Sustained Dashes combine Morse Code with Word Prediction and facilitate Scanning too

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Abstract

Some speechless or severely dysarthric people activate switches in order to communicate with speaking software. Sustained Dashes allow to do more than either press switches or not and may integrate word prediction with Morse Code. They appear to be new in this context and are first described and analyzed. Sustained Dashes also allow to access active row-column scanning with a single switch, especially so if the scanning matrix has an empty first column. To document how learning Morse Code compares to learning active row-column scanning, two healthy test-subjects used either one or two switches in a copy task. Morse Code presented on screen appeared easy to learn and input rates in the first hour were little different from those with active scanning (n=2). A third test-subject (n=1) spent about twenty hours to practice and frequently used Sustained Dashes for word prediction in open conversations with the author. Therefore, he learned Morse Code, learned to use it with Sustained Dashes for word prediction *and* learned to communicate with synthetic speech at a low rate. One may conclude that both Morse Code and Sustained Dashes can have value for switch users.

Keywords. Morse Code, word prediction, row-column scanning, synthetic speech, switches, communication aid, learning curve, Sustained Dashes.

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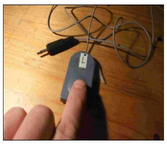
Part I   Introduction

For speechless or severely dysarthric people with additional motor problems, switches are a means of access to computers that they may use to communicate. Switches also are an affordable alternative to eye-tracking by software. Picture 1 shows one that reacts on presses by a finger, others may react on movements registered by infra-red light, on eye-blinks, on muscle contractions or on sounds as of humming. Figure 1a and Figure 1b illustrate the idea of Sustained Dashes with a variable length.



Picture 1. Switches discern subtle body movements and may be connected to a mouse or to specialized input gear.

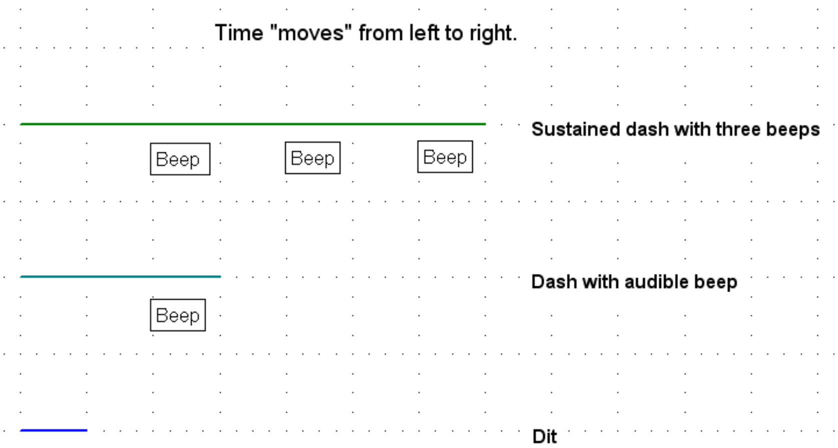


Figure 1a. Time lines with a single switch. A short click (. or dit), a long click (- or dash) and a Sustained Dash of length two (__) are shown. Sounds like Beep and several visual cues may inform users.

This paper discusses how Sustained Dashes integrate Morse Code, word prediction and abbreviation expansion and how they can be employed in row-column scanning as well. Diverse experiments were done with either two switches or one, copy tasks and open conversations to document learning, input rate and ease of use.

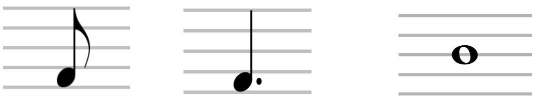


Figure 1b. Musical notation of a dit, a dash and a Sustained Dash of length one.

Encoding

Dits and dashes can be combined to encode the alphabet with Morse Code. Users must be able to read, spell, think and click with some measure of dexterity. See Table 1 for a variant of Morse Code.

a .-	f ..-.	k -.-	p .--.	u ..-
b -...	g --.	l .-..	q --.-	v ...-
c -.-.	h	m ..--	r .-.	w .--
d -..	i --	n -.	s ...	x -..-
e .	j .---	o ---	t -	y -.--
				z --..
BS ----	SP ..	, ---.	Ret -.-.	
1 .----	2 ..---	3 ...--	4 ....-	5 .....
6 -....	7 --...	8 ---..	9 ----.	0 -----

Table 1. International Morse Code with 'm' changed from '--' to '..--', SP (Space) changed from '..--' to '..' and 'i' changed from '..' to '--'. Note that BS (Back Space) and SP are frequent, but have codes longer than one.

Using mnemonics such as PU for Page Upwards, one may encode all of the keyboard and, with special 'modes', this even includes mouse movements and numerical keypads. Sustained Dashes may replace numeral codes to access word prediction and may be used elsewhere. Morse Code was abundantly used between 1840 and 1960 for telegraphy and radiotelegraphy and is still used by short wave radio amateurs and, rarely, in Augmentative and Alternative Communication. For correct understanding of the following it is important to carefully study Figure 2, that illustrates a time line of the character 'u' with a single switch.

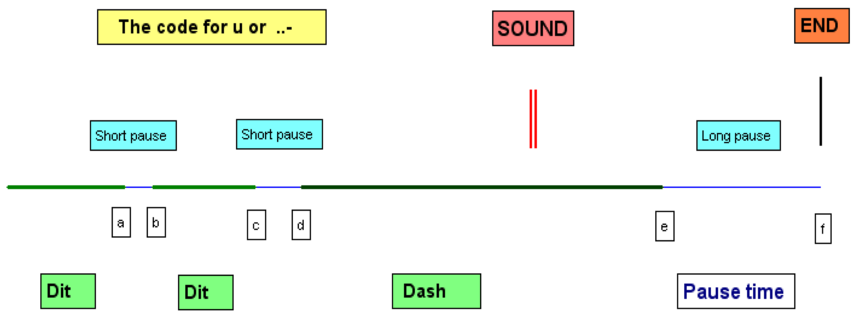


Figure 2. Drawing of a time line of the code for 'u' with a single switch. Moments **a** to **f** are marked, and the next code starts at **g**, not displayed because with novices it is far to the right of this page. Proportionally, all pauses are somewhat longer than is shown.

In Figure 2 two short pauses **a**-**b** and **c**-**d** are shown, of unequal length, and one long pause starting at **e**. After the pause time interpretation of '..-' (= 'u') follows at **f**. Novice users especially have to wait a bit before they can start the next code and if another code starts at **g** the period **a-f** will be considerably *shorter* than the period **f-g**. With experience several psychological processes, such as to verify that the correct code was given, to forget it, and to remember the next code(s), will gradually merge and will become faster. Therefore, with continued training the period **f-g** will shrink to a few hundred milliseconds, approximately **d-e**, and input rate will rise. Related phenomena occur with active scanning techniques.

A sound may indicate that not a dit but a dash is entered. If two switches are used, clicks have almost the same duration and such sounds appear superfluous. Extensive background information on Morse Code is available over the internet[1] and several readable books are available on elements of its history (Standage, 1998) and on its use in Augmentative and Alternative Communication (King, 2000). Morse Code is used, though not much, and can be used with low tech only, if a family member or a caregiver learns to decode it. For a specification about Morse Code with computers consult Anson and Lynds, 1999.
Sustained Dashes are not completely new. In other contexts 'Long hold' has been described as for selecting from pie-menus, or 'Sustained hold' for autorepeat of dashes in Morse Code by EZMorse and by so-called iambic paddles, see www.iditdahtext.com/iDitDahText.html for a fascinating video. They can also influence the speed of a moving mouse or can be used to travel trees as in Mehta, 2007. They may however be used for various other purposes, as two dimensional scanning with a single switch, list selection and word prediction. This will be explained in detail below.

Sustained Dashes for word prediction

The input rate that may be achieved with Morse Code is extremely variable, as it was in the distant past when Morse Code was used abundantly for commercial and for military purposes, often with a single switch called a key and by professional telegraphers. Morse Coding is somewhat addictive and exams and competitions with it still exist. To combine it with word prediction using special codes and a technique called recency marking was tried in Verrips, 2000, and worked, but required much attention and was found rather difficult to operate. As will be explained in detail below, Sustained Dashes may select from a list of text predictions.
Numeral codes appear more straightforward, but they are five clicks long and most contain several dashes. Therefore, Sustained Dashes should provide a faster way to enter numerals 1, 2, 3 if we *only* consider the time spent to press a single switch and if the Beeps in Figure 1 are not spaced too far apart. This was confirmed experimentally for 1 to 3 with a single switch. With two switches only 1 was appreciably faster with a sustained dash. This has led to preceded Sustained Dashes like ..__ that starts at 3 and like ...__ that starts at 5. .__ selects a (repeated) BackSpace. Numeral codes may be redefined, for instance 1=-.... 2=.-... 3=..-.. 4=...-. 5=....- and 6=....., unlike the assignment in Table 1, and these are a reasonable alternative to Sustained Dashes. This is not further discussed in the following, and neither is that Sustained Dashes may select from text prediction if combined with scanning and two switches[2].

Two speaking communication aids that may employ Sustained Dashes

Figure 3 is a screen shot of a speaking communication aid implemented under Microsoft Windows. Sustained Dashes help to combine word prediction with slightly changed Morse Code as displayed in Table 1. This is projected on screen to minimize the need for prior instruction. A Sustained Dash of length two will display in the prediction list and will mean 'How are you ', the second item. The code for '2' or '..---' will likewise select *and* speak 'How are you '.

1 http://en.wikipedia.org/wiki/Morse_code.
2 Or even with a single switch, if we precede a Sustained Dash with another sustained dash.

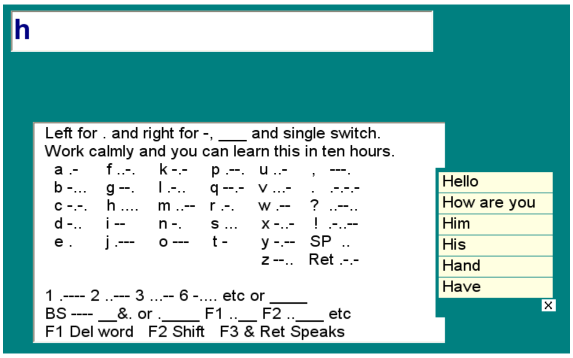


Figure 3. Speaking communication aid after entering the code '….' for 'h'.

Figure 4 shows a traditional matrix for row-column scanning with an empty first column where the focus may rest[3]. If a normal click moves the rectangular focus vertically, Sustained Dashes may move the focus horizontally. Therefore we can have active row-column scanning with a single switch[4].

	Sp	Bs	a	b	c	d
	e	f	g	h	.	,
	i	j	k	l	m	Del1
	n	o	p	q	r	Del2
	s	t	u	v	w	Del3
	x	y	z	F1	F2	F3
	1	2	3	4	?	!

Figure 4. Row-column scanning with empty first column.

Figure 4 is learned easily, is error tolerant and supports word prediction, a vertical jump option and a rather special and presumably new technique called 'Down Accept'. Also, instead of the focus the whole matrix may move for people with lateral eye-gaze paralysis as if it were a bidirectionally rotating torus. Neither technique plays a role in the following, see Appendix for details. As is the case with Figure 3, keyboard, mouse and touch screen can be used, as might eye-gaze, and up to three different switches.

Morse Code can be entered blindfolded and needs fewer clicks and pauses per character than (active) row-column scanning. The difference is rather large, about 2.6 frequency weighted clicks and one pause with Figure 3 instead of around 4.1 frequency weighted clicks and one pause with Figure 4, using two switches. If several dits and dashes are combined into a code, the pauses between dits and dashes must be shorter than the pause time at the end as is shown in Figure 2. Pause time is significantly longer than individual clicks and plays an important role in the input rate that can be achieved after continued training.

[3] Nothing happens in the first column so users may pause as long as they want and a selection sequence can be cut in two parts. Though extremely simple, as far as I know this is a new trick.

[4] In active scanning the user moves the focus by clicking. In passive scanning the focus is moved by the machine and movement is interrupted by clicks. Generally speaking active scanning is the faster system as is evident from drawing a time line with several pauses and clicks. Pauses must be drawn longer than clicks because users must be able to click before a pause has passed.

Word prediction

Word prediction is possible with both scanning and Morse Code, low tech (called 'user scanning') as well as high tech. It will usually cost time when copying text at low speed, as was admirably researched by Koester and Levine (1996, 1997). To read a list of predictions and pick the right one does not pay off. Sustained Dashes probably are no exception for the average copy task but might be useful in conversations *if* one knows beforehand what useful items the prediction list contains. Use must be influenced by properties of the word predictor, like if recently used words are high in the prediction lists and if a small set of frequently used words are always presented on top. Usefulness, or the lack of it, must also be influenced by the (repetitive) nature of some conversations and by preferences, training and experiences of the users themselves.

Appendix. A bidirectionally rotating torus that may be combined with Down Accept.

Figure 5 shows a small part of the screen, as is visible to people with a paralysis of lateral eye-movements that occurs in about one in three locked-in patients. Because word prediction is used, numerals must occupy the first row, and therefore the arrangement of characters is subtly different from that in Figure 4.

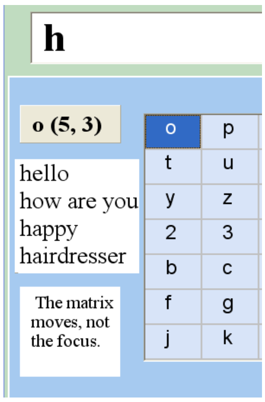


Figure 5. Active scanning with empty first column, Moving Matrix set and word prediction active.

The character 'h' was selected previously as is shown in the edit line. The focus now rests on the fifth row, third column after Down Down Down Down Right Right. If the user waits a bit, he or she will select 'o', perhaps with the intent to select 'how is it ' at a later stage. It is possible to scan with a single switch and also to scan with acoustical cues to indicate where the focus is. With the jump option set, Right Right Down gives the same effect, as would Right Down Right.

'Down Accept' may bypass the pause, intended for people with severe athetosis but also useful with a rotating torus. To select 'j' with this property active in Figure 4, one enters Down Down Right Right Down. The last Down accepts 'j' and replaces the pause. Like the rotating torus this trick is only possible because of the empty column, where Down just moves the focus downwards, and is also possible with a single switch.

Part II

Learning Morse Code compared with learning Active Scanning

Most care givers believe that Morse Code must be slow at first, compared to active scanning, and are reluctant to participate in laboratory work. As a reasonable command of Morse Code is necessary to combine it with word prediction, one may ask if Sustained Dashes will be learned and used at all. Therefore *if* Morse Code is learned in acceptable time, and in the laboratory, another experiment is needed to document use of Sustained Dashes in conversations, and perhaps later a third experiment might show that learning this combination can be justified from an economical point of view.

Ideally both experiments would have been done by several bright friends, for reliable data, repeated by several interested caregivers, for reproducible data, repeated again by careful psychologist and in protracted copy tasks, to document feasibility on the long run, and also repeated by several representative members of diverse intended user groups, for relevant data. These user groups are highly variable and might involve patients with cerebral palsy as well as patients with Amyotrophic Lateral Sclerosis (ALS). A case can be made to also include other tasks than copying and having a conversation. This proved impossible to achieve at reasonable cost, and a compromise was made.

When researchers compare different input systems like Dasher versus the eye-tracking system MyTobii (Majaranta, 2009) or evaluate a 'scanning ambiguous keyboard' (MacKenzie, 2009), one hour is spent to inform subjects and get used to the switches. Then the first hour hands-on is studied with a copy task. This necessarily is but part of the total learning curve. Input techniques are not 'over-learned' in one hour and it can be hard to study them with relevant tasks and in the context of use. In the following, first the learning rate of Morse Code is studied with the *same* data as used by these authors and with the *same* pause time as the scanning matrix that it is compared with. Generally speaking this pause time, of 280 milliseconds, is appropriate for novices. Later use of Sustained Dashes in conversations is described, with a somewhat higher pause time, as was appropriate for the third test subject.

Experiments with two switches

A bright friend (JvD, aged 66 at the time of study), who works as a teacher for all subjects in secondary education, trained Morse Code for less than one hour using paper and pencil. He copied the alphabet forwards, backwards and ordered in groups of equal code length. Also he studied the codes and encoded about forty lines with symmetrical nonsense words like 'nnaa aann naan anna', made up of characters of equal code length. This trick, advised by King (2000), was also inspired by mnemotechnique. Next he copied plain English phrases taken from popular culture[5] and encoding rate was measured with paper and pencil with Table 1 present to look up codes when needed. His rate rose from sixteen to twenty four characters per minute encoding speed in one hour. After this first hour my friend knew most of Table 1 by heart, but not all. Almost a year later, and without further practice, he copied text from the same source, with *two* switches and with Figure 3, but without word prediction. The astonishing Figure 6 is based on his log files.

[5] See McKenzie, 2009. The subset we used is not very appropriate, because it starts with long words like 'prevailing'. For rapid learning short words seem a better choice.

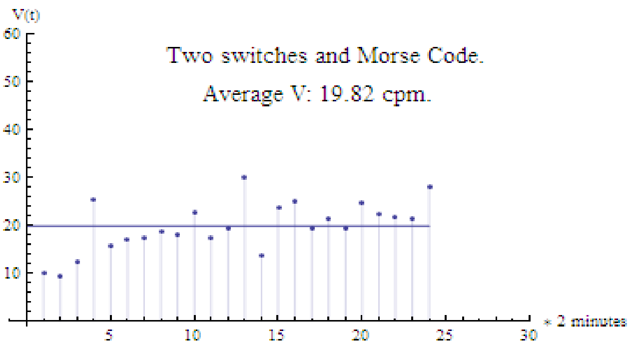


Figure 6. Learning curve with a healthy test subject, two switches, a copy task and *one* hour of previous training. Pause time was 280 milliseconds, somewhat higher than strictly necessary, to reduce the number of errors. All errors had to be corrected and pause time was *not* varied.

Input rate appears to rise and has an average value of 19.8 characters per minute in the first hour with switches. This is much higher than expected, though it only allows very simple communication. Slow conversations are demanding and can be extremely frustrating for everyone involved until about fifty characters per minute.
He also tried row-column scanning for an hour, using the same texts and a matrix related to Figure 4[6], with comparable average input rate (19.1 characters per minute) and SD (4.45 instead of 5.17). This is another most amazing result because generally speaking care givers assume that Morse Code takes too much time and too much effort to learn when compared to scanning. This experiment was repeated a few months later with Figure 3 and Figure 4 and with different phrases from the same source. Average input rates now were 21.3 cpm with Figure 3, 20.7 cpm with Figure 4, coincidentally the same SD of 4.0 and more errors with Figure 4.

Experiments with a single switch

To verify again, and to study text input with a *single* switch, Figure 3 without word prediction was compared with Figure 4 and with a copy task by another test subject (KB, aged 43, and again with intelligence above average). See Figure 7 and Figure 8 for results with the same texts, about 90 minutes each and an ABBA-design to reduce the effect of starting with Figure 4. He felt that row-column scanning was mastered in less than one hour while learning Morse Code still continued. On visual inspection his graphs resemble each other, perhaps in Figure 7 the rate rises slowly, and less so in Figure 8.

6 Word prediction had accidentally been activated so numerals occupied the first row.

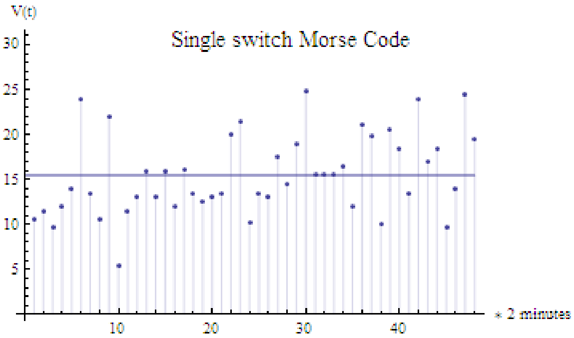


Figure 7. Input rate with Figure 3, no word prediction, single switch and a copy task. The average rate was 15.48 characters per minute and SD was 4.48.

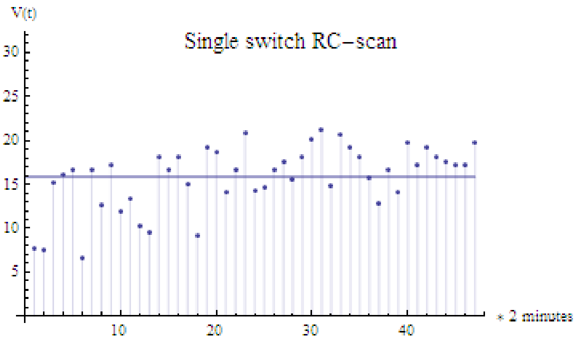


Figure 8. Input rate with Figure 4, single switch and a copy task. Average was 15.8 characters per minute and SD was 3.61.

Both test subjects needed some time to get used to the switches and this casts some doubts on the comparison made above. We may conclude that again, in a paired comparison, *no* significant difference in input rate was found in the first hour of a copy task between this form of active row-column scanning and Morse Code. And again, this is an amazing result. Some difference is to be expected on the long term, because the lower number of clicks per character and the lack of visual attention needed with Figure 3, once learned, must make it faster.

Conversations with Sustained Dashes

Another friend (SvdP, then aged 36 years) was between jobs and has a minor learning disability due to a car accident as a teenager with some motor asymmetry as well[7]. He needed several hours to learn the codes of Table 1 and needed over twenty hours to learn to use Morse Code as well as learn to communicate with speaking software that includes word prediction. This time period comes as no surprise in view of previous experiences with bright university students. Sustained Dashes were learned easily and

[7] He agreed in writing that this information would be published. It is relevant because it influenced learning and also influenced pause time (that started at 400 msecs) and learning to deal with the switches,

after practicing for a while he used a high percentage of sustained dashed in open conversations with the author, who wrote down his words before speaking them, to achieve a symmetrical rate problem. After each conversation we wrote down our experiences and discussed them, as is customary in usability work.

Data logged by the software were used for Figure 9 and Figure 10 after about twenty six hours of practice. At that time learning had *not* ended but we both felt that these conversations were agreeable and of acceptable quality. This test subject never learned scanning and therefore no comparison with Figure 4 is possible. Due to the experimental set up it is impossible to say whether we had 'normal' conversations. No arguments ensued but some words must have been selected because they were present in the prediction list, not presented then selected because they were needed in the first place.

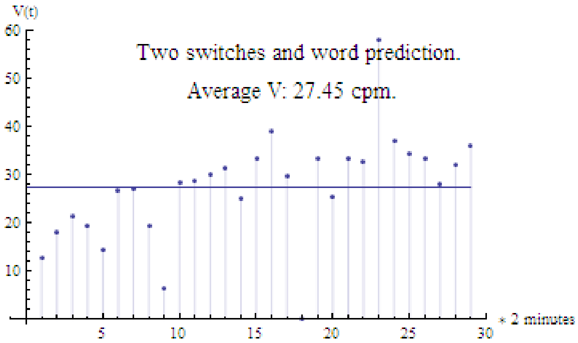


Figure 9. Four conversations by test subject SvdP with Figure 3, two switches, pauses of 300 milliseconds and Sustained Dashes.

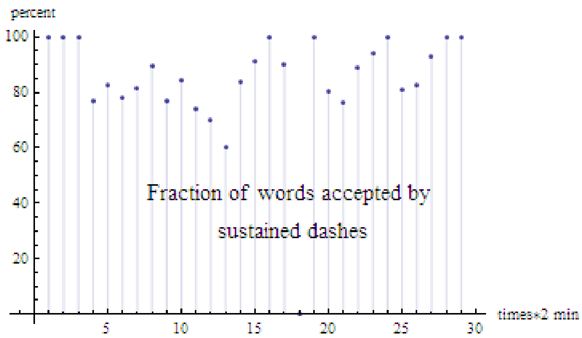


Figure 10. Same conversations, percentage of word selection ended by Sustained Dashes.

Discussion

With Morse Code projected on screen *two* test subjects achieved an acceptable input rate in about one hour of exercise. Active row-column scanning with alphabetical ordering and an empty first column was equally fast. Both test subjects acted as their own controls. The combination of Sustained Dashes and word prediction was used in *some* open conversations with *one* other healthy test subject and significantly more training. This suggests that Sustained Dashes may be found useful in open conversations where recent words are frequently reused.

Do Sustained Dashes have practical value?

The practical value of Sustained Dashes is not clear. They may have a role to play in switch access to communicate with synthetic speech, relevant in a small part of care that is studied in Augmentative and Alternative Communication, or AAC. Well known experts in AAC find input rate much less important than training caregivers to learn to wait, to listen carefully, and to let users gain some control over the topic of conversation. For interesting videos that are truly helpful to understand this point of view consult Murphy and Scott, 1995, or Murphy, 2010.

Many technical questions may be posed that are hard to answer. One may wonder what happens after using Figure 3 for, say, two hundred hours, by a cerebral palsied test subject who needs pause times of two seconds and has a minor reading problem[8], what conversations would profit from what forms of text prediction and how Morse Code compares to different forms of scanning and eye-tracking in conversations, story-telling, with special switches, and on the long run. Sustained Dashes might also be applied in very different fields such as to navigate while gaming, to select items from a list, and this not just by the handicapped. Therefore they raise many more questions than were investigated in the above.

To the author it has become clear that *all* such questions can not be answered by psychological experiments performed either in some sort of laboratory or in clinical practice. To advance understanding into switch access of text based communication aids clear design, simple yet accurate mathematical models and feed back both from test subjects and from real users can not be missed. To see how these techniques may best serve patients, family and caregivers, cooperation with specialized institutes appears desirable and cerebral palsy a tempting but not the only patient group to try out. Together this represents a significant amount of work.

Conclusion

Morse Code with Sustained Dashes for word prediction appears usable, easy to learn, fast and therefore clinically relevant. The same may be said about row-column scanning with an empty first column, that strikes as being error tolerant and remarkably flexible as well. Much more research is possible to see what can and what can not be achieved by these techniques, how much service they require, how they compare to currently available alternatives, and how cost effective they may be.

Conflict of interest. There is a clear conflict of interest because the author is both (re-)designer, programmer, evaluator and distributor of the software. Therefore, investigator bias is probable.

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[8] This, by the way, is a frequent occurrence.

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Details From www.depratendecomputer.nl/results.htm several videos are available, some of them with 'primed' word prediction. Two implementations of Morse Code that replace both keyboard and mouse are called the TandemMaster, see www.TandemMaster.org and the Darci 2, see www.westestengineering.com. On www.depratendecomputer.nl > English site > Sponsoring provides information on sponsoring and > Research offers information on Alternative (Morse) Code.

Figure 1 and Figure 2 were created with Graphic Calculus, software for mathematics education from VuSoft. Figure 3, Figure 4 and Figure 5 are screen shots, Figure 6 to Figure 10 were made with Wolfram's Mathematica based on log-files created by the relevant software.

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