Input and output alternatives in word prediction

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C. INPUT AND OUTPUT ALTERNATIVES IN WORD PREDICTION
Sheri Hunnicutt

Abstract
An adaptive word prediction program developed at the Royal Institute of Technology in Stockholm, Sweden has more recently been used as a base to explore prediction alternatives. Several programs have resulted which take different inputs and produce output in various forms. Two of these programs, called ACCESS and COHORT, incorporate several alternatives. Among these alternatives are speech recognition input, speech synthesis output, and input of word information such as number of syllables and word class. Part I describes the base program and the programs called ACCESS and COHORT. Part II is a general description of prediction alternatives which have been explored. The various programs are discussed in relation to each area.

Part I: The Base Program, ACCESS and COHORT

Introduction
An adaptive word prediction scheme was developed several years ago to be used in conjunction with our speech synthesizer (Hunnicutt, 1986). It was developed in response to the need of a non-vocal user of the synthesizer who found that her listeners were guessing the word she was typing before she finished. In order for the word to be synthesized and pronounced correctly, however, it was necessary for her to finish typing it. It seemed that a word prediction scheme, based on a frequency-sorted lexicon, could be a decided help.

A first program was written in FORTRAN for an Eclipse computer, and hardware implementation was begun while the system was developed and tested. This implementation is only now nearing completion, however, and is not capable of the adaptive functions of the program. In the meanwhile, the predictor was rewritten in TURBO PASCAL for an IBM-compatible personal computer.

The Base Program
The basic prediction program is used by simply typing one letter of a word at a time. If a prediction is possible, it is presented to the user after each keystroke. The user may then accept the prediction or type a further letter.

Given an initial letter by the user, a word is predicted based on word frequency and recency of use, and optionally, on a simple phrase structure grammar. Typing the first letter of a word results in accessing the most frequent word beginning with that letter from a special
small lexicon. Successive predictions are made from a large lexicon and from a lexicon that stores typed words if predicted letters are overwritten by the user. A lexicon containing word pairs is consulted when a word is terminated. If found, the word following it is automatically predicted without its initial letter being typed.

A prediction may be accepted completely or conditionally. Conditional acceptance places the cursor at the end of the word just predicted. The user may then either delete or add a character to get a further prediction. This facility is useful for accessing suffixed words and compounds.

An important part of the system is a set of lexical data files, the lexicons. The Main Lexicon contains up to 10,000 words, the most frequent words according to published corpus statistics. A second data file, the Subject Lexicon, is initially empty and accumulates data as the program is used. This file may be saved for later use. The Swedish system also uses a Two-word Lexicon, containing the most frequent word pairs. The English system has a rudimentary Two-word Lexicon. A First Choice Lexicon contains the most frequent word for each letter, for quick and easy access. The Main Lexicon is updated to reflect the user's vocabulary by incorporating into it the Subject Lexicons generated by the user. This is an automatic process.

This base system has been tested on a 4500-word Swedish text to determine savings in keystrokes by prediction and the contributions of particular data files. The test is a transcription of one person's (a teenager's) communication via a personal communicator, i.e., a sequence of typed one-sided conversations. The result of keystroke savings is given in Table I.

Table I: Prediction results in a 4500-word communicator text.

<table>
<thead>
<tr>
<th>Description</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Words partially or fully predicted</td>
<td>80%</td>
</tr>
<tr>
<td>Savings in keystrokes</td>
<td>26%</td>
</tr>
<tr>
<td>Savings in letters</td>
<td>34%</td>
</tr>
</tbody>
</table>

From the table we see that some help is provided in typing of 80% of the words. In fact, 88% of the words in the text occurred in the lexicon, but 8% were so short that they had to be typed in their entirety. The actual savings in keystrokes is 26%. One-third of the letters are successfully predicted, however. The 8% discrepancy lies in typing of the acceptance characters, final punctuation marks and carriage-return.

The 34% savings in letters may be further divided into the contribution made by each of the various lexical data files, as shown in Table II below:
Table II. Contribution of various lexicons: savings in letters.

<table>
<thead>
<tr>
<th>Lexicon</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Lexicon (10,000 items)</td>
<td>17%</td>
</tr>
<tr>
<td>First Choice Lexicon (27 items)</td>
<td>13%</td>
</tr>
<tr>
<td>Two-word Lexicon (1500 items)</td>
<td>2%</td>
</tr>
<tr>
<td>Subject Lexicon</td>
<td>2%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>34%</strong></td>
</tr>
</tbody>
</table>

The Main Lexicon accounts for half of the savings in letters, and the First Choice Lexicon, almost as many. The other two lexicons are seen to contribute little in percentage, but the fact that the word pairs in the Two-word Lexicon are quite common and that the Subject Lexicon reflects recency of usage argues for their inclusion in the system. A user can reasonably expect this data support. Wherever a prediction is clearly indicated, it should be given if possible.

ACCESS

The program ACCESS also provides word prediction to aid in easier message construction. However, it does not presuppose the ability to spell a word. The goal is to use any information that the person has about a word to "access" it. The word, or a list of word predictions, can then be synthesized for the user to hear and to choose among.

A possible way to access the word "exhibition" using the Word Builder is shown in Fig. 1.

The number of syllables is chosen first, as "4." Then the first letter, "e" is chosen. This produces the five word candidates, "economic," "economy," "education," "educated" and "efficiency." Since none of these is the required word, another letter, "b" is typed. The next list includes the desired word, "exhibition" as the fourth choice, with "elaborate," "establishment" and "establishing" ranking higher. The chosen word, "exhibition," is then added to the sentence upon typing the function key F4.

COHORT

The program called COHORT is used together with a phonetic word recognition system. It is also designed to access a word given partial information. That information can be in the form of phonemes, phonetic features or stress. It is also possible to specify an ordered set of options for a phoneme. Phonetic word recognition systems such as this are not sufficiently advanced in their accuracy at present, but we can
STEP 1

O.K. Ready to go.

Did you see the _______

WORD BUILDER
Number of syllables: 4
First letter: e
Other letters: b
Part of speech: F3

Word Choices...
F1 elaborate
F2 establishment
F3 establishing
F4 exhibition
F5

Fig. 1. The four steps in accessing the word "exhibition"
expect in the future to be able to use this type of recognition system for persons whose only means of communication is vocal. It is superior to a pattern-recognition system in that the vocabulary for input can be as large as the accompanying lexicon (e.g., 10,000 words instead of 200). The limitation of a pattern-recognition system to a few hundred utterances has led us to the strategy of using coded input for letters with such a system. In this situation, the number of utterances needed to input a word is the number of letters in that word. With a phonetic recognition system, there would only be one utterance per word, the word itself.

Fig. 2 shows a sample lexicon search with COHORT:

<table>
<thead>
<tr>
<th>Input string: NASL, &lt;A:,A&gt;, STOP, I, FRVL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output list:</td>
</tr>
<tr>
<td>27 naturligtvis</td>
</tr>
<tr>
<td>35 materialet</td>
</tr>
<tr>
<td>33 antaglagen</td>
</tr>
<tr>
<td>23 materiella</td>
</tr>
<tr>
<td>38 initiativet</td>
</tr>
<tr>
<td>43 generaldirektör</td>
</tr>
<tr>
<td>23 materiel</td>
</tr>
<tr>
<td>33 magnifika</td>
</tr>
<tr>
<td>27 naturalistiska</td>
</tr>
</tbody>
</table>

Fig. 2. Input specification and output list in COHORT.

The program has been run on a 10,000-word Swedish lexicon. The input string consists of a sequence of phonemes and phonemic feature classes. The first element (NASL) is a nasal, i.e., one of the phonemes <N,M,NG>, the second is a vowel, i.e., A, in either of its forms, short or long, the third (STOP) is a stop, i.e., one of <P,B,T,D,K,G>, the fourth is the vowel I in its short form, and the fifth (FRVL) is a front vowel, i.e., one of <I:,I,E:,E>. The output list gives nine words whose pronunciation contains these elements in the order given but not necessarily adjacent. The numbers before each word give a score for the word based upon the order in the option lists. The order of the words in the output list reflects their frequency in the lexicon.

Part II: Prediction Alternatives

Types of Input
Input Modes

Letters, or other input characters, can be typed on a keyboard or with a keyboard emulator. This is the normal input mode.

It is also possible, however, to use speech recognition or a combination of speech recognition and keyboard input. To use recognition
input, the user trains a vocabulary for the set of letters. A set of words such as "alpha," "bravo," etc. that is constructed for good discrimination is very useful for a vocabulary, but any set of distinct utterances, one for each letter, is possible to use. The input of the word recognition system, then, is one of the utterances from the vocabulary, and the output is the letter it represents. This letter is then used as input to the prediction system. This facility allows a person with a small discriminable vocabulary to use the system even if they are not motorically able to type or use a switch.

The speech recognizer which is employed was also developed at our laboratory (Elenius & Blomberg, 1986). It is a language-independent, trainable pattern-matching system, and is available from Infovox AB in an IBM-PC-compatible form. The recognizer digitally implements a 16-channel filter bank. This filter bank covers frequencies from 200 to 5000 Hertz in bands spaced according to the critical band scale which represents the frequency characteristics of the human auditory system. Thirty-two sample points derived from this information are matched with the stored reference patterns by dynamic programming time alignment. A NEC7720 signal-processing chip is employed for speech analysis and dynamic programming. Control of the recognition process and storage of the reference vocabulary are handled in the microprocessor and memory of the PC.

Input Units
As previously mentioned, orthographic (spelling) input is used most frequently in the prediction programs, but the COHORT program accepts phonemic (pronunciation) input. COHORT is a component of a speech recognition scheme called NEBUJA under development at our laboratory, part of which includes a phonemically-based speech recognizer (Blomberg, Carlson, Elenius, Granström, & Hunnicutt, 1987).

Prosodic information can also be input. In particular, the number of syllables in a word can be an input parameter, and, with phonemic input, the stress or accent pattern can be given.

Another possible input parameter is part-of-speech or word class. In the ACCESS program, one may optionally specify both the number of syllables in a word and its word class.

Order of Input Units
In the base prediction system, the order of input letters is sequential. That is, one first inputs the first letter of a word, then the second, and so on. In the prediction system used for speech recognition, however, it is more useful to allow ordered, but not necessarily sequential input. When attempting to recognize a word, one may be sure of some phonemes, have several choices for others, be unsure of the identity of other phonemes or even how many there are. The information
about what order the known phonemes are in is valuable and needs to be retained. Allowing a string of ordered, non-sequential input units with lists of phoneme options meets this need. Non-sequential ordered input allows for accessing words with most abbreviations. Thus "ytd," "yrd," or "ydy" will access "yesterday" as a prediction choice without needing to specify any of these abbreviations in a lexicon and without the user having to remember exactly which abbreviation to use. The number of keystrokes necessary to access "yesterday" depends, of course, on the number of words in the lexicon containing these letters in the given order and the number of prediction choices the algorithm makes.

In ACCESS, the first letter of a word is requested, and other letters found in the word are accepted in arbitrary order thereafter. The need to specify a first letter can also be made optional. This facility would allow a child learning to spell or a person with certain types of aphasia to "access" a word they have some information about, even if they could not spell it. A list of possibilities -- words containing those letters -- is then provided by the predictor. A further list is produced if other letters are input.

Function Key Input

Function keys are used in specifying types of acceptance. In the base system, there are three types of acceptance. One can accept a predicted word as given, or conditionally. Conditional acceptance allows one to change the way a word ends, e.g., for suffixes and compounds. And one can "accept" a word that is typed in by typing a "space" after it. In ACCESS, function keys are used to indicate choices from a list of predicted possibilities. In addition, a function key can be used to access suffixes to be added to a predicted word.

Types of Output

Prediction

Predictions may be either written out on the computer screen or synthesized and presented auditorily. In this latter case, however (current implementation), the complete message cannot be heard because all predictions are entered in the synthesis output stream together with the accepted words.

Text size to some extent determines the presentation, and thereby the output options. For a short message such as one side of a conversation, short assignments, or letters, an elaborate presentation such as that in ACCESS can be used. Then space is available for "building words," for requesting and supplying various inputs such as number of syllables and multiple choices. A long text, on the other hand, will be cumbersome to work with if only half the screen is available. Long texts also require the facility of scrolling.
Single word prediction requires less time for the user to scan options, but requires more keystrokes on the average to attain the desired output word. The number of alternatives chosen for ACCESS is five. This is enough to cut down the number of keystrokes noticeably, but not so many that scanning time seems unreasonable or that screen writing space becomes too restricted.

In the early base prediction program, a single prediction was made as a continuation of the word the user had begun to type. This presentation seemed to be confusing in that the user sometimes misinterpreted the cursor location, assuming that part of the prediction was something he/she had typed. This problem was overcome by presenting the prediction directly under the letters in the input, thus removing the confusion.

**Non-Predictive Output**

In all programs, additional output is in the form of two files. One file, called WRITPR, saves the final text. This file can be accessed at a later time for printing or further editing with a text processing program. The other file, LOGGER, keeps information about what has transpired during a session, i.e., which letters, symbols and control characters have been typed and the time (with a maximum of two minutes) between each keystroke. This information can then be used to test the efficiency and usefulness of the program, and to check a user’s progress.

In COHORT, it is also possible to get output lists of choices. The entries in these lists are ranked according to a metric which takes into account the order of options in the input.

**Lexicons**

**Lexicon Sources**

Most lexicons that have been constructed are orthographic. With COHORT, however, a phonemic lexicon is required. The larger lexicons used with the prediction algorithms, the Main Lexicons, were originally part of our multi-language text-to-speech project (Carlson, Granström, & Hunnicutt, 1982). As a base for development of both text-to-speech rules and exceptions dictionaries, we needed large collections of frequency-ranked basic vocabulary in the different languages. These corpora were generally available in print only and were created during the last two decades from large samples of newspaper material. The Italian material, however, is based on a more varied selection of printed material and the French samples are drawn from modern novels. References for this material are presented in Table III.

The studies which produced these corpora are based on between half a million and a million words of running text. The number of different word forms varies between about 110,000 for the Swedish 1 million-word
Table III. Frequency-sorted corpora for six languages.

<table>
<thead>
<tr>
<th>Language</th>
<th>Author and Year</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swedish</td>
<td>ALLEN, S. 1970</td>
<td>&quot;Frequency Dictionary of Present-Day Swedish&quot;</td>
</tr>
<tr>
<td>English</td>
<td>KUCERA, H. and FRANCIS, W.N. 1967</td>
<td>&quot;Computational Analysis of Present-Day American English&quot;</td>
</tr>
<tr>
<td>German</td>
<td>ROENGEN, R. 1972</td>
<td>&quot;Ein Frequenzwörterbuch der deutschen Zeitungssprache&quot;</td>
</tr>
<tr>
<td>Italian</td>
<td>BORTOLINI, U., TAGLIAVINI, C., AND ZANOLLI, A. 1971</td>
<td>&quot;Lessico di frequenza della lingua italiana contemporanea&quot;</td>
</tr>
<tr>
<td>Norwegian</td>
<td>HEGGSTAD, K. 1982</td>
<td>&quot;Norsk Frekvens Ordbok&quot;</td>
</tr>
</tbody>
</table>

Text to about 30,000 for the French half million-word material. Approximately 10,000 of these words -- the most frequent -- were chosen to be used with the text-to-speech system, and are now available for use with the prediction algorithms.

Creation of the phonemic lexicons which are used with COMORC were attained with a semi-automatic procedure. The first step was to process the words through a preliminary version of the orthographic-to-phonetic component of the text-to-speech system. The next step was to check and edit the proposed phonetic transcriptions. This was accomplished interactively on a computer terminal with the possibility to listen to the corresponding synthesized words. The final edited version was used as a vocabulary base for the system in each of the languages.

In English and Swedish, the more productive suffixes were removed in order to form "root corpora." Most of these suffixes are inflectional and non stress-affecting. No prefixes were removed, and no analyses of compound words were made.

Lexicon Types and Construction/Sorting Procedures

The so-called Main Lexicon for prediction is derived from the 10,000-word text-to-speech lexicons by a procedure devised to perform a quick conversion. The rank order of each word is included with the spelling or pronunciation of each item, and in the Swedish Main Lexicon, the word's part of speech, or word class, is also included. Main Lexicons are most usefully partitioned according to the first two letters of a word and frequency-ordered within this partitioning. This allows quickest access for most prediction work. It is also possible to construct a lexicon in a strict alphabetic fashion.
In ACCJESS, if one chooses a completely arbitrary order of letter input, a lexicon which is sorted strictly by frequency allows quickest access. Such a lexicon can be constructed when the program is loaded from one of the alphabetically-sorted lexicons.

The Main Lexicon can contain up to 10,000 words. It can also be initially empty, if desired. It is necessary in the present IBM-compatible PC system to decrease the size of the Main Lexicon to make room for other large lexicons.

One such large lexicon currently exists only for Swedish. This is the Two-word Lexicon which contains two-word combinations. (Allén & al., 1975). Up to 3,000 of these word pairs can be included. A small Two-word Lexicon has also been constructed for English, but without the benefit of a statistical study to base it on.

First Choice Lexicons are very useful for immediate access without an extended search. One such lexicon simply contains the most frequent word beginning with each letter. Another contains the most frequent word containing each letter.

For English and Swedish, Suffix Lexicons are available. These can be accessed using a function key. They are not completely inclusive of suffixes, but rather contain the most used suffixes in the two languages that do not affect the stress of a word to which they are affixed.

One further file, the Subject Lexicon, has space for up to 510 words and is initially empty. Each word typed (or, if desired, each word with rank greater than 1000) is entered in this lexicon, and a count kept of the number of times it has been used. A message is sent to the user when this lexicon is full and when program usage terminates. The user may then choose whether to save this Subject Lexicon and whether to incorporate these words in his/her permanent (Main) lexicon. A decision to incorporate these words will result in an automatic update of the frequencies of words in the Main Lexicon. Words not previously occurring in this lexicon will be added to it, while the lowest frequency words drop out.

A second use for this file is reflected in its name, the Subject Lexicon. It is possible to set two frequency values for this lexicon, one value for word inclusion and another value for word prediction. A preliminary test indicated that words with rank greater than 1,000 (words not in the 1,000 most frequent) should be placed in the Subject Lexicon and given a temporary rank beginning with rank 201. This rank for prediction allows only the 200 most frequent words, most of which are function words which can be expected to make up over 50% of a text (Kucera and Francis, 1967 -- also known as the "Brown Corpus") to precede words with rank greater than 1,000 but currently in usage. In this way, word frequency can be temporarily raised during a conversation about a specific topic.
Such Subject Lexicons can be accumulated to be used in a future session in the same situation or about the same subject.

Other Lexical Information

As mentioned previously, the frequency or rank of a word is always listed with the spelling or pronunciation of a lexical entry. In the Swedish lexicons, word class also appears.

Another form for the orthographic or phonemic information has also been explored for ACCESS and COHORT where input is not strictly sequential. A mask for each entry is constructed when the lexicon is read in before beginning prediction. For letter input, this is a 4-byte mask denoting which letters the word contains. Searching the lexicon using the mask, rather than the word spelling, decreases search time substantially.

The syllable count information which can be required by ACCESS is calculated from a phonemic lexicon, then transferred to the orthographic lexicon of the same language. Provision has not yet been made for calculating the syllable count of words that are added to the lexicons through use of the prediction program.

Information about capitalization in proper nouns has not yet been added to the lexicons. This is clearly useful information for word prediction, though, and should be considered for capital letter input preceded by something other than a terminal punctuation mark.

Semantic categories will be added for some entries after further work.

Lexical Access Strategies

An area which must be addressed when various input types are permitted is their relative priority. In the base system, given the beginning of the spelling sequence, access is determined by frequency (or rank) and recency. Frequency and recency were accommodated by inserting the list of recently used words, the Subject Lexicon, into the list of frequency-ordered words, the Main Lexicon. As previously mentioned, the rank for inclusion of the Subject Lexicon into the Main Lexicon was set at 200, allowing most function words in the Main Lexicon more priority than the recently-used words.

When the precedence-type grammar was added to the base system, it was decided to accommodate grammatical information by simply ruling out any word with a word class considered unlikely by the algorithm. That is to say, grammar had veto power. It was found that this veto power was too strong; correct words were vetoed as often as incorrect words were prohibited and the correct word chosen in the communicator text. This text was quite irregular grammatically, but was probably exemplary of texts one could expect from a conversation. Thus, overall performance in keystrokes saved was not improved by supplying this grammatical
information. It is to be remembered, however, that this problem is tightly coupled to single predictions. As soon as multiple predictions are allowed, veto power is no longer necessary. It can be replaced by priority decisions.

In ACCESS, priorities may be set for output choices. It is not as yet clear how to set these priorities. If, for example, only letters have been specified, and five choices are to be given, how many of them should have the most probable word class? This remains as a further topic for research.

The extent to which semantic classifications should affect lexical access is also a subject of further research. Questions to be addressed are: "How large is a semantic context?" and "To what extent should semantic category take precedence in listing predictions?" These questions are likely to be interdependent. The longer it has been or the more words that have been typed since a particular semantic category appeared, the less the category of a predicted word should affect its placement in a list of predictions. On the other hand, giving priority to words with previously appearing semantic categories within a paragraph or an even longer text area seems recommendable.

**Updating and Adaptivity**

Updating of the main lexica occurs either when the Subject Lexicon is filled or when a session ends, and only if the updating query is confirmed by the user. The rank of a word in the Main Lexicon is reduced by one if the word use meets one of the criteria given in Table IV below. If the option is chosen to enter only words with rank 1,000 or greater in the Subject Lexicon, there is a single use criterion, i.e., if the word appears once, it is used for updating.

**Table IV. Criteria for rank advancement in Main Lexicon**

<table>
<thead>
<tr>
<th>Rank Range</th>
<th>Times</th>
</tr>
</thead>
<tbody>
<tr>
<td>50-99</td>
<td>20</td>
</tr>
<tr>
<td>100-199</td>
<td></td>
</tr>
<tr>
<td>200-299</td>
<td>4</td>
</tr>
<tr>
<td>300-499</td>
<td>3</td>
</tr>
<tr>
<td>500-999</td>
<td>2</td>
</tr>
<tr>
<td>1000-...</td>
<td>1</td>
</tr>
</tbody>
</table>

The table above was determined by scaling down by 100 the word counts in the Brown Corpus. For example, words having a rank of 300-499 in the Brown Corpus occurred between 194 and 311 times (311/100 = 3 rounding off to the nearest integer). Function words with rank between 1 and 49 cannot be changed unless the lexicon file is edited directly.
The number of times a word is used is accumulated by a counter and kept in the Subject Lexicon. Each time a word is used which already appears in the Subject Lexicon, that word is brought to the head of the list in the Subject Lexicon and its "Use Count" counter incremented by one.

Any new word occurring even once in the Subject Lexicon is added to the Main Lexicon. Removal of unintentional entries must be done directly by editing the lexical file. It would be possible to query each possible new entry at the end of a session, but this facility has not been implemented. Information other than spelling and rank number must be edited in directly as well. The word is still useful, even without this additional information, however. A word without a word class denoted is simply reckoned as having any word class. The rank number of a new word is the highest rank, usually around 10,000.

There is, as yet, no procedure implemented for updating lexicons other than the Main Lexicon. The requisite space is not available for keeping statistics on such information as word pair usage, for example. It would be possible, though, to save all of a user's files, and calculate ranks of word pairs in a separate process, afterwards updating the Two-word Lexicon.

Calculations of this sort, on larger user texts, raises an important question, that of statistical significance. A useful lexicon, which could be expected to cover around 90% of the words entered as text, can contain around 10,000 entries (Kucera & Francis, 1967). Such a lexicon could be compiled from running text containing around 60,000 words. It would take a full year to type such a text if someone types five words per minute and uses a system about two hours a day, typing about half this time. In order to establish word ranks with as much statistical significance as the Brown Corpus, one would need about a million words of running text. A million words would take seventeen years to type in at the above rate. This argues for beginning with a corpus such as the Brown Corpus (a lexicon compiled from spoken sources would be even better), and allowing a user's lexicon to adapt itself to his/her personal vocabulary through use. Even so, it will take a good bit of use for words to find their proper rank for an individual's vocabulary.

Grammars

As mentioned previously, a grammar has been implemented for Swedish only. It appears that it gives small reward for a great deal of effort if one looks at a measure such as keystroke savings. In a 1331-word sample from the earlier-mentioned communicator text, it was found that perfect knowledge of part of speech would have improved keystroke savings by 2.6% for one choice or by 5.1% for six choices. In a similar test by Swif tin, Arnott, & Newell (1987), a keystroke savings of between 0.5% and 2% was found for known word class. The texts for their study
were 3 samples of 3,500 words each, covering three different subject areas. They used prediction lists of 1, 5, and 10 words, and a lexicon containing precisely the words in the texts, marked for word class. A further test indicated that known word class would improve keystroke savings between 4.3% and 6.4% if frequency (rank) information were removed.

It seemed clear, however, in both studies, that removing words with an inappropriate word class from a prediction list would improve a user’s degree of comfort and pleasure in using a system. This aspect should certainly not be overlooked even if the percent savings in keystrokes appears small.

**Semantic Categories**

A project is now in progress to label about 1500 of the lexical entries with semantic categories. The 1500 words chosen correspond to standard Blissymbols, and their categories are those designated for these Blissymbols in a standard classification (Hehner, 1980). Information about the semantic categories of words will contribute to ranking of choices in the prediction list.

**Conclusions: Potential Users**

The particular facility of ACCESS to allow alternative input could be helpful both to children who have not yet learned to spell well and to certain aphasic persons in rehabilitation. Including the output mode of synthetic speech could help these two groups of persons, as well. It has been well demonstrated that the feedback a child gets from synthetic speech is helpful in improving his/her language skills (Dahl & Galyas, 1987). And an aphasic person renewing his/her language skills might profit, as well. Since ACCESS allows multiple "access points" to a word, any information a person has about that word can be brought to bear without the requirement that the word be spelled sequentially.

The phonetic speech recognition system which COHORT is a part of will, in the future, be usable by persons whose only (or best) ability to communicate is his/her vocal ability. In the more near future, a person will be able to say one word at a time and have that word recognized, or a list of alternatives given which can then be accessed by voice. Such a system can support a large vocabulary, and in some languages, will be able to produce a correct spelling for a word if it does not appear in the system’s lexicon. Farther in the future, one can see such a system able to recognize much of connected, or continuous speech, so that a person would be able to speak carefully, but otherwise normally, and have his utterances transcribed.
References


