THE LA TROBE TALKING COMMUNICATOR FOR THE

SEVERELEY DISABLED SPEECHLESS

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ABSTRACT
The La Trobe Talking Communicator is a personal computer with video, speech, and print output designed to meet the needs and capabilities of severely physically handicapped school children. Using specially designed keyboards, footswitches, or a suck/blow switch , the handicapped user makes selection of item and function from self-scanned menus displayed on a video monitor and/or voiced. Using the utility TALK, the non-vocal can compose, store, voice, and revise statements from menus of letters, words, phrases, and editing functions. Programming experience and artistic expression is offered by a one-key version of the OZNAKI language WHAM. Video games are used to train users in keyboard operation. A battery of 10 Mark II Communicators is being installed at the Yooralla Special School, Glenroy, Melbourne.

EDUCATIONAL NEEDS OF SEVERELY HANDICAPPED CHILDREN

Language acquisition is a matter of two-way communication from the child to and from its parents and teachers. Consider how a normal child learns English. The child hears many instances of English. The child may say "Daddy car". whereupon its mother says "Yes. Daddy IS IN THE car", both reinforcing what the child has correctly said and demonstrating further refinements. When a normal child learns to read its parents and teachers can monitor letter by letter an effort to read a word or sentence. In the case of the non-vocal student, communication via pointer board devolves about a subset of English, in which most connectives are guessed by the receiver. Far a non-vocal child a teacher must assess reading ability by discussion over a pointer board of the meaning of sentences. The normal student writes thousands of sentences thereby enriching knowledge of grammatical minutiae while simultaneously learning handwriting. The severely handicapped child cannot write at all.

A child's total development, knowledge of self, intelligence, emotional and social stability, depends to a large extent on its ability to move, manipulate and explore self and environment. In fact the psychologist the late Jean Piaget termed the stage of intellectual development of roughly upper primary school level as the "concrete operational" stage. If severely physically handicapped children are to attain their fullest potential means must be given them to play and explore in wide ranging learning environments. Only through personal computing can the severely handicapped have these compensating experiences,

The La Trobe Talking Communicator was conceived as a personal computer far severely handicapped children. The prime feature of potential users is limited capability for use of hands, so that handwriting is inconceivable. Some such children can use a conventional typewriter equipped with keyboards which ensure that only one key at a time is struck. They are inherently one-finger typists, and with effort locate a particular key. The initial emphasis has been an non-speech cerebral palsy children, but the system developed is applicable to a much larger range of the severely disabled, both children and adults, possessing either reasonable vision or hearing.

THE NON-VOCAL SEVERELY HANDICAPPED

The handicap combination of inability to produce intelligible speech, and poor motor control, is fairly rare. and a highly speculative estimate of the numbers involved would be 3000 in Australia. At the Yooralla Special School Glenroy, of 130 children with cerebral palsy and other neurological conditions, there are 11 such handicapped children. This disability combination can arise in cerebral palsy (BOBATH 1980), where brain damage has occurred at or before birth, or as a result of brain damage in accidents (which is an increasing phenomena (Ford 1977; Steiner 1981)), or as a result of cerebral haemorrhage ("strokes"). The victims of certain degenerative neurological conditions also pass through such a stage. Brain lesion need not significantly affect the potential for intelligence, but sadly it can be very difficult to assess the intelligence of the communicatively disabled, some if whom therefore receive no education.

For the non-vocal with good finger control or capable of precise control of a head-stick there are a number of communication aids available. For example, the Phonic Mirror "Handi-Voice" features a membrane keyboard with approximately 30 keys, including 4 shift keys, so that 200 words/phrases can be selected and then synthesized. The Sharp "Memo-Writer" is an extremely tiny hand-held computer that prints on a continuous strip of thermal paper.

COMPUTER COMMUNICATION, ACCESS AND PROGRAMMING

In 1979 the School's Commission commissioned a survey by Andrews et al (1979), on the needs and priorities of children with handicaps and learning disabilities. Subsequently, the Commission has offered support for a "beacon" project under this writer's direction, titled "Computer Communication, Access, and Programming by Severely Handicapped Children." The broad concern of the project is the needs of children with neurophysical disability that interferes with the normal coordination of muscle action and who consequently have very poor hand control. Many such children cannot speak or perhaps have very difficult to understand speech. Such children could never write, and use some sort of pointer board, together with limited gestures to communicate. The first task of this project is to provide means for the child to communicate in a classroom situation, both by speech, using synthetic speech, and in hard-copy.

The project is directed initially at a group of severely handicapped non-speech children at the Yooralla Special School, Glenroy, Melbourne. In addition to computer-based class-room communication, the project aims to provide these children with computer access and programming. Whereas with normal kids such experiences are desirable in the 1980's, for the severely handicapped the computer now so affordable is actually essential. These children miss out on the normal experiences and total development is retarded, so they are doubly handicapped. For some years now various "early intervention" programs, see , e.g., Bobath (1980) have been followed at the preschool stage essentially to guide and enrich sensori-motor experiences for these children.

THE PROTOTYPE TALKING COMMUNICATOR

In 1981 a prototype "TALKING COMMUNICATOR" was constructed that enables a handicapped person capable of pressing as few as one but preferably four or five keys to readily communicate with people by speech and by typed text and to conveniently communicate with another computer.

The prototype is based on a 1976 model s-100 bus microcomputer, equipped with 5 inch single density floppy, and is mounted together with keyboard selector, video monitor and speech synthesizer on a wheeled video cart. The keyboard selector is a simple device for swapping between full keyboard (for program initiation and development), and the handicapped user's keyboard. The first models of the prototype incorporated a phoneme synthesizer marketed by Votrax. This synthesizer offers just 63 phonemes, including silences and some different lengths of the 43 phonemes required for English. Using this phoneme synthesizer entails storing in the memory both text and phonetic forms for words/phrases. Subsequently, Votrax have released a single chip phoneme synthesizer, the SC-01 (see Cohen, 1981 a). The current synthesizer, also manufactured by Votrax, incorporates the SC-01 chip, and incorporates a text-to-phoneme translator, with the particular advantage that words composed by letter selection are properly voiced. The synthesizer produces intelligible speech, of a somewhat mechanical male voice.

During the first half of 1982, the project continued to use the prototype Talking Communicator, developed in 1981. Hence all photos in this paper show this system. However under construction has been a battery of Mark II communicators of notably distinct features. In the Mark II, all RAM is CMOS, which is battery backed. Thus this communicator has in-built "mass-storage", so floppy discs are not required. This makes for a far more compact and portable system, with low power needs, that could be powered by a wheelchair battery.

V. using early version of foot controller. The program she is running is really a game for pre-schoolers, but affords her plenty of opportunity to practice control. V. was found to have very good foot control, while in fact she could not control with her hands even a single key.

THE UTILITY "TALK"

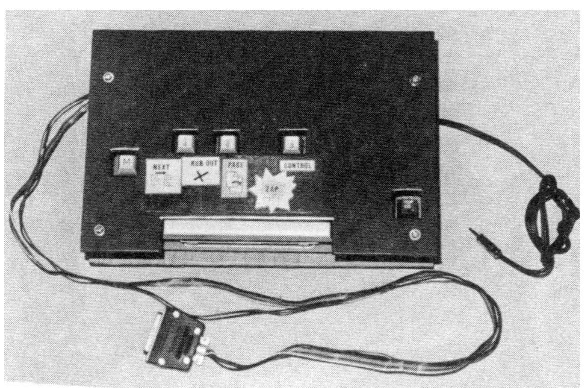
Central to the Talking Communicator is the utility TALK. In the prototype system, TALK offered the user 386 words over 8 pages of menu. In TALK, one menu item at a time is displayed on the monitor, above the 4 screen lines in which the statement under construction is composed. Statements, limited to 200 selected items, scroll upwards. Up to 4 different statements can be prepared at a time. The word menus were designed in conjunction with Mrs Leone Phelan, speech pathologist at Yooralla. The organizational principle is apparent from the contents: menu pages 1-8.

Page	Contents
0	Letters, statement select, a few phrases
1	When or where it happened
2	Names occupations, pronouns - who did it.
3	Verbs - what was done.
4	Adjectives describing feelings, people, things.
5	Modifiers e.g. very, that.
6	Places.
7	Noun groups, clothes, foods, household objects.
8	Miscellaneous.

Within the pages 1-8 words are arranged in groups, such as a friends names group, and a food group. The sequence of pages are designed to minimize the keystrokes needed for selecting in sequence the words of a simple sentence such as

On Saturday afternoon I went to see the North Melbourne football match.

Below the theory of keyboards is discussed at some length. For the moment the keyboard used in 1981 with the first prototype communicator is described.



The above photo shows a 5 key keyboard used in the first stages of the project. This keyboard was adapted from an ordinary ASCII keyboard by shielding out most keys. Only the more accessible key, the space bar, was used for time-slot selection -- this was the ZAP key. All the other four keys could be struck at any time independently of the location of the cursor to execute a function as marked.

COL Next column
DEL Delete last selection.
PAGE Next page.
CONTROL

The CONTROL key by itself returned menu page 1. If followed by another key within a time-slot other functions were performed.

THE QWERTY KEYBOARD

An ordinary ("ASCII" keyboard, often called a QWERTY keyboard, has more than 50 keys. And on a single keystroke a particular alpha-numeric symbol is produced. In addition, there are one (or more) shift keys to be applied simultaneously with a particular key. The QWERTY keyboard design was not the first patented, but it had a brilliant design feature: keys more likely to be used in sequence, such as O and U, were placed as far apart as possible in order to avoid jamming when a one finger typist picked out letters one by one. In other words, the QWERTY keyboard was designed to be as SLOW as possible in operation by a one key typist. (See, Montgomery, 1982) Subsequently touch typing was discovered, so that the spread of the alphabet over the QWERTY was found to be, if not optimum, at least useful in spreading the effort over all fingers. But in this project we are dealing with users who are at best one finger typists, who can with effort pick out just one key at a time provided some mechanical barrier prevents more than one key at a time being depressed. For them the QWERTY keyboard is optimized for frustration, while conventional shift keys are simply impractical.

SELF-SCANNING KEYBOARD

To enable a person capable of striking just a few keys to have a wide selection of possibilities, the user must be offered a self scanning menu. The idea of self scanning is best explained by reference to the following layout of the letter select system available in one version of TALK.

	Space	E	I	O	U	Y
>	T	A	Æ R	C	G	Q
	N	H	F	P	B	Z
	E	D	W	X		
	L	M	K	?		
	V	J	Rub			
	0	1	2	3	4	5
	Speak					

, the cursor

In this letter menu, a ROW cursor denoted by a > waits for a programmable time (of the order of 1 second)at the beginning of each row of the row. If, however, the user depresses the ZAP key, the cursor will enter the row, when it assumes the form of a Æ. The Æ cursor jumps in front of each letter (or whatever) in turn, waiting the usual time, and the item is selected if the user presses the ZAP (select) key. Following a ZAP, or if no selection is made after two complete passes through a row, the cursor reappears as a > as a row selector at the beginning of the top row. Note that the number of jumps the cursor makes before selection of the more accessible letters are thenceforth:

0 Jumps	Space
1 Jump	E T
2 Jump	I A E
3 Jump	O R H S

The number of jumps to select a letter is what one can call the "accessibility" of a letter. The accessibility order has been chosen consistent with letter frequency, with minor variations, so as to make the top row all vowels etc. The expectation of the number of jumps for a selection is between 2 and 2.1 depending only marginally on slightly differing published data on letter frequency, e.g., ABRAMSON, page 34.

Note that the above “menu of letters” in fact is extended at the bottom by a further two rows.. These additional rows do not increase the jump expectancy, provided the user does not make frequent non-zapping passes over the menu.

Instead of displaying such a menu over 7 or more lines, the menu could be first shown as “clumps” over a single screen row. Then, if a particular clump is selected it would expand to occupy the whole row. Such a scheme is especially appropriate to tiny displays.

The most effective way to use five keys is to offer the user menus arranged in matrices of five columns, which are scanned row by row. Then when the user pressed a particular one of the five keys the corresponding column entry will be zapped. However, a row of five entities is a sizeable quantity to visually scan. An effective layout will be a compromise between minimality of row to row jumps and complexity of optimization.

PROGRAMMING BY THE HANDICAPPED

In order to achieve personal independence, the severely handicapped must be capable of programming a range of robotic devices, from knives and forks to shaves. These robotic appliances are not yet marketed, though already there are “one-off” like applications. Hence it is simply essential that the severely handicapped learn programming.

But what sort of programming is appropriate? The Communicator will interface (through an RS-232 link) with other computers, and thus run BASICor PASCAL. However, an educationally more worthwhile approach has been taken in introducing programming to children who will use the Communicator.

WHAM, one of the OZNAKI robotic languages (Cohen, 1978) will be adapted to the Communicator. At the moment a one key version of WHAM for the Apple][is available.

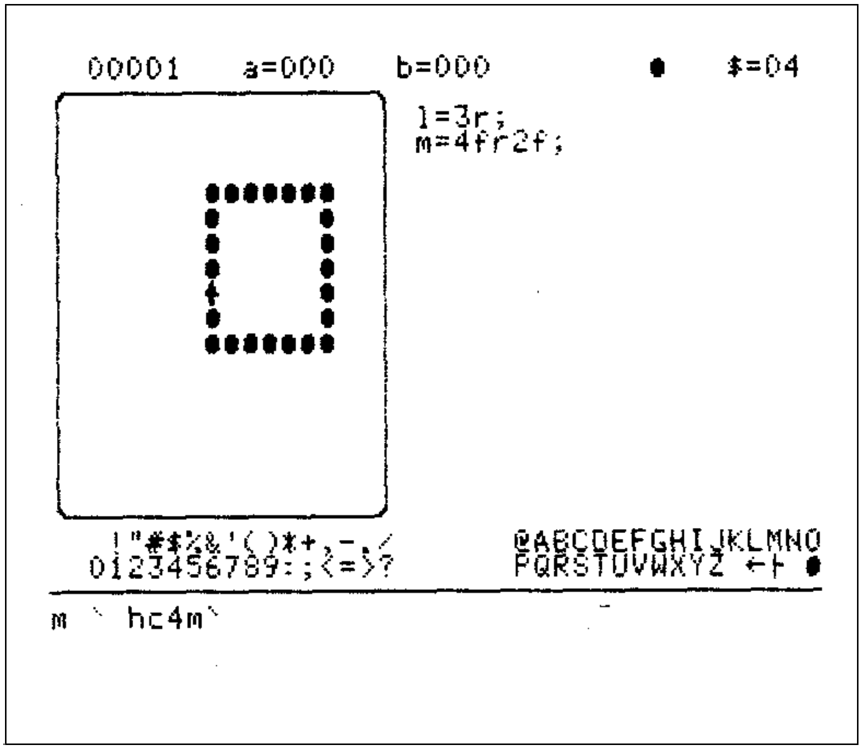
OZNAKI is a family of languages designed to stimulate mathematical thinking. In a very carefully evaluated study (Cohen and Green, 1977) it was shown that normal students using WHAM showed remarkable enhancement of their spatial abilities. Spatial abilities are a major component in mathematical problem solving. Handicapped children, being wheel-chair bound, miss out on some of the concrete experiences which Piaget attests are needed for the development of spatial skills.

In WHAM a creature called a NAKI is directed about the screen, where it leaves a discrete trail: basic commands are F for FORWARD and R for RIGHT TURN (of 90 degrees). These are the same commands as the LOGO Turtle obeys, but the moves are discrete. The dump character can be altered, and the pattern formed saved in an “album of snaps”. By showing a sequence of SNAPS one after the other a movie is produced. It is not appropriate here to give a full account of WHAM. However the following screen print-out of Apple WHAM is illustrative. Note that as WHAM is a “tiny” language a very simple alphanumeric character selector suffices. What has been done is to break the menu into four groups, and a cursor first pauses before each group in turn. Following a keystroke, a ZAP, the cursor enters the row and pauses before each character in turn.

WHAM for the 1-key user

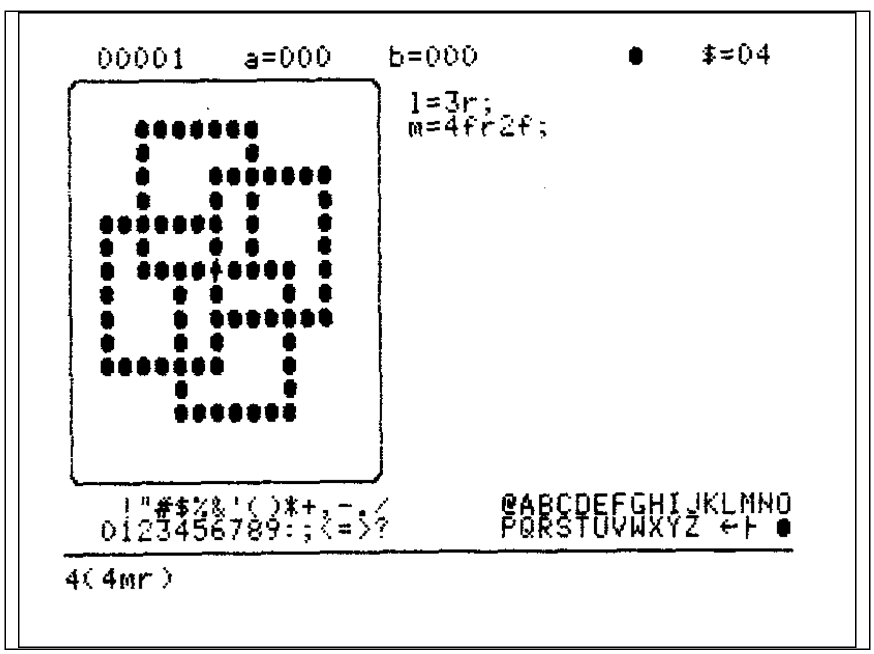
The key selector is below the square NAKI territory.
To the right of the territory is a list of macros defined by the user.

To draw this square, the NAKI was sent home (Territory center) on the command h, the screen was then cleared with the c command, The macro m, simply composed of F commands (forward) and R (right turn) commands, was requested 4 times, via the two keystrokes 4m to produce the square.



The dump graphic character is displayed on the top screen line, together with an iteration counter, and two registers a and b. $ is the page number of the album of SNAPS, into which a copy of the screen can be saved, or from which the screen can be filled.

In the second printout of a WHAM screen, the pattern displayed was generated, after a clear screen and home command, by the command shown in the buffer area at the bottom of the screen: namely "4(4mr)".



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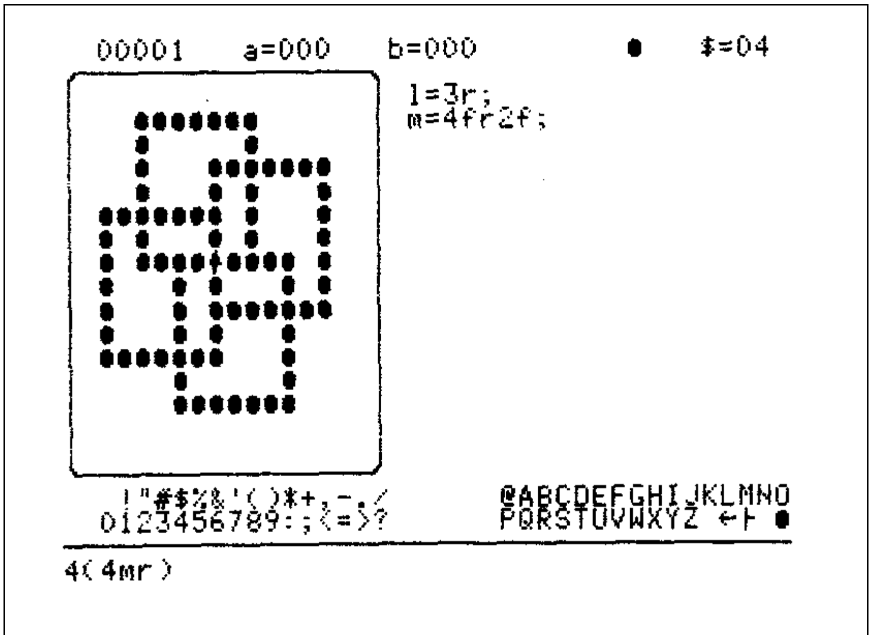
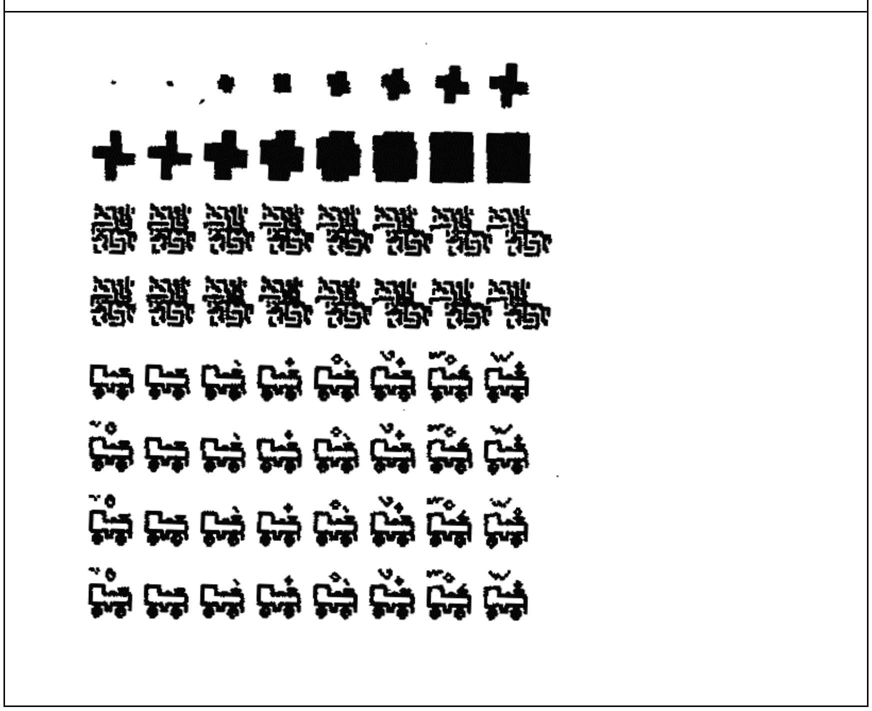


Here is a screen printout of an entire library of SNAPS



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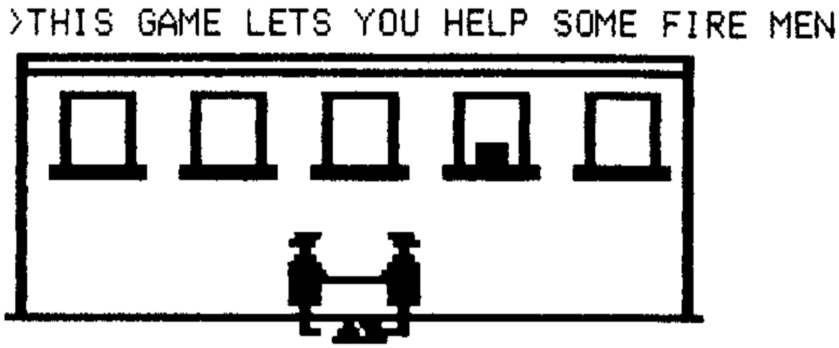
By displaying SNAPS of the train, in sequence, one generates a movie. Each frame of this movie was easily adapted from an initial SNAP of a train (image); a simple macro serves to run the movie, or merely apt use of brackets in this highly algebraic programming language.

TRAINING 0F USERS

Persons with neurological dysfunction must be trained to use keyboards. For the five key keyboard the user has to learn not to strike other than the wanted key, and to do this in a precise manner as speedily as possible. To promote such skills games are being devised. One such is the Fireman Game



In this game a house with five windows is displayed on the TV screen, and the synthetic voice gives the game rules and advises that the furniture within is being thrown out For instance there may be a message, "Here cones a chair" and an object appears at a particular window, say number 2, pauses an instant, then slowly falls. If the user strikes key 2 in time. the firemen will rush across and catch the chair, otherwise it crashes onto to ground, with accompanying noise. After 40 moves the game tally is presented The child pictured below could originally only catch the object 15 tines out of 40 but was instantly addicted to this simple game. After two weeks zealous practice her regular score became 39 out of 40

In the above photo is shown a 5 key user The : keys are made from commercial light switches with the actual switching mechanism replaced by micro-switches,

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EDITORIAL REMARK: The pub lished paper was printed in monochrome. For the PDF version, (identical) colour images have been included in lieu, where available.