressed and unstressed vowels should not be seriously compared; since most of the unstressed vowels were coded as schwas, and since wherever possible in the analysis syllables were matched in terms of stress, one would expect fewer errors for unstressed schwas than for the stressed vowels which were more highly differentiated. Thus the major difference between the effect of stressed and unstressed syllables on segment perception occurred in polysyllable words, in which consonants in unstressed syllables were misperceived more often than in stressed syllables, and misperceptions in unstressed syllables were affected by position within the word.

It seems immediately obvious from an examination of the data that there were two sources of error—acoustic misanalysis and lexical decision. Assuming that the initial processing of the acoustic signal involves some sort of feature analysis, it seems probable that a misperception such as van → fan is a simple failure to perceive the correct value of a feature, which is presumably a low level perceptual failure. But it seems unlikely that the low-level analyzer would fail so grossly as to produce all the wrong segments in an error such as clean teeth by tonight → my tea butter knife. Instead, the severity of the errors probably results from the choice of the wrong word, i.e., lexical decision. The choice of the wrong word may be triggered by a relatively simple single misanalysis by the low-level acoustic processor; this possibility, however, is difficult to either confirm or refute at present. In any case, assuming the existence of two origins of errors, the question arises as to possible differential effects of word structure on the two kinds of errors.

Supposing the above general model of perceptual processing, then the acoustic errors should be characterized
by a higher proportion of single feature errors than the lexical decision errors. That is, when the wrong word is chosen, the errors should be more severe and have more multiple feature changes. From this starting point, it becomes feasible to tease out the number of acoustic errors and lexical errors at each position in the word, and thus to determine the effect of word structure separately for each.

Consider the description of a corpus of perceptual errors depicted in Figure 30. By counting, we know N (the total number of segments), E (the number of segmental errors or misperceptions), S (the number of segments with single feature errors), and M (the number of segments with multiple feature errors). We want to determine A (the number of segments with acoustic errors) and L (the number of segments with lexical errors). That is, we want to determine the probability of an acoustic error, p(A), and the probability of a lexical error, p(L). (I shall approximate the probability p of an event by its percentage occurrence, and consequently will use p(X) to refer both to the probability of occurrence of X, and the percentage of times X occurs in the observed data.) From counting, we know the percentage of all the errors that are single feature errors (=the probability of a single feature error given an error):

\[
p(S|E) = \frac{S}{E} = \frac{x_1 + x_2}{x_1 + x_2 + x_3 + x_4}
\]

We also know the probability of an error

\[
p(E) = \frac{E}{N} = \frac{x_1 + x_2 + x_3 + x_4}{x_1 + x_2 + x_3 + x_4 + C}
\]

We define the percentage of acoustic errors that are single feature errors (=probability of a single feature error given an acoustic error) as

\[
p(S|A) = \frac{x_1}{A} = \frac{x_1}{x_1 + x_3}
\]

We further define the percentage of single feature errors that are acoustic errors (=probability of an acoustic error given a single feature error):
\[ N = \text{total number of utterances} \]

\[ E = \text{misperceptions} \quad \quad \quad \quad \quad C = \text{correct perceptions} \]

<table>
<thead>
<tr>
<th>( x_4 )</th>
<th>( x_3 )</th>
<th>( x_2 )</th>
<th>( x_1 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( M = )</td>
<td>( S = )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>multiple</td>
<td>single</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>feature</td>
<td>feature</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>errors</td>
<td>errors</td>
<td>( )</td>
<td>( )</td>
</tr>
</tbody>
</table>

\[ A = \text{number of acoustic errors} = \text{number of single feature acoustic errors} + \text{number of multiple feature acoustic errors} \]

\[ = x_1 + x_3 \]

\[ L = \text{number of lexical errors} = \text{number of single feature lexical errors} + \text{number of multiple feature lexical errors} \]

\[ = x_2 + x_4 \]

Figure 30: Distribution of lexical and acoustic errors in terms of single and multiple feature errors
\[ p(A|S) = \frac{x_1}{x_1 + x_2} \]

Finally, the probability of an acoustic error is
\[ p(A) = \frac{A}{N} = \frac{x_1 + x_3}{x_1 + x_2 + x_3 + x_4 + C} \]

Then it is true that
1) \[ p(S|A) p(A) = p(E) p(A|S) \]

To show that equation 1) is true, substitute using the above definitions
\[
\begin{align*}
\frac{x_1}{A} &= \frac{A}{N} = \frac{S}{E} \cdot \frac{E}{N} = \frac{x_1}{S}
\end{align*}
\]

Cancelling appropriately then yields
\[ \frac{x_1}{N} = \frac{x_1}{N} \]

Further, define the percentage of lexical errors that are single feature errors:
\[ p(S|L) = \frac{x_2}{x_2 + x_4} \]

Define the percentage of single features that are lexical errors as:
\[ p(L|S) = \frac{x_2}{x_1 + x_2} \]

Note also that:
\[ p(L|S) = 1 - p(A|S) \]

since \[ p(L|S) = \frac{x_2}{x_1 + x_2} \]

\[ p(A|S) = \frac{x_1}{x_1 + x_2} \]
and \( p(L|S) + p(A|S) = \frac{x_1}{x_1 + x_2} + \frac{x_2}{x_1 + x_2} = \frac{x_1 + x_2}{x_1 + x_2} = 1 \)

Finally define the probability of a lexical error as

\[
p(L) = \frac{L}{N} \frac{x_2 + x_4}{x_1 + x_2 + x_3 + x_4 + C}
\]

Then, using the above definitions, it is true that:

2) \( p(S|L)p(L) = p(S|E) p(E) (1 - p(A|S)) \)

Finally, if one assumes that an error is either an acoustic error or a lexical error but not both, then

3) \( p(A) + p(L) = p(E) \)

Given equations 1), 2), and 3), one can solve for the probability of an acoustic error:

4) \( p(A) = p(E) \frac{p(S|L) - p(S|E)}{p(S|L) - p(S|A)} \)

Therefore, to determine the probability of an acoustic error \( p(A) \), we need only plug in appropriate numbers for the variables on the right. Now we know \( p(E) \) (percentage of errors) and \( p(S|E) \) (percentage of single feature errors) by counting the data. Therefore we only need to determine \( p(S|L) \) (percentage of lexical errors that are single feature errors) and \( p(S|A) \) (percentage of acoustic errors that are single feature errors). Both these probabilities were estimated from other data as follows.

To determine \( p(S|A) \), I calculated the percentage of single feature errors for a set of 16 consonants from a study by Wang and Bilger (1973). The consonants, in both initial and final positions of nonsense syllables (sets CV1 and VC1), were presented at several S/N ratios and the (mis)perceptions recorded. Because of the use of nonsense syllables, this data seemed a good approximation to purely acoustic errors. To estimate \( p(S|L) \), I calculated the percentage of single feature errors in a confusion matrix of 24 consonants, where the number of confusions was determined by the overall frequency of occurrence of each consonant in the language. This confusion matrix approximated the number of single feature errors between randomly matched phonemes. Since the extreme form of lexical decision as an origin of error claims that the perceived segment bears only a random relation to
the uttered segment, this seemed a reasonable approximation to \( p(S|L) \). The feature set displayed in Table 8 was used for the estimation of both \( p(S|L) \) and \( p(S|A) \), as well as for the SLOE analysis itself.

The probabilities thus determined happily supported the original intuition that acoustic errors should have more single feature errors:

\[
p(S|A) = .47
\]
\[
p(S|L) = .22
\]

From the SLOE data, using consonants only,

\[
p(E) = .30
\]
\[
p(S|E) = .42
\]

and hence, substituting in equation 4),

\[
p(A) = .24
\]

Finally, since \( p(A) + p(L) = p(E) \),

\[
p(L) = .06
\]

That is, in the present corpus, about a quarter of the consonants had acoustic errors, and 6% lexical errors.

Given these base probabilities of acoustic and lexical errors, it was possible to determine how the percentages of acoustic and lexical errors differed for different positions within the word. The percentage of acoustic errors \( p(A) \) was computed for each word position and stress type using equation 4), but with position-specific values for \( p(E) \) and \( p(S|E) \). The \( p(E) \) values used were those displayed in Figure 29; the \( p(S|E) \) values were the percentage of single feature errors for each position and stress type considered separately. Once the \( p(A) \) values were determined, \( p(L) \) values were computed using the formula \( p(A) + p(L) = p(E) \), where all the percentages were position specific. By graphing the position-specific \( p(A) \) and \( p(L) \) in relation to the overall expected values, as in Figure 31, the distribution of errors over the word can be seen separately for lexical and acoustic errors. Again, the exact percentages are meaningless: it is only the relationship between the various positions that is important. Note also that, although \( p(A) \) and \( p(L) \) are inversely related for the data set as a whole, and also for each specific position, it is still possible for the overall distribution of the acoustic errors and lexical errors to vary independently, because the values of \( p(E) \) vary from position to position.
<table>
<thead>
<tr>
<th>Consonants</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>p</td>
<td>L S - - - -</td>
</tr>
<tr>
<td>t</td>
<td>A S - - - -</td>
</tr>
<tr>
<td>k</td>
<td>V S - - - -</td>
</tr>
<tr>
<td>b</td>
<td>L S + - - -</td>
</tr>
<tr>
<td>d</td>
<td>A S + - - -</td>
</tr>
<tr>
<td>g</td>
<td>V S + - - -</td>
</tr>
<tr>
<td>f</td>
<td>L F - - - -</td>
</tr>
<tr>
<td>s</td>
<td>A F - - - +</td>
</tr>
<tr>
<td>v</td>
<td>L F + - - -</td>
</tr>
<tr>
<td>z</td>
<td>A F + - - +</td>
</tr>
<tr>
<td>θ</td>
<td>A F - - - -</td>
</tr>
<tr>
<td>ð</td>
<td>A F + - - -</td>
</tr>
<tr>
<td>ñ</td>
<td>P F - - - +</td>
</tr>
<tr>
<td>ʒ</td>
<td>P F + - - +</td>
</tr>
<tr>
<td>ʒ</td>
<td>P S + - - +</td>
</tr>
<tr>
<td>m</td>
<td>L S + + - -</td>
</tr>
<tr>
<td>n</td>
<td>A S + + - -</td>
</tr>
<tr>
<td>ñ</td>
<td>V S + + - -</td>
</tr>
<tr>
<td>l</td>
<td>A X + - + -</td>
</tr>
<tr>
<td>r</td>
<td>A X + - - -</td>
</tr>
<tr>
<td>j</td>
<td>P X + - - -</td>
</tr>
<tr>
<td>w</td>
<td>L X + - - -</td>
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<tr>
<td>h</td>
<td>G X - - - -</td>
</tr>
<tr>
<td>r</td>
<td>A S + - - -</td>
</tr>
<tr>
<td>?</td>
<td>G S - - - -</td>
</tr>
</tbody>
</table>

Table 8. Feature set
Figure 31: Error rates for lexical and acoustic errors (consonants only)
Consider first the unstressed polysyllabic composite in the top left portion of Figure 31. The acoustic errors show the same decreasing error rate from left to right that we saw in the overall error distribution (again with the exception of the final consonant in the initial syllable). Notice too the same relative increase in acoustic errors for syllable-initial consonants over syllable-final consonants as occurred for the errors overall. But note that the lexical errors do not show the left to right distribution of the acoustic errors. Instead there were relatively more lexical errors word-medially than in initial and final positions of the word. The unstressed monosyllables, shown in the upper right of Figure 31, had yet another pattern, with lexical errors relatively decreasing and acoustic errors relatively increasing from left to right. There were also relatively more lexical errors and fewer acoustic errors for the unstressed monosyllables.

The pattern for the stressed polysyllabic composite in the lower portion of Figure 31 is less clear, largely because half of the positions did not have enough errors to be computed (I selected 15 as the cutoff point). The acoustic errors appeared to decrease from left to right just as for the unstressed. There also appeared to be fewer errors syllable-finally, as with the unstressed. In each position, the stressed consonants had relatively fewer acoustic errors than the unstressed. Again, the lexical errors show a different pattern, although with the three positions including the consistently anomalous final consonant in the initial syllable, it is unclear what the pattern is. The stressed monosyllables had exactly the opposite pattern as the unstressed monosyllables--acoustic errors decreasing and lexical increasing from left to right, and acoustic errors relatively increased and lexical errors decreased.

2. Discussion

The distribution of lexical errors, at least for unstressed syllables in polysyllabic words, correlates nicely with the effects of word structure on lexical retrieval as evidenced by tip-of-the-tongue data and memory tasks. In the present data, lexical errors were at a minimum at the beginning and end of a word. The first chapter of this work showed that the initial and final positions of a word are frequently remembered in the tip-of-the-tongue phenomenon, even though the entire word is not retrievable. Thus the same pattern is evidenced in strictly lexical retrieval data and in the lexical errors in the slips of the ear.

Note, however, that the similarity of patterning for
the two kinds of data must be explained in terms of selective attention during retrieval rather than in terms of strengthened memory traces. That is, the relative importance of word-terminal segments must be due to increased attention to the processing of the acoustic information rather than to increased clarity or strength in storage. If the latter hypothesis were correct, one would expect the serial position effect in the misperception data to be the inverse of the actual effect. That is, if word-terminal segments were more strongly or clearly stored, then they should tend to be retrieved regardless of the information supplied by the acoustic signal, thereby introducing more lexical errors word-terminally rather than fewer. But the mechanism of selective attention provides that the beginnings and ends of words will be attended to more closely and hence the associated information will be relatively more important, regardless of whether the focus of attention is the memory trace (in TOT) or the processing of the incoming signal (in SLOE).

The structure of lexical errors in unstressed monosyllables was less straightforward. There were more lexical errors in unstressed monosyllables than in stressed monosyllables, which makes sense given that the unstressed monosyllables included grammatical words. One would expect grammatical words to be strongly affected by the syntactic analysis and choice of lexical items, and hence more likely to introduce lexical errors. However, while the stressed monosyllables showed the expected pattern of fewer lexical errors word-initially, the unstressed monosyllables had more errors word-initially. I have no particularly constructive explanation for this reversal, except to suggest that unstressed monosyllables may effectively be a portion of a larger unit.

The stressed syllables in polysyllabic words had an even less clear relationship to the general lexical error structure. Mostly this was due to lack of data; only half of the consonantal positions had enough data to be reliably analyzed. But of the remaining three positions, the final consonant in the first syllable showed the fewest errors, rather than falling between word-initial position and the following consonant. Recall that this particular position had been anomalous throughout the analysis. The anomaly may reflect the smallness of the data set, as it is not an additional wrinkle in the patterning of lexical errors, at least based on the TOT study in Chapter 1.

The distribution of the acoustic errors can be resolved into separate patternings, most of which can be directly related to aspects of the acoustic signal. There were fewer acoustic errors on stressed syllables than on unstressed syllables in polysyllabic words, probably because of the greater prominence of the stressed syllables.
The increased duration and intensity of stressed syllables yield a stronger signal; these plus the intonation extremes associated with stress may additionally cause greater attention to the acoustic signal by the acoustic analyzer. On the other hand, stressed monosyllables had relatively more acoustic errors than unstressed monosyllables. This apparent anomaly is probably due to the differing definitions of stress for polysyllables and monosyllables. A stressed syllable in a polysyllabic word is stressed in relationship to the other syllables in the word; a stressed monosyllable is stressed relative to other words in the phrase, and hence probably has a high information content. Given that most of the stressed monosyllabic errors comprise an entire misperception, the patterning of acoustic errors for monosyllables can be interpreted as being a result of reporting. That is, an acoustic error on a word with potentially high information content (a stressed word) will disrupt communication more, and hence be more likely to be noticed and reported. Most of the polysyllabic words are probably stressed words in this sense too. (Recall that over half of the misperceptions involve nominals.)

For all syllables except unstressed monosyllables, consonants in final position had fewer errors than consonants in initial position. This pattern of misperceptions was very likely due to differences in the acoustic signal between initial and final consonants. Broad and Fertig (1970) showed that formants 2 and 3 have a greater frequency change syllable—finally than syllable—initially. Lehiste and Peterson (1961) demonstrated that, except for /e/ and /i/, the transition to the final consonant was of greater duration than the transition from the initial consonant. Both of these findings suggest that a consonant in syllable—final position is more clearly represented in the acoustic signal than one in initial position, and hence should be easier to perceive. Moreover, the syllabic nucleus provides a variety of specific cues for final consonants and not for initial consonants. Voiced final consonants are associated with a lengthening of the vowel (eg, Peterson and Lehiste 1960). The same study showed that final fricatives are also accompanied by vowel lengthening. Final nasals cause much more nasalization of the vowel than initial nasals. Note that these effects are relatively independent of the vowel quality. Therefore, whether or not the vowel is correctly identified, there is information about the final consonant over a greater span of the acoustic signal than for the initial consonant. Again, the increased amount of information should improve perception of final consonants.

Let us now return to the question posed at the beginning of this paper concerning the interaction of the lexi-
ical decision level with the acoustic analysis level. The model schematized in Figure 32 explicitly accounts for all but one of the major regularities of the perceptual errors. The strength of the acoustic signal varies in relation to syllable structure and word structure: there is more information syllable-finally and word-terminally. The output from the acoustic analyzer retains the within-syllable strength relationships, but has a changed word pattern, with strength increasing from the beginning to the end of the word. (This changed word pattern is the only portion of the model neither explicitly described nor related to other evidence; it will be discussed at greater length below.) The segment recognizer attends selectively to different portions of the incoming acoustic analysis, with more attention being paid to the beginning and the end of the analysis of the word than to the middle. The segment recognizer provides input for the lexical decision; in turn the lexical decision affects the segment recognizer.

The major regularity of the data still left hidden in a black box is the decreasing error rate for acoustic errors throughout the word. Patterns in the acoustic signal do not account for the decreasing rate. The portion of the acoustic signal likeliest to account for the regularity seems to be duration. That is, if the duration of the syllables (or consonants) increases throughout the word, then the increasing strength of the acoustic signal should mean decreasing numbers of acoustic errors. A study by Oller (1973) using intervocalic consonants (open syllables) suggested that consonant duration does not increase throughout the word, but instead decreases from initial to medial syllables and then increases again word-finally. An informal study by the author using closed syllables confirmed this finding. Four native American-English speaking subjects read the words 'compassion' vs 'incomplete,' and 'condition' vs 'reconcile' (each word was in the frame 'say again'). In every case, the medial syllable was no longer than the comparable initial syllable; again in every case, the syllable-initial /k/ was not longer in the medial syllable than in the initial syllable. Thus duration cannot account for the decreasing error rate.

Apparently, then, the decreasing error rate reflects the mechanism of the acoustic analyzer itself. The most obvious hypothesis is that the analyzer works from left to right in sequential temporal order, and then recycles at the word boundary. It could be, for example, that knowledge of the expected form class yields finely detailed phonotactic constraints that continually reduce the class of possible segments as the word is processed. But it is impossible to test this hypothesis using the present
The length of the arrows represents the relative strength of the information (longer = stronger).

Stress adds length (= strength) to every arrow associated with the affected syllable.

The dashed arrow (− −) represents less certainty about the acoustic information.

Figure 32: Processing model (details for consonants only)
analysis. Although previous analyses suggested that the window over which analysis proceeds is the word, this is by no means certain—and of course, if the window is not the word, then the hypothesis no longer holds as stated. Moreover, to test the left-to-right hypothesis it is necessary to differentiate it from other plausible hypotheses, such as that processing begins with stressed syllables and proceeds from there, either in a sequential fashion or spreading in both directions from the stressed syllable. To differentiate these hypotheses, it is crucially important to know the relationship of the errors to the rhythmic pattern of the words, as well as to the word boundaries. Thus future analyses must decompose the composite of words into separate rhythmic patterns.

These hypotheses do not, of course, exhaust the possible alternatives. In the next chapter the correlation of lexical and perceptual errors provides a possible answer to the question of the mechanism of the acoustic analyzer.
CHAPTER 4

The Relationship between Lexical and Perceptual Errors and the Acoustic Signal

The most fruitful relationship between the lexical errors (TOT) and perceptual errors (SLOE) involves both areas of similarity and areas of differences. If the two types of errors show no similarities of patterning, then they are not tapping the underlying structure of language, but rather are providing only process-specific information. If, on the other hand, the two types of errors show no differences of patterning, then it is questionable whether any information is gained about the specific processes of recall and perception. Only if both similarities and differences appear would there be evidence that both underlying and process-specific structures were being tapped. Not surprisingly (given the above lead-in), the data suggests that lexical and perceptual errors are similar in certain ways and different in others. The particular patterns discussed in this paper include the distribution of errors with respect to word structure and stress. These error distributions are compared to patterning of the acoustic signal, in order to suggest an explanation of the similarities and differences.

1. An Overview of Error Relationships

The patterns of the perceptual and lexical errors, as concerns word boundary and stress information, are summarized in Table 9. A plus indicates that relatively more segments (or units, as relevant) were correct in that position. A plus for the acoustic signal indicates that I will postulate that the information is somehow acoustically marked in such a way as to facilitate correct identification. Note that, given this postulate, lexical errors (TOT) correlate well with the acoustic signal, while perceptual errors (SLOE) differ selectively. The implications of these pattern distributions will be discussed in succeeding sections.

The selective attention mechanism posited in Chapter 3 will be invoked in the following sections, and tested as a possible mechanism common to both types of language errors. Durational cues will be shown to be correlated with perceptual processes.

Since selective attention will play a large role in the following discussions, the arguments for its importance will be briefly recapitulated here. The crux of the argument rested on the relationship between lexical and
<table>
<thead>
<tr>
<th></th>
<th>acoustic signal predictions</th>
<th>lexical errors (TOT)</th>
<th>perceptual errors (SLOE)</th>
</tr>
</thead>
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<tr>
<td>word-initial consonant</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>stressed syllable</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>word-final VC</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

relative number of segments (units) correct

Table 9. Summary of error effects
perceptual errors. It was argued in Chapter 3 that perceptual errors could be separated into lexically-induced errors and acoustically-induced errors. The lexically-induced perceptual errors were then related to straight lexical errors, using the TOT errors as a source. The lexically-induced perceptual errors showed the inverse pattern to that predicted on the assumption that lexical structure is a function of storage. It was argued that selective attention could adequately account for both the patterns of lexical (TOT) errors and lexically-induced perceptual errors. The mechanism involved was assumed to attend selectively to the beginnings and ends of words. That is, the beginnings and ends of words were more important to the decision process. The structure of this attention mechanism will be expanded in succeeding sections to include stress effects.

2. Patterns in the Acoustic Signal

While the acoustic signal is a more or less continuous stream, it nevertheless contains cues for chunking. These cues include information about the beginnings and ends of words as well as the location of stressed syllables. The cues are of different types (duration, intensity, pitch, and spectral) and are associated with different portions of the signal, i.e., vowels or consonants.

The word-initial potential boundary cues are carried primarily on the initial consonant. Word-initial consonants are longer than word-medial or word-final consonants (in non-phrase-final position) (Lehiste 1960, Oller 1973, Umeda 1977, Klatt 1974). They also have a variety of spectral and timing differences when compared to word-medial and word-final consonants: for example, initial voiceless stops have a greater degree of aspiration; initial voiced stops have less intensity in the higher harmonics; laterals have different formant structures word-initially and word-finally (Lehiste 1960, Coker & Umeda 1975).

Word final boundaries are marked by increased duration of the final syllable, especially the vowel and final consonant, when compared to initial and medial syllables, and in particular when unstressed (Oller 1973, Umeda 1975, Lehiste 1960); they are marked also by decreased intensity on the final syllable (Lehiste 1960), again, particularly the vowel and final consonant.

Stress is marked in a variety of ways. Initial consonants of stressed syllables are longer than initial consonants of unstressed syllables (Umeda 1977) and exhibit spectral and timing differences similar to that for word-initial consonants (Umeda & Coker 1974). Stressed vowels have greater duration, greater intensity, and frequently a
rise in pitch, compared to unstressed vowels (Lieberman 1967). Perceptual tests, however, suggest that duration is a more important cue for stress than intensity (Fry 1955), but somewhat less important than sentence intonation (Fry 1958).

For the purposes of this paper, the various cues will be separated into two categories, each category having two kinds of classes. These two categories will be referred to as the 'initial segments' and 'lengthening' categories; they will be sub-divided into cues for word position, and cues for stress.

The category of 'initial segments' includes a variety of types of cues. Initial consonants that act to mark initial word boundaries belong to this category. The cues for stressed syllables that are marked on the initial segment of the stressed syllable are also members of this category. The category of 'lengthening' comprises word-final lengthening of the vowel in the final syllable (compared to medial and initial syllables; the word-final consonant shows some lengthening compared to medial consonants) and lengthening of stressed vowels.

3. Lexical Errors (TOT) and the Acoustic Signal

From the previous section, we have seen that the acoustic signal may be considered to contain points of prominence. These points of prominence are the word-initial consonant, word-final syllable (actually VC sub-syllable), and stressed syllable. A straightforward relationship between the acoustic signal and TOT would predict that the prominent portions of the acoustic signal would be associated with the fewest lexical errors. This is in fact generally the case. In the TOT data, the portions of the word recalled most accurately are the word-initial consonant, the initial portion of the stressed syllable, and the final portion of the word (VC). Thus those portions of the lexical entry recalled most clearly are exactly those portions of the acoustic signal that are most prominent, with the single exception of the stressed vowel. Whereas stressed vowels are prominent in the acoustic signal, they are apparently recalled no more accurately than expected by chance in the TOT data. In order to adequately account for the TOT data, the selective attention mechanism must be refined to include the initial consonant of the stressed syllable. Then the distribution of lexical errors is predicted by the application of this mechanism during retrieval. Word-initial consonants, stress-initial consonants, and final VC's are attended to more closely during retrieval, and hence are recalled more accurately.
4. Perceptual Errors (SLOE) and the Acoustic Signal

The most straight-forward model of perception would predict that those portions of the acoustic signal that are most prominent would be perceived most accurately; that is, the prominent portions of the acoustic signal should have the fewest perceptual errors. This is not the case in general. Word-final syllables have fewer errors than word-medial or word-initial syllables, and stressed syllables have fewer errors than unstressed syllables, as predicted. But word-initial consonants have more errors rather than fewer errors. The question is, then, what mechanism can be proposed to account for this difference.

In Chapter 3, it was argued that the distribution of lexically-induced perceptual errors implied that the structure of lexical errors was a property of an attention mechanism rather than of storage. It was argued, moreover, that this attention mechanism was applied in perception as well as in recall. Suppose this to be the case. Then this mechanism attends more to the beginning and ends of words and to the beginning of stressed syllables. That is, the terminal and stressed portions of words in the processing of the acoustic signal are more important. If, for whatever reason, one of these important sections is not decoded accurately, then the error will be important in the identification of the signal. On the other hand, if an important portion of the acoustic signal is accurately decoded, this too will play an important role in identification. Thus it is necessary only to suggest a mechanism that favors accurate decoding of final and stressed syllables over initial consonants in order to adequately explain this discrepancy between the patterns of perceptual errors and the acoustic signal. Note that this mechanism corresponds to the role of the acoustic analyzer in the model in Chapter 3.

Such a mechanism has been described by Huggins (1975), Pisoni (1972), and Massaro (1972), among others. They suggest that recognition of a syllable requires from 120 to 250 msecs of processing. Below 120 msecs, accuracy of recognition drops rapidly. Both stressed syllables and final unstressed syllables have durations above the minimum threshold [stressed: 180 to 240 msecs after Umeda (1975, 1977), 200 to 320 msecs after Oller (1973); final unstressed: 80 to 240 msecs after Umeda, 220 to 260 after Oller]. Unstressed initial and medial syllables, however, have durations just at or below the minimum time required for processing [unstressed initial: 90 to 140 msecs after Umeda, 120 to 160 msecs after Oller; unstressed medial: 60 to 130 msecs after Umeda, 120 to 160 msecs after Oller]. Thus there should be more errors on medial and initial
syllables than on final.

Notice that this mechanism does not, on the face of it, completely explain the distribution of perceptual errors found in the data. The mechanism predicts fewer final syllable errors compared to initial and medial; it does not predict fewer medial syllable errors compared to initial syllable errors. The additional mechanism of attention to the beginning and ends of words is necessary to explain the relative increase of errors word-initially. The final syllable tends to be accurately recognized and also to be closely attended; thus the accuracy of recognition word-finally will play an important role in the overall perceptual process, and final syllables will have fewer errors than initial or medial syllables. The initial and medial syllables are accurately recognized less often; since the initial syllable in particular is also attended to closely, the inaccuracy of recognition word-initially will play an important role in the overall perceptual process, and initial syllables will tend to have more errors than medial syllables.

Thus the attention mechanism plays an important role in the prediction of perceptual errors, and should therefore have independent confirmation of its existence. The proposal for its relevancy to perceptual errors is based on two arguments. The first argument claims that the attention mechanism is necessary to explain the distribution of lexically-induced perceptual errors (see chapter 3 and section 4, this chapter); the second claims that the attention mechanism is necessary to explain the distribution of (acoustic) perceptual errors. The first argument would be further supported by showing evidence for the role of the attention mechanism in production errors. Evidence in accord with the second argument has been provided by Cole and Jakimik (to appear), Treisman and Squire (1974), and Cutler (1976).

The structure of the attention mechanism as posited in this study includes increased attention to the initial consonants of words and stressed syllables (as opposed to all other consonants in the word and the initial consonants of unstressed syllables, respectively). Cole and Jakimik (to appear) found that mispronunciations of initial consonants at the beginning of the word were detected more often than word-final consonant mispronunciations, and also that mispronunciations of the initial consonants of stressed syllables were detected more often than unstressed syllable-initial mispronunciations. Treisman and Squire (1974) found in a phoneme monitoring task that word-initial consonants were identified accurately more often than word-final or word-medial consonants. Neither of these studies provides evidence for the necessity of invoking an attention mechanism; rather, they provide
further evidence for the relative importance of word- and stress-initial consonants. This evidence is in accord with the hypothesis of an attention mechanism, but does not distinguish between the attentional mechanism and acoustic cues. A third study, however, does separate out the two possibilities.

Cutler (1976) found, also in a phoneme monitoring task, that reaction time was faster to initial consonants of a stressed syllable than to initial consonants of an unstressed syllable. This was true even though no acoustic cues for stress were present. Stress was indicated instead on the basis of the preceding intonation contour, which predicted the presence or absence of stress on the acoustically invariant word being tested. Only some sort of attention mechanism can explain this result.

To summarize, the distribution of perceptual errors differs from that of lexical errors and from the pattern predicted on the basis of the acoustic signal. There are fewer perceptual errors on word-final syllables and stressed syllables, as predicted, but more on word-initial consonants. A combination of a duration-based processor and an attention mechanism are posited to account for the difference.

5. Summary and Suggestions for Further Research

A model has been proposed that includes one mechanism common to perception and retrieval, and one mechanism specific to perception. The common mechanism is selective attention, in which attention is focused on word- and stress-initial consonants and on word-final syllables (VC). The attention is always focused on the input: in perception on the processing of the acoustic signal, and in retrieval on the lexical item. The mechanism specific to perception involves the processing of the durational components of the acoustic signal (stressed and word final vowels). The general and specific mechanisms interact to adequately predict the distribution of lexical retrieval and perceptual errors, with respect to word and stress patterns.

Two directions for further research seem particularly profitable. If the mechanism of selective attention could be shown to be operative in production errors as well as perceptual and lexical errors, then selective attention might well be part of the underlying processing of language. If, moreover, the mechanism of selective attention were to be related to evidence from psychological experiments, particularly in the realm of short term memory, the model would be further corroborated.
APPENDIX A: TOT Orthographic Transcription and Context

The format of the orthographic transcription is as follows:

N. T-target A-approximation Searcher's initials

The context and elucidations, if any, are continued on the same line on the page facing the transcription.
<table>
<thead>
<tr>
<th>No.</th>
<th>Term</th>
<th>Alternative 1</th>
<th>Alternative 2</th>
<th>Alternative 3</th>
</tr>
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<td>A- Madison</td>
<td></td>
<td></td>
</tr>
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<td>2</td>
<td>T- distances</td>
<td>A- differences</td>
<td>R. H</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>T- tentativeness</td>
<td>A- hesitancy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>T- Hartshorn</td>
<td>A- Cornford</td>
<td></td>
<td></td>
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<tr>
<td>5</td>
<td>T- &quot;</td>
<td>A- Cairnross</td>
<td></td>
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<tr>
<td>6</td>
<td>E</td>
<td>E A- Korner</td>
<td></td>
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<td>A- Rogers</td>
<td></td>
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<tr>
<td>9</td>
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<td>A- antler</td>
<td></td>
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<td>T- &quot;</td>
<td>E A- Hornblower</td>
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<tr>
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<td>T- tone</td>
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<td>T- warlock</td>
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<td>M.M.(1)</td>
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<td>A- Mazda</td>
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<td>sic A- Perseus</td>
<td>L.R.</td>
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<td>A- Heidinger</td>
<td>C.B.</td>
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<td>A- Heissinger</td>
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<td>T- Arthur</td>
<td>A- Ron</td>
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<td>A- Congress</td>
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<td>E A- Corinth</td>
<td>R.B.</td>
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<td>A- Bowman</td>
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<td>A- Bauerman</td>
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<td>A- Barnett</td>
<td>T.S.</td>
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<td>A- Basman</td>
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<td>A- bricabrac</td>
<td>V.W.</td>
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<td>A- Rinaldi</td>
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<td>36</td>
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<td>A- live</td>
<td>A.F.</td>
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<td>T- vivid</td>
<td>A- vital</td>
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<td>38</td>
<td>T- vivid</td>
<td>A- vibrant</td>
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<td>39</td>
<td>T- speculum</td>
<td>A- suppository</td>
<td>V.W.</td>
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<td>40</td>
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<td>A- clucksbill</td>
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<td>T- paradigm</td>
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<td>A- diagraph</td>
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<td>46</td>
<td>T- paradigm</td>
<td>A- dichotomy</td>
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<td>47</td>
<td>T- Barnes</td>
<td>A- Clarke</td>
<td>A.F.</td>
<td></td>
</tr>
</tbody>
</table>
in discussion about Montana and Wisconsin
"difference between these 2 differences"

T: Charles Hartshorn. Searcher consciously parsed the last name. A: philosopher
A: philosopher

A: Karl Rogers

"tone it down" re. sarcasm
T: a scan converter, searcher retrieved after picturing company logo to self.

T: name of a friend's cat
T: wine. Searcher knew number of syllables.

T: Talking about coins in a collection—trying to find name of city covered by volcano
Searcher pictured conditions, city on side of volcano, then eruption. Vesuvius.
T: Heisenberg's uncertainty principle A: composer
A: Heidegger perhaps intended?

T: Street name, searcher didn't get.

T: Searcher's dentist. Searcher "knew" there were 3 syllables, initial stress.

After saying "contribute" earlier
A: After driving on the street named Rinaldi.

Searcher didn't get

T: A folder. Searcher didn't get
| 48. | T- Pompeii               | A- Ptolemy              | L.R. |
| 49. | T- Pompeii               | A- pilaf                |     |
| 50. | T- Jennifer             | A- Jessica              | L.J. |
| 51. | T- Bressler             | sic                     |     |
| 52. | T- Bressler             | A- Bollinger            |     |
| 53. | T- chrysanthemum        | A- Bossinger            |     |
| 54. | T- manzanita            | A- carnation            | A.F.|
| 55. | T- exhaust              | E- Modigliani           |     |
| 56. | T- exhaust              | A- expire               | B.M.|
| 57. | T- disintegration       | A- exploit              |     |
| 58. | T- Chris                | A- degradation          | B.M.|
| 59. | T- manzanita            | A- Charles              |     |
| 60. | T- Madrone              | A- manitou              |     |
| 61. | T- acronym              | A- Mandrake             |     |
| 62. | T- auburn               | A- anachronism          | M.J.|
| 63. | T- auburn               | A- aurora               |     |
| 64. | T- auburn               | A- artichoke            | L.J.|
| 65. | T- auburn               | A- amber                |     |
| 66. | T- auburn               | A- brunette             |     |
| 67. | T- tonus                | A- tenor                | L.R.|
| 68. | T- tonus                | A- velum                |     |
| 69. | T- catenary             | A- caterwauled          |     |
| 70. | T- catenary             | A- cantilevered         |     |
| 71. | T- D.H. Lawrence        | A- Dylan Thomas         |     |
| 72. | T- prescribe            | A- prognosis            |     |
| 73. | T- Mona Lindau          | A- Myrna Loy            |     |
| 74. | T- fern                 | A- violet               |     |
| 75. | T- Kelliherr            | A- Kinelly              |     |
| 76. | T- Olivia Hussey        | A- Simone Signoret      |     |
| 77. | T- Olivia Hussey        | A- Baba Rossa           |     |
| 78. | T- Olivia Hussey        | A- Sylvia Synder        |     |
| 79. | T- Kelliherr            | A- Kennedy              |     |
| 80. | T- Olivia Hussey        | A- Betty Hutton         |     |
| 81. | T- Olivia Hussey        | A- Olivia de Havilland  |     |
| 82. | T- consequences         | A- circumstances        | M.H.|
| 83. | T- consequences         | A- coincidences         |     |
| 84. | T- DiMaio               | A- Malpere              |     |
| 85. | T- DiMaio               | A- Mavis                | F.R.M.|
| 86. | T- DiMaio               | A- Louvis               |     |
| 87. | T- DiMaio               | A- Meyer                |     |
| 88. | T- syllogism            | A- synergy              | S.P.|
| 89. | T- perseverance         | A- stubborn             | J.M.|
| 90. | T- perseverance         | A- tenacious            |     |
| 91. | T- confusion            | A- configuration        | M.H.|
| 92. | T- expediency           | A- existentialist       | M.H.|
| 93. | T- expediency           | A- epistemology         |     |
| 94. | T- expediency           | A- epidemiology         |     |
| 95. | T- expediency           | A- egghead              |     |
| 96. | T- expediency           | A- experiential         |     |
| 97. | T- expediency           | A- eminent              | M.H.|
| 98. | T- expediency           | A- entropy              |     |
| 99. | T- expediency           | A- elegant              |     |
| 100.| T- expediency           | A- empiricist           |     |
| 101.| T- expediency           | A- elemental            |     |
| 102.| T- expediency           | A- evident              |     |
A perpetual confusion for the searcher.
T: Stan Bressler, a computer specialist. A: A linguist

T: Restaurant  A: Restaurant
A: A parrot's name
A: Restaurant
A: Friend's maiden name

T: Synonym of opportunist. A perpetual difficulty for the searcher.
103. T- confederation
104. T- Goldman Eisler
105. T- croquet
106. T- croquet
107. T- Ingo
108. T- Ingo
109. T- Ingo
110. T- Ingo
111. T- ice plants
112. T- magnifying glass
113. T- magnifying glass
114. T- Nathaniel
115. T- Nathaniel
116. T- Nathaniel
117. T- Nathaniel
118. T- velcro
119. T- velcro
120. T- velcro
121. T- Bristlecone
122. T- tungsten
123. T- Quine
124. T- Quine
125. T- Quine
126. T- confetti
127. T- Bartlett
128. T- Bartlett
129. T- suppletive
130. T- Wineberg
131. T- National
132. T- National
133. T- bibliography
134. T- initials
135. T- Fulton's Steamboat
136. T- etymology
137. T- etymology
138. T- etymology
139. T- etymology
140. T- etymology
141. T- furious
142. T- tangerine
143. T- tangerine
144. T- ellipsis
145. T- carrots
146. T- interpreter
147. T- suspicious
148. T- Thanksgiving
149. T- calque
150. T- Nicol
151. T- Watanopa
152. T- Watanopa
153. T- tickets
154. T- bonus
155. T- Spencer

A- brotherhood
A- Goldwin Meyer
A- crochet
A- cricket
A- Olaf
A- Sven
A- Nils
A- Ingmar
A- water- weeds
A- microphone
E A- microscope
A- Alexander
A- Nicholas
A- Jonathan
A- Peter
E A- teflon
A- tygon
A- zelcron
A- Brandywine
A- titanium
A- Orwell
A- orgone
A- Chomsky
A- graffiti
A- Hockett
A- Bloomfield
A- depleted
A- Greenberg
A- American
A- Americana
A- vocabulary
A- syllables
A- Fulton's Fishmarket
A- ethnology
A- empitology
A- entomology
A- emptimology
A- emtyology
A- furor
A- mandarin
A- nectarine
A- elliptics
A- lettuce
A- innovator
E A- suspect
A- San Francisco
A- copout
A- Cobil
A- Wínona
A- Topanga
A- tissues
A- burden
A- Stewart

106
T: "Lady who wrote the book 'Psycholinguistics: Experiments in...
"

T: name of person the searcher worked with briefly

T: Name of Martha and Steven Johnson's son. on the way said "Stephen - no that's It's a New England old folks at home home". After "Peter", (the father. I said "you know the letters", and she got it.

in same conversation
"
"
T: tree searcher has visited. A: restaurant searcher has visited.


T: Author of psychology text "Remembering". Searcher a linguist.

T: Lee Wineberg
T: National Blvd. in West LA by linguistics 1 student. Did not retrieve correctly.

A linguist.
"Since I've been in China I've been talking in syllables" meaning initials. A linguist. A New Yorker and linguist.


"Some sort of elliptics". Linguist "lettuce and celery"
"She is not a real folk singer but an outstanding innovator (of other people's work)"
"become suspect"
"What are you doing for San Francisco?" Californian.
"A left-over from Latin"
T: Name of language A: like Cobol? Linguist and programmer
T: Camp Watanopa A: Name of grade school acquaintance! (meant to be Indian) A: Name of present city. Indian? Referring to a concert "It was an added burden" perhaps?
T: G. Spencer Brown, philosopher. Didn't get.
| 156. | T- preoccupied | A- preemptive | M.M. (1) |
| 157. | T- Panza | A- Poncho | |
| 158. | T- Boojum | A- Cajon | C.B. |
| 159. | T- Boojum | A- Ocotillo | |
| 160. | T- dinosaur | A- dodo | J.G. |
| 161. | T- dinosaur | A- alligator | |
| 162. | E A- brontosaurus | | |
| 163. | T- allergy | A- glurm | |
| 164. | T- allergy | A- mung | J.G. |
| 165. | T- allergy | A- hay-fever | |
| 166. | T- Whitman | A- Harvard | |
| 167. | T- Whitman | | |
| 168. | T- Whitman | A- Wisconsin | |
| 169. | T- Terminal | A- Telegraph | |
| 170. | T- Terminal | A- Federal | C.B. |
| 171. | T- Terminal | A- Telemann | |
| 172. | T- Terminal | A- Telemark | |
| 173. | T- animal cracker | A- crackerjack | W.W. |
| 174. | T- Fernwood | A- Ferndale | R.C. |
| 175. | T- pronoun | A- preposition | |
| 176. | T- contraction | A- conjugation | L.R. |
| 177. | T- scatological | A- scurrilous | T.M. |
| 178. | T- conflict | A- interfere | |
| 179. | T- conflict | A- control | |
| 180. | T- conflict | A- correspond | T.G.? |
| 181. | T- conflict | A- clash | |
| 182. | T- conflict | A- hinder | |
| 183. | T- Ghirardelli | A- Garibaldi | |
| 184. | T- Ghirardelli | A- Gabrielli | L.R. |
| 185. | T- Ghirardelli | A- Granatelli | |
| 186. | T- vivid | A- tepid | C.B. |
| 187. | T- discursive | A- discourse | L.G. |
| 188. | T- needle | A- snub | L.G. |
| 189. | T- Wendy | A- Vicki | C.B. |
| 190. | T- singled | A- centered | |
| 191. | T- singled | A- pointed | |
| 192. | T- singled | A- cornered | J.O. |
| 193. | T- singled | A- selected | |
| 194. | T- singled | A- fingered | |
| 195. | T- singled | A- picked | |
| 196. | T- singled | A- landered | |
| 197. | T- singled | A- sidled | |
| 198. | T- singled | A- fendered | |
| 199. | T- jacaranda | A- japonica | C.B. |
| 200. | T- Shakey | A- Sparkey | C.B. |
| 201. | T- Sparkey | A- Snappy | F.R.M. |
| 202. | T- Sparkey | A- Sharkey | C.B. |
| 203. | T- decomposition | A- degeneration | |
| 204. | T- decomposition | A- declustering | |
| 205. | T- Atkinson | A- Anderson | |
| 206. | T- Plato | A- Socrates | J.H. |
| 207. | T- Bond | A- Bow | P.L. |
T: Sancho Panza
T: desert plant in Baja  A: pass in San Bernadino into Mojave Desert
A: desert plant - tall and skinny and spiny-very similar
trying to think of word to adequately describe some academic-administrator types!

question "did you ever have your blood cholestrol checked?" Answer: "yes last
year when I had some tests for, um--""glurm( a nonsense word in my vocabulary
denoting physical ailment, flu, cold, etc)" "mung(a syn. for l, but of stronger emphasis
(on the epithelial discharge factor)"
"Where did Jean Gleason begin her work?" (actually, it was the aphasia res. unit in Boston

A: perhaps Telegraph Hill? T: Terminal Island in LA, Ca. Searcher thinks there is
a prison there, as in A: Federal Island in NYC.
A: A composer. Searcher lived in CA. near NYC, was musician and skied
A: A ski turn

T: Fernwood Pacific, street where friend lived
by linguist

T: "this class won't conflict with any other"

T: Ghiradelli Square in San Francisco, Didn't get it.

re. talking a lot
T: needle nose pliers
Searcher knows a Vicki and a Wendy, both linguists
"Verb-plus-preposition 'out' meant 'emphasized', 'focussed on', 'to set off from
the rest.' The images that came to mind of contexts in which the word would
be used were: God choosing someone from among a crowd; a teacher choosing someone
in a class (to do something, Other synonymous expressions: 'concentrate on'
or 'isolate from a group"

Didn't get- knew had 4 syls. and ended in -a.
T: Shakey the Robot  A: Sparkey the Magic Piano??
T= above Approx. "Sparkey"
T= above Approx. "Sparkey"
-------- of consonant cluster

"My grandmother was born on Bow Street"
208. T- Mulenberg
209. T- mendacious
210. T- mendacious
211. T- mendacious
212. T- mendacious
213. T- mendacious
214. T- Irridentist
215. T- Irridentist
216. T- opportunist
217. T- expedient
218. T- expedient sic
219. T- expedient
220. T- expedient
221. T- facilitation
222. T- John Coltrane
223. T- Slaughterhouse Five
224. T- Slaughterhouse Five sic
225. T- cigar
226. T- Mignon Eberhardt
227. T- cosmopsis
228. T- immovable
229. T- evocation
230. T- aorist
231. T- Kelyn
232. T- brush off
233. T- brush off
234. T- brush off
235. T- brush off
236. T- brush off
237. T- brush off
238. T- brush off
239. T- brush off
240. T- brush off
241. T- brush off
242. T- brush off
243. T- brush off
244. T- susceptible
245. T- competent
246. T- competent
247. T- Feynman
248. T- autistic
249. T- Fullerton
250. T- fossils
251. T- fossils
252. T- colloquial
253. T- colloquial
254. T- colloquial
255. T- colloquial
256. T- Kucera
257. T- paragoge
258. T- pilchard
259. T- Sheve

A- Mulesborough
A- mendicant
A- mentir L.G.
A- mendicant
A- mensage
A- mensoge
A- recidivist S.F.
A- revanchist
A- obsolescent M.H.
A- experiential
A- ecdysiast M.H.
A- exponent
A- easy chair
A- reverberating L.G.
A- Cannonball Adderley D.M.
A- Staag Seventeen C.M.
A- Farenheit Fortyfifty one
A- guitar R.H.
A- filet B.L. (2)
A- cosmopolis C.B.
A- indecisive L.G.
A- equivocation abstract file
A- aorta C.B.
A- Keenan C.B.
A- banish
A- bar
A- bash D.M.
A- beta
A- blank
A- destroy
A- blot
A- bring down
A- blight
A- black out
A- blast
A- brand
A- submissive D.M.
A- efficient D.M.
A- dependable
A- Venneman D.M. (2)
A- anaphoric L.G.
A- Ferguson
A- zeniths M.B.
A- Watusis
A- colloidal
A- collateral C.B.
A- collocation
A- cloacal
A- Kierkegaard C.B.
A- agoge C.B.
A- mackerel I.M.
A- Sheri S
"synonym for liar"
"French"
cued on stress. then "mendacious—but that's not a word"
"French"
"French"

T: other word that goes with "opportunist"; recurrent TOT

T: effect after psychological fatiguing
Jazz musician
Talking about shorts of old bldg. in King of Hearts. Another movie with beautiful
After #1, "O no, it was science fiction." After #2, (shots of an old town.
"it was Vonnegut, o yeah, it was the name of a kind of building like a bunker" got it.
225. "He whips out a guitar, I mean a cigar"
226. T: a mystery writer

T: Kelyn Roberts
T: brush off a theory

A: Hausa for "spoil"

A: as in "blot out"

re downdrift: "hi tones are ___ to low tones"

T: physicist A: linguist; by psycholinguist (psychologist)
did not get
T: UC, where Geri Anderson teaches (did not get)

saw mackerel in flat tin, wrong shaped tin, should be tall, narrow, no label
with fish curving ♂ , like that other one—pilchard! tried to remember for 4 years.
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<td>T- Sheve</td>
<td>A- Shenni</td>
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<td>T- Bajiyas</td>
<td>A- Bajari</td>
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<td>T- Bajiyas</td>
<td>A- Bajati</td>
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<td>T- pantomime</td>
<td>A- panoramic</td>
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<td>T- reckoning</td>
<td>A- restitution</td>
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<td>sic T- prestor</td>
<td>A- preacher</td>
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<td>A- Sylvia</td>
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<td>T- Gruber</td>
<td>A- Bever</td>
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<td>T- Pyrex</td>
<td>A- Kotex</td>
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<td>271.</td>
<td>T- Strangelove</td>
<td>A- Lonely.hearts</td>
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<td>T- Leggwater</td>
<td>A- Licklider</td>
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<td>273.</td>
<td>T- Schegloff</td>
<td>sic A- Schiaparelli</td>
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<td>274.</td>
<td>T- blinders</td>
<td>A- blinkers</td>
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<td>275.</td>
<td>T- Carl</td>
<td>A- Clarence</td>
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<td>T- Kryter</td>
<td>A- Kresge</td>
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<td>277.</td>
<td>T- Kryter</td>
<td>A- Karlovich</td>
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<td>278.</td>
<td>T- Schweitzer</td>
<td>A- Einstein</td>
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<td>279.</td>
<td>T- Schweitzer</td>
<td>A- Bethune</td>
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<td>280.</td>
<td>T- Schweitzer</td>
<td>sic A- Schoepenauer</td>
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<td>281.</td>
<td>T- Stickgold</td>
<td>A- Goldberg</td>
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<td>282.</td>
<td>T- proscenium</td>
<td>sic A- praesidium</td>
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<td>283.</td>
<td>T- Tebaldi</td>
<td>A- Rinaldi</td>
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<td>284.</td>
<td>T- Grover Hudson</td>
<td>A- George Bever</td>
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<td>285.</td>
<td>T- Phyllis McGinley</td>
<td>A- Peg Bracken</td>
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<td>286.</td>
<td>T- McGinley</td>
<td>A- McGracken</td>
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<td>287.</td>
<td>T- Kung Fu</td>
<td>A- FuManchuy</td>
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<td>288.</td>
<td>T- Kung Fu</td>
<td>A- Chiang.Kaishek</td>
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<td>289.</td>
<td>T- binomial</td>
<td>A- binary</td>
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<td>290.</td>
<td>T- binomial</td>
<td>A- bimodal</td>
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<td>291.</td>
<td>T- Wickelgren</td>
<td>A- Winograd</td>
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<td>292.</td>
<td>T- Frisian</td>
<td>A- Faroese</td>
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<td>293.</td>
<td>T- Salzinger</td>
<td>A- Selzer</td>
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<td>294.</td>
<td>T- Alabama</td>
<td>A- ambush</td>
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<td>295.</td>
<td>T- Alabama</td>
<td>A- avalanche</td>
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<td>296.</td>
<td>T- Austin</td>
<td>A- Ashley</td>
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<tr>
<td>297.</td>
<td>T- bracero</td>
<td>A- sombrero</td>
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<td>298.</td>
<td>T- bracero</td>
<td>A- ranchero</td>
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<td>299.</td>
<td>T- Rex Harrison</td>
<td>A- Rock Hudson</td>
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<td>300.</td>
<td>T- Will Rogers</td>
<td>A- Woodrow Wilson</td>
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<td>301.</td>
<td>T- Hogan</td>
<td>A- Segal</td>
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<td>302.</td>
<td>T- Roy Acuff</td>
<td>A- Roy Kinkaaid</td>
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<td>T- Schachter</td>
<td>A- Chaha</td>
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<td>304.</td>
<td>T- compatibility</td>
<td>A- coherence</td>
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<td></td>
<td>sic</td>
<td>A- Savannah</td>
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<td>305.</td>
<td>T- Santa Anna</td>
<td>A- axiomatic</td>
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<td>306.</td>
<td>T- differential</td>
<td>A- algebraic</td>
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<td>307.</td>
<td>T- differential</td>
<td>A- analytical</td>
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<td>308.</td>
<td>T- differential</td>
<td>A- Fortran</td>
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<td>T- Hopkins</td>
<td>A- Norfolk</td>
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<td>310.</td>
<td>T- Hopkins</td>
<td>A- Hawkins</td>
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<td>311.</td>
<td>T- Hopkins</td>
<td>A- affidavit</td>
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<td>312.</td>
<td>T- ficta</td>
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After Neve "Oh that's right, she's from someplace else"

Looking for the name of an Indian? Dollie gave her "I did it by hearing you say it"

In drama class, told to do pantomime."I have to do some—oh you know—panoramics, no, that's not right, pantomimes

T: Jeffrey Gruber. by linguist

T: (Dr.) Strangelove A: (Miss) Lonely Hearts: movies

"A friend was telling a group of us about someone who was getting too excited
T: Carl Lavelle (about something, and she suggested that the person
    (should get some 'blinkers'"

T: Art Stickgold (Jewish)

T: Renata Tebaldi
T: Linguist A: (Tom) Bever psycholinguist, by linguist

Didn't get. By mathematical psychologist

T: (Wayne) Wickelgren A: (Terry) Winograd
T: Language A: Language. by linguist

T: Alabama Hills, where many western movies have been made
T: Restaurant

T and A: movie stars
T: Will Rogers State Beach
T: political name
T: country singer A: actually Bradley Kincaid
T: Linguistics professor

T: The winds that blow in the fall (in Los Angeles)
T: Differential geometry

"sandals made of Fortran" by programmer
T: proper name
T: in music
313. T- ficta
314. T- Stroop
315. T- Dick
316. T- Dick
317. T- Kirsten
318. T- antistrophe
319. T- antistrophe
320. T- reticule
321. T- paprika
322. T- paprika
323. T- macrobiotic
324. T- macrobiotic
325. T- macrobiotic
326. T- complementary
327. T- complementary
328. T- esoteric
329. T- esoteric
330. T- selfish
331. T- selfish
332. T- consultation
333. T- consultation
334. T- consultation
335. T- consultation
336. T- consultation
337. T- improvise
338. T- improvise
339. T- improvise
340. T- Fries
341. T- Fries
342. T- Jerry
343. T- Tristana
344. T- Tristana
345. T- Tristana
346. T- Tristana
347. T- Tristana
348. T- Amy
349. T- Deese
350. T- Boccherini
351. T- Boccherini
352. T- Aaron
353. T- Betsy
354. T- Sandy
355. T- Cathe
356. T- Cathe
357. T- compunction
358. T- Stevenson
359. T- Berendo
360. T- self sufficiént
361. T- paradigm
362. T- Hiroshima
363. T- palimpsest
364. T- palindrome

A- infinity
A- spoof
A- Bill
A- Bob
A- Kirsch
A- antiphone
A- antipode
A- periwig
A- pepper
A- pimento
A- bio
A- bio organic
A- bionic
A- enhance
A- overlap
A- exotic
A- elaborate
A- jealous
A- modesty
A- coordination
A- committee
A- meeting
A- conclusion
A- relation to
A- inovation
A- makeshift
A- making do
A- fried
A- sied
A- Larry
A- Tristesee
A- toujours
A- dulcima
A- tristeza
A- Belle de Jour
A- May
A- Reese
A- cherubim
A- Clemente
A- Adam
A- Becky
A- Sharon
A- Karen
A- Laurie
A- compulsion
A- Sullivan
A- Bronson
A- self-sustaining
A- lexicon
A- Kemo-sabe
A- palindrome
A- paideuma
T: type of psychological experiment
T: Dick Moore?? (on letter from mutual friend)

T: Small purse used in 17th and 18th centuries by ladies to keep their pomades in. T: from Dagwood cartoon, attempt- (Someone said "diced ginger", then T (ing to recall to report to me.

Sudden flash, 8 hours later

In Australia 9 years

In Australia 3 years

T: Linguist

T: Movie by Buñuel A: Bonjour Tristesse
Spent 2 hours thinking

"Something about sadness, it's her name"

T: (Eran) Zaidell

"without any ---"
T: brand name for tent
LA street names, in Hollywood

"motivation for inserting the ---"; by linguist

A; Greek for substance of existence
Phil Lieberman, a phonetician
name of street equal stress (on A?)
talking about a paper someone wrote on a topic very interesting to searcher
who also thinks that they (i.e. the searcher) have a better analysis. "I
hope he publishes it because then I could write a ___".

Calico Hills

Lake Louise
car name (in fraud incident)

Name of city where mathematician teaches in upstate New York
Name of college for above

"Science and other ____"
"quarried (your next question)"

Jon Feldman (searcher"doesn't know a Feldman"
Congestive heart failure A: stuffed-up heart

was talked about immediately prior

Didn't get
Didn't get
Street name

trying to remember a recipe name: wilted spinach
trying to remember the above source in writing down
"as a habit [pause-realized wrong] of course" T: "As a matter of course".
on Seconal. in context of food. on Seconal.

Over course of 3 hours
418. T- Emmaus
419. T- Cries and Whispers
420. T- Pick your brain
421. T- Nathan's
422. T- Suez
423. T- algorithm
424. T- algorithm
425. T- algorithm
426. T- microtome
427. T- microtome
428. T- exposition
429. T- limbic
430. T- quarterback
431. T- quarterback
432. T- Musto
433. T- Musto
434. T- Mathus
435. T- script
436. T- Twyla Tharp
437. T- glaucoma
438. T- stake
439. T- stake
440. T- Dennis the Menace
441. T- obliterating
442. T- obliterating
443. T- obliterating
444. T- hustle
445. T- hustle
446. T- hustle
447. T- metaphor
448. T- Glover
449. T- Bird of Paradise
450. T- ear
451. T- hopper
452. T- Delphi
453. T- La Valencia
454. T- La Valencia
455. T- conflict of interest
456. T- conflict of interest
457. T- conflict of interest
458. T- conflict of interest
459. T- conflict of interest
460. T- neural
461. T- neural
462. T- Load and Ladle
463. T- Nita
464. T- Nita
465. T- Kitty
466. T- Lori
467. T- Seljuk
468. T- arbitrary
469. T- arbitrary
470. T- arbitrary

sic 418. A- Crimea
419. A- Loves and Kisses
420. A- bleed your mind
421. A- Norman's
422. A- Sinai
423. A- hieroglyphic
424. A- astrolung
425. A- euphemism
426. A- trichonoma
427. A- metronome
428. A- exhibition
429. A- lymphatic
430. A- rightguard
431. A- halfback
432. A- Malthus
433. A- Wolfesey
434. A- Malthus
435. A- score
436. A- Trisha Brown
437. A- ophthalmia
438. A- stock
439. A- stack
440. A- Peanuts
441. A- obfuscating
442. A- obviating
443. A- obliviating
444. A- huddle
445. A- hurdle
446. A- hobble
447. A- analogy
448. A- Geller
449. A- Firebird
450. A- tongue
451. A- hamper
452. A- Mecca
453. A- La Fantasia
454. A- hacienda
455. A- split personality
456. A- divided attention
457. A- torn heart
458. A- conflict
459. A- fight between ideas
460. A- neuronal
461. A- neurotic
462. A- Bowl and Board
463. A- Niki
464. A- Rita
465. A- Nicki
466. A- Tony
467. A- Selknam
468. A- artificiality
469. A- absurdity
470. A- ambivalence
Ques: What's a recent Bergman film. A: "about 2 years old? Kisses?" no, it's "I want to ___" (something linguist and something, they're plural and have sibilants. A - that's a Bergman motif"

T: Suez Canal
T: Flow about I case of T. "A determinate list of instructions that shows branching. A Turing machine"

T: Exposition Park (alcoholic)

T: Author on cocaine re. Sherlock Holmes A: Jane Malthus, screen writer re. Valentino
A: Author on lateralization in infants
A: Correct name is Jane Mathus not Jane Malthus didn't get

"I stock .... stack ... what is it you do when you want to get rid of your reputation ... stake!"
"that little kid"

"like analogy in semantics" linguist
T: Bonnie Glover (didn't get) A: Bonnie Geller

T: Slips of the ear A: Slips of the tongue

T: hotel
"I have a _____"

_____ living
T: restaurant

T: Turkish tribe A: language of S.A. linguist
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during a talk on Hawaiian Creole "they will attempt ... admit ... claim that
(they don't speak this language"
T: name of book - thought based on song A.
T: Susan Havillard
T: C.B.'s sisters name

T: pastry Proust effectively wrote a book about. A: a dentist
(in same effort as above)

T: computational linguist A: psycholinguist; searcher a psycholinguist
(Jonas says this is a common mistake)
## APPENDIX B: TOT Phonetic Transcription

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<tr>
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</table>

Segments used in transcription: IPA and ARPABET
APPENDIX C: SLOE Orthographic Transcription and Context

The format is as follows:

N. production context/error/context N. misperception error

The production transcription includes as much context as was reported. The portion actually misperceived is isolated between slashes (/error/). The misperception transcription includes only the misperception, and no context, since the context is identical for production and misperception. Thus the misperception transcription corresponds to the portion of the production isolated between slashes. If no context was recorded, the production also appears without slashes:

N. error

If the context is identical for two consecutive items, then the second item refers to the context of the first by using [ditto]:

\[ N_1: \text{context/error/context} \quad N_2: \text{[ditto] error}_2 \]

In this case the context for \( N_2 \) is the same as for \( N_1 \).
LOOKS VERY /WIDE/
YOU WONT HAVE TO PUT /APPLES/ DOWN.
FEATURE DETECTORS
THATS /BROAD/ ON MY NOSE
[ DITTO ] BROAD
[ DITTO ] BROAD
YOU MAY HAVE THE /REST/ OF IT
REAL HYPOCRITE
/DOLLIE/ TOMORROW
MAJORCA
JOURNAL
WHAT /DO YOU DRINK/
TALK /ON THE PHONE/
BARCELONA
MADRID
/RECIPES/ FOR A SMALL PLANET
WONT BOTHER ME
SENTENCES
ENTROPY
YES NO
WHOSE TEA THAT IS
Ratatouille
ACOUSTICAL SOCIETY
NEEDLES
FUDGE
FULL REEL
VIOLIN
SENSORIC
/ITS/ DOWN AT
IF ONE /IS NEUROTIC/ ABOUT
/ORGAN/ PIPE CACTUS
BILL /MOVERS/
PRIVATEER
SHE LIVED IN /OAKLAND/ FOR 3 YEARS.
DO YOU LIKE /PULP/ IN YOUR ORANGE JUICE?
THE /NATIONAL/ LANGUAGE OF THAILAND
/HORSE/ TRANQUILIZER
HOLLYWOOD /SHIETS/
CHIMPS
IM NOT /REALLY INSPIRED/ THO.
A /VIVACIOUS/ /SOUNING FEMALE
A /SIMPLE/ AND UNDECORATED NAME
/FREUDIAN/ SLIPS
A WISE OLD /BARD/ ONCE SAID
DO YOU WANT SOMETHING TO /READ/?
THIS, F*CKING, /VAN/ DOESNT WORK

BLIND
UP WITH
FRIGIDITY
BOARD
POOR
RAW
REST
RAHOBRAHAT
DAWN OF
MALAGA
TURTLE
ARE YOU DOING
ABOUT FOOD
CARCINOMA
MAGRITTE
BREASTPIECE
LOBOTOMY
SONS
ENTRANCE WAY
S NODE
WHO S TEETHING
ON THE WHEEL
COUS-COUS
NOODLES
FRENCH
FOVEAL
MANDOLIN
SOMATIC
I WAS
ISNT IRONIC
ORCHID
MORRIS
PROFITEER
OATMEAL
COKE
NATURAL
WHOSES
SHIETS
SHRIMPS
LOOKING AT SPIDER
VIOUS
SINPUUL
ACCORDIAN
FART
EAT
FAN
THE PROGRAGE'S INSENSITIVE
I'LL SEE YOU NEXT WEEKEND
I'LL SEE YOU AFTER COLLOQUIUM
JUST SAVING FILES
IT KEEPS MY HEAD WARM
FROMKIN
STICKGOLD
INTELLECTUAL FADDIST
LADEFOGED
LADEFOGED
THE GARRETT PAPER
POPPING REALLY SLOW
BUY A CHEAP CHEAP
LUSH VERDANT GARDEN
PHONEME
SAN XAVIER
LIMITED BANDWIDTH
JUDAH SCHWARTZ
JUDAH SCHWARTZ
NEUROLEPTIC
WHERE ARE YOUR FLOWER SEEDS?
THAT'S A GLASS KNIFE
WANT SOME CAKE
PUBLICATIONS
I'M NOT GONNA WIRE IN WATERGATE
DOES ANYBODY HAVE A CAHYF OF COGNITION?
IS HE LOOKING FOR 100 MEMORIAL DRIVE
ASSISTANT
KORFEE
DID YOU PUT YOURSELF DOWN AS A DEPENDANT
BOOK ON LEARNING
I'M GONNA GET THE ERASER
NOT A LOT OF HARD FACTS ARE KNOWN
TRANSCRIPTION
MINUS RED
THE TRAITORS
LOOP HOLE
HAVE YOU EVER BEEN ON A SNIFLE HUNT
I USED TO HAVE A VERY EXTENSIVE BIBLIOGRAPHY
I'VE NEVER HAD AN EISWEIN
HI I'M JOHN'S FACE
SHE'S GOT HERPEZ ZOISTER
DO YOU KNOW WHERE THERE'S A NOTARY PUBLIC
I WAS APPRISED THAT
A RECENT RECORDING OF THE MUSICAL HERITAGE SOCIETY
(DITTO) HERITAGE
YOU MEAN YOU HAVE A REFT LIGHT PROBLEM
PROGRAM IS SET UP
WEEK THEN
ABOUT FOUR THEN
SEEING IF IT COMPILES
YOU MAY HAVE ONE
FRANKLIN
STICKLE
SADIST
LADY FOGED
LADDIE FOGED
CARROT
PRODIAL SON
VIR EGYPT
VIRGIN
FUNNY
SANTA VIER
FATHER'S
NUTS
CAR
COMPLICATIONS
IRE
COPY
HALL
HIS SISTER
PORFEE
DEFENDANT
ALERTING
RAZOR
ARTIFACTS
TRANSFICATION
LINE SPREAD
TREASURERS
POLE
SNY PUNT
EXPENSIVE
A NICE NINE
JOHN SPACE
HER PEAR OYSTER
NOTA REPUBLIC
SURPRISED
PARITY
PARITAGE
LEFT
WHY DON T YOU TAKE THAT.
I TALKED /HIS EAR OFF/.
The /DICK LINDA MESS/
HIS MOTHER /NOW/ LIVES
WHAT A VETCHY PLACE
CHARLOTTE S
PLEASE, DONT PUT MY /PLANT/ IN A PAPER BAG.
THIS HAS /GOTGA BE LUDICROUS/
I LL /SHOOT/ FOR LUNCH
YOU /OUT TO/ CHECK OCCASIONALLY.
I GET MY /TEETH CLEANED/ TODAY.
I M GOING TO HAVE CLEAN TEETH BY TONIGHT.
TURPENTINE
LOVE POEMS ABOUT /CHEESES/
APPLES
IS IT /FOR AN OCCASION/?
FORNICATION
LEFT DISLOCATION
QUESTION FOR /BARNIE/
STOP /BEATING/ YOUR HEAD AGAINST A BRICK WALL
HE S HEAD & TAILS ABOVE THE /REST/.
RIGHT-TO-KNOW ACT
DRAWSAID-REISSEN LEAD/
SAY GOOD NIGHT TO BONNIE
S-P-A-N-/DOT-2-A
ALL YOU NEED IS A /BOWLER/
TESTABLE THEORIES
EVERYBODY IN THE /ASA/
GO DOWN TO /ASA/ OFFICE
IT S /EAR TRAINING/
IF I HAD ANY ENERGY AT ALL IT WOULD BE PERFECTLY /FINE/
HE FORGOT HIS /KEYS/
VALLEY VIEW
I WANT TO /MEET/ HER.
ACCUMULATING /SHELLS/
I M GOING TO /DRAW A FEW/ DOTS BEFORE THE...
SLOWING
NOEL COWARD
I VE GONE SOMEWHERE /DURING RUSH HOUR/
ABOUT /ANATOMY/
DID YOU /NOT WANT THAT NEW YORK BACK/
TEACH /YOURSELF HAUSA/
BOILING AND /BARKING/
GIN /RUMMYS/
SATIE
SCRIBIN
I GOTTA /GO TO THE CAR AND GET THE TUNA/.
TAPE
TO ZERO
DEGLINDA MASS
IN LAW
WHERE DID SHE GET THE SPACE
SCHULTZ
CLIENT
CONVOLUDICROUS
EXCUSE
GOT TO
TEASPOON
MY TEA BUTTER KNIFE
MARTIN SHEEN
JESUS
EXAMPLES
FORNICATION
FOR AN OCCASION
LEFTIST LOCATION
BONNIE
EATING
BREAST
NORM
RECENTLY
YOU HAVE A NICE BODY
AND
REVOLVER
TESTICLE
ASC
SAS
RAINING
DEFINED
SKIS
FELLINGHAM
PAT
SHELVES
DRIVE YOU
FLOWING
ROLE HOWARD
FOR A SHOWER
AN ATOM
HEAR ABOUT THAT NEW YORK BAG
YOU HOUSING
MARKING
RUNNY
SAUTEED
SCRUB YOUR NECK
GET MY CAR TUNED UP
WHAT'S \LA CIENAGA/?
OIL /FILTER/ WRENCHES
TOPS
FUEL FLASK
SHE'D BE /BETTER LOOKING/
/FUNNY LOOKING BUT/ NICE
I DO BELIEVE /IN FAIRIES/
THEY WERE DOWN IN /THEGN'S ROOM/ SORT OF SCREWING AROUND.
/META/ CONVERSATION
/META/ CONVERSATION
THEY TRIED TO /THUMBPRINT/ ME.
NEPAL
I WAS GIVEN A GRADE WHICH I DID NOT SAY /BLAH TO/
I LIKE /PLAYING BRIDGE/
ART FEELS
VARIABILITY
/NO EMPIRICAL/ CONSEQUENCES
AN INCREASING PROBLEM OF HEAD /LICE/
TILL THEY STOOD UP
LET'S SEE HOW THAT HOCKEY GAME IS GONNA /TURN/ OUT
IT DOESN'T OCCUR /INITIALLY/
SEE YOU /IN A MOMENT/
OH, /LICE/ IS DELIGHTFUL
/AN ESTIMATED/ 40%
THAT'S REALLY GOOD /DIP/.
BURL
TWO POST DOCS
DID YOU GIVE THE /NEW YORKERS TO RENEW/?
K IS REALLY WORRIED ABOUT THIS /POPULATION/ EXPLOSION.
/ARM/ TIRED?
/NATIVE/ STYLE
HUGE RIP
YOUR /Good/ DEEDS ARE/
WHERE'S /REVERSE/?
WHERE'S /YOUR PURSE/?
I HAD TO PUT IN SOME STEERING WHEEL /FLUID/.
/PLENTY/ OF MINUTES
SOME ARE MORE /POWERFUL/ THAN OTHERS.
/SODIUM/ NITRITE
GRANDMOTHER
TURNED IT /DOWN/
MY NAME'S /ROY/.
UNKEMPT AND DISHEVELED
CALIFORNIA
HOW BIG /MY ARRAYS'RE/ GONNA BE
A /QUARTER BACK/
"LOST INTEREST" IS RATHER A COVER TERM.
188 LOS ANGELES
189 ANDY /LIPPINCOTT/
190 BIZARRE TRAILING OF A POEM
191 I'M /EATING/ LESS
192 OIL /SHEIKS/ RICH
193 A /CRADLE/ BOARD
194 SPE
195 ARE YOU /GOING TO PAINT YOUR RULER/?
196 I WAS RAISED IN /INDIANA/.
197 ANYONE WANT /A FRENCH FRY/?
198 WHERE DID YOU HIDE /HIM/?
199 GONNA GO TO /BACH/ SUNDAY NIGHT WITH STEVE
200 NBC
201 ACTUALLY I WANTED SOMETHING /NON-/MENTHOLATED.
202 RESEARCH
203 THE /EIGHTY-EIGHT/ RUNS TIL 10:30
204 WE SKATED
205 SIGNERS
206 SIGNERS
207 /BLACK FOREST/ TORT
208 /COULD I HAVE/ /A PAPER CLIP/?
209 I WENT OUT AND RODE ALL OVER THE PLACE AND /LOTS/
210 LOTS
211 THE INCREDIBLE MACHINE
212 IS IT /WORMY CEDAR/?
213 REFLECTIONS ON WAGNER'S /RING/
214 /PUT THOUSAND ISLAND ON/ FOR THE BOYS
215 IS /JOY CHILD/... IN OUR DEPT?
216 RIDE TO SANTA BARBARA /OR NOT/?
217 IT'S AN /UNBIRTHDAY/ PRESENT
218 BORN
219 CARPENTER'S /LOCAL
220 /SHORT-LEGGED/ PERSON
221 DIANA VAN LANCKER
222 JACKIE KENNEDY MADE /LOVE IN/ FRENCH

188 LOST INDIANS
189 LICKINGHOT
190 CAR BROKE DOWN
191 MEETING
192 SHIFTS
193 GRADING
194 STE
195 USING PAINT REMOVER
196 NFI
197 TO FUCK ME
198 IT
199 BOX
200 NBC
201 MORE
202 GARBAGE
203 IDIOT
204 ITS EIGHTY
205 SCIENTISTS
206 SIGHS
207 BRATHWURST
208 IS THAT
209 LOCKS
210 BLOCKS
211 CITIZEN KANE
212 WARM SEATED
213 BRAIN
214 BUT THAT'S A NYLON
215 GEORGE AILES
216 TONIGHT
217 BIRTHDAY
218 BORING
219 LEVEL
220 SHORT LITTLE
221 ARRAHAN LINCOLN
222 LEMON
### APPENDIX D: SLOE Phonetic Transcription

#### Consonants

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**Segments used in transcription:** IPA and ARPABET

**No context is transcribed in this appendix.**
APPENDIX E: Matching Algorithms used for SLOE

In order to find segmental errors, it is necessary to match the phonemes in the utterance and in the perception. Since slips of the ear include many insertions and deletions, and also many segmental changes, the matching was done using a set of interactive computer programs developed by the author and Louis Goldstein for the PDP-12 computer in the UCLA Phonetics Lab. Because deletions and insertions of syllables or words are extremely difficult to detect automatically, an initial pass of syllable-matching was performed by the humans. Because computers are faster and more consistent than humans at applying complicated algorithms to a large amount of data, the rest of the matching was done automatically.

The first pass of syllable matching was trivial so long as the utterance and the perception had the same number of syllables (where a syllable was defined in terms of its nucleus, i.e., a vowel or syllabic I, R, N, or M). In this case matching proceeded left to right, first syllable to first syllable, etc. If a syllable that occurred in the utterance was deleted in the perception, or a syllable was added in the perception, then syllables were matched to maximize similarity, in the judgment of the person doing the matching (in this case, the author). Here too matching was constrained to proceed from left to right, although of course syllables could be skipped. That is, no metatheses of syllables were permitted in the matching scheme. For example:

<table>
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<tr>
<th>Utterance:</th>
<th>fuel</th>
<th>flask</th>
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<tbody>
<tr>
<td>Perception:</td>
<td>field</td>
<td>glasses</td>
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</table>

U: popping really slow
P: pro di gal son

U: go to the car and get the tu na
P: get my car tuned up

Throughout this discussion, underlined syllables have no match.

After the initial pass of syllable matching, the programs took over. Segment matching proceeded from the clearest cases to the least clear cases. First, only matching syllables were considered. Moreover, only consonant clusters and vowels in the same positions within the syllable were compared. That is, the vowel of the utterance U was matched with the vowel of the perception P, the segments in the initial cluster of U with those in the initial cluster of P, and the segments in the final cluster of U with those in the final cluster of
P. Within any cluster, order was ignored. First all segments that were identical in the cluster in U and in P were matched. Then the remaining non-identical segments in the cluster were matched, using the criterion of maximizing the total number of features in common between the U cluster and the P cluster. Only in the case that two or more ways of matching the non-identical segments resulted in equal maximization was order invoked. In such a case of a tie, the pattern of matching the segments that retained the most order information beginning from the left was chosen. For example:

\[
\text{sprain} \rightarrow \text{freight} \quad \text{(an imaginary example)}
\]

\[
\text{spreyn} \\
\text{frett}
\]

Then any r, l, m or n still unmatched were checked for metathesis across the vowel. That is, if one of these segments occurred in the initial cluster of one syllable, and in the final cluster of the matched syllable, then the two segments were matched. After this pass, the three examples given above now would be matched as follows:

\[
\text{fuel} \rightarrow \text{field glasses}
\]

\[
\text{fjul} \\
\text{fild glæ}
\]

\[
\text{på puᵣu li sloo} \\
\text{pra du gal s n}
\]

\[
\text{go to the car and get the tuna} \rightarrow \text{get my car tuned up}
\]

Next, the consonants in those syllables that were deleted or inserted (i.e., whose nucleus was deleted or inserted) were considered. If more than one syllable was deleted (or inserted) in a row, only the first and last were considered for possible consonantal matches. The segments from the initial cluster of the first unmatched syllable were compared to the unmatched segments from the final cluster of the immediately preceding syllable (i.e., for insertions, the initial cluster of the inserted syllable in the perception was compared to the final cluster of the syllable in the utterance after which it was inserted, and vice versa for deletions). Similarly, the segments
from the final cluster of the last unmatched syllable were compared to the unmatched segments in the initial cluster of the immediately following syllable. As before, matches were made first on the basis of identity and then on the basis of common feature maximization, with order information breaking any ties. Thus:

```
fuel flask + field glasses
    fjul    flask
       f    il d glas    s az
```

popping really slow + prodigal son

```
p a p t o r l i s l o c
    pra di gal s an
```

go to the car and get the tuna + get my car tuned up

```
g oo te ðə kar and get ðə tu n\n    get n\at kar tund \ap
```

(final match)

Next the same procedure was followed for any unmatched segments in the matched syllables. That is, unmatched segments from the initial cluster of a matched syllable were compared with unmatched segments from the final cluster of the immediately preceding matched syllable; similarly, the final cluster was compared to the initial cluster of the immediately following syllable. As usual, segments were matched on the basis of identity first, and then common feature maximization. For example:

to zero + his ear off

```
before:       after:
    te z i r oo      te z i r oo
        h i z i r af   h i z i r af
```

we skated + it's eighty

```
before:       after:
    wi s k e r a d      wi s k e r a d
        its it ri   its it ri
```

Finally, in case any consonants remained unmatched, the following procedures were applied. First, another pass was performed for the deletions and insertions, where the same positions in the same deleted
(or inserted) syllables were considered as for the first pass. This time, however, the unmatched segments from the initial cluster of the deleted/inserted syllable were compared with unmatched segments from the initial cluster of the immediately following syllable, as opposed to the final in the preceding syllable. Analogously, segments from the final cluster were compared with those from the final cluster of the immediately preceding syllable. Both identity and common feature maximization were used.

```
fuel flask + field glasses

    fjul    flsk
    fild gls sez
```

Then another pass was performed for the matched syllables. Any unmatched segments preceding the vowel were compared with any following the vowel, again using identity and then feature maximization.

```
fuel flask + field glasses

    fjul    flsk
    fild gls sez
```

(popping really slow + prodigal son)

```
p a pu r l i sloo
pra du gel s an
```

(final match)

Throughout all the analyses, if a consonant (non-h) was matched with h in an earlier pass, and that consonant could be matched to an identical consonant on a later pass, then the later result was chosen. This exception was intended to account for aspiration. Thus:

```
loop hole + loo pole

before:

    lup hol
    lu pol

after:

    lup hol
    lu pol
```
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