

AN ASL DICTIONARY IN APL

David V. Moffat
Department of Computer Science
North Carolina State University
Raleigh, North Carolina

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INTRODUCTION. This paper summarizes a project to develop a computerized dictionary of American Sign Language. The topics discussed are: project scope and development, the resulting system of programs, applications in sign language studies, and problems for future development. Appendices describe details of the notation used for sign descriptions, show an example dictionary, and tell how some of the programs are used.

SCOPE. The task of implementing all of the ideas to which the concept of a computerized sign language dictionary leads would be a task of large dimensions. It was necessary, therefore, to limit the scope of the initial project to a readily manageable size and then merely indicate the paths of potential development in the project summary. The project thus became oriented toward accomplishing four goals:

1. Find a way to put a sign language dictionary on the computer in a usable notation and format. Write programs for maintaining the dictionary.
2. Find a way to generate English language descriptions of how the signs are made. (This goal was set under the assumption that the constraints involved in the attempt would force a regularity in the notation and format, and would mean that it would also be possible to generate pictures of the signs.)
3. Develop programs for doing basic syntactic searches, where the syntactic elements are the special symbols used in the notation.
4. Present an analysis of problems, possible future work, and potential applications.

DEVELOPMENT

Developmental work was concerned with searching for the various methods by which to satisfy the goals listed above, isolating the methods most suitable to the project, and implementing them on the computer. The next several paragraphs describe many of the decisions that had to be made before the system could be implemented. A description of the resulting implementation follows this discussion.

The American Sign Language dictionary prepared by Stokoe (Stokoe 1965) served as the foundation for the project. Although special notations for body movement exist (Eshkol 1958, and Hutchinson 1970) and have been used on computers, the notation developed by Stokoe is the only practical sign language notation for use on the computer. The notation did, however, pose a few problems in the attempt to use it on the computer. These problems have been solved, at least for the purposes of the present project, as the following discussion demonstrates.

PRINT FONT. There is a striking and fortunate similarity between Stokoe's notation and the print font used with the APL programming language (Iverson 1962). Many of the symbols in the APL font are identical to those used by Stokoe, and many others are quite similar. Thus, the APL font was used in this project. An attempt was made to use Stokoe's notation as the basis, and keep all necessary substitutions and changes in the same flavor as his. More will be said about the APL programming language later.

FORMAT. Any notation used with a computer--as opposed to a typesetter--is practically restricted to an in-line form. That is, it is necessary to represent superscripts and subscripts in line with the rest of the notation. This was done by copying Stokoe's notation unchanged when it was given left to right, and transcribing it left to right when given as super- and subscripts. Thus B' becomes " $B|$ ", and the sig \vee becomes " $\vee>$ ".

ORDER OF NOTATION. Other rules had to be established to govern the order of the symbols, since both the computer and common sense prefer a regularity of format. Thus, the sign descriptions are always given in tab-dez-sig order (as in the printed dictionary), and the tab is always included in each entry. In addition, the most significant element of each aspect is placed at the left, with elements of lesser significance to the right. Thus $\vee A$ becomes " $A|$ ", and \dot{A} becomes " A' ". It was obviously difficult to assign a relative significance to each of the symbols, so that

wherever the ranking was otherwise arbitrary, it was established in a way easiest to program.

ADDITIONS TO THE NOTATION. Some symbols were added to the notation to delimit the various parts of each sign. These delimiters make visual distinction and automatic processing easier.

Two special symbols were added as abbreviations for the general "person suffix," and for the "-er" and "-est" endings. They are treated as separate signs in sign pairs such as that given for "LIBRARIAN."

The several allochers of various hand shapes were included as additional basic hand shapes. This strategem reduces the complexity of searching algorithms, and does not appear to cause problems elsewhere.

Finally, the ambiguity of some symbols was corrected by introducing new symbols to carry some of the weight.

The notation used in the computer entries is described completely in Appendix I. It is also compared in detail with Stokoe's notation.

DICTIONARY CONTENT. Each entry of the dictionary consists of one English gloss, one or more syntactic values, and the corresponding sign described in the special notation (Appendix II). Each sign may have several applicable English glosses. (Frequently this is because the sign has several syntactic values.) Each unique gloss-sign pair is given as a separate entry in the dictionary. Each gloss may also apply to several different signs. Again, each unique gloss-sign pair is given as a separate entry. Stokoe's notation for syntactic value is used--N for nominal, V for verbal, and X for adjectival and adverbial. Each gloss-sign pair will have one or more syntactic values, but these are combined in a single entry for that pair.

It is thus possible to search the dictionary for all signs to which a given gloss may apply, or for all glosses that apply to a given sign. The search can also be restricted to entries having a given set of syntactic values.

To keep the project within reasonable bounds, much of the valuable information in Stokoe's work was left out of the dictionary--all of the notes about usage, details of the signs, meanings, and so on. This is a significant deficiency, but it was felt that the strategies for a computerized dictionary could best be addressed using a skeletal dictionary. The problem will be brought up again

in a later section.

Finally, all of the glosses and signs were transcribed directly from Stokoe with only the minor modifications in notation described earlier. Because the concept of a computerized dictionary was the dominant motivation for the project, no attempt was made to account for some of the ambiguities and differences of opinion in the descriptions of the signs. Possible ambiguities and differences of opinion will, however, be touched upon in a later section.

THE APL PROGRAMMING LANGUAGE. Because of the coincidence between Stokoe's notation and that of the APL language, APL was the obvious language in which to write the programs for the dictionary. (The symbols can be manipulated using other programming languages, but this is easiest with APL.) APL is an excellent language and system for developing programs quickly and cheaply. It is oriented toward interactive usage and gives the programmer instant feedback while developing programs. It is now generally available, through commercial time-sharing companies, at many university computation centers, and even on a variety of minicomputers and microcomputers costing as little as \$8,000. sk 2;.ce.
RESULTS

The results of the project are a notation and format for sign descriptions, data structures for a sign language dictionary, a system of programs to build and manipulate the dictionary, and many ideas for future work.

NOTATION AND FORMAT. The notation and format of the sign descriptions were introduced in the section on development. All of the details are given in Appendix I, along with several examples that show how Stokoe's notation is transcribed into the notation used on the computer.

DATA STRUCTURES. The data structures by which the dictionary and programs have been implemented are of little consequence to the user of the system. It should be noted, however, that the data structures have been devised to allow as large a dictionary as possible, while retaining "instant" and inexpensive access to it. A dictionary containing 2,500 entries should be possible. There is no limit on the number of separate dictionaries available to the system.

THE PROGRAMS. One of the results of the project is a system of programs for creating, maintaining, and using an automated sign language dictionary. The programs rely upon

the use of the special notation that has been developed, but they are independent of the particular set of entries contained in the dictionary. A small dictionary of 153 entries was set up for program development and testing. The entries were selected to be a representative sample of the notation. They represent a wide range of complexity and encompass all of the changes and additions made to Stokoe's notation. Part of this dictionary is shown in Appendix II.

There are several kinds of programs in the system: "UTILITY", "LOOKUP", "EXPLAIN", and "SEARCH".

1. The "UTILITY" programs provide the means for creating, correcting, and printing a dictionary. One program prompts the user for new glosses and their corresponding sign descriptions and syntactic values. It displays the entries for immediate correction or acceptance. Another program allows the user to go back and correct any erroneous entries that had been overlooked. Two other programs will list the entire dictionary or only the English glosses.
2. The "LOOKUP" programs are used to find all entries with a given gloss, or all entries having the same sign as that for a given gloss.
3. The "EXPLAIN" programs will tell, in English, how to make any of the signs in the dictionary. They can also be used to explain a separate tab, dez, or sig.
4. The "SEARCH" program allows fairly sophisticated syntactic searches through the sign descriptions. The program is given a "model" sign description that tells it which syntactic elements are or are not important in a search. The program then selects and prints all dictionary entries whose signs fit the constraints defined by the model. An example might be to print all signs, regardless of handshape, that use two hands with the tab and sig of the sign for "explain". The entries for "explain" and "control" would be selected, along with that for "direct", which uses two D-hands, and others like these. The search can be broadened or narrowed by removing or adding detail to the model sign.

The "SEARCH" program has the greatest potential for future work. It is described in detail in Appendix III. Examples of the output from the "EXPLAIN" and "SEARCH" programs are shown in Appendix IV.

APPLICATIONS

Perhaps the most important result of the project is that having a notation for signs like the one described here makes sign languages subject to all of the automated analyses to which other written languages are subject. There is a large body of literature describing programs and strategies for natural language processing. Such processing is in fact significantly enhanced by the close relationship between the "spelling" of the signs and their articulation.

There are many possible applications of the programs, given that we have a reasonably large dictionary:

1. Computer assisted instruction. Although the best way to learn signs is to see them made, an English description of a sign can be a reasonably good reminder. The "EXPLAIN" programs can thus be used as a reviewing aid to supplement personal instruction. Of course, one could write a more complex program to actually draw the signs as they appear in many books.
2. Syntactic analysis. The "SEARCH" program can be used to find classes of signs based upon any tab, dez, or sig, or sub-classes within groups of signs having a given syntactic value. For example, one could derive figures for the incidence of two-handed versus one-handed signs. Statistics such as these can be derived very quickly, and with great assurance, from an automated dictionary.
3. New sign "fits." As new signs are developed to fill a void in, for instance, a technical field, a search can be made to find out if the sign "fits" the general syntax of signs, and to see if it might be ambiguous, a duplicate, or otherwise inappropriate.
4. Special dictionaries. Since the system and programs are independent of the specific dictionary used, special dictionaries can be set up for dialects, idiolects, "baby signs," poetic signs, sign puns, and so on. This would conveniently isolate a specific group of signs for study, and make comparative studies easier. One such dictionary might be, for example, a set of signs used to test informants for regional dialects.
5. Duration of utterance studies. New programs can be written to generate duration of utterance (or morpheme duration) indices, and to look up glosses or signs to find the total duration. Obviously, if such indices were available, statistical analyses and comparisons could be done for these concepts.

6. Sign recognition studies. The programs can be used to select groups of signs for sign recognition and differentiation studies. Signs might be selected on the basis of any given criteria by using the "SEARCH" program.

7. Written sign language. Although the best media for distributing sign language literature are video tape and film, these media and the equipment necessary to use them are expensive and not available to many persons. There may be a use for an easily published form of sign language to record and distribute literature that is distinctively sign oriented and which can not be translated into English without great loss of content. Such areas as folklore, poetry and humor are potential applications. The automated dictionary and programs could be used to define a minimal, unique symbolic notation for each sign in the language, with rules for expansion of the "spelling" of signs where elaboration is necessary for more precise description.

8. Training. The programs can be used to train sign language observers in the use of the special notation, and to help resolve ambiguities or detect errors in transcription.

PROJECT CONTINUATION

The best way to test the adequacies and inadequacies of a system is to use it in "real life" situations. Application of the current system to realistic problems has been rudimentary because the intention was merely to solve the basic problems of implementation. The system is now oriented more toward solving the latter than toward answering questions in the studies to which it might be applied. To be really useful, the system must evolve in response to the demands made upon it by its application.

The next phase in the project would thus probably consist of three steps: (1) begin using the dictionary system, (2) gather opinions and notes on the system and its use, (3) incorporate recommended changes and additions into the system.

These three steps define an iterative process that would continue until the system reaches an acceptable form.

PROBLEMS FOR FUTURE ANALYSIS

Although several of the major implementation problems have been solved, as discussed in the section on development, others were postponed as outside the scope of the present project. More questions and problems were set aside because they can properly be addressed only by persons active in sign language studies. The purpose of this section is to present some of the problems whose solutions are known to impinge upon the content of the dictionary and the organization of the programs:

1. Orientation of the dictionary. There are now sets of entries having the same gloss, and sets with the same sign. It would be possible to lump together all of the glosses for each sign, or all signs for each gloss. The dictionary, in other words, can be set up to emphasize the distinctions in either language. This could save space and remove unnecessary detail.

2. Scope of content. It is possible and desirable to augment the simple syntactic values contained in the present dictionary. Notes concerning idiomatic expressions, formal or informal usage, colloquial variations, figurative and literal senses, special negatives, directed signs, and much more could be included. Some balance between maximum information and minimum cost must be decided.

3. Notation. Here there are several problems. The current notation allows a degree of ambiguity that may or may not be desirable. The definition of the sign for "king", for example, neither indicates the tab precisely nor tells the length of movement in the sig. A more precise notation, however, will be more cumbersome; a balance is necessary. Another problem is that some of the symbols are not well defined or denote ranges of activity that overlap the range of activities denoted by other symbols. Observers may have different opinions about which symbol applies in a given instance. In addition, observers will differ in emphasis and perception. In either case they may set down different descriptions (or "spellings") of the same sign. Finally, it might be desirable to expand the notation to encompass body and eye movements.

4. Programs. The relative cost and utility of the current interactive system versus a batch system must be considered. The former is faster and easier to use, but the latter would allow a dictionary of unlimited size and programs of much greater complexity. Size and program complexity could become issues sometime in the future.

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Appendix I: Notation for Sign Descriptions

A. Correspondence to Notation of Stokoe

WCS DVM MEANING

Tab symbols

1. Ø O zero, the neutral place where the hands move, in contrast with all places below
2. ○ o face or whole head
3. ^ n forehead or brow, upper face
4. Δ Δ mid-face, the eye and nose region
5. U u chin, lower face
6. } ε cheek, temple, ear, side-face
7. Π ∇ neck
8. [] E trunk, body from shoulders to hips
9. \ Γ upper arm
10. / L elbow, forearm
11. Q 4 wrist, arm in supinated position (on its back)
12. D Ψ wrist, arm in pronated position (face down)

'Dez symbols, some also used as tab

13. A A compact hand, fist; may be like 'a', 's', or 't' of manual alphabet
14. B B flat hand
15. 5 5 spread hand; fingers and thumb spread like '5' of manual numeration
16. C C curved hand; may be like 'c' or more open
17. E E contracted hand; like 'e' or more clawlike
18. F F "three-ring" hand; from spread hand, thumb and index finger touch or cross
19. G G index hand; like 'g' or sometimes like 'd'; index finger points from fist
20. H H index and second finger, side by side, extended
21. I I "pinkie" hand; little finger extended from compact hand
22. K K like G except that thumb touches middle phalanx of second finger; like 'k' and 'p' of manual alphabet
23. L L angle hand; thumb, index finger in right angle, other fingers usually bent into palm
24. 3 3 "cock" hand; thumb and first two fingers spread, like '3' of manual numeration
25. O O tapered hand; fingers curved and squeezed together over thumb; may be like 'o' of manual alphabet
26. R R "warding off" hand; second finger crossed over index finger, like 'r' of manual alphabet
27. V V "victory" hand; index and second fingers extended and spread apart
28. W W three-finger hand; thumb and little finger touch, others extended spread
29. X X hook hand; index finger bent in hook from fist, thumb tip may touch fingertip
30. Y Y "horns" hand; thumb and little finger spread out extended from fist; or index finger and little finger extended, parallel
31. 8 B (allocheric variant of Y); second finger bent in from spread hand, thumb may touch fingertip

WCS DVM MEANING

Sig symbols

32.	^	^	upward movement	} vertical action
33.	v	v	downward movement	
34.	N	N	up-and-down movement	
35.	>	>	rightward movement	} sideways action
36.	<	<	leftward movement	
37.	z	z	side to side movement	
38.	T	T	movement toward signer	} horizontal action
39.	⊥	⊥	movement away from signer	
40.	⌞	⌞	to-and-fro movement	
41.	α	⤴	supinating rotation (palm up)	} rotary action
42.	∅	⤵	pronating rotation (palm down)	
43.	ω	ω	twisting movement	
44.	∩	∩	nodding or bending action	} interaction
45.	□	□	opening action (final dez configuration shown in brackets)	
46.	≠	≠	closing action (final dez configuration shown in brackets)	
47.	z	z	wiggling action of fingers	
48.	⊙	⊙	circular action	
49.	x	=	convergent action, approach	
50.	x	x	contactual action, touch	
51.	π	π	linking action, grasp	
52.	+	+	crossing action	} interaction
53.	⊙	⊙	entering action	
54.	÷	÷	divergent action, separate	
55.	↕	↕	interchanging action	

WCS DVM MEANING

-	-	THIS TAB OR DEZ BELOW MOVING HAND
-	-	...ABOVE MOVING HAND
?	;	...IN FRONT OF MOVING HAND
!		...BESIDE MOVING HAND
.	'	FINGER OR THUMB EXTENDED FROM BASIC HAND SHAPE
...	~	FINGERS BENT FROM BASIC HAND SHAPE
.	°	SHARP, SHORT, OR TENSE MOVEMENT
.	.	REPEAT ENTIRE SIG
..	..	TWO OR MORE REPETITIONS
~	~	ALTERNATE MOVEMENT OF HANDS
-	-	SEPARATES TAB-DEZ-SIG DESCRIPTIONS
\	\	SEPARATES HANDS IN TWO-HANDED DEZ
	→	SEPARATES SIGNS IN SIGN PAIRS, TRIFLETS
/	/	SEPARATES SEQUENCES OF MOVEMENTS IN SIG
?	!	TAB OR DEZ BEHIND MOVING HAND

B. Additions to Stokoe's Notation

Hand Shapes

These hand shapes were added for dez and/or tab descriptions: S, T, 4, D, Q, and P.

Relative Positions

The semicolon (;) denotes that the moving hand is behind the given hand or tab (toward the signer). The exclamation mark (!) denotes that the moving hand is in front of the given hand (away from the signer).

Special Signs

Two single-symbol signs were added: the upward arrow (↑) for the -er and -est endings, and the downward arrow (↓) for the person ending.

Delimiters

The hyphen (-) separates the tab, dez, and sig within a sign description. The slash (/) separates sequences of distinct movements in a sig. The backslash (\) separates descriptions of the two hands in a two-handed dez.

A Deletion

The changed handshape after an opening or closing movement is placed at the end of the sig without the square brackets ([]).

C. Format of Sign Descriptions

Rules

The sign descriptions in Stokoe are transcribed and augmented according to these rules:

Tab, dez, and sig are given in that order, and separated by a hyphen (-):

$\wedge I \wedge$ BECOMES $\eta - I - \wedge$

A tab is given as the tab symbol followed by the position (if any) of the tab relative to the dez:

$\subseteq G_x^\wedge$ BECOMES $U - G - \wedge x$

A hand (dez) used as a tab, or as the left hand in a two-handed dez, is described in this order:

handshape
forearm symbol, if any
finger(s) bent or thumb prominent
position relative to body
position relative to right hand

\overline{G} BECOMES G^-

$G \wedge \rho$ BECOMES $G \wedge \rho$

\sqrt{B}_T BECOMES $B \mid_T$

$\sqrt{\overline{B}}_\rho$ BECOMES $B \mid \psi^-$

The moving hand is described in the order shown above, but never with a position relative to the other hand.

The descriptions of the two hands in a two-handed dez are separated by a back slash (\):

$\emptyset \emptyset O^+$ BECOMES $\emptyset - \emptyset \backslash \emptyset - 1$

Simultaneous movements are written from left to right:

\vee BECOMES $\vee \rangle$

Sequences of movements are separated with a slash (/):

$\times \vee \times$ BECOMES $\times / \vee \times$

The symbol for sharpness precedes the movement:

\times BECOMES $\circ \times$

The entire sig is described in this order:

all movements of individual hands
alternation of hands (\sim)
repetition of the sign (\cdot and $\cdot\cdot$)
changed shape of hands

$\square \sim [G]$ BECOMES $\square \wedge \sim G$

$\times \# [A]$ BECOMES $\times / \# \wedge A$

$\times \sim \cdot$ BECOMES $\times \sim \cdot$

Double and triple signs are separated by a right arrow (\Rightarrow):

$u-w-x, \Rightarrow 0-B \setminus \psi \setminus B \setminus \psi - \wedge$ (FLOOD)

Person endings are added as the second sign in a sign pair:

$0-L-g$ (LIBRARY) $0-L-g \Rightarrow \downarrow$ (LIBRARIAN)

The -er and -est ending is added as another sign:

$0-L \setminus L - \div \Rightarrow \uparrow$ (LARGER)

Further Examples

$B \mid -T-x / \vee / x$ (THEORY)

$n-B \setminus -x / \# \wedge A$ (BECAUSE)

$u_- -G-\wedge x$ (SHOOTY)

$0-X \setminus \perp \mid \setminus X \setminus \perp - \square \wedge \sim G$ (STARS)

$0-0 \setminus 0 - \perp$ (NOTHING)

$\Gamma -H-Tx / \vee x$ (HOSPITAL)

$H-K-x / \vee \times / x$ (KING)

$\nabla -L'' -Tx$ (PRIEST)

$H-F-Rx$ (FIR)

$H-A' \psi -\wedge x$ (PRIDE)

Appendix II: Excerpts from the Dictionary

ENGLISH DICTIONARY			
INDEX	ENGLISH	VAL	TAB-DEZ-SIG
[1]	ABLE,.....	..X	0-AΨ\AΨ-v
[2]	ABOUT,.....	..X	G>-G<-a.
[3]	ABOUT,.....	..X	0>-G<-a.
[4]	ABOUT,.....	..X	H>-H<-aX
[5]	ACCEPT,.....	.V.	E-5\5-#x0Φ\0Φ
[6]	ACCEPTANCE,...	N..	E-5\5-#x0Φ\0Φ
[7]	ACCURATE,.....	..X	0-X \X-x
[8]	ADMINISTER,...	.V.	0-A'-Λ
[9]	ADMINISTER,...	.V.	0-AL'-Λ
[10]	ANY,.....	N,X	0-A'-Φv
[11]	ANYTHING,.....	N..	0-A'-Φv→0-BΦ-v/⟩v
[12]	APPROXIMATELY,	..X	H>-H<-aX
[13]	ASK,.....	.V.	0-B \B-vτ
[14]	ASK,.....	.V.	0-B\B=τ/x
[15]	AUTUMN,.....	N..	L-EΨ-vX.
[16]	BABY,.....	N..	E-BLΔ~\BLΔ-Z
[17]	BABY,.....	N..	E-BLΔ<-XZ
[18]	BABY,.....	N..	0-BLΔ~\BLΔ-Z
[19]	BAD,.....	..X	u-Bτ-x/Ψv
[20]	BAD,.....	..X	0-BL-Ψv

ASL DICTIONARY			
INDEX	ENGLISH	VAL	TAB-DEZ-SIG
[145]	TRY,.....	NV.	0-A\A-1
[136]	STRIVE,.....	NV.	0-A\A-1
[151]	WOM'IT,.....	.V.	0-AL-°τ
[124]	REFUSE,.....	.V.	0-AL-°τ
[90]	GUARD,.....	.V.	0-ALΨ;\ALΨ-°1
[58]	DEFEND,.....	.V.	0-ALΨ;\ALΨ-°1
[93]	HEAD,.....	N..	0-AL'-Λ
[31]	BOSS,.....	N..	0-AL'-Λ
[9]	ADMINISTER,...	.V.	0-AL'-Λ
[21]	BE ABLE,.....	.V.	0-AΨ\AΨ-v
[119]	POSSIBLE,.....	..X	0-AΨ\AΨ-v
[33]	CAN DO,.....	.V.	0-AΨ\AΨ-v
[1]	ABLE,.....	..X	0-AΨ\AΨ-v
[11]	ANYTHING,.....	N..	0-A'-Φv→0-BΦ-v/⟩v
[10]	ANY,.....	N,X	0-A'-Φv
[30]	BOSS,.....	N..	0-A'-Λ
[92]	HEAD,.....	N..	0-A'-Λ
[8]	ADMINISTER,...	.V.	0-A'-Λ
[130]	RING DOORBELL,	NV.	0-A'-1.
[122]	PRESS BUTTON,.	NV.	0-A'-1.
[143]	TOGETHER,.....	..X	0-A \A-a1

'*-*-*	all signs (any tab, dez, and sig)
'u*-*-*	all signs with a chin tab not specifically located relative to the dez. (any dez and sig)
'u--*-*-*	all signs with a chin tab and having the dez positioned under the tab
'u*-*-*-*	all signs with a chin tab
'n-I-^'	only the sign for IDEA
'n-G_T-X->*	all compound signs beginning with the sign for THINK
'*-**-*-*	all signs with a two-handed dez
'*-*-*-A*'	all signs with a dez that changes into an A-hand
'*->*'	all double signs

There are also some special symbols that represent specific groups of symbols. These special symbols are used to indicate that a symbol must be present at the given location in the sign description, but that the symbol may be any one of the group. These special symbols and groups are:

I	any tab which is not also a dez
D	any dez (may also be used as a tab)
E	dez must have finger(s) bent or thumb prominent
F	any position relative to the body
G	any position relative to the dez
C	any change in shape of dez

So, for example:

'D*-*-*	all signs using a dez as tab
'I-D*-*-*	all signs made with one hand
'O-D\D*-*-~*'	all two-handed signs in which hand shapes are not important, but in which the hands move alternately in the neutral tab
'*-*-C'	all signs in which the dez changes shape

Appendix III: The "SEARCH" Program

PROGRAM FUNCTION. The SEARCH program was discussed earlier in this paper. Its function is to locate and print dictionary entries whose sign descriptions satisfy a set of criteria determined by the user of the program. These criteria can be the presence of specific elements (symbols in the notation), the presence of particular kinds of elements (any element from a given class of elements), or the absence of specific elements. Another criterion can be that the presence or absence of certain elements makes no difference. These selection criteria are given to the program in the form of a "model" sign description. (The model is formed much like a normal sign description, but it can contain several symbols that have special meanings to the SEARCH program.) The result of a search is a list of all of the signs that satisfy the given criteria-- that is, a set of signs having certain features in common-- a two-handed dez, or a movement away from the signer, or a palm-down B-hand, or any combination of such things.

SYNTAX OF THE COMMAND. A search of the dictionary is initiated by typing a command like this:

```
'val' SEARCH 'model'
```

The 'val' is the syntactic value or values that the signs to be selected must have. The selected signs may have other syntactic values in addition to those specified. If '*' is typed for the values, then all syntactic values will be ignored-- that is, any will be accepted.

The 'model' is the model sign description that gives the selection criteria.

DEFINING MODELS. In general, the format of the model is the same as that of all sign descriptions-- with some exceptions.

Type the specific symbols that MUST be present in the signs to be selected. Between (or instead of) these you may type an asterisk (*) to indicate that everything up to the next specific symbol (if anything) does not matter. Here are some examples and the signs they would select:

Appendix IV: Example Program Output

```

      FIND 'SEE'
[ 132] SEE..... .V.  Δ-V_T-1'
1 ENTRIES FOUND.

```

EXPLAIN 132

```

THE TAB IS THE NOSE OR MIDFACE
THE MOVING HAND IS THE V-HAND
POINTING TOWARD YOURSELF
MOVE THE HAND(S) OUTWARD

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^ FIND ALL SIGNS WITH G HAND FOR DEZ

```

      'X' SEARCH 'X-GX-X'
[  2] ABOUT..... .X  G>-G<-α.
[  3] ABOUT..... .X  O>-G<-α.
[ 27] BITTER..... .X  U-G_T-°X
[ 29] BLUSH..... NV.  U-G_T-XV→O-5_T-Λ
[ 34] CAN'T..... .V.  GΨ-GΨ-°VX
[ 55] DEAF..... .X  ε-G-X→O-BΨ|BΨ-X
[ 56] DEAF..... .X  ε-GΛ-X→U-GΛ-X
[ 57] DEAF..... .X  U-GΛ-X/T/X
[ 59] DISAPPOINT.... .V.  U-G_T-°X
[ 62] DISAPPOINTMENT N.  U-G_T-°X
[ 67] ESCAPE..... .V.  5ΨΘ-GΛ-1
[ 75] FACE..... N.  Θ-G_T-η
[104] INSULT..... NV.  H-G_T-°XΛ
[112] LOOKS..... N.  Θ-G_T-η
[114] NOSE..... N.  Δ-G-X
[131] RUN AWAY..... .V.  5ΨΘ-GΛ-1
[146] UGLY..... .X  Δ-G+G-°X/X

```

17 ENTRIES SELECTED.

^ AS ABOVE, BUT ONLY THOSE WITH HANDS FOR TABS

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      'X' SEARCH 'GX-GX-X'
[  2] ABOUT..... .X  G>-G<-α.
[  3] ABOUT..... .X  O>-G<-α.
[ 34] CAN'T..... .V.  GΨ-GΨ-°VX
[ 67] ESCAPE..... .V.  5ΨΘ-GΛ-1
[131] RUN AWAY..... .V.  5ΨΘ-GΛ-1

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5 ENTRIES SELECTED.