Conversations with a single switch, rate enhancements and stored text

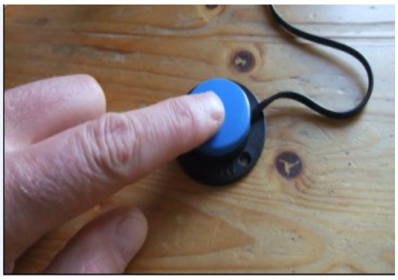
Joris Verrips[1]

Conversation with switches and a speaking alphabetical communication aid was studied. This aid combines encoding and sustained dashes with text prediction, character macros, word macros and stored text. First we tested with six acquaintances, a single switch and open conversations. A second study compared having none, some and many rate enhancements available again using single switches and open conversations. A third study considered repeated prepared conversations and some learning with one switch, two switches and finger pointing. In each study, conversations with a single switch were possible and significantly re-used stored text.

Keywords: AAC, switches, speaking communication aid, synthetic speech.

Introduction

Some people can read and can spell, but cannot speak, or cannot articulate very well. This may be due to conditions such as Amyotrophic Lateral Sclerosis or ALS, motor dysarthria or cerebral palsy. Problems with speaking are the first complaint in about 10% of all cases of ALS and are often combined with muscular weakness or paralysis. Some patients continue to speak normally, or get by with a bloc note, others use eye-blinks, eye-gaze and gestures. Many communication aids have been developed to voice messages selected and sometimes also created by the use of switches[i] as shown below. As a rule, open *conversation* with switches is not possible because input rates with scanning are around ten characters *per minute* or less, much slower than normal speaking of about ten characters *per second*, when pauses to think or to just listen are not counted.



Picture 1. A switch allows users to deliver short clicks and long clicks. If users can actually deliver timed responses is highly variable.

The role and value of communication techniques for speechless people is studied in AAC, or Augmentative and Alternative Communication and is informed by Assistive Technology, Psychology, Linguistics, Human Computer Interaction or Computer Science and ideally by individual clients and families too. AAC is concerned with much more than techniques and traditionally focuses on children with multiple complex handicaps who cannot read, as is true for many children with cerebral palsy. Excellent introductions are Beukelman & Mirenda (1992) and Loncke (2014). For a video of how modern text based speech

1 Mail: j.verrips@planet.nl. Website: www.depratendecomputer.nl.

generating devices (SDGs) look like see www.inmaninnovations.com or www.smartboxat.com/software/text-communication-2 .The latter describes the Grid 3 that contains over five thousand stored messages raising obvious questions like if they are all needed, useful, or worth the effort of memorizing. Such questions are hard to answer. See www.communicationmatters.org for more background on AAC, a large field.

Goals of these studies

Goals of these studies were many, including to inform almost endless redesign of the communication aid WriteEasy and of the stored text contained therein and also to see what might be learned on using rate enhancements and stored text in the laboratory. We focused, however, on open conversations with a single switch, text and synthetic speech.

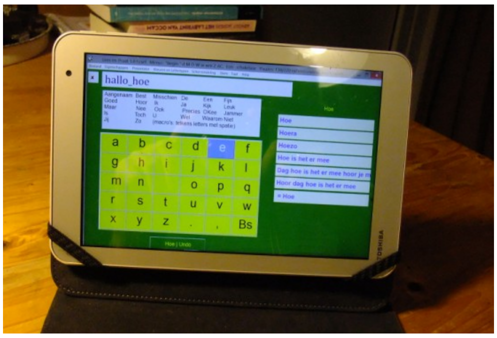
Why work with able-bodied test subjects

To research into communicating with switches can be done in many ways, practitioners stress the importance of working with the target groups themselves above laboratory work. To even try create a text-based aid designed to be as fast as possible with switches however, this will *not* do because it is complex from a technological point of view and requires expertise unavailable in health care. We learned much from able-bodied test subjects, often in a lunchroom, often with full experimental control and sometimes improvising, with frequent new versions, much time spent reading and some experiments done with the author as his own test subject. One cannot do that kind of thing for years on end with excellent multidisciplinary cooperation in institutions as we have come to know them. And in our experience it was hard to motivate even the friendliest and ablest of test persons to put in the effort needed to become as fluent with WriteEasy as the author. Taken together, this implies that our results are *less* than convincing from a clinical point of view and that they only *appear* reproducible.

Description of WriteEasy

Only a small fraction of people that are unable to speak[ii] are sufficiently literate to use text-based aids and to combine character macros as in 'f ' = 'Fine ', word macros as in 'wp ' = 'wait please ' and word prediction. WriteEasy was designed and implemented by the author and combines those rate enhancements with stored phrases and Alternative Code (Verrips, 2012). Alternative Code translates clicks and pauses into characters and is combined with sustained dashes to select from text prediction and from menus with stored phrases. Once selected, texts are displayed for reading and are voiced by synthetic speech.

Abbreviation expansion by character macros and by word macros should help to maintain contact, to take turns and to exercise influence. Text prediction can help to repeat recently used words, especially long words, and may also predict phrases, either recently used or part of the text stored in menus. Menus with stored text may prepare a story, a joke, answer to a question asked the other day, initiate another topic and more. Stored text may ease predictable phases of conversations, like to say goodbye, but it may do more and is not a rate enhancement properly speaking. It seems useful for situations that may be scripted in advance but we can not say more about those situations. Picture 2 and Figure 1 offer a first impression of WriteEasy.



Picture 2. A speaking touch book with WriteEasy. From top to bottom we see an edit line, character macros and the alphabet for use by touch or by mouse. Word prediction and stored text is displayed to the right.

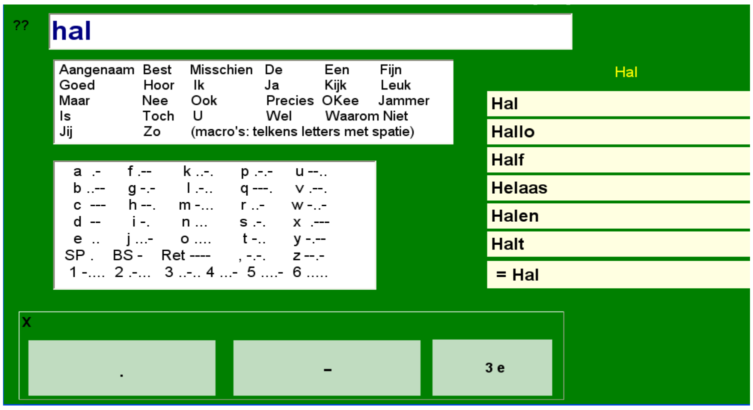


Figure 1. Write Easy with edit line, dutch character macros, Alternative Code and dutch word prediction after entering 'hal' using '--. .- .-.. '. A dash or - means a long click and a dot or . means a short click. These are also displayed on the three buttons below that may replace switches for some.

In Figure 1, encoding with either one, two or three switches is possible. A sustained dash of length 4 ____ as well as the code for 4 or '...-.', will select the fourth word, 'helaas '. Here <3e><3e><3e><3e><pause> (3e is dutch for 3^{rd}) would have had the same effect. Entering '.- . ' or 'a ' would have selected 'Aangenaam ', the character macro that is bound to 'a' followed by space. More details are in Appendices A and B.

First study Open conversations

First question

Can one have open conversations with a single switch, character macros, word macros, word prediction and stored phrases combined?

Method

Three acquaintances FH, FV and AK were offered a drink. We had open conversations on whatever subject occurred to us while the author used a single switch and WriteEasy. One conversation lasted for almost forty-five minutes, the other two lasted about twenty minutes each.

Results

Table 1 lists experiences and Table 2 shows the log file.

Author	Conversation partners
Not bad.	Can I ask something? Needs getting used to (FH).
Conversations with *customized* stored text must be faster. Less tempted than before to enforce attention with character macros. Unclear what word macros have you got.	Feels good, I can take part normally. Much like chatting, try to have much effect with few keystrokes. Faster than before[iii], I feel less tempted to anticipate on the next word (FV).
Conversation is acceptable, again, using mainly word prediction and character macros.	Nice but I feel clueless how it works. This is a conversation but I would need much time to learn it well (AK).

Table 1. Experiences.

4451	spoken length
5430	Clicks on Right Mouse Button
1952	dit to dash or to sustained dash
171	sustained dashes
333	total length sustained dashes
122	Backspaces
427	Macros
108	of those word macros the others character macros
2270	Total macro length
848	length of total macro length were word macros
164	Predicted words accepted
1261	Length of predicted words
216	Length of stored phrases
5392	Total active time in seconds
983	Time in seconds inactive periods of >= 10 seconds (inaccurate)
Characters per minute:	49.5
Clicks per character:	1.21

Table 2. Log file of three open conversations.

Table 1 shows participants were rather positive and Table 2 shows almost ninety minutes were spent to give 5430 clicks for an average of 49.5 characters spoken per minute. 13% of the spoken length was clicked in without input enhancements, 4451 – 2270 – 1261 – 216 = 704 characters, 4% was selected using stored phrases, 216 characters.

Interpretation

Character macros, word macros and word prediction all selected significant length and the experience was acceptable or satisfactory. Stored phrases were hardly used, due perhaps to what menus were available. This hypothesis was tested in a second experiment of the first study.

Second question

Is stored text used more often in prepared conversations with *customized* stored phrases?

Second experiment

Three more acquaintances were invited to have conversations with a speaking computer. We agreed on at least one subject that the author prepared with a menu of stored text as described in Appendix A. Two conversations were short at eight minutes each, the other took thirty-five minutes.

Results

Selected comments are in Table 3 and Table 4 contains part of the log file.

Author	Conversation partners
Quality of voice is important.	It is funny but how do you do it? (AT).
Listening goes all right with character macros. Emotions of *both* participants are important. Hard to say the right thing. Feels like I talk too much, to keep the floor perhaps.	Funny, sometimes not natural, see only the last few words spoken. Feels like I talk slowly so think more. What do you want to do with it? (BL).
A bit superficial this time.	I like the artwork. Seems easy to learn? (PK).

Table 3. Comments.

3273	spoken length
2965	RMB Right Mouse Button
1035	dit to dash or to sustained dash
136	sustained dashes
364	total length sustained dashes
55	Backspaces
222	Macros
42	of those word macros the others character macros
1195	Total macro length
347	length of total macro length were word macros
96	Predicted words accepted
686	Length of predicted words
919	Length of stored phrases
3202	Total active time in seconds
458	Time in seconds inactive periods of >= 10 seconds (inaccurate)
Characters per minute:	61.330
Clicks per character:	0.907

Table 4. Log file of three prepared conversations.

Interpretation

14% of the spoken length was clicked in without rate enhancements, 3273 – 1195 – 686 – 919 = 473 characters, the number of characters per minute was 61 cpm for only 0.9 clicks per character. As in Table 2 above, the length selected by character macros and word macros combined is larger than the length selected by word prediction alone. Stored phrases were used more often than previously, 919 / 3273 = 28% of the spoken length, so we did not falsify our hypothesis. This result suggests a role for stored phrases *beside* other rate enhancements, and especially so in prepared conversations.

Test

Six out of six conversations were of acceptable quality or better. According to the Sign-test this is significant with $\alpha = 0.025$. There are several methodological problems with this test because quality of conversation was just an impression and because the concept of having a conversation is somewhat vague as well.

Third question

To understand Table 2 and Table 4 one may wonder how fast is Alternative Code for the author and *without* rate enhancements.

Third experiment

An input rate without rate enhancement of about 30 characters per minute was expected based on previous experiments and comparable with the author typing with a single finger on his Windows phone. Therefore, having conversations with Alternative Code without rate enhancements would not be comparable with conversations as reported above. Because we are also bothered about ease of experimentation, a repeated copy task of a poem[iv] was used to estimate the author's input rate with Alternative Code, a single switch and *no* rate enhancements. Errors were corrected without striving for perfection.

Result

Input rate was 34.75 cpm with a standard deviation of 4.7, based on twenty-two consecutive periods of one minute[v] and with a pause time of 250 milliseconds. Compared to 49.5 cpm in Table 1 this is significant by statistical tests on location. As the average number of clicks per character is only 2.5 with Alternative Code without rate enhancements, it is unlikely that any available scanning technique would be faster for the author[vi].

Interpretation

To copy a repetitive poem is not the same thing as having a conversation, therefore we did not proof that the author would be better off with than without rate enhancements. Due to the size of the difference with Table 2 and Table 4, results do suggest that these rate enhancements do enhance rate. If that holds for word prediction alone is unsure[vii] and results with two switches might well be significantly different.

Limits to first study

We did *not* have conversations by test subjects representative of the rather varied intended user groups, we did *not* compare with other communication aids, the author was his own test subject and there are several other methodological issues[viii]. Neither long time use nor experiences in real contexts of use were considered and one may wonder if having conversations is what intended users need most.

Conclusion of first study

The author did three open and three prepared conversations with a single switch, Alternative Code, character macros, word macros, stored phrases and synthetic speech combined. This combination was effective and was fast when compared to a copy task *without* rate enhancements.

Second study Relative merit of rate enhancements

What merit do different available rate enhancements have?

Our first study suggests that rate enhancements can be useful in conversation. To further study their merit conversations with two speaking computers were done alternating a condition with no rate enhancements (I, just AC), a condition with word prediction and character macros (II, AC +

wp + cm) and a condition with word prediction, phrase prediction, character macros, word macros and menus with stored text (III, AC + wp + pp + cm + wm + st)[ix]. To this aim cooperation was sought with FV, who had previously helped to study ease of learning of WriteEasy. In each condition we used the same screen presentation and the same pauses[x]. Learning was also studied with another test subject as reported in Appendix G.

Method

The author and FV practiced with two speaking computers and single switches until we both felt at ease with I to III. This took about eight hours hands on, at that time FV had spent about twenty-five hours hands on with WriteEasy. Next we practiced with sessions of at least fifteen minutes for each phase starting with the same database. All sessions were followed by a short discussion of a simple form. We adapted our menus of stored phrases before each session of III and also removed typos. I to III were alternated: I, II, III then II, III, I and finally III, I, II. We practiced in a relaxed atmosphere illustrated in Picture 3 for about four more hours hands on. Results are in Table 6 and in Appendix F.

Picture 3. Conversations were held in a lunchroom.

	FV	JV
Phase I: AC	20,9 ± 3,9	24,4 ± 7,8
Phase II: AC + wp + cm	23,3 ± 6,6	32,6 ± 6,6
Phase III: AC + wp + pp + cm + wm + st	26,5 ± 12,8	41,0 ± 11,7

Table 6. Input rates ± Standard Deviation in characters per minute computed over periods of at most two minutes that the software was actually used.

Interpretation

We see high measures of variance for both the author and for FV. The high measure of variance of JV in I can be explained by the way hands-on time is measured by the software[xi]. Variance is natural in open conversations and will not diminish with continued practice. The fact that III > II > I, true for both FV and JV, illustrates that rate enhancements were used. These differences in input rates are not significant according to statistical tests on location.

Conclusion of second study

Rate enhancements as described seem to be effective in open conversations with two able-bodied test subjects, one of them the author, and two speaking computers, both of them accessed with a single switch.

Third study Learning

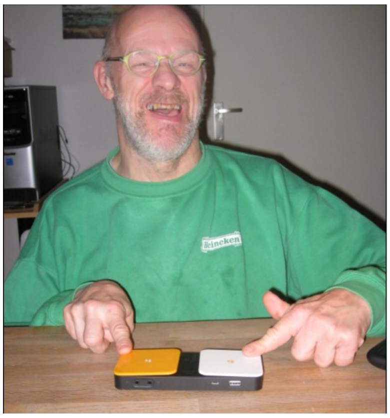
Neither handling switches, nor encoding, word prediction, character macros, word macros, or stored text are inherently difficult. But they must be learned, do claim attention, and it may be hard to combine them in conversations. Therefore ease of learning with a relevant task as well as frequency of use after sufficient learning inform on practical value of rate enhancements.

Past experiences

Over the years, many people helped to test WriteEasy and several other speaking communication aids intended for research. People tried to chat with the author clicking, tried to have a conversation with a mouse or typing with a single finger, compared learning of Alternative Code to learning of Oriented Scanning, helped to study re-use of stored text, and more[xii]. We often exercised having conversations with two speaking computers, that is with a symmetrical rate reduction and symmetrical claims for our attention.

Two hypotheses

Past experiences informed two experiments with JWH, a man with cerebral palsy since birth who speaks with athetosis, lives independently and volunteers for the Bosk[xiii]. After meeting in person and a demonstration we wondered if repeated conversations would be pleasant with the author using WriteEasy with a single switch. Also, we wondered if JWH would learn WriteEasy.



Picture 4. JWH with switches[xiv].

First experiment: prepared conversations

We started with three prepared conversations. The author employed character macros, word macros, word prediction, text prediction and stored text. JWH employed his athetotic voice at about twenty words per minute on average.

Results

See Table 7, Figure 2 and Table 8.

```
4824 spoken length
2181 chars chosen
 115 Backspaces

 382 Macros 91 of those word macros the other 291 character macros
2039 Total macro length 704 word macros and 1335 character macros
 172 Number of predicted words and phrases that were accepted
1291 Length of predicted words and phrases

 760 Length of stored phrases selected from menus
 734 Length clicked in without rate enhancement
 812 Spoken by Space Repeat

7357 Total hands-on time in seconds
 Characters per minute:  39.342
 Clicks per character:    1.772
```

Table 7. Selected data from logfile of JV with a single switch. Space Repeat repeats the last word, the number 812 is wrong due to a software error[xv].

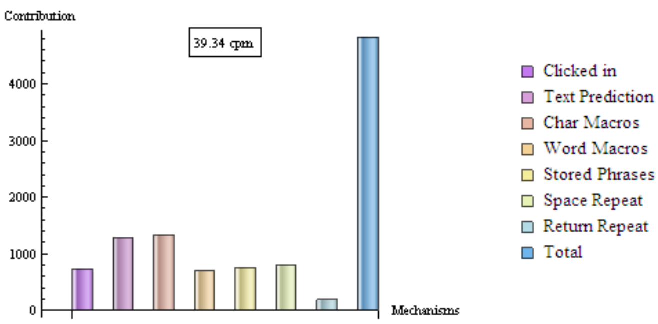


Figure 2. Bar chart based on logfile of JV. Total gives the sum of the first *five* bars, 4824 = 734 + 1291 + 1335 + 704 + 760. All rate enhancements contributed, word macros 704 / 4824 or 14.5%. Return Repeat (196) speaks the edit line and remembers it for re-use.

JWH	JV
Quite fast, amazing. I want to learn this too. Perhaps with more macros and more stored text you will be faster? I like to read while it speaks. Would be pleasant if you were faster yet. I want bigger keys on the alphabet[xvi]. Trying the alphabet: Must exercise to find characters and spell too. Slow, for now, but it works.	Several small bugs, again. Lends itself to teasing, be careful! Menus can be much fun. How satisfactory this is must depend on what is meant with 'having a conversation'. Tempted to use only word prediction and macros, feel time pressure. Sometimes you must indicate end of turn with a gesture. Honesty and trust are important too. I use a limited subset of word macros[xvii]. Wonder how to use this more convincingly.

Table 8. Selected comments. During the third session JWH started with phase A reported below.

Interpretation

The author used all rate enhancements in pleasant conversations at a higher input speed than his copy speed. For the author WriteEasy is neither too small, nor too big, because he combines all available functions in repeated prepared conversations with a single switch.

Second experiment: scripted partial learning

Soon enough, JWH wanted to learn WriteEasy. Scripted partial learning was used with neither stored text nor word macros because this seems the shortest possible learning curve according to Appendix E, G and I. Stored text and word macros might be added later and expanded gradually according to a client's needs.

Details

JWH signed an agreement that his input data could be used for research. He tried out things, tried to maintain contact and first pointed on the alphabet and later introduced character macros and word prediction[xviii]. The author offered instruction on demand and took part with a single switch. Pauses were taken to discuss experiences and to get to know each other. We exercised playfully, as when using character macros only or trying to do communicative functions such as to accept or to interrupt[xix]. We occasionally used our own voices or gestured but tried not to.

Results

Quality of conversation gradually improved but remained somewhat limited. We needed much time to get to know each other and had fun. JWH's slow reading made using WriteEasy quite tiring for him. Table 9 offers some figures after about ten hours practice, four hours hands on. We decided not to use encoding because the experiment would become too time-consuming.

Phase	Total time spent hands-on in minutes	Characters per minute in last session of this phase	Length per mechanism in last session
A	47	11,6	Pointing: 100%
B	72	21,9	Pointing: 18% Word prediction and character macros: 72%

Table 9. Data from JWH's logfiles.

Interpretation of second experiment

Scripted partial learning was feasible and was pleasant.

Conclusion of third study

After long learning all rate enhancements are used by the author in repeated prepared conversations with a single switch. A speaking person with cerebral palsy learned to use word prediction and character macros with finger pointing in about ten hours time.

Pilot studies besides development

Over the years, WriteEasy and its ambitious precursor Htyp[xx] were shown to many a Speech Language Pathologist (or SLP), some medical doctors, several small firms and eleven potential clients, three of them thanks to the author's background as a medical doctor[xxi]. SLP's saw few practical possibilities and pointed out that (precursors) looked a bit complicated and that many of their clients can not read well and need not want to learn much. All involved had valuable criticism to share and those contacts provided important motivation to go on. See Table 10 for details on potential clients.

Name, condition(s)	Events	Opinion
FN Speechless boy due to meningitis as a young child.	Early version of Htyp was demonstrated and tried out shortly on a borrowed pc when he was sixteen years of age and lived with his family.	Liked it but preferred the LightWriter 'and doing fun things'.
? Speechless man after stroke with high blood pressure, who wrote several books at the same time.	Satisfied with Canon Communicator and writing. Severe second stroke made reading and communication virtually impossible.	Interested but never tried.
JvA Speechless man due to slowly progressing ALS.	Appreciated WriteEasy and Htyp and tried WriteEasy for a while but preferred a word predictor available in all of Windows (probably WiVik) combined with small notes and mail.	Nice research but not what I need most.
JS Speaking male patient with ALS.	Appreciated Htyp but was not motivated to try out and anticipate on loss of speech.	Not what I need now.
DS Speaking male patient with ALS.	Appreciated Htyp but was not motivated to try it and anticipate on loss of speech.	Not what I need now.
HP Speechless male patient with rapidly progressive ALS and breathlessness.	Appreciated Htyp and used it for a while on his pc, and until his death a few weeks later.	Would prefer using it on a laptop.
MSF Woman recovering speech after temporary Locked In syndrome due to an infection.	Valuable criticism on design, presentation and functionality. Preferred to practice with her own voice that had returned in part.	Sceptical, 'you write long articles that nobody need read'.
VS Reading speechless girl with Cerebral Paresis who uses switches.	Family opposed because general lack of time. 'There is so much more that we would like to do'.	??
MEK Severely dysarthric man with left sided hemiplegia after multiple strokes.	Never saw WriteEasy because his family was opposed and because he was often very tired. They had experienced three times failure with speaking computers, giving rise to much frustration.	??
MT Woman with left sided hemiplegia with severe dysarthria due to repeated cerebrovascular accidents.	Looked at WriteEasy but preferred her own voice combined with a character card, making a stroll, having coffee and listening to music[xxii].	Not for me.
SV Man with several years of severe aphasia with left sided paresis due to stroke.	His speech recovered, as his walking, but he remained easily tired by speaking. Preferred to continue with his own voice.	Nice, and I will look out for potential clients, most afasic people are worse off than I am.

Table 10. Results from pilot studies over the years limited to educated people who could read and write and who were found more or less by hazard. *No* clients were met who depend on a single switch.

Conclusions of pilot studies

Much was learned from pilot studies but they did not lead to satisfied clients and makes one wonder if WriteEasy has practical value.

Further questions

More research can easily be defended because unanswered questions abound[xxiii]. Most important seems if stored text has value for real patients and at what cost. One needs but little experience to understand that many neurological diseases are of a chronic character and imply extremely varied care with a limited role for high-tech. This has also been noted by speech language therapists such as Murphy (2004) and Koster (2015). At the time of writing, we intend to do another pilot study with dysarthric patients who would also use low tech.

Conclusion

WriteEasy allows conversations with a single switch for people who can read, spell, operate a switch and combine several rate enhancements. Learning to do so takes time and effort and can be pleasant with amazing results. As yet no clinical work was done and combined with other considerations this makes practical value of WriteEasy uncertain.

Thanks to Test subjects Frits Hermans, Frank Voorhuis, Arthur Koning, Angelique Trouw-Nooit Genoeg, Bing Lie, Peter Kouthoofd, Jack van Dillewijn and Jan Willem Hollink for their time, effort and comments.

Thanks to Norman Alm, Horabail Venkatagiri and Annalu Waller for moral support and for criticism.

Declaration of interest Researcher bias is probable because the author writes his own software, uses himself as a test subject and distributes speaking software paying for every bug found, see www.depratendecomputer.nl/advertisement.pdf.

Download WriteEasy 1.0 is at www.depratendecomputer.nl/writeeasysetup.exe that also contains several other speaking communication aids. Select Demo version/trial version and enter your email address. WriteEasy is protected, runs under Windows and is distributed for free with the request to 'only pay something if you like it'.

Further documentation Appendix A below describes WriteEasy. Appendices B to Appendix E are in www.depratendecomputer.nl/DetailsofWriteEasy.pdf and were written as a design rationale, trying to clarify not how but why. This implies, of course, that they are somewhat incomplete and contain details of little importance. They are entitled: Details of WriteEasy, Background, mental model and character of stored text, Linguistics of design and of stored text, and Learning WriteEasy. Appendices F to K are in www.depratendecomputer.nl/MoreDetails.pdf and are entitled Details of second study, Reproducible learning?, Integration of word and phrase prediction, Pursued studies, Stepped Encoding and Stepped Cueing, and Criticism. This file also contains references.

Pictures All Figures were made by the author with the help of Mathematica 9.0 and of Grabbit2.

Videos on WriteEasy are www.depratendecomputer.nl/writeeasythevideo.asf, www.depratendecomputer.nl/writeeasysecondvideo.asf and www.depratendecomputer.nl/writeeasystokje.asf.

Appendix A. Description of WriteEasy

Figure 3 shows WriteEasy with Alternative Code. An edit line is visible with text recently spoken that people may read. With the code for Return this line is repeated, often used to indicate end of turn[xxiv].

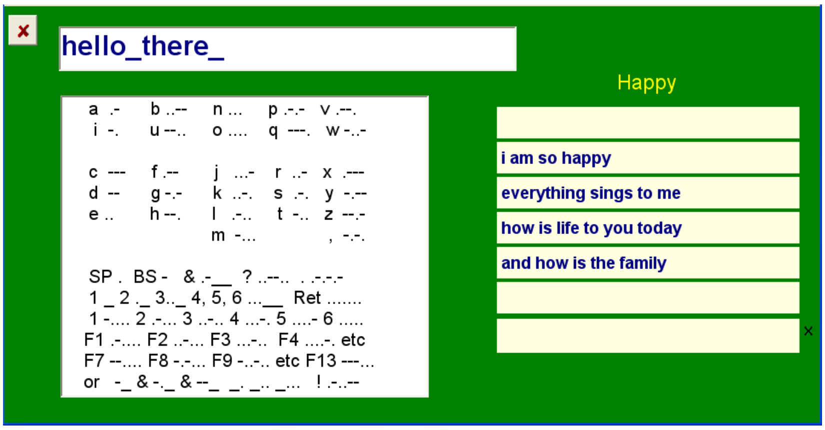


Figure 3. Software WriteEasy. On the left Alternative Code is shown and on the right a short menu of stored phrases called Happy.

In Figure 3 a short click is indicated by a dot . and a long click is indicated by a dash -. Alternative Code assigns groups of consecutive characters to groups of related codes, to make for easy learning. More frequent characters have shorter codes with more dits than dashes[xxv]. Sp for Space is assigned to a single dit. To repeat the last word takes a single click, because Sp = '.', to repeat the edit line takes either comma or Return. In previous research AC was faster than Oriented Scanning in the first hour (Verrips, 2012) and this will probably apply to Row-Column scanning too. This same paper offers comparisons of different switch based input techniques based on frequency-weighted clicks per character and so forth.

Sustained dashes of variable length display as one or several underscores _, __ and so on. They either can be preceded or be followed by dits. ..-.. or ___ or .._ or ._. or _.. or even __. chooses 'everything sings to me ', copies it to the edit line and speaks it. To issue _ takes about as long as -- and this time period can be influenced. Codes are defined for numbers and function keys and one may use up to three switches and may also use Stepped Morse and Stepped Cueing, with a single switch that need *not* be held, as is further discussed in Appendix J.

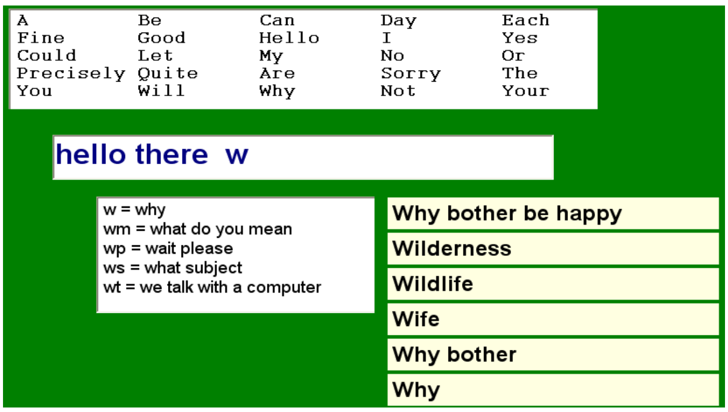


Figure 4. After selecting w with .--. in Figure 2 we see word prediction and word macros with w. Character macros are shown on top.

On top of the screen of Figure 4 character macros are presented alphabetically. 'a ' means 'A ', 'b ' means 'Be ', 'c ' means 'Can ' and so forth, or rather their Dutch equivalents[xxvi]. These macros may function as 'back-channel communication', rapidly offered comments to confirm, to deny or to qualify. Text prediction is on the *right* side, with the most recently used word or phrase on top. The third word macro in the list to the *left* is 'wp ' and means 'wait please ', a formulaic utterance. Most word macros are regular in the sense that all first characters of words appear in the abbreviation. They can also be selected with comma and any number of dits or with a *repeated* sustained dash. This illustrates that WriteEasy is compact, many characters can be selected with a few clicks. All thirty codes with length up to four are assigned, including Space, BackSpace, Comma and Return, and almost every click, and almost every pause, has *some* effect. Therefore WriteEasy, even if used with a subset of these rate enhancements, must be error prone.

Screen images of experiments

In the second experiment and on the request of FV maximal metacommunication was presented on screen including the names of menus. See Figure 5a for a screen shot in phase III after entering .--. or 'v' and see Figure 5b for a rotated edit line.

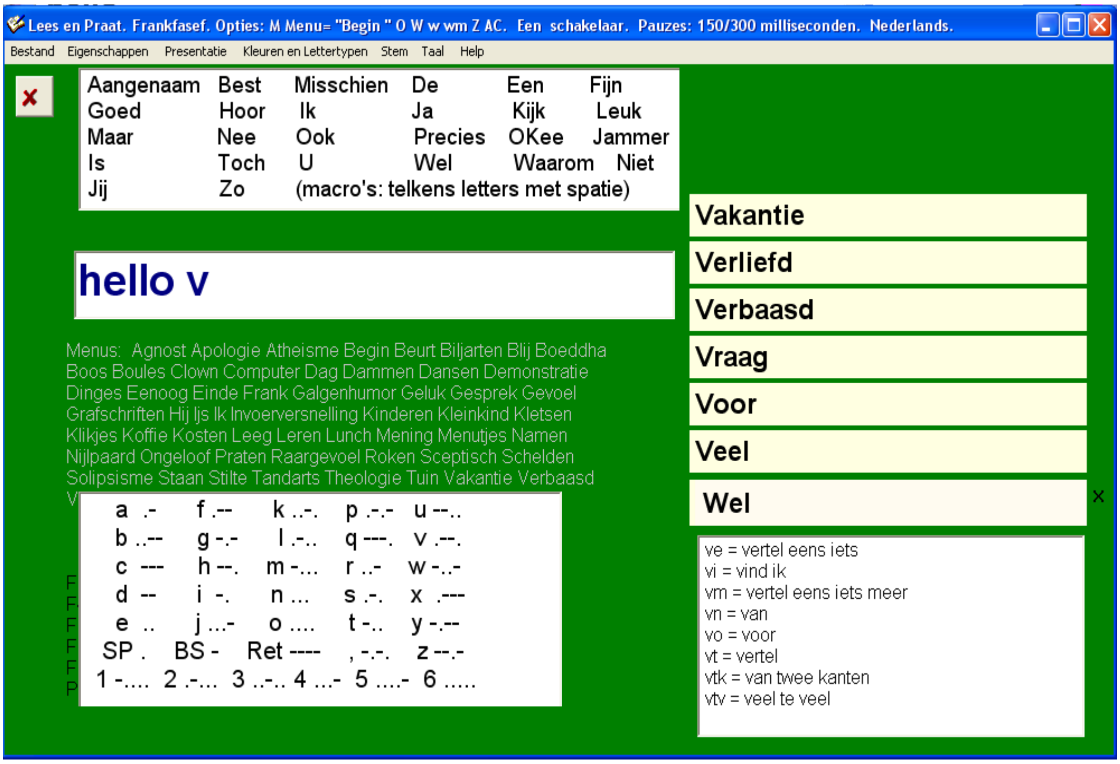


Figure 5a. Phase III of the second study with the dutch version of WriteEasy that is called Lees and Praat. On the right side, word macros are displayed below the word prediction.

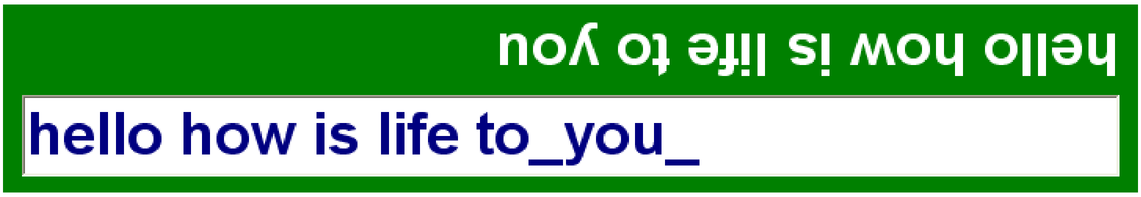


Figure 5b. Rotated edit line to assist in reading for conversation partner.

i A multitude of switches has been described that can recognize gestures, blinks, coughs, ocular movements, electro-myographic signals, sip and puffs, pulling on a string, moving ones' tongue, cheek, knee or what not, see www.ablenetinc.com for a first impression. From time to time a new switch is presented such as lever switches, that contain a spring much like the Morse keys as of old, and more recently the headset Emotiv from Philips and Accenture that is intended to register EEG. If work such as Schoenmakers et al, 2014, is representative this will allow a handful of correct characters per minute. It is not just the switches that are extremely variable; in AAC virtually everything is, including patients, families, users and caregivers. A project for a miniaturized sip and puff switch coupled to Morse Code and speech is at https://www.indiegogo.com/projects/talk-an-innovative-aac-device-for-people-with-speech-impairments. It looks like ideal to implement Stepped Morse as described in Appendix J. Neither product comparison in the lab nor a patient study is presented, or not yet, but it looks good and cheap too. Another interesting link is to the Sprout, a Windows 8.1 computer with neither keyboard nor mouse …. but with a 3D camera instead. See http://www.businessinsider.in/HPs-Crazy-New-Sprout-Computer-Ditches-The-Keyboard-And-Mouse/articleshow/44976417.cms. A good introduction on keyboard designs is McKenzie (2007). Even head movements registered by a webcam may act as switches (called sviacam).

ii Often estimated at around 1.3% of the population of the USA. Of those less then 0.1% need high-tech AAC and only a part of those 0.1% can read and spell. Such estimates are unreliable, and in recent years more people than ever before used their tablet or iPad without service or assessment.

iii FV was a test subject in Verrips (2013a) and refers to his experience at the time.

iv The poem was Days by Philip Larkin.

v When used in conversation this is two minutes with WriteEasy.

vi … and with *this* pause time of 250 milliseconds. See Verrips (2012b) for frequency weighted clicks per character of various input mechanisms.

vii The same poem was also copied with word prediction and no other rate enhancements. Input rate was 41.8 cpm and standard deviation was 4.8. This result must *overestimate* the effect of word prediction, if present, by about 5 cpm because recent words are on top of the suggestion list. This poem repeats itself and had been copied a few days earlier. Therefore all words were recent and many could be selected with a sustained dash of length one. Recency first ordering is intended to support repetition in conversations, as with names. Not all conversations are repetitive and therefore the effect of recency first ordering in conversations is hard to study. This is true for word prediction in general also because the input rates of real users is extremely variable, see Newell et al (1992) and because it is difficult to model user processes in sufficient detail, also important in the design of switch based software. Verrips (2013b) also illustrated rate enhancement by a *repeated* copy task using word prediction and recency ordering but generally speaking the literature on word prediction is critical as to its potential to enhance rate because scanning predictions is time consuming, see Koester and Levine (1997). Some authors are optimistic about better quality of word prediction, documented in copy tasks by able-bodied people, as Trinka et al (2009). Many other ideas are reviewed in Higginbotham et al (2012), but require to look at the screen, scan lists of predictions and make a decision. The time and distraction that this implies, combined with the effort to select the n^{th} word, appear to be the reasons word prediction easily *costs* time. Verrips (1993) described a beep if the first word is the *only* word that has the correct left substring and is therefore unique. Combined with a sustained dash that need not cost much time, or combined with a code for '1', this allows to select a word that is not recently used, but that one knows for sure is present, without looking at the screen. If one enters 'xbu' the system may say 'beep' to suggest one accepts 'xbuddha ' and present stored phrases concerning the Buddha, while staring in the void, not looking at ones' screen.

viii First, the author had practiced much. Second, *without* rate enhancements more attention might be available for input, therefore the pause time, now 250 milliseconds, could in that case be shortened to 200 milliseconds or less. The rate in a repeated copy task will rise above 34.75 cpm as pause time contributes to time spent. As rate enhancements also influence ones' vocabulary the comparison *with* or *without* rate enhancements is not completely convincing. Also one might object that 28% is more than 4% for phrase prediction, and this looks like a significant difference, but we have but few conversations, comparing n = 3 with n = 3. Finally results appear reproducible, but this has not been shown either.

ix The stored phrases we started with are to be found in www.depratendecomputer.nl/tekstvanmenus.txt and the word macros are in www.depratendecomputer.nl/dutchwordmacros.txt. Together with the interface and Alternative Code they represent a considerable memory load. Also, they overlap to a certain degree and therefore word macros are introduced in III, not II.

x 150 milliseconds for dit to dash and 300 milliseconds for end of code. The screen presentation is shown in Figure 5a of Appendix A.

xi If a short word is created in ten seconds the software takes ten more seconds before it decides that the user pauses. If this happens several times in a certain period of two minutes we may measure half the rate that we would measure in a copy task and such exceptions will much influence the SD.

xii Sandra van der Meijden and Petra Sleeman, in Verrips (2003), Sem van der Pol, Andy Kerr, Jack van Dillewijn and Maarten Wang in Verrips (2011), Mente Nauta and Marjo Biesboer in Verrips (2012a), Frank Voorhuis in Verrips (2012b) and in Verrips (2013) and currently Jack van Dillewijn, Frank Voorhuis and Jan Willem Hollink. Marian Sipma Flokstra, a recovering locked-in patient, helped with redesign of WriteEasy in the past. In the more distant past Martien de Cley, Joyce Hess, David Frankenhuizen, Carl Raes and all members of the family Nauta helped with two-bit quartering and with several other scanning mechanisms. Terry McKee and Esther Parigger helped study re-

use of stored text in Verrips (2000).

xiii Dutch organization for parents of people with cerebral palsy.

xiv The Blue2 from AbleNet Inc. Picture published with written consent from JWH.

xv Usually Space Repeats is *less* than Clicked in above it. If one clicks 'hi ' Clicked in will be three and Space Repeat should be zero. Add another space will lead to values of six and three, respectively. Clicked in is the length of all text entered without rate enhancements as well as the length of text repeated with a Space. The error consisted in adding four to Space Repeat when we would speak 'hi ', with two spaces, while adding three to Clicked in.

xvi And try qwerty instead, and, later, bigger word prediction too.

xvii This number was computed based on the logfiles. Only thirty-four different word macros were used, sixteen of them short words and many several times. This is rather meager compared to over two hundred and twenty different available word macros: almost two hundred word macros were learned but not used as are some character macros. It is in line with the experience of radio telegraphists that only about a hundred so-called QCodes and Morse Code abbreviations like SOS were found useful and with the decisive discovery by Vail in 1836 to 'throw all code books out of the window', a quote from Samuel Morse. Vail designed classical Morse Code as we know it and also discovered and built several machines needed for telegraphy. Time and again such trade-offs are met when designing user interfaces: fast yet accurate, simple yet subtle, powerful yet easy to understand, easy to learn yet efficient and applicable elsewhere, little memory load and little thinking too, customizable and convincing at first sight. As designers in this particular area must *also* combine linguistic reasoning with psychology, AAC and some neurology, a principled design of each and every detail is close to impossible apart from differences between intended users.

xviii One might continue with a phase C doing just Alternative Code and D adding word prediction and character macros. If displayed on screen, Alternative Code is usable from the start and once automated Alternative Code is easier to combine with rate enhancements than any other input method with switches. Most people need much time before they can use encoding with eyes closed but still, Alternative Code with two switches was faster than Active Oriented Scanning during the first hour in Verrips (2012) and this will probably be true of ordinary Active Row-Column Scanning and of Passive Row-Column scanning as well. Therefore, if a single switch is inevitable, and although encoding has a long learning curve, it probably pays off to use it from the start. If switches are not inevitable, or not *yet* perhaps, starting to point with a finger may motivate to learn macros and word prediction before learning to encode with switches will claim attention. As Alternative Code was designed to be an efficient encoding that is easy to learn, this looks like the shortest possible learning curve for conversation with switches and rate enhancements. We employ a *symmetrical* input handicap to facilitate learning and especially to facilitate learning to have conversation. To also study learning of word macros and stored text would have made the experiment too subtle and impossible to repeat because purposes of stored text must necessarily vary individually.

xix Heim (2012) lists sixteen that were trained with videos: attention for partner, express feeling, interrupt, take turn, accept, protest, choose, greet, ask for help, ask for activity, ask for attention, answer yes or no, offer information, ask for information, formulate feelings, teasing or pretending.

xx Htyp or Helps Type Your Prose was used in Verrips (2000) and contained about six hundred lines of stored text ordered in paragraphs as well as twelve scanning mechanisms including two bit quartering, stepped quartering, word- and phrase prediction with computed predicates using FLUC or First Letters Upper Case and character macros. A Windows version can be downloaded from www.depratendecomputer.nl.

xxi In Academical Medical Centre Amsterdam, by courtesy of Dr J.M.B.V. De Jong, neurologist, in 2003 and 2004.

xxii See www.depratendecomputer.nl/volunteering.pdf.

xxiii One might study if results are reproducible, how WriteEasy compares to other communication aids and in the laboratory, if learning it can be documented with statistical significance, what word macros or stored text are useful, for what purposes, what practical use it might have in actual contexts of use, what families think of it, with eye-gaze, and more. Interested researchers will encounter serious methodological and linguistic issues and might much from it. Interested caregivers, families and developers may download WriteEasy, use it for whatever purpose they see fit, and are likewise invited to share their comments.

xxiv And *not* counted in the log files that were repeatedly changed a bit.

xxv This last detail is also evident from Table 2 and from Table 4 because in each table only a minority of clicks are dashes, not dits. As dits are shorter than dashes and as both Sp and Bs have short codes consisting of dits, this helps to make Alternative Code of comparable effectiveness to classical Morse Code with a single switch as indicated by the average number of clicks per character or as the average code length per character. Wolphram Alpha gives relative character frequencies in Dutch of 20% for e, 11% for n and 5.2% for o. Add 30% for Sp, due to frequent macros.

xxvi Dutch character macros used in the studies were, in alphabetical order, as follows: Aangenaam, Best, Misschien, De, Een, Fijn, Goed, Hoor, Ik, Ja, Kijk, Leuk, Maar, Nee, Ook, Precies, Okee, Jammer, Is, Toch, U, Wel, Waarom, Niet, Jij, Zo. One might translate as Agreeable, All right, Perhaps, The, One, Nice, Good, Listen, Me, Yes, Look, Pleasant, But, No, Also, Precisely, OK, A pity it is, Is, Though, Thou, Really, Why, Not, You, So. Many can be easily combined to say, for instance, 'why not'. Apart from some self-evident words as a denial or a confirmation and ways to indicate ones' turn has not ended, like Though, qualifications were chosen such as Precisely. To the author it is an open question if this assignment might be improved upon and/or should be varied cross-culturally. For ease of learning the first characters should comply but this is not always feasible. Exceptions were 'c ' = Misschien, 'q ' = Okee ', r ' = Jammer, 's ' = Is, 'v ' = Wel, 'x ' = Niet and 'y '= Jij. Word macros were added for Tell me (Vertel='vt '), Listen (Luister = 'lu ') and I like to listen (Ik luister graag = 'ilg '). Some people, and some cultures, employ many more ways to say, for instance, 'No '. The length of the dutch macros above is higher than the length of their English equivalents and this is typical: average word length in dutch is almost 20% higher and this must influence effectiveness of word prediction too.