Unipad:
Single Stroke Text Entry With Language-based Acceleration

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Mobile Text Entry

- Over a trillion SMS messages were sent in 2005
- Companies are ambitiously searching for improvements to mobile text entry techniques
- Many methods currently exist

Two Broad Categories

- Key-based

- Stylus-based

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Stylus Based Methods

- Handwriting with automatic recognition

- Tapping on soft or virtual keyboards.

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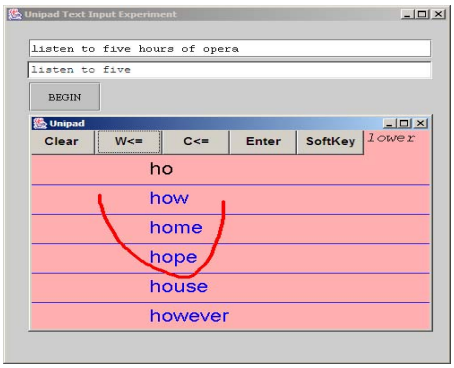
Unipad

- Single-stroke handwriting recognition
- Language-based acceleration



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Features Promoting High-speed Entry

- Movement minimization
- Reduced attention demand.

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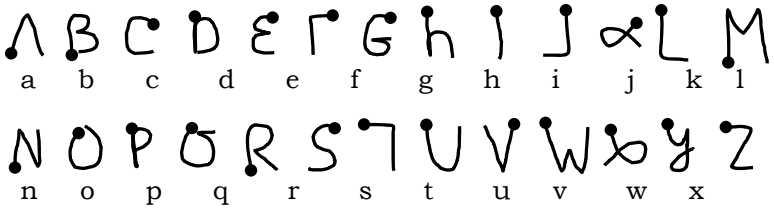
Text Entry Speeds

- Desktop touch typing: 60+ wpm are common with practice
- Soft keyboard entry rates: 40+ wpm with practice,
  18-28 wpm for a novice with Qwerty layout,
  5-7 wpm for a novice with an unfamiliar layout or method
- Handwriting speeds are in the 13-22 wpm range

Alphabet

- Higher speeds with handwriting recognition, therefore, necessitates new strategies, such as using a simplified stroke alphabet or reducing the number of required strokes using word completion.



Is Eyes-free Handwriting Possible?

- Generally, no
- But Unistrokes and commercial implementations such as *Graffiti* and *Jot* (aka Graffiti 2) do

Graffiti

- Quickly learned – with about 97% accuracy after five minutes of practice

Word Completion

- Benefit of eyes-free entry is mitigated by the attention required by the word completion list.

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The Sweet Spot

- Combine single stroke text entry with word completion
- Key feature in our *Unipad* method is *movement minimization*
- The single-stroke-per-symbol feature inherently reduces required stylus movement in our method
- As well, the input and output regions are superimposed

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Dictionary

- 64,566 words with their frequencies from a 90,563,964 word corpus.
- The average word size is 8.45 characters based on a simple mean, or 4.59 characters if weighted by word frequency

Method

- As entry proceeds, a list of candidate words is produced on each pen-up. If the desired word appears, the user simply taps on it. This terminates entry of the current word and delivers the result to the application with a terminating SPACE
- The user may ignore the list, choosing instead to continue entering single stroke characters, or attend to the list if there is a sense that the desired word is present.

Sort Order

- Words are sorted first by size, then lexically within size
- Why? To reduce the visual scan time to find the desired word.

Suffix Completion

- ↘ stroke = suffix completion mode
- 12 suffixes total
- “s”, “ed”, “er”, “est”, “ly”, “able”, “ful”, “ing”, “ion”, “ive”, “ment”, “ness”
- Benefit: does not clutter the candidate list

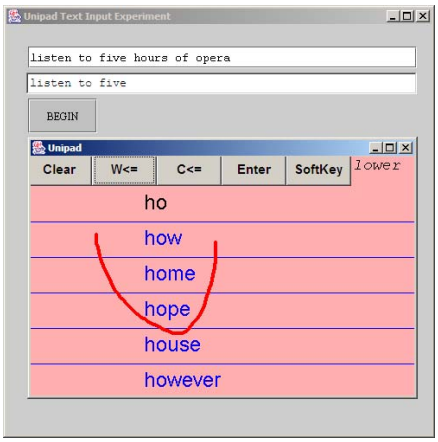
Frequent Word Prompting

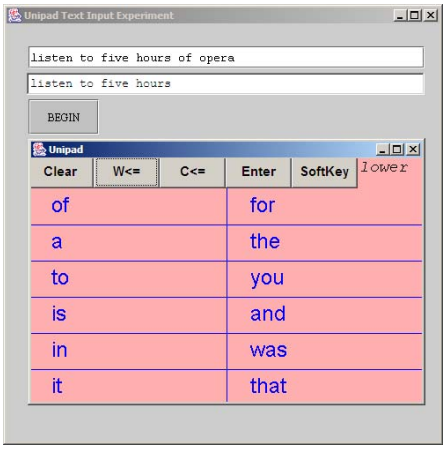
- At the beginning of each word the input pad would be blank, as there is no word stem upon which to generate candidates.
- This void is filled with a list of the most frequent words in the dictionary. We call this the "frequent word prompt"
- "for", "the", "you", "and", "was", "that", "of", "a", "to", "is", "in", "it" (about 30% of English)

Other Features

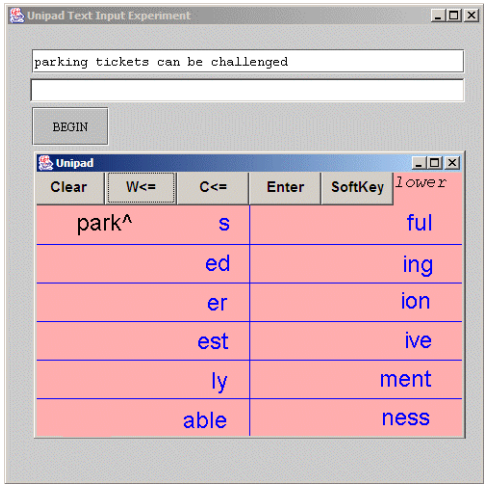
- Uppercase and caps lock modes are implemented using a bottom to top (↑) stroke
- A right to left stroke (←) serves as a backspace
- The default space terminating a word is removed if the following character is a period

Unipad in Action

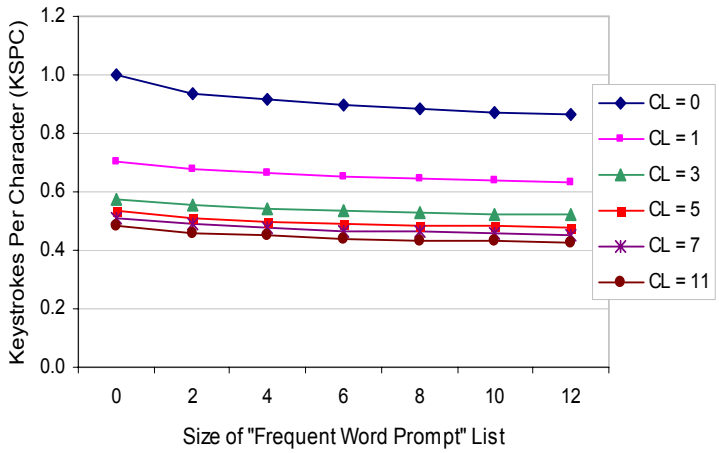




Suffix Completion



Keystrokes Per Character (KSPC)



METHOD: Participants

- Ten paid volunteer participants (6 male, 4 female)
- From 18 to 35 years old (*mean* = 26.1, *sd* = 5.9).
- All used computers 3 to 8 hours per day
- Self-assessed typing speeds ranged from 35 to 52 words per minutes

Apparatus

- Standard desktop computer system
- 13.3 inch Wacom *PL-400* tablet for stylus entry. The *PL-400* tablet is both a digitizer for input and a 1024 x 768 LCD colour screen for output.
- Software was an in-house Java application for text entry evaluation

Parameters

- Candidate list size: 5
- Frequent word prompt list size: 12
- Suffix list size: 12
- 500 phrases ranging from 16 to 43 characters (*mean* = 28.6)
- 2712 total words, including 1163 unique words
- Words ranged from 1 to 13 characters (*mean* = 4.46)

Procedure

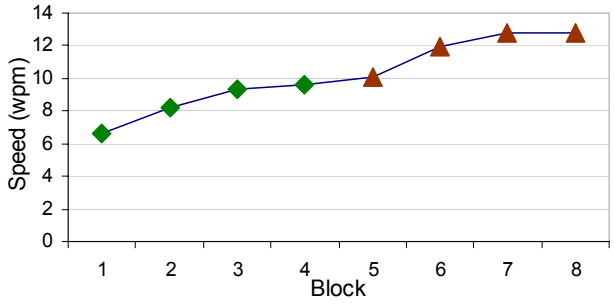
- Participants completed a pre-test questionnaire soliciting demographic and computer usage information and a post-test questionnaire on their subjective impressions of the methods
- Each participant completed two one-hour sessions
- Plain single stroke text entry was used in the first session. This served to bring participants up to speed on learning the single stroke alphabet. In the second session, word-completion was introduced.
- 4 blocks of 15-minutes each

RESULTS

- Participants entered 754 phrases using the single-stroke method (blocks 1-4) and 937 phrases using the single-stroke method with language-based acceleration (blocks 5-8)
- 30 of the 937 phrases (3.2%) were eliminated as outliers

Speed

- Entry speed increased significantly with practice ($F_{1,9}$ = 40.7, p < .0001).
- Significant increase in speed by entry mode ($F_{3,27}$ = 58.1, p < .0001)



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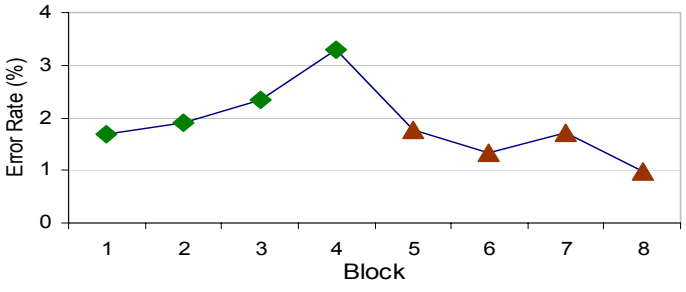
Error Rate

- Error rates were below 3%
- Error rates improved during blocks 5-8, dropping to just under 1% by the end of the experiment



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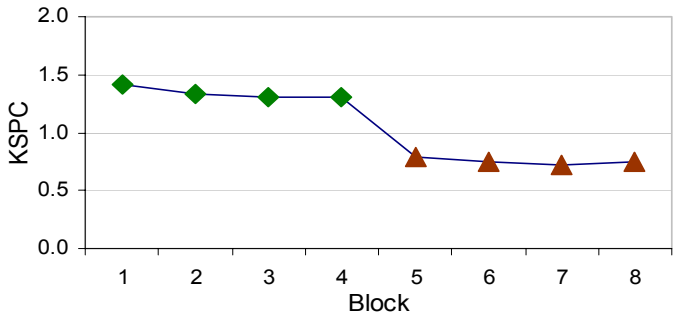
KSPC

- During blocks 1-4, *KSPC* was relatively stable
- While using language-based acceleration (blocks 5-8), *KSPC* was markedly less



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DISCUSSION

- Unipad's language-based acceleration features failed to yield a significant increase in text entry speed
- Overall, the plain single stroke method was slightly preferred over word completion (3.8 vs. 3.2), likely because of the added cognitive load in the latter case.
- However, most participants felt word completion is useful and is a quicker and more accurate entry method.

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EXTENDED SESSIONS

- three subjects agreed to perform an extra one-hour session wherein they repeatedly entered just one phrase:

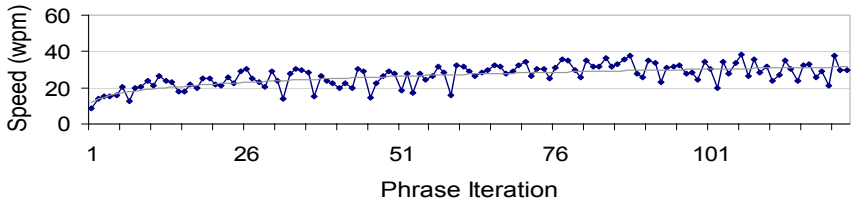
the quick brown fox jumps over the lazy dog

Results for the Fourth Block

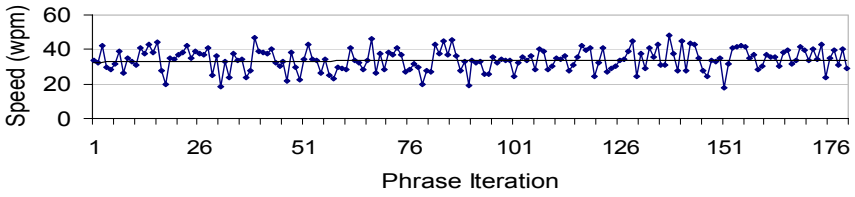
		Keystroking		
Participant[a]	Error Rate (%)	KSPC	Percent Above Optimal	Speed (wpm)
#1	5.70	0.6852	9.11	30.0
#2	4.08	0.8463	34.8	20.3
#3	0.00	0.8074	28.9	17.1
JC	4.15	0.7446	18.6	35.1

[a] Participants #1-3 had two hours prior practice during the first phase of the experiment. Prior practice for the second author (JC) is estimated at 15 hours.

Progression in Speed Over Four Blocks

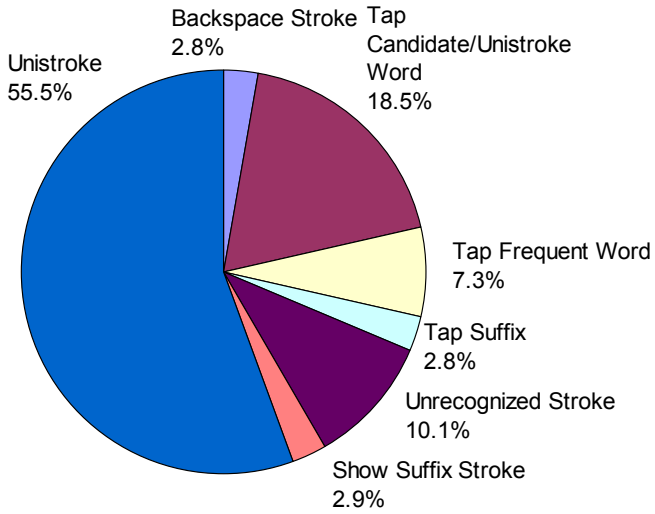


Participant #1



JC (2nd Author)

Distribution of Strokes by Category



CONCLUSIONS

- Entry rates ranged from 8.1 to 18.8 wpm after two hours of practice
- Average rates on the last block of extended sessions ranged from 17.1 to 35.1 wpm
- Peak rates reaching 48 wpm
- Attention demand of language-based acceleration aides, such as word completion, remain an issue as there is both a time cost and cognitive load for users to monitor and utilized the on-going predictive features.

Thank You