

Chapter 8

Switch Access using Scanning and Encoding

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8.1 Switch Access Quick Assessment Guide

The chart summarises common difficulties with switches and suggests some techniques and tools that might help. Refer to the text in the chapter, and to Chapter 9, which deals with switches and switch assessment, for further details.

Observation	Access tool
<i>The user can use 4 or 5 switches...</i>	<i>Investigate...</i> Directed Scan
<i>The user can hit 1 or 2 switches...</i>	<i>Investigate...</i>
...repeatedly with good timing	Morse Code
...with good timing	AutoScan
...hold, and then release a switch with good timing	UserScan
...but has difficulty with timing	1 or 2-switch StepScan
<i>The user can operate the scanner but...</i>	<i>Investigate...</i>
...often selects incorrect items	seating and positioning vision switch type increase switch acceptance or post acceptance delay slow down the scan speed a different scan method switch or items to quickly delete the last selection switch or items to restart the scan quickly
...writing is unacceptably slow	seating and positioning switch type increase scan speed a more efficient scan method a more efficient scan movement a more efficient selection set layout split the set into several linked grids acceleration software - 'word prediction', abbreviation expansion

8.2 What is scanning?

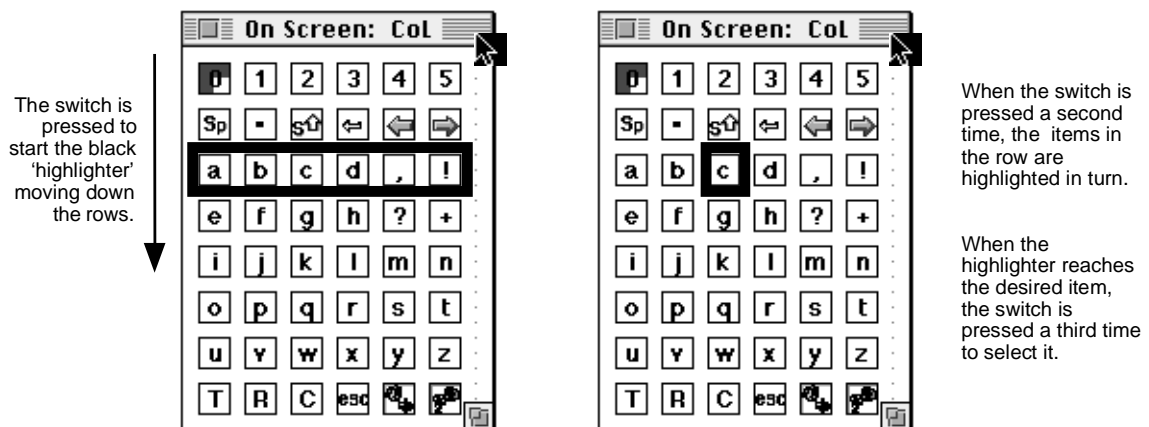
This chapter discusses how one or a few switches can be used to control the computer – either by ‘scanning’ and selecting from an on-screen keyboard (see Chapter 7) or via Morse Code.

Throughout the chapter we make reference to particular programs and features: refer to *Chapter 7: Introducing on-screen keyboards*; *Chapter 9: Using On-screen keyboards*; and *Chapter 12: Reviews of On-Screen Keyboards* for more information on the programs.

The word **scanning** has several meanings. In the computer world generally the term is used to refer to the process of digitizing a picture into an electronic format. In this book about special access, however, we use it to refer to a technique for sequential display of a set of items and selection using a small number of switches.

A traditional single-switch **row-column** scanning system display is given below. The program starts scanning, by **highlighting** each row of items in turn. When the row with the item required is highlighted, the user presses the switch, and each item in the row is highlighted in turn. When the required item is highlighted, the switch is pressed.

Figure 8-1 Discover: Switch Autoscan



This is an example of one type of scanning system. Scanning systems may:

- be controlled by one, two, three, four or five switches
- offer different **Scanning Methods** for moving the highlighter from item to item
- employ particular **Scanning Movements** - how items or group of items (such as rows) are highlighted during scanning
- have screen layouts, items and actions designed for individual users and tasks

By carefully tailoring the scanning system to the access task and the user you can create an effective and efficient access system. Conversely, if you get it wrong it can be frustrating and slow to operate.

This chapter discusses the mechanics of scanning; compares the different scanning techniques; and considers good practice for designing selection sets. You should also read Chapters 7 to 11, which cover on-screen keyboards, switches, use to access different aspects of the curriculum, and reviews the programs available.

Who might use scanning?

Students who have severe physical impairments and who cannot use keyboard, mouse or voice can use switches and scanning to write and control the computer. Scanning should be evaluated when direct selection movements are limited, too fatiguing, or lack accuracy (Glennen & DeCoste p. 260). If a person can physically control only one or a small number of muscle movements, then scanning or Morse code may be their only viable control options (assuming voice recognition is not a possibility).

Case Box

Glenn is in Primary 6 and has cerebral palsy. He uses the *Ke:nx* single switch scanning system on an Apple Macintosh, accessed with a chin switch. He can operate the switch with excellent timing, and so uses AutoScan. He has a wide range of different selection sets for different tasks: letter and word sets for writing; number sets for maths; and mouse control sets for drawing.

Scanning can also be helpful for **people with learning disabilities** because a small number of items can be presented one at a time and selected with a switch, and this can be simpler than making a choice from several items on a keyboard.

People who use other types of access tool may find that scanning makes certain **tasks** easier - a student might use an adapted keyboard for writing, but have difficulty with the mouse and so use scanning to operate a multimedia program, for example.

Often there is no hard and fast answer to a question about whether someone should use scanning. Some people (particularly with athetoid cerebral palsy) can access a keyboard, but only slowly and inaccurately, and are faster and more accurate with a scanning system. Others do not have the patience to use a scanning system and are happier with direct selection because they feel more in control (even if it is less efficient than a scanning system).

Case Box

Terry is six years old and has cerebral palsy. For writing, spelling and other tasks which involve keyboarding he uses a headpointer to access the standard keyboard. But for activities based on whole words he uses switch and scan and an on-screen keyboard because it is faster (for a small number of words) and involves less effort. As he progresses through school, he may come to rely more upon the headpointer, perhaps with word prediction, or use another pointing technique (such as a headpointer and touchscreen, or head-operated mouse with on-screen keyboard); or scanning – it depends on how his skills develop.

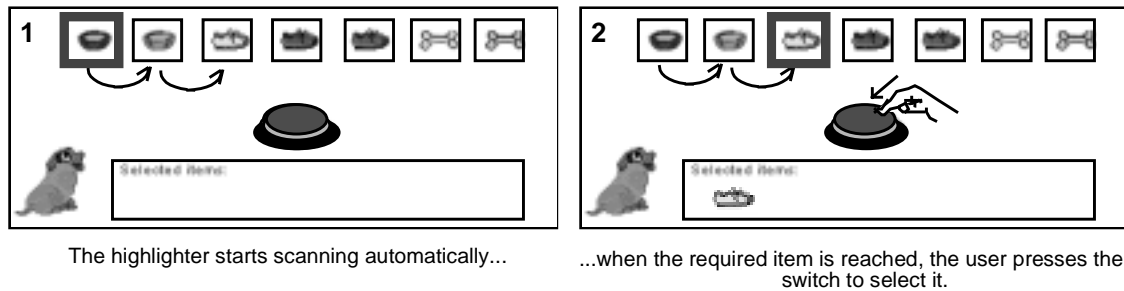
8.3 Scanning Methods

There are several methods of moving the highlighter from item to item in the selection set. The descriptions below are based upon methods commonly available in scanning systems together with information from references such as the ACE Centre's *A Common Terminology for Switch Controlled Software*.

Static descriptions and pictures only give a limited experience of what is involved in using different scanning methods. Before inflicting them on a pupil you *must* try them yourself; ideally by trying out the program, or use the demonstration and tutorial programs that accompany this book, available on disc or at the CALL Centre web site.

Autoscan

Figure 8-2 Autoscan (Single switch, with automatic start)



The highlighter starts and moves automatically from item to item at a set rate. When it reaches the item required, the user activates a switch and the item is selected.

With some programs (e.g. *Switch Clicker*) the scan will start by itself as soon as you run the program, while with others (e.g. *Discover*, *EZ Keys*) the user must press and release the switch to get the scan moving. (ACE refer to this as a *Toggle scan*.) Many users prefer the latter because they can ready themselves before starting the scan, and the scan is not constantly flashing away on screen (or worse, offering speech prompts) while the user is attending to something else. The disadvantage is that it requires an extra switch press to get things moving.

The time that an item is highlighted for is called the *Scan Delay* and can vary between a tenth of a second to 10 seconds. The smaller the Scan Delay, the faster the highlighter moves.

With most programs you control Autoscan with a single switch, although *SAW* and *Wivik* let you use two. With *SAW*'s 2-switch Autoscan, pressing and releasing a switch starts and stops the scan but does not select the item: to select it you press the second switch. With *Wivik*, one switch starts the scan and selects as usual and the other switch can be programmed to do one of several different things: stop the scanning; delete the last text entry, increase or decrease the scan speed, or swap the direction of scanning.

Other terms for:

Autoscan	<i>Automatic Scanning; Regular Scanning; Interrupted Scanning; Single Switch Scan.</i>
Scan Delay	<i>Scan Time</i>

Why use Autoscan?

Consider Autoscan when the user:

- can control one or two switches;
- has good timing to activate the switch, but cannot hold it on;
- needs the simplicity of only having to operate one control.

If the user does **not** have good switch timing, consider Userscan or Stepscan.

Auto-scanning can be surprisingly fast: some experienced users can operate with a scan delay (the time that an item is highlighted for) of only 0.1 seconds. This is good going when you consider that the average human reaction time is over 0.5 seconds. The only way to achieve this sort of performance is to practice and learn the 'rhythm of the scan' so that you can anticipate and move to operate the switch when the highlighter is three or four items ahead of the one you want. Experienced users may not even pay much attention to the screen display at all because they have learned the exact timing between each switch activation required to select a particular item. Systems which 'beep' as each item is highlighted can help the user learn the 'code' for selecting each item. For example, to select 'd' in Figure 8-1 on page 127, running with a scan delay of 0.5 seconds, the user would:

- hit the switch to start the scan;
- wait for about 1.25 seconds (or count 3 beeps) until the correct row was highlighted;

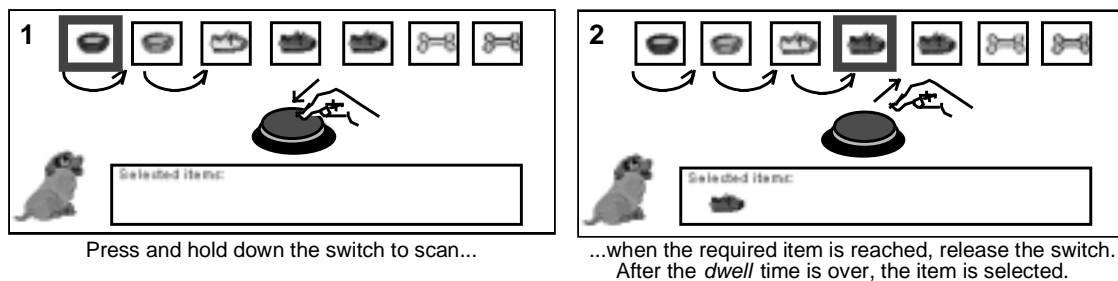
- hit the switch again;
- wait for about 1.75 seconds (or count 4 beeps) until 'd' was highlighted;
- hit the switch to select the item.

Scanning can therefore be described as a form of coding where any given item is selected by generating a pattern of switch presses separated by different time delays, with progress through the pattern illustrated by the visual display.

2-switch Autoscan can offer some advantages over single switch Autoscan. A SAW user, for example, can start and stop the scan at any point without actually selecting an item, and then use the second switch to select, so there is less pressure and less chance of selecting the wrong item. However, because selection requires an extra switch press it may be slower than single switch Autoscan. *Wivik* and *HandsOff!* let you use a second switch to do several time-saving tasks such as stopping the scan or deleting the last text entry and these can increase speed and user control over the scanning system.

Userscan

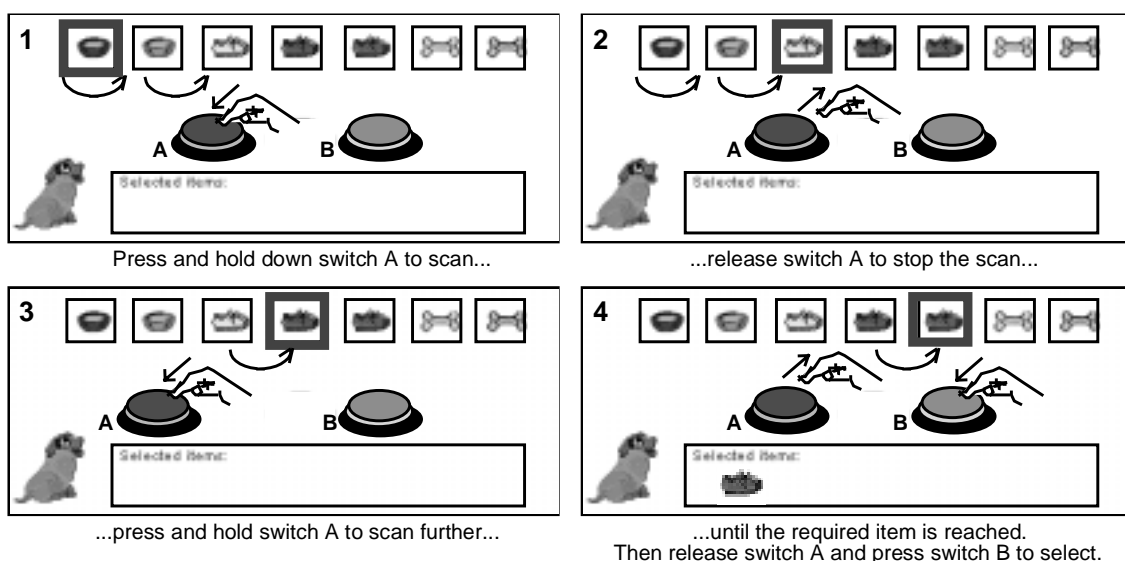
Figure 8-3 Userscan (Single switch with *dwell* select)



When the switch is activated and **held on** the scan starts and moves along as with Autoscan. When the switch is released the scan stops and the item is highlighted. The highlighted item can be selected, or the switch can be pressed again to move the highlighter on to the next item.

Userscan can be controlled by one or two switches. With one switch, **dwell selection** is used: if the switch is not pressed again to move the highlighter on within the *dwell period*, the item is selected. With two switches, the item is selected with a second *select* switch.

Figure 8-4 Userscan (2 switch)



There are therefore two quite different Userscan techniques, with quite different skill requirements, depending on the number of switches used.

Other terms for:

Userscan ***Two-switch Scanning; Inverse Scanning; Directed Scanning***
Dwell Period ***Input Acceptance Time***

Why use Userscan?

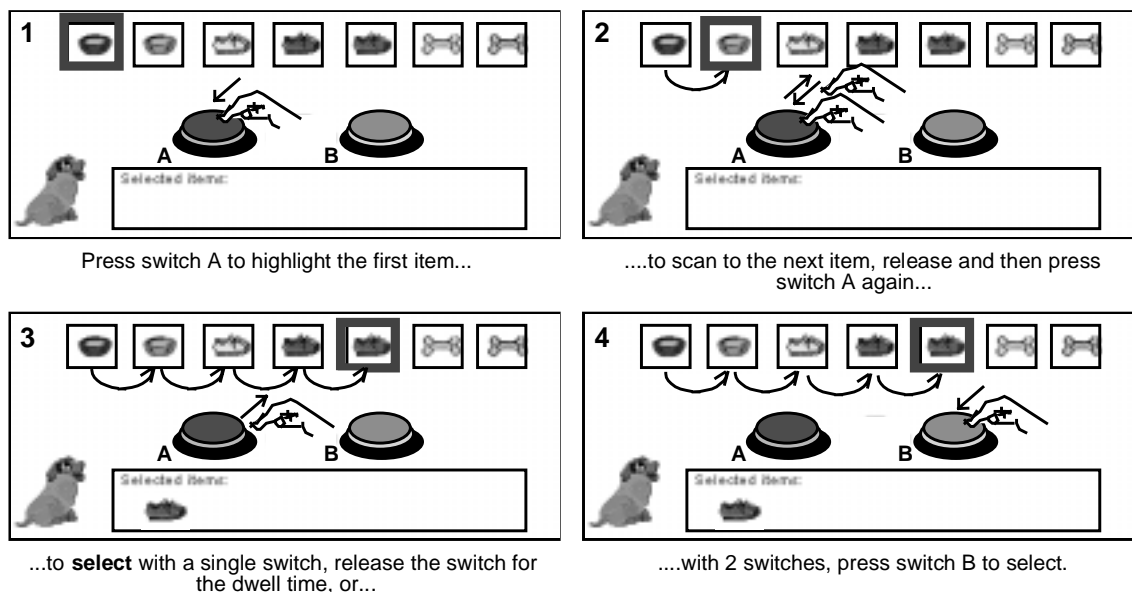
Consider Userscan when the user:

- can control one or two switches;
- can activate a switch, hold it on, and release it with good timing;
- has difficulty waiting and activating the switch with good timing (so Autoscan is not suitable);
- becomes anxious or stressed waiting to press the switch for Autoscan.

If the user cannot hold the switch down or release it with good timing, then Stepscan should be considered.

Stepscan

Figure 8-5 Stepscan (single and 2 switch)



Stepscan is a little like Userscan, except that when the switch is activated the highlighter moves (steps) along **one** item only. To move to the next item you must release and then activate the switch again. The highlighted item can then be selected, or the switch can be pressed again to move the highlighter on to the next item. It is generally slower than Auto- or Userscan, and requires more switch activations.

An item is selected using either *dwell selection* or by pressing a second *select* switch.

Other terms for:

Stepscan ***Two-switch Scanning; Stepped Scanning***

Why use Stepscan?

Consider Stepscan when the user:

- can control one or two switches;
- can repeatedly activate and release the switch (quick repeats may be needed for single switch Stepscan, to avoid dwelling on an item and selecting it by mistake);
- has difficulty waiting and activating the switch with good timing (so Autoscan is not suitable);
- becomes anxious waiting to press the switch for Autoscan;
- cannot hold on or release the switch with good timing (so Userscan is not suitable);
- has learning difficulties – two switch Stepscan is simple to understand.

Critical Overscan

Critical Overscan attempts to make Autoscan faster, for large selection sets. The scan starts like Autoscan, but scans at a faster rate than the user can manage. The user tries to stop the scan at the desired item by pressing the switch, but is likely to miss and stop it a few items after. However, instead of selecting that item, Critical Overscan scans backwards at a much slower rate until the required item is highlighted, and the switch is then pressed again to select it.

Why use critical overscan?

Critical Overscan is only available on a few on-screen access programs (*Windows Switch*, *Wivik*). This suggests that practical experience has shown it does not offer much advantage over other techniques for increasing Autoscan selection speeds, such as splitting a large selection set up into several smaller ones.

8.4 Why use two or multiple switch scan?

All scanning access programs provide single switch scanning. Single switch *Autoscan* or *Userscan* are straightforward and can be fast and efficient. However, if more switch sites are available, it may be possible to make scanning faster, less tiring and sometimes considerably less frustrating.

Because scanning is so slow generally, any increase in efficiency or speed can make a big difference, so it is important that other techniques with more switches are considered.

Switch timing difficulties

To use a single switch *Autoscan* you must be able to *activate* the switch with good timing when the required item is highlighted. Some students have a great deal of difficulty with this: they become anxious as the highlighter approaches the item they want, and they hit or release the switch too early or too late and select the wrong item. Lack of success can be deeply de-motivating particularly if it requires considerable effort to operate the switch.

Single switch *User* or *Stepscan* can suffer from similar timing problems: if the user cannot *release* the switch accurately, *Userscan* may select the wrong item; if the user cannot *press* the switch *after it has been released*, single switch *Stepscan* may select the wrong item.

Two or more switch scanning can help with some of these difficulties because a second switch is used unequivocally to select, regardless of the scanning method. The crucial demand for good timing is reduced or removed and both scanning and selection is under control of the user completely. The disadvantage is that two switch sites are required, although there are few people who cannot physically operate two switches: the issue is whether they can be accessed with sufficient accuracy, control and speed. If one switch site is easier or more accurate than another, use the best switch for scanning (because it will be accessed more often and the timing requirements are higher) and the less accurate one for selection (since it is used less often, and timing is not generally important). Some

users have difficulty activating two switches *independently*: one switch may be activated accidentally while the user is reaching for the other switch. In these cases adding an *input acceptance* or *post-acceptance delay* may help (see section 8.11).

The main disadvantage of two switch scan is that it can be slower than single switch *Autoscan* or *Userscan* because the user has to move from one switch to another.

Learning difficulties

Some students may have difficulty activating or releasing the switch to start and stop the scan because of a mixture of learning and physical difficulties. This may be particularly true if Dwell selection is used, because there is little feedback about why an item is suddenly selected. A two-switch *Stepscan* may be simpler to understand because a press-and-release on the Scan switch moves on one item, and a press-and-release on the Select switch selects it. There are therefore no timing demands at all, and a clear distinction between the switch which scans and the switch which selects.

Introducing scanning

When learning scanning there are many new skills to acquire: control of the switch(es); judging scan speed and timing; hand-eye co-ordination; and so on. Two-switch scans, because they can reduce cognitive load and anxiety, may be useful when introducing scanning. Once experience and confidence are gained, the user can move to another, possibly faster method.

Reducing the number of errors

Although moving from one switch to another several times during scanning may reduce the speed of operation (and increase fatigue), there may be overall efficiency gains. By using a second switch for selection, rather than relying on switch timing, the number of mis-selections, the time needed to correct errors, and frustration may be reduced.

Correcting errors

Wivik and *HandsOff!* let you use extra switches to restart the scan if a group is selected by mistake, or delete the last selection. This can increase overall speed and reduce effort and frustration.

8.5 Matching Scanning Methods to User Skills

Different scanning methods demand different control and other operational skills. Once the user's switch control skills have been assessed the most appropriate scanning methods can be chosen for evaluation. Chapter 9 suggests methods of assessing switch activation, release and timing skills and Table 8- (based on Beukelman & Mirenda 1992, p. 129 and Cook & Hussey 1995, p. 358) summarises the control demands for the different types of scanning method.

Table 8-1 Control demands for scanning methods

DEMANDS	1-switich Autoscan	1-switich Userscan	1-switich Stepscan	2-switich Autoscan	2-switich Userscan	2-switich Stepscan	Directed Userscan
Wait	High	Medium	Low	High	Low	Low	Low
Activate	High	Low	Medium	Medium to High	Low	Low	Low
Hold	Low	High	Low	Low	High	Low	High
Release	Low	High	Medium	Low	Medium to High	Low	Medium to High
Motor Fatigue	Low	Medium	High	Low to Medium	Medium to High	High	Medium to High

DEMANDS	1-switch Autoscan	1-switch Userscan	1-switch Stepscan	2-switch Autoscan	2-switch Userscan	2-switch Stepscan	Directed Userscan
Sensory / Cognitive	High	High	Low	Medium	Medium	Low	Medium

Once you have a short-list of switch sites and scanning methods you must test them using a real system before making firm conclusions: in most cases significant changes in the control device(s) or selection method will be required as the user's skills develop.

8.6 Scanning Movements

The **Scanning Movement** refers to the manner in which the highlighter moves around the selection set (as opposed to the **Scanning Method**, which defines *how* it is moved with the switches).

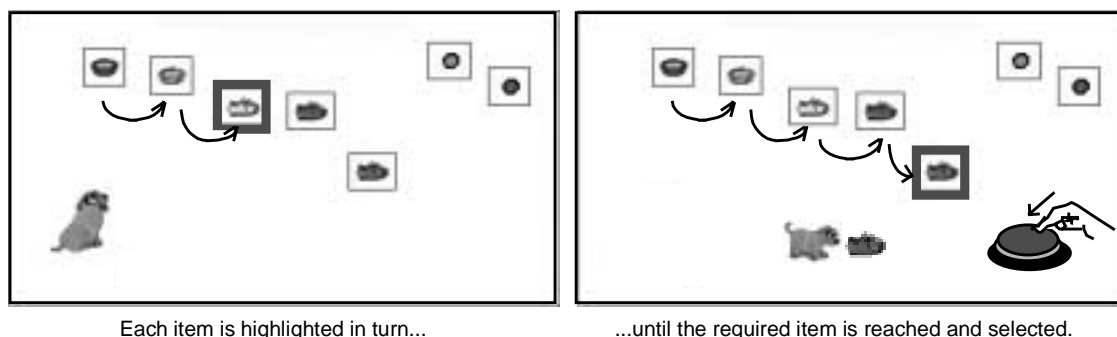
Common Scanning Movements are:

- Simple/Linear
- Group (Row-Column, Column-Row, Nested)
- Directed

You can try out these Scanning Movements by running the programs that accompanies the electronic version of this book, on disc or at the CALL Centre web site.

Simple Scan Movement

Figure 8-6 Simple Scan Movement



Each item in the selection set is highlighted in turn; when the desired item is reached, the user selects it with a single switch press or release. Usually the items are arranged in a simple order such as a single row with items scanned from left to right.

Why use Simple Scan Movement?

Simple scan is ideal for a small number of items (up to 12, perhaps) – for example, a menu of programs or facilities, tools on a drawing program, or 'hot spots' on screen.

With larger sets such as alphanumeric layouts, simple scanning is slow and tedious because items at the end of the set take more time to select, and if the user misses an item the system has to scan right round again before it can be selected.

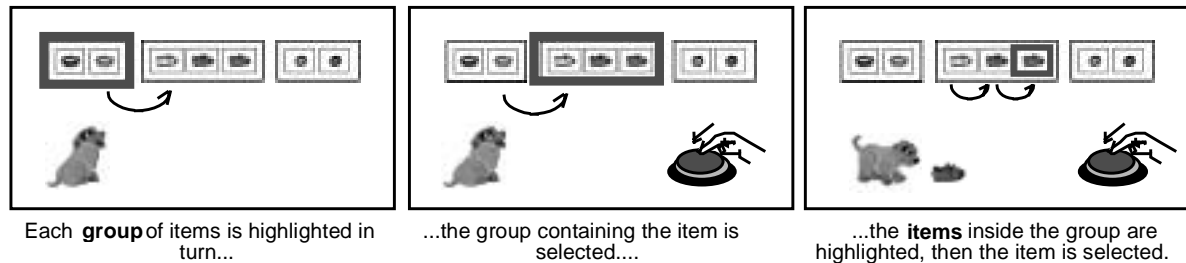
Simple Scan Movement is often used to introduce scanning to new users, and may also be suitable for people with a learning disability because it is easy to operate.

Other terms for:

Simple Scan Movement **Linear Scan; Tracking**

Group Scan Movement

Figure 8-7 Group Scan Movement

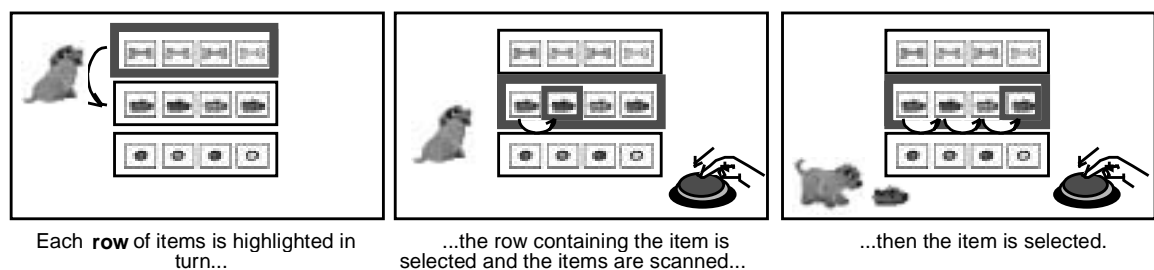


The selection set is divided into a number of groups of items which have some logical or spatial relationship. Selecting an item is a two stage process: first the group containing the item you want is chosen; then the items in the group are scanned one at a time (simple scanning) until the required item is selected. Group scanning is more efficient and faster than simple scan when the selection set contains a large number (more than 12) of items. For example, to write the word 'Hello' using the selection set in Figure 8-1 on p. 127 with single switch Autoscans and a 0.5 second scan delay, group scan would highlight 39 items to generate the word, taking 19.5 seconds. Simple scan would have involved scanning 128 items and take 60 seconds (assuming no errors).

Group Scan is more complex and harder to understand because the user has to navigate and control the highlighter to select the group and then the item, rather than selecting the item directly. It also requires two switch activations per item selected rather than one. There are several types of group scan: **Row-Column**, **Column-Row**, and **Nested**.

Row-Column scanning

Figure 8-8 Row-Column Scan Movement

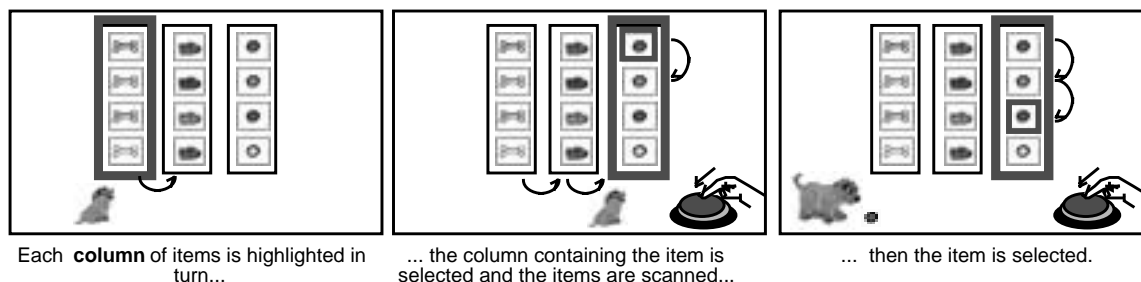


Row-column scanning is a particular sort of group scanning that is widely used in access software and assistive technology. To select an item the user scans down the rows to the one containing the desired item, selects it, then scans to and selects the item in that row. Some scanning programs allow you to define the scan direction (e.g. rows scanned from bottom to top; items scanned from right to left).

The most efficient row-column arrangement is a square regular grid: for example, 8 rows x 8 columns. Since the computer screen is usually wider than it is tall, row-column selection sets often have more rows than columns to make the most use of the screens width. Some users prefer row-column compared to column-row for *letter grids* because they find it easier to visually scan along a row to check if the item is there, than look down a column. Conversely, many people find it easier to find a word in a vertical list of *words*, than a row.

Column-Row scanning

Figure 8-9 Column-Row Scan Movement

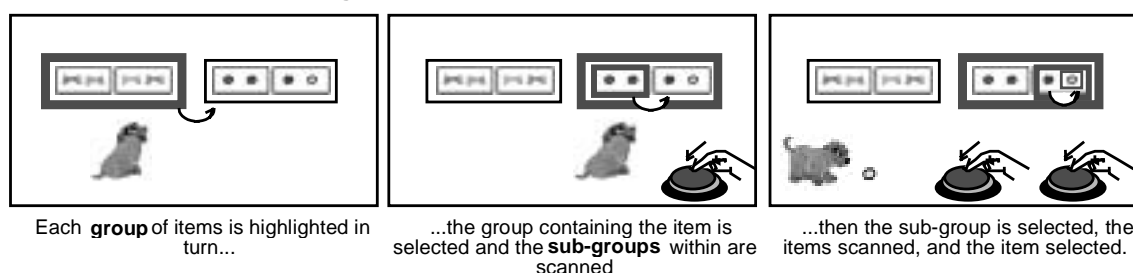


To select an item in the selection set, the user scans to and selects the column containing the desired item, and then scans to and selects the item in that column.

Column-row scanning was used in the original *Possum* scanning communication/writing aid – the precursor to the computer-based aids of today. It is often used for sets containing word lists because many people find it easier to spot a particular word in a column rather than a row (most word prediction programs use a column of words for this reason). Readability may also be improved by arranging words in alphabetic order.

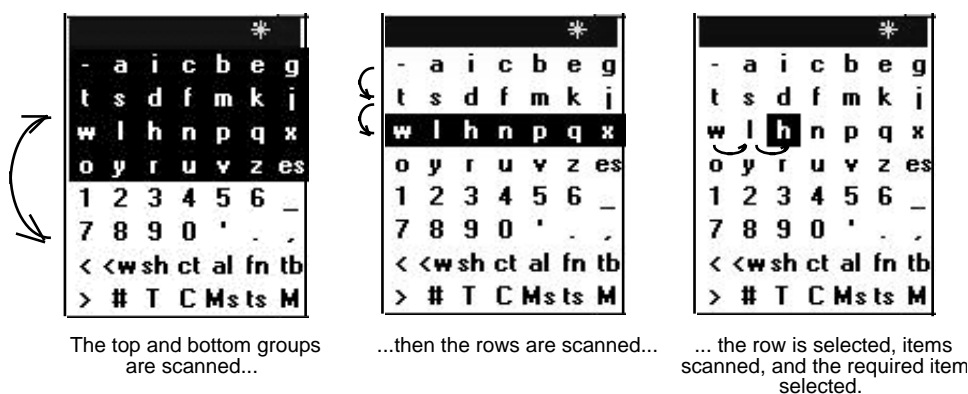
Nested scanning

Figure 8-10 Nested Group Scan Movement



Nesting means that a group may contain one or more ‘child’ groups of items, and in turn each of these child groups can contain more groups. In Figure 8-10, the selection set is scanned in smaller and smaller groups until the desired item is reached. Nesting can be faster than other types of scan because fewer irrelevant items are highlighted, although it usually involves a larger number of selections than other methods. Nesting is also useful for sub-dividing a large number of items into several small groups of related items. The arrangement should reflect, and be appropriate to, the context in which the selection set is used.

Figure 8-11 EZ Keys ‘Half Scan’



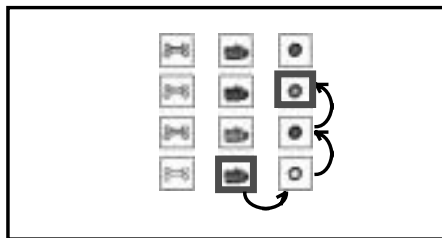
It is also possible to scan the nested groups in different ways: Words+ claim that the most efficient method of scanning their alphanumeric set with prediction is to first select between top and bottom groups ('half' scanning) and then use row-column scanning within each group (Figure 8-11).

Other terms for

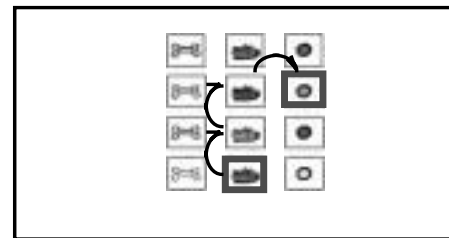
nested scanning: half scan; binary scan; quadranting

Directed Scan Movement

Figure 8-12 Directed Scan Movement



The highlighter is moved right, then up, and then the item is selected



The highlighter is moved up, then right, and then the item is selected

Directed scanning is so called because the user directs the highlighter movement freely in a number of directions (left, right, up, down, or all eight compass directions) to reach the desired item. Four or five switches or a switched joystick are normally used to direct the scanner. Userscan (i.e. move the stick to move the highlighter, release the stick to stop it - 'momentary' control) is most commonly used although a Stepscan method is also possible. Selection is either via dwell selection or an extra switch.

Directed Scanning is similar to the point-and-click selection method: the main difference is that point and click uses the standard mouse or equivalent, whereas directed scan uses switches to move the highlighter.

Only *EZ Keys* and *Wivik* offer Directed Scanning. For other programs you can engineer the technique by setting up an on-screen point and click program with a **MouseMover** or **MouseKeys** (see Chapter 4) and an interface and switches to replace the up (8), down (2), left (4) and right (6) keys on the numeric keypad.

Who might use Directed Scanning?

Directed Scanning or point and click with switches is most useful for people who can control several switches or a switched joystick effectively. In some situations it may be faster and more convenient than one or two switch scanning, particularly when the user needs to use the mouse pointer to control both the on-screen keyboard and other applications. It does depend upon the nature of the selection set and the task, however: Autoscan can be just as fast and much less tiring because there are fewer switches being used occasionally compared with several switches being used continuously.

Other terms for:

Directed Scanning Joystick Scanning

8.7 Other Scanning Techniques and Features

Cancelling the Scan

Like everyone else, scanning system users make incorrect selections so it is very important to have good strategies for getting out of the wrong row, column or group.

The slowest method is to wait until the program has scanned around the programmed ***number of scan cycles*** and stops by itself. If a user often selects the wrong group it may be helpful to only scan a row once before stopping - although if the user *has* chosen the correct row it means there is only one opportunity to select the item before the scan restarts (and the average user will select the correct row more often than not).

Another technique is to place a ‘cancel’ item at the beginning or end of each row or column to give an opportunity to exit quickly (Figure 8-13). *SAW* has an ‘invisible’ scan cancel pauses at the end of each row - the highlighter disappears for a delay known as the *scan pause* and if the switch is pressed during this time, the scan is cancelled.

Figure 8-13 *Discover:Switch* selection set with cancel buttons at the start of each row



If the user can activate another switch, *Wivik*, *SAW* and *HandsOff!* can cancel the scan when the extra switch is pressed. This can give a very fast and less frustrating way of dealing with errors.

Next scan item

Generally when an item is selected, the scanning system restarts from the usual start or ‘home’ position (most commonly, the top left hand corner). Some programs let you to specify where the system goes next after an item has been selected – to the next item in the group, or back to the start of the row or column, for example.

Scan Delay on First Item

Good scanning systems users achieve fast scan speeds by anticipating as the highlighter moves towards the chosen item. It is harder to anticipate and select the first item in the row or column and therefore it can be very helpful to have an extra delay while this first item is highlighted, to give more time to respond.

8.8 Introducing Scanning

Blackstone (1989, p. 3) lists these pre-requisites before introducing scanning:

- seating and positioning must facilitate function
- movement, control site and switch options must be specified
- switch and device must be correctly positioned
- the user may need explanation and training in how the scanning works

In Chapter 1 we suggested that the user learns one thing at a time. Goosens & Crain (1992) refer to this as layering, where more complex tasks are added one as the previous ones are mastered:

1. develop motor and visual scanning skills
2. develop motor and visual scanning, plus cognitive skills
3. develop motor and visual scanning, plus cognitive, plus communicative skills

If you do not have a computer available you can use switches, toys and musical instruments to train scanning skills. For example:

- hitting a switch connected to an electronic sound generator or instrument in a group music session can develop timing and rhythm for Autoscan;
- pressing, holding down and releasing a switch connected to a tape recorder for 'pass the parcel' develops skills appropriate to Userscan;
- pressing a switch connected to a toy via a Switch Timing box develops basic switch press and release skills for Stepscan.

Generally, it is better to actually practice scanning using a scanning system. In Goosens & Crain's first stage, basic scanning control is practised in different contexts, using a simple scanning pattern with a small number of items.

You can either devise activities yourself using an on-screen keyboard program, or purchase ready-made selection sets (such as *Switch Activities Pack* for *Switch Clicker Plus*; or *Ke:nx Curriculum Scans*, for *Ke:nx* and *Discover:Switch*; see the lists in Chapter 11 for other sets). There are also many good educational packages with switch and scan access built in (*Table 8-2*).

Table 8-2 Introductory scanning programs

Introductory Scanning programs	Description	Price Guide	Supplier
Acorn, PC Blob 1 & 2	New versions of the very popular 'Blob' originally developed for BBC micro, with a range of switch and scan-operated early learning activities.	£20-£25	Widgit, Inclusive Technology
Acorn, PC Choices	Early learning switch-operated matching, sorting and sequencing. You can easily create your own personalised activities.	£35	Widgit, Inclusive Technology, Semerc
Acorn, PC Make it Happen 1, 2 & 3	For pupils with severe learning difficulties, to develop attention, switch access and cause and effect skills.	£20 each	Inclusive Technology
Mac, PC Switch Suite	Activities to develop switch and language skills.	£29 each	Inclusive Technology
Acorn, Mac, PC Switch On	<i>Switch On Original, Travel</i> and <i>Zoo</i> . Early learning programs for developing basic switch and recognition skills.	£25 each	Semerc
PC Sensory Software	A range of programs for learners with profound and multiple learning difficulties. <i>Build It, Picture Switcher</i> and <i>Splatter</i> have switch access.	£29 each	Semerc, Inclusive Technology

Introductory Scanning programs	Description	Price Guide	Supplier
Mac, PC Edmark CD's	Popular educational CD's including <i>Bailey's Book house</i> , <i>Millie's Math House</i> , <i>Thinkin Things</i> etc, with built-in switch and scan access. Teacher's support materials available.	£25 each	Semerc, TAG, Inclusive Technology
Mac Don Johnston software	Early learning programs with built-in switch access: <i>Circletime</i> & <i>Storytime Tales</i> , <i>KC & Clyde</i> , ' <i>Little Books</i> ', <i>Jokus</i> software, and others. Teacher's support materials available.	£44 to £65	Don Johnston

It is usually helpful to begin with a slow scanning speed which is gradually increased. Giving an audible click or beep as each item is highlighted helps the user get into the rhythm of the scan. For very long scan delays you can try counting through the time to cue the user in to when the highlighter is about to move to the next item. Do not assume that slower is necessarily easier some users are more accurate with a fast scan because of the stress and increase in muscle tone caused by the longer time for anticipation. Bear in mind that there is often a trade-off between accuracy and speed and that even expert users of scanning systems are not 100% accurate.

In stage 2, more complex and efficient scanning patterns can be introduced (e.g. row-column scanning). Break the task down into components for practice: learn row scanning by scanning down a vertical column of single items; then add a second column to create a very small row to scan. Use a variety of selection sets linked to simple but appropriate curriculum activities to maintain interest and motivation.

At stage 3, the scanning system starts to be used for more functional curriculum tasks like writing and communication (see Chapter 10).

How much training is needed?

It is impossible to say since it depends on the access method and the user, and the research to answer this question has simply not been done. It is probably much longer than you would think though! "*It can take months or years to increase speed and accuracy with this [group scan] approach.*" (Glennen & DeCoste, 1997).

How can scanning accuracy be improved?

Seating and positioning

First, look again at seating, positioning and the switch and switch site. Is the user stable and secure? Is the poor accuracy because the user hits the switch too early (an intentional error – see below) or by accident (an unintentional error – see below)? Look at the switch position: can the user reach the switch easily, but not so easily that it is activated by accident? Does the switch stay in the same place relative to the user throughout the session?

Change the scan speed

If the switch is in the best position and the errors are mostly intention, try changing the scan rate (slower gives more time to activate the switch, faster may offset any anticipation).

Use switch filtering

For unintentional errors, try increasing the switch acceptance time to filter out accidental hits. Does the user often select a row and then select the first item in the row by mistake? If so, it may be because there is a double hit when the row is selected. Filter this out by increasing the post-acceptance delay.

Adjust the first item

Does the user select a row and then *miss* the first item in the row? Try increasing the **scan delay on first item** to give more time to react, or add a dummy item at the start of the row.

Use acceleration techniques

Accuracy is relative: the more you hit the switch, the larger the number of errors you are likely to make. Therefore, if you can reduce the number of switch activations and selections, you will reduce the overall number of errors. The obvious solution is to write fewer words and do less work, but this is not what we are trying to achieve! Acceleration techniques such as word prediction and abbreviation expansion that reduce the number of keystrokes required to write a word will have an immediate improvement on accuracy because fewer mistakes per number of words will be made.

How can scanning speed be increased?

Increase the accuracy

Speed and accuracy are closely related because time taken correcting errors will significantly add to the overall time required to produce a piece of work. Therefore, use the techniques above to reduce the error rate and adopt measures to recover from or delete errors. Consider extra switches or add buttons to cancel the scan when groups are selected by mistake; add a separate 'Delete last item' switch and place the 'Delete' button so that it is easily accessible. Include items to delete one character; delete 2 or 3 characters, and delete whole words.

Change Scan Method

Assuming that the seating and switch are optimum (see above), the next aspect to consider is the **Scan Method**: is it the most appropriate for the user and the task? *Autoscan* is fastest for many people, but if the user is better at releasing the switch than pressing it, try *Userscan*. *Autoscan* and *Userscan* are both faster than *Stepscan*, in theory, but if the user is making lots of errors and wasting time correcting them, try a two-switch *Stepscan* which may be slower when scanning but more accurate overall.

Change Scan Rate

The most obvious way of increasing speed is to increase the scan rate, although if accuracy is reduced because the speed is too fast, overall speed will be reduced.

Change selection set design and layout

Careful selection set design has an effect on speed because the size and layout of the selection set and the type of scanning movement directly correlate to the amount of time it takes to select a particular item. On average, you select items faster if they are in as small a selection set as possible so rather than having a huge set with all letters, numbers, punctuation, function keys, mouse controls and macros, break them up into a number of linked subsets. Layout within the set will also effect speed: put the most frequently used items at the start of the scan so they can be reached first.

Change Scanning Movement

Group scanning movement is much faster than simple linear scanning. Words+ claim that the fastest scanning method for a typical letter selection set is binary, then row-column scanning (see Figure 8-11).

Use acceleration techniques

Acceleration techniques are specifically designed to increase rate by reducing the number of selections which are needed to generate text or speech or control the assistive device. Selecting a whole word from a list or a word predictor is clearly faster than typing it letter by letter. See the sections on *Tools for supporting and accelerating writing* and *Communication* for more information on these systems.

8.9 Access with Switches and Encoding

What is Switch Encoding?

Switch encoding uses one or two switches and an extended version of Morse Code, to write text and control the computer. Each letter of the alphabet, number, key on the keyboard and computer control function has a particular code consisting of ‘dits’ (•) and ‘dahs’ (-).

Figure 8-14 Examples of extended Morse Code

a	• -	space	• • - -
b	- • • •	Return	• - • -
c	- • - •	Scan menu (<i>Discover:Code</i>)	- - • • • •
d	- • •	Rotate mouse pointer (<i>EZ Keys</i>)	• - • - •
e	•	Rotate mouse pointer (<i>Discover:Code</i>)	• • - • • •

With one switch, a ‘dit’ is produced by holding the switch down for a short time, while a ‘dah’ is generated by holding it down for a longer period. Usually, the hold times for dit and dah are adjustable. Two switches can also be used to generate Morse Code - one switch produces a dit and the other a dah. With one and two switches, the user signals the end of a code by waiting for an adjustable time delay, after which the computer accepts the code and converts it into text or a command. *Discover:Code* also has a three switch version where a third switch is used to send the code to the computer.

The alphanumeric codes are based upon the original system devised by Samuel Morse, augmented by extra codes for the keyboard, mouse and computer commands. These extra codes vary from program to program - the *EZ Keys* code to start the mouse pointer rotating is different from the one used in *Discover:Code*.

The access programs can provide auditory feedback (with a short or high tone for dit and a longer or low tone for dah) to confirm codes as they are created. *Discover:Code* also has visual feedback whereby the dits and dahs are displayed as they are entered. Visual and auditory feedback are very helpful when learning Morse Code.

Who might use switch encoding?

The main advantage of switch encoding compared to other access methods is speed. Switch encoding is much faster than scanning with switches and can even be faster than direct selection. Words+ claim ‘*the fastest users of communication and computer access systems are Morse Code users, achieving rates of over 40 words per minute using word prediction and abbreviation expansion*’ (Words+ 1997, p. 4-22). This level of expertise requires considerable practice and cognitive ability. There is considerable demand on memory and encoding skills: each letter has a Morse code; words have their own letters codes (spelling); and the fastest users also code longer words and phrases into short abbreviations. Clearly, if the user is capable of coding and sequencing there is considerable advantage in exploring the technique.

However, the user must:

- usually be literate - codes are normally used to generate letters³;
- have sufficient memory and sequencing skills to learn the codes;
- have good switch control and be able to repeatedly operate the switch many times without fatigue. One switch encoding requires the user to be able to hold the switch down accurately for different time delays. Two and three switch codes do not require the same timing ability but instead demands quick access to more than one switch.

Although switch encoding systems do require a higher level of cognitive ability than other accessing techniques, they are not always considered because it is easy to overestimate the difficulty of introducing the system. McDonald (McDonald et al, 1982) recorded that pupils of age 7 equivalent spelling ability were able to learn Morse code. In addition, while there is no doubt that encoding is harder to learn than scanning, once learnt it is arguably less demanding both perceptually and cognitively, because it is a learned motor-pattern and does not require the user to attend to the screen display. Since switch encoding relies on the user's memory and does not require an on-screen display, there is no visual selection set to obscure the application program. For the same reason, encoding may be suitable for good switch users with visual impairments who would have difficulty seeing a scanning display (and for whom auditory scanning is too slow).

Physically, encoding demands good switch control and the ability to repeatedly activate the switch(es). Switches which can be accessed with little effort such as suck-puff, chin and small finger and thumb movements are preferred and multiple switches should be located so that they are easily accessible.

8.10 Mouse control for switch users

Scanning directions

Many of the on-screen keyboard and Morse Code programs provide facilities for using switches to control the mouse pointer and buttons. The pointer may either be moved by selecting a direction from the selection set (Figure 8-15 a & d), or a 'rotating' pointer can be used (Figure 8-15 b & c). Actions to click, double click, lock down and release the mouse button are also available.

Rotating Pointer

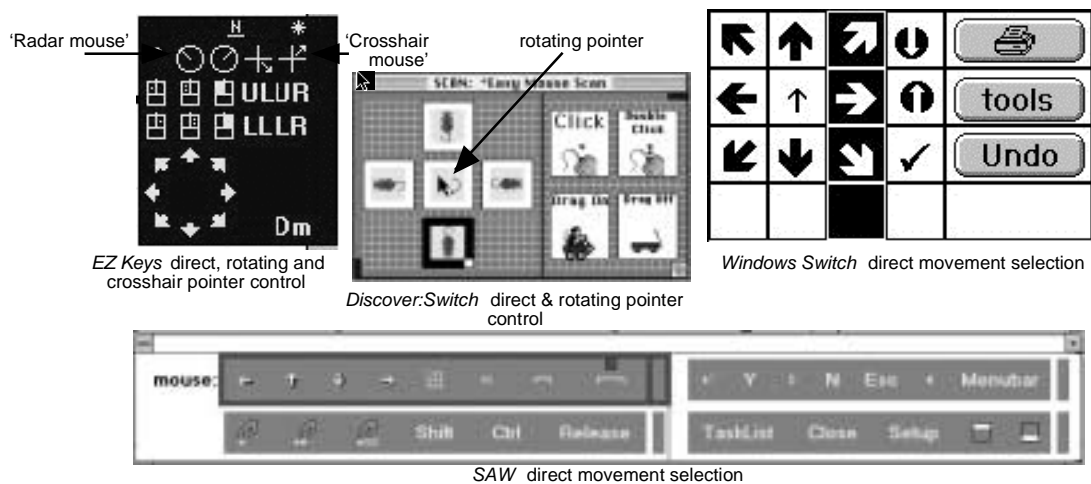
Four or eight directions limits the angle at which the pointer can move. The rotating pointer feature available with *Discover*, *EZ Keys* and *Wivik* gives finer control over movement. The pointer itself rotates clockwise or anti-clockwise until the desired direction is reached, and then the switch is activated and the pointer moves in that direction. *EZ Keys* also has a 'Crosshair Mouse' facility whereby a line sweeps vertically down, then horizontally along, to move the pointer to the required location on screen.

³ Although most switch encoded systems use Morse Code for text, *Discover:Code* allows any code to perform any action. For example, with two code switches and a third 'send' switch you have a total of six 'two-hit' switch sequences which could be used to define a very simple voice-output selection set:

•	'yes'	-	'no'
••	'I like it'	- -	'I don't like it'
• -	'My name is Jerry'	- •	'What's your name?'

Realistically, scanning is a better access method for most users requiring access to this sort of limited vocabulary, although those with visual impairments may be able to make use of this type of simple switch encoding scheme.

Figure 8-15 Various Mouse Control selection sets



Movement Control

Some programs let you alter the speed at which the pointer moves, so you start off slowly (for doing fine work) and accelerate as the switch is held down (to move fast across the screen). With others you can move in large or small steps depending on how far and fast you want to move the pointer.

Hold to repeat control means that the pointer moves as long as the switch is held down (like *Userscan*), while **Toggle Repeat** means that the pointer moves until the switch is pressed again (like *Autoscan*).

Key Combinations and Macros

Pointer movement control using switches is slow and so anything which reduces the need to manually move the pointer is worth having. One technique is to create items on the selection set which operate keystroke combinations (e.g., b-P to print) instead of using the mouse to select from pull-down menus and dialogue boxes. If menu selections do not have key equivalents, many application programs have 'macros' which let you record the sequence of mouse movements under a key combination, then play them back whenever the key combination is pressed.

Markers and Hot Spots

Markers or **hot spots** are buttons for marking particular locations on screen. You can place the markers anywhere you want, and then the user can 'move to them either by scanning round one by one; by pressing a particular keystroke combination; or by programming 'jump to marker x' into an item on the selection set (Figure 8-). Markers are a very useful tool for making standard programs much more accessible to switch and alternative keyboard users. They can be used to give quick access to: particular areas on the screen (for example, corners and the centre); 'buttons' on talking stories or multimedia programs; or toolbars and paint palettes in word processing and painting programs.

Figure 8-16 Screen markers added to a Sherston *Talking Book*

Discover has screen markers built in, or they can be added to a Mac or PC with the *ClickIt!* program, and to Acorn with *HotSpots!*.

Automatic Computer Access

Discover, *SAW*, *Wivik*, *HandsOff!* and *Windows Switch* have features to help switch users control the computer more efficiently: items in the selection set can be programmed to: automatically scan along menus and dialogue box buttons; scan text fields (in databases, for example); move and re-size windows; and operate the scroll bars and other control buttons (for example, 'minimize') in the window.

8.11 Input Filtering

Input filtering can help minimize or eliminate the effect of unintentional activations regardless of whether the input device is a key on a keyboard, a mouse button, or a switch used for scanning or Morse Code.

The effect of these filters can be explored using the Special Access Technology interactive tutorials available on disc or at the CALL Centre web site.

There are three primary techniques for adjusting the response of the switch:

- Input Acceptance filtering
- Repeat filtering
- Post Acceptance filtering

Some input filtering techniques may be built into the computer's operating system: most have repeat filtering because it is a useful feature for any keyboard user. Macintosh and Windows systems have *Easy Access* and *Accessibility Options* respectively, which provide input acceptance and post acceptance filtering as well as a number of useful features for single finger typing.

Most special access software and hardware have a range of input filtering methods available to the user.

It is possible for the operating system and special access filters to interfere with each another: for example, if the operating system repeat rate is turned *off*, but the special access software is turned *on*, the key may not repeat effectively. If the computer is shared by several users, it is better to use the

special access filter because turning off the operating system repeat filtering would affect *all* users of that computer, including those who use the standard keyboard.

Input Acceptance Filtering

What is it?

Input Acceptance Filtering slows down the response of the input device (e.g. switch, keyboard) so that the user has to keep it continuously pressed for a certain time before the input is accepted and registered by the computer. This time period is called the *input acceptance time*.

Why might it be needed?

Movement Difficulties. To reduce the likelihood of accidental selections being made by a user with clumsy or uncoordinated movement. For example, switch users who cannot press the switch with a definite action but tend to hit it several times due to involuntary or uncoordinated movements; keyboard users who tend to knock other keys when typing. (Note: for keyboard users, input filtering is often used in conjunction with a keyguard fitted over the keyboard).

Attention Difficulties. Some users may delight in triggering an immediate computer response by random activations of keyboard or switch. Setting a long input acceptance time may encourage such a user to focus on the program.

How do you use it?

The input acceptance time should be increased until the user's unintentional switch/key presses are no longer accepted by the computer.

For example, an input acceptance time of 0.2 seconds might be sufficient for a user with a slight hand tremor, while anything up to about 1 second might be needed for those with a more severe tremor or with gross movements.

Repeat Filtering

What is it?

Repeat Filtering comes into effect immediately after an input has been accepted. If the user continues to hold down the input device (e.g. switch, keyboard), the action is repeated once after an initial time, called the *repeat acceptance delay*, followed by successive repeats at intervals determined by the *repeat time*. This automatic repeating continues for as long as the input device is held down. When the input device is released, automatic repeating stops and *post acceptance* filtering starts.

Repeat Filtering is useful for any computer user and so is built into most operating systems (e.g. Macintosh, Acorn, Windows 95). There is also usually an option in to disable the automatic repeat.

Why might it be needed?

Movement Difficulties. Users who have sufficient control to keep the switch or key pressed until automatic repeating can begin will benefit from this physically simple way of producing repeated selections (e.g. for moving the cursor letter-by-letter before editing a piece of text)

Attention Difficulties. There may be occasions when you want to reward a pupil for managing to keep a switch or key pressed for a certain time. Repeat filtering can be used to achieve this by setting the repeat acceptance delay to the desired time, and the repeat time to be much shorter. Ideally, the result of each repeated selection should be enjoyable: for example, an interesting sound is heard.

How do you use it?

The repeat acceptance delay can be turned off if not required, or it should be set so that automatic repeating does not begin too quickly. If repeating is required, start by setting the repeat acceptance delay to about twice the input acceptance time, but it should be at least 0.5 seconds to prevent accidental triggering. Start with the repeat time (time between successive repeats) set to roughly the input acceptance time, and gradually decrease it to achieve a sufficiently fast automatic repeating action but one which the user can reliably stop (by releasing the switch) when it is no longer required.

Post Acceptance Filtering

What is it?

Post Acceptance Filtering comes into effect *after* an input has been accepted and any repeat filtering has finished. Its purpose is to slow down the response of the switch or key by ignoring all further input for a certain time, called the *post acceptance delay*.

Why might it be needed?

Physical Difficulties. Some users have difficulty in releasing a switch or key without immediately pressing the same or another one. Setting a post acceptance delay will reduce the effects of such difficulties.

Attention Difficulties. A long post acceptance delay may help to encourage the user to re-focus on the new task after making a selection.

How do you use it?

The post acceptance delay should be increased until any unintentional switch/key presses made after input has been accepted are filtered out.

For example, a post acceptance delay of 0.2 seconds might be sufficient for a user with a slight hand tremor, while anything up to about 1 second might be needed for those with a more severe tremor or with gross movements.

8.12 Further Information

Web sites

ACE Centre - <http://www.rmplc.co.uk/orgs/acecent/homepage.html> Information and software. Publishers of SAW.

Advisory Unit. <http://www.advisory-unit.org.uk/> Information and resources about *Windows Switch*, *Point for Windows*, and other software.

Crick Computing. <http://www.cricksoft.com> Information and resources about *Clicker*.

Don Johnston - <http://www.donjohnston.com/> Information and resources for Discover, Ke:nx and other Don Johnston software and products.

MAPE. <http://www.chelt.ac.uk/guests/mape/> Micros and Primary Education web site. Information and software deals.

Meldreth Manor School. <http://www.rmplc.co.uk/eduweb/sites/meldreth/> Ideas and information for symbol users.

NCIP <http://www.edc.org/FSC/NCIP/> U.S. association with lots of useful information, advice on classroom applications, and reviews of software.

Widgit. <http://www.widgit.com/index.htm> Excellent site with lots of information about symbols, switch software and techniques for introducing switches and scanning.

Words+ <http://www.words-plus.com/mnframe.htm> Information on EZ Keys and other Words+ communication and computer access products.

Suppliers

ACE Centre, Ormerod School, Waynflete Road, Headington, Oxford OX3 8DD, Tel. 01865 63508.

Advisory Unit for Computers in Education (AU Enterprises Ltd) 126 Great North Road, Hertfordshire AL9 5JZ, Tel 01707 266714

Cambridge Adaptive Communication (CAC), The Mount, Toft, Cambridge CB3 7RL. Tel. 01223 264244

Crick Computing, 123 The Drive, Northampton, NN1 4SW. Tel. 01604 713686.

Don Johnston Special Needs Ltd., 18 Clarendon Court, Calver Road, Winwick Quay, Warrington, WA2 8QP. (Tel. 01925 241642)

FCD, 25 High Street, Woking, Surrey GU21 1BW. (Tel. 014862 27844)

Inclusive Technology, Saddleworth Business Centre, Huddersfield Road, Oldham OL3 5DF, Tel. 01457 819790.

Liberator, Whitegates, Swinstead, Lincs. NG33 4PA. (Tel. 01476 84391)

REM (Rickitt Educational Media) Great Western House, Langport, Somerset TA10 9YU. Tel. 01458 253636

SCET, 74 Victoria Crescent Road, Glasgow G12 9JN. Tel. 0141 337 5000.

Semerc 1 Broadbent Road, Watersheddings, Oldham OL1 4LB, Tel. 0161 627 2381.

TAG Developments 25 Pelham Road, Gravesend, kent DA11 0HU. Tel. 01474 357350

Widgit Software, 102 Radford Road, Leamington Spa, Warwicks. CV31 1LF. Tel. 01926 885303

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Words+ (1997) *EZ Keys for Windows User Manual 1.00*, Words+, 1997.

