Typing Quickly and Relaxed with the Eyes

A case study comparing switch based and eye controlled input methods

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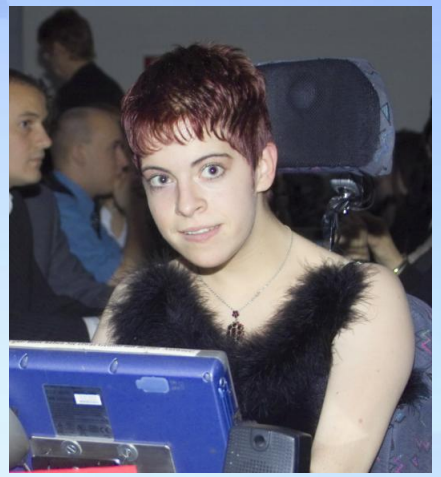
Overview

- Introduction / Motivation
- Kathrin Lemler
- ERIC – Efficient Reduced Input Communication
- Requirements for Gaze Friendly Applications
- Comparison of Switch and Gaze Controlled Input
  - Efficiency
  - Convenience
- Conclusion and Prospects

Motivation

- Standard input devices are not suitable for people with motor impairments
- Computers provide unparalled new opportunities for AAC
- Customized communication aids
- Hardware/Software systems to control computer

Kathrin Lemler



- 21 years old
- Suffering from Cerebral Pulsy
- Severe motor imairments
  - Has to use a wheelchair
  - Cannot produce voice
- No further impairments
- Currently finishing her university-entrance diploma (Abitur) in a regular school

Kathrin‘s communication skills

- Excellent language skills in German and English
- Superior written language skills
- Modes of communication
  - Basic sounds (yes, no, …)
  - Eye script
  - Virtual letter grid
  - AAC devices

Basic sounds

- Can be used for some words (yes, no, whatever, …)
- She can produce vowels
- Standard Repertoire: About 10 words
- More words can be infered from the context
- Clairity deteriorates „under pressure“
- Usually hard to understand for outsiders

Virtual script

- First „written language“ experience
- Used only with her mother
- Letters are written with the eyes into the air
- Similar letters are augmented with sounds for better distinction
- Fast: human predictors are very efficent
- A lot of experience is required
- Cannot be used with strangers

Letter grid

- 3x2-Grid of 3 columns and 2 rows

1	2	3
4	5	6

- Gaze selection (used with humans)
- To increase the number of choices sub-cells are introduced
- Each cell contains 6 sub-cells (36 cells)
- Selection in two steps
  - Select a cell
  - Select a subcell

Letter grid [2]

A	B	C	G	H	I	M	N	O
D	E	F	J	K	L	P	Q	R
S	T	U	Y	Z	ST	EI	AU	PF
V	W	X/ß	CH	SCH	EU	Ä	Ö	Ü

- Letters and letter combinations
- Hello: 2-2 1-5 2-6 2-6 3-3
  World: 4-5 3-3 3-6 2-6 1-4

Letter Grid [3]

- Pretty fast because humans use a lot of background and context knowledge
- Word completion and part of speech prediction
- Only used with a limited number of people
- Exact wording (accent) is not guaranteed

AAC devices

- First device in use PRD „Delta Talker“
- Symbol based approach
- High proficiency with MinSpeak
- First uncontestible demonstration of language and cognition skills
- Scanning with one switch is very slow (less than 5 words per minute)
- Limited vocabilary (inefficient for spelling)

Higher Expressive Capabilities

- At the age of 15 Kathrin seeked for expressive improvements of her AAC device
- The number of word forms readly available is low
- Creating and remembering custom made sequences requires time and effort
- Written language skills are available

Higher Expressive Capabilities [2]

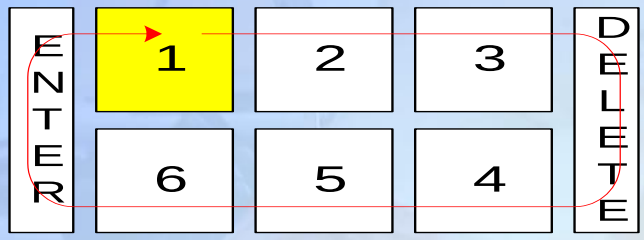
- Written language provides full expressive possibilities (also foreign languages)
- Kathrin approached the university of Koblenz
- The computer scientists were asked for a more efficient way to add new words to the Talker

Higher Expressive Capabilities [3]

- Soon it became clear that the high number of symbols was inefficient in combination with scanning
- Typing with a reduced set of keys would be a more suitable solution
- Goal: Making written language efficiently accessible with a single switch

Something New (UKO)

- Basic idea



- Cyclical scanning of 8 controls
  - Six controls with letters
  - Control for correction
  - Control to complete a word
- Challenge: Writing 26+ letters with 6 keys

Ambiguous Input

- In German 30 letters have to be distributed on the keys
- Selecting a key is ambiguous
- Disambiguation can be done on
  - Letter level (cf. letter grid)
  - Word level (select the correct word after typing)
- Hypothesis: Word level disambiguation is more efficient

Letter Distribution Problem

- Problem: Typing efficiency crucially depends on the distribution (partition) of the letters on the controls
- Simple approaches (e.g. cell phone text input) lack efficiency
- Thesis in Computer Linguistics (Meyreis 2000)
  - Rule based approach
  - Based on trigram probabilities

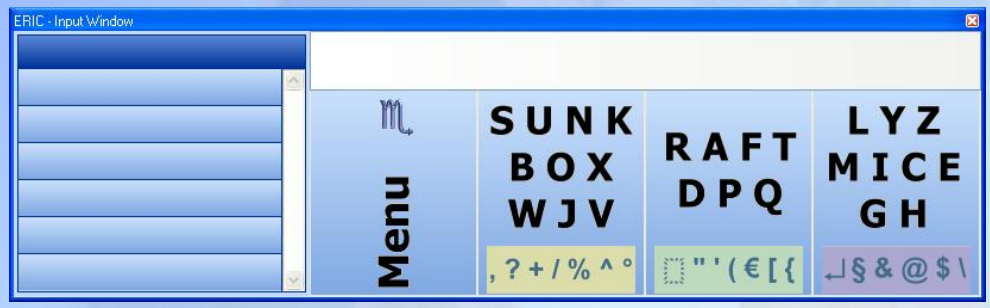
Computerized Optimization

- Optimization using a genetic algorithm (Garbe 2001)
- Can be applied to different layouts and dictionaries
- Provides a “near optimal” solution in reasonable time

Optimization Results

- Compared to the computer linguist's solution typing speed is increased by 17%
- A faster solution using only 3 letter controls increases the speed by 32%
- The correction and enter controls can be combined into a single menu
- The ERIC system came alive

ERIC's Interface

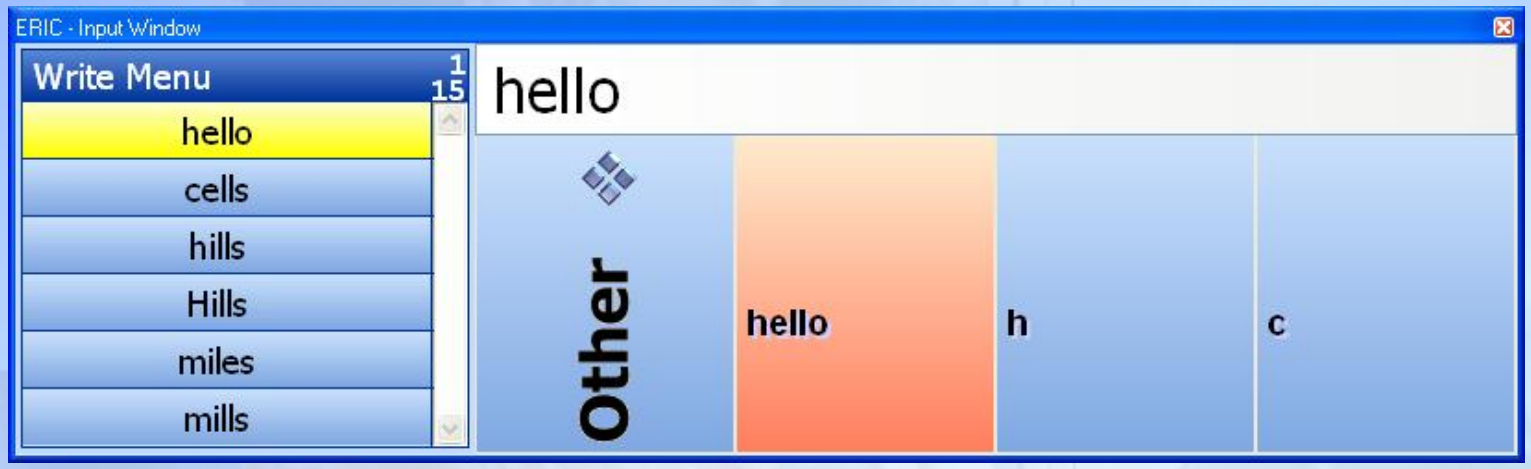


- 3 controls for letters
- 1 control to switch to a menu providing functions
- The letter controls are reused for menu items in the menu mode

Direct Access with 4 Switches

- ERIC still only requires a single key for scanning operation
- Kathrin could operate 4 switches
  - 3 in the head rest (left, center, right)
  - 1 knee switch for the menu
- With 4 switches ERIC can be used in direct access mode – further improving typing speed

Example


ERIC - Input Window
Write Menu
1
15
hello
cells
hills
Hills
miles
mills
hello
Other
hello
h
c

Go for Gaze Control

- Gaze control is the natural next step
- Potential to further increase the speed
- Few controls limit accuracy requirements
- She already uses gaze interaction (with humans) to communicate
- A camera system is more flexible than the switch solution
- Potential reduction of effort and stress

Gaze Friendliness

- Special attention to the user interface
- Interaction is reduced to point and click
- Clear layout, no distracting parts
- Customizable controls
  - Size
  - Position

Considerations for Controls

- As few and as large as possible
- Icons must not distract the user
- Nice but not too fancy
- Facilitate focusing the center
- Avoid dynamic controls whenever possible

Unintended User Attraction

- Humans pay special attention to moving or changing things
  - Dynamic items will attract user attention
  - A pointer that has a little offset to the user's actual gaze position will attract the user
    - The gaze shifts in the direction of the offset
    - The pointer will move further in the undesired direction
    - The cycle starts over

Avoid Pointer Chasing

- Pointer latency
  - Method: Pointer moves slowly
  - Effective in most situations
  - Not efficient as it slows down selection

Proximity Filter

- Method: Pointer moves only if the distance of the old and new position is greater than a preselected threshold
- Effective in most situations
- The pointer may get stuck close to a control the user wants to select
- The threshold is application specific

Control Snap-in Function

- Method: The user can only select controls registered for gaze control, the pointer is always shown in the center
- Effective and efficient
- Works only for “partner applications” of the gaze tracker
- Method of choice for ERIC/Tobii

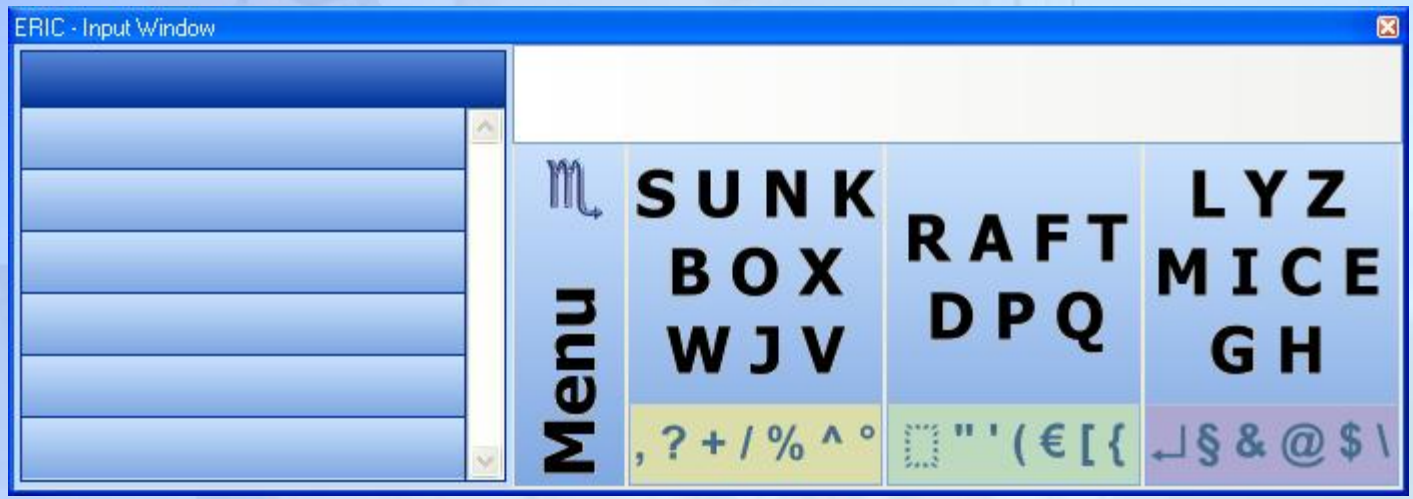
Hybrids

- Usually a combination of the different methods has to be employed
  - Snap-in for partner applications
  - Distance, user and application specific latency for other applications

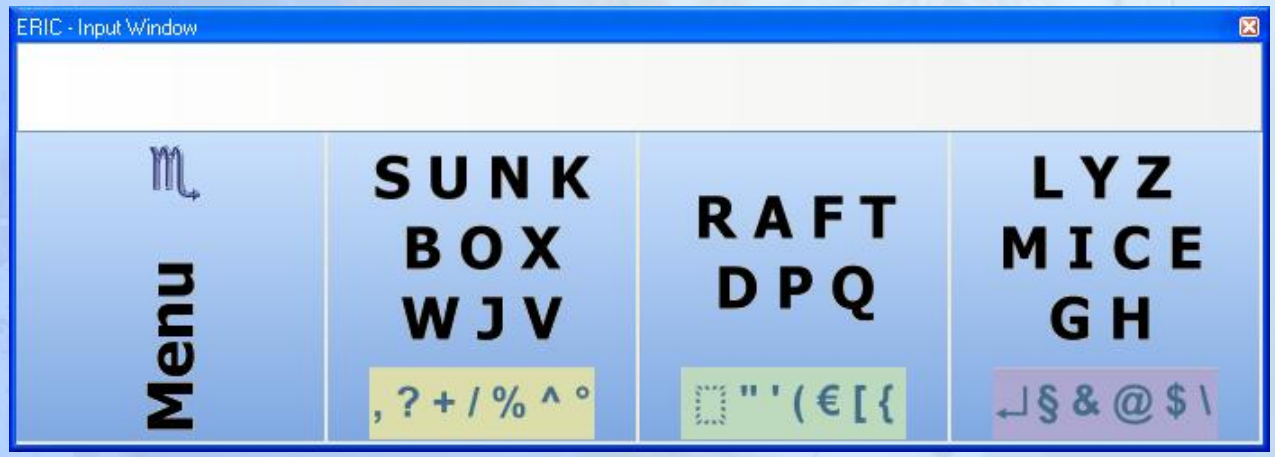
Changes in ERIC

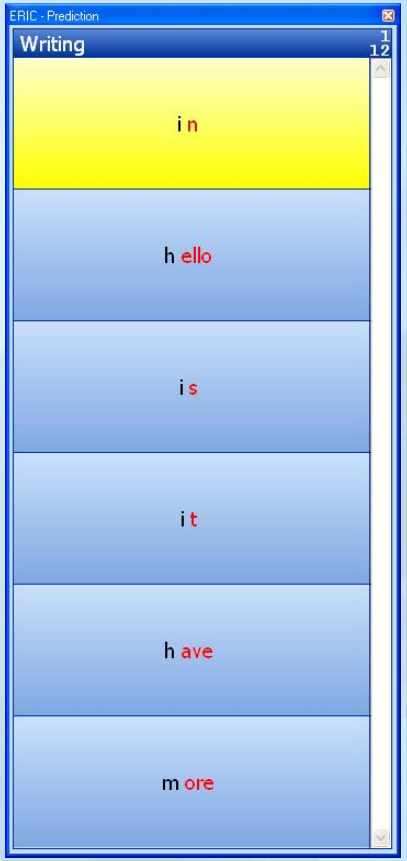
- User interface
  - Resizable controls
  - Center oriented controls
  - Customizable layout
- Gaze tracker of choice: Tobii
- Gaze control interface to Tobii
  - Register all controls

Classic Layout (for Switches)

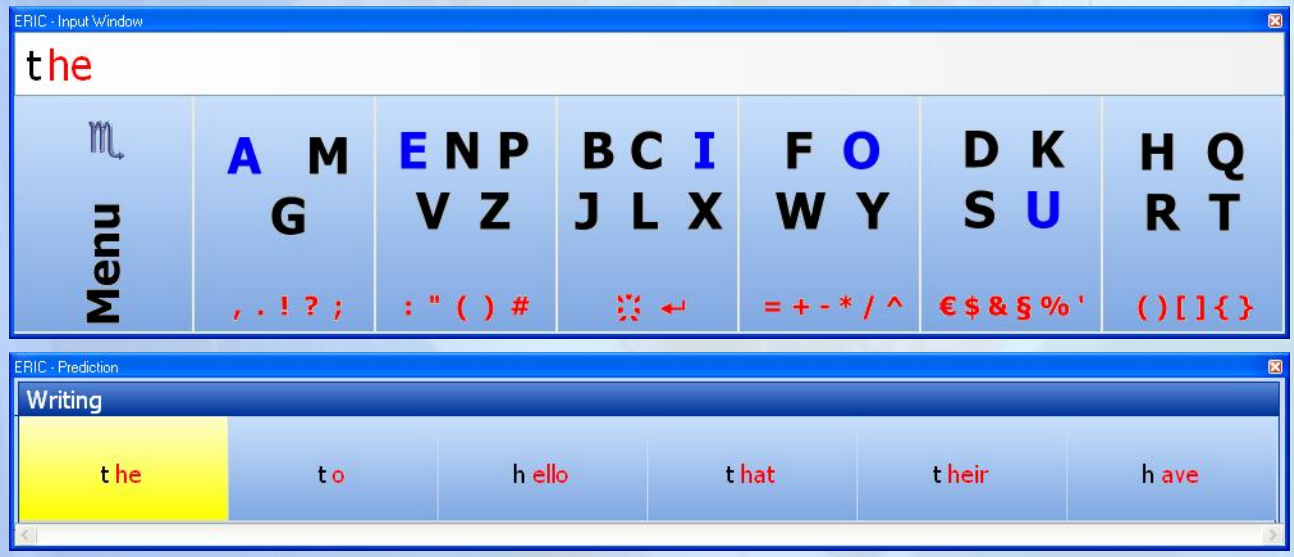


New Layout (Gaze Control)





Final Layout



Switch vs. Gaze Interaction

- Kathrin is working for more than 5 years with Eric controlled with 4 switches
- Changing to a new system requires time and effort
- The cost for a Gaze Controller is very high
- The effort is not worth while if there are no significant benefits

Possible Benefits

- Improve typing speed (in the long run)
- Reduce physically exhaustive head movement and body tension
- Improve endurance when writing long texts

Experiment goals

- Find out how fast Kathrin can type text with switches and gaze control
- Find out how much effort is required
  - User's impression
  - Observer's impression
  - Objective data (pulse, blood pressure, etc.)

Experiment Design

- Type several short texts
  - Shortest text: 301 characters
  - Longest text: 1649 characters
  - Six texts with 5032 characters in total
- Additional text to get familiar with the setup

Experiment Design [2]

- She could read the complete text before typing
- Not allowed to test-type or store words not yet contained in the dictionary
- The text is written on a “teleprompter” on a second computer
- The prompter program only advance if the word is written correctly

Experiment Design [3]

- Typing errors and misspellings have to be corrected immediately
- The prompter program logs the exact time (in milliseconds) required for each token
- The texts are written with both input methods on the same day
- Half of the texts are written starting with gaze control

Experiment Design [4]

- The results are presented after all texts are finished
- Kathrin is interviewed after each text (qualitative statement about the effort)
- Some experiments are filmed

Component Setup

- Switches
  - 3 letter controls + 1 menu control
- Gaze control
  - 6 letter controls + 1 menu control
  - 6 prediction controls
  - Dwell time of 0.5 seconds
  - Mobile Tobii P10

Speed comparison

Text	Characters	Words	Average time per character [ms]		Median time per character [ms]	
			Gaze	Switch	Gaze	Switch
1	301	53	1559	1554	1299	1440
2	670	99	1381	1403	1106	1241
3	540	87	1492	1443	1334	1189
4	1649	234	1555	1383	1301	1048
5	783	110	1570	1501	1304	1180
6	1088	196	1895	1914	1322	1490
Corpus	**5032**	**779**	**1514**	**1530**	**1251**	**1218**

- No significant difference in speed
- On average 1.5 seconds to write a character

Performance Measures

Text	Letters	PM	Words	Syllables	Average time per punctuation [ms]		Words per minute, actual (W5)		Actual syllables per minute	
					Gaze	Switch	Gaze	Switch	Gaze	Switch
1	285	16	53	83	2451	1868	7.9 (8.4)	7.9 (8.5)	12.3	12.4
2	640	30	99	185	2501	2280	7.4 (9.5)	7.3 (9.4)	13.8	13.6
3	518	22	87	144	2331	2609	7.5 (9.0)	8.0 (9.5)	12.5	13.3
4	1578	69	234	445	2530	2197	6.0 (8,1)	6.9 (9.4)	11.5	13.2
5	753	30	110	223	2384	2024	5.8 (8.0)	6.3 (8.6)	11.8	12.7
6	1006	82	196	257	3723	3014	8.0 (8.2)	7.5 (7.7)	10.5	9.8
Corpus	4780	249	779	1337	2879	2470	6.9 (8.5)	7.2 (8.8)	11,8	12,5

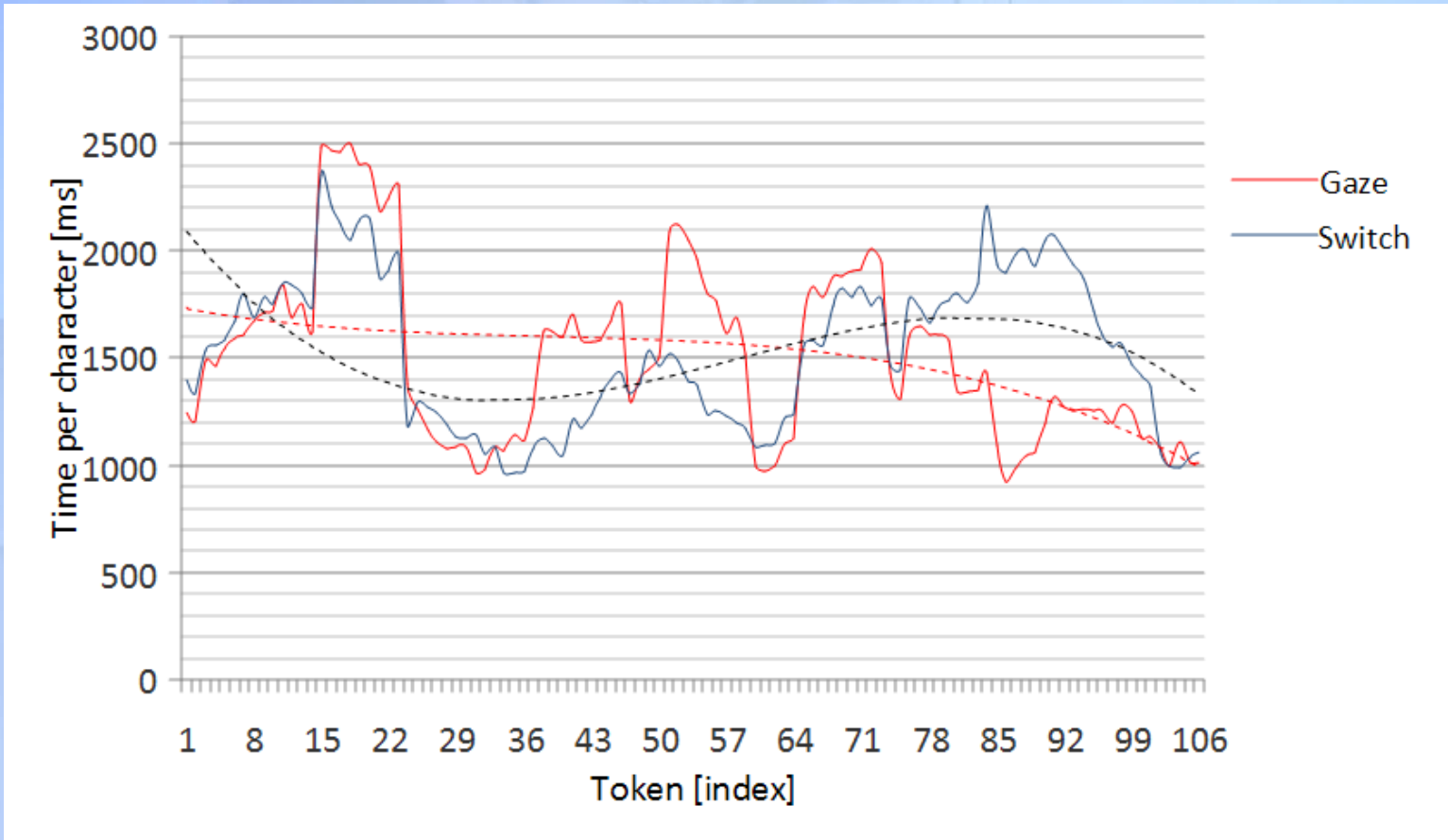
PM: Punctuation marks
W5: Normalized to words with 5 characters (including space)

Video

Effort Comparison

- No hard facts (numbers)
- Kathrin reported that the gaze controlled input caused less stress
- The analysis of the videos and the observation during the test came to the same conclusion
- She is clearly more relaxed when using gaze control

Moving Average of 9 tokens



Conclusion

- After a few weeks of gaze control usage the efficiency is as high as with switches
- High potential for speed improvements
  - Get used to gaze control
  - Get used to the new character distribution
  - Reduce the dwell time on static items from 0.5s to 0.3s or less

Results [2]

- Writing longer texts Kathrin does not slow down towards the end of the text
- She reaches an average speed of 42 cpm (8.5 wpm) with gaze control and 44 cpm (8.8 wpm) with switches
- Punctuation marks deteriorate the performance
- Gaze control is more convenient for Kathrin and she stays much calmer

Future Research

- Improve efficiency for punctuation marks
- Introduce control specific dwell time
- Reduce dwell time on static controls
- Try unambiguous input (virtual keyboard)
- Conduct further trials after some month of permanent usage