Longitudinal Evaluation of Discrete Consecutive Gaze Gestures for Text Entry

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(Wobbrock et al., 2008)

Motivation

- Motivated by Isokoski (2000)'s work desire to circumvent dwell time, we developed EyeWrite
- A new system for eye-typing that uses gestures similar to hand-printed letters
- EyeWrite is based on EdgeWrite's unistroke alphabet (Wobbrock et al., 2003; Wobbrock & Myers, 2006b)
- EyeWrite reduces the need for eye-tracker accuracy, a large screen footprint, and tedium

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On-screen Keyboards

- Dwell-time on-screen keyboards usually need layouts with large keys (Majaranta & Räihä, 2007)
- They often require a large screen footprint (e.g., Tobii Technology's (2007) patent-pending MyTobii or the ERICA system (Hutchinson et al., 1998))
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Other Forms of Input

- Besides dwell-time, input can be performed by gaze gestures
  - Isokoski's (2000)'s MDITIM used discrete, consecutive gestures
  - MDITIM's gestures did not necessarily resemble roman letters
- Other well-known system is Dasher (Ward & MacKay, 2002)
  - Dasher's zooming display is modeless—no dwell time needed
  - Very fast input times have been reported with word completion feature (25-34 wpm)
- Other gestural approaches include Urbina and Huckauf's (2007) pEYEdit, with which 6-10 wpm rates have been reported

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Why Gestures?

- Pros and cons of mouse gestures well documented
- Precise target acquisition is circumvented (Dulberg et al., 1999)
- Gestures can be faster than point-and-click
- Consecutive (compound) gestures, however, are slower since they carry an inherent multi-stroke handicap
- EyeWrite's weighted average number of strokes per character (with initial and terminating saccades) is 4.52

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- EyeWrite is EdgeWrite (Wobbrock et al., 2003) for the eyes
- To our knowledge, first letter-like text entry system for the eyes
- Two important styles for input
  - Alphabet resembles roman characters, enhancing memorability
  - Input mode is based on crossing, not pointing
- Three design iterations (Wobbrock et al., 2007)
  - v1.0: mimicked EdgeWrite with literal trace between input areas
  - v2.0: vector-based approach—worked well but decoupled stroke corner from POG
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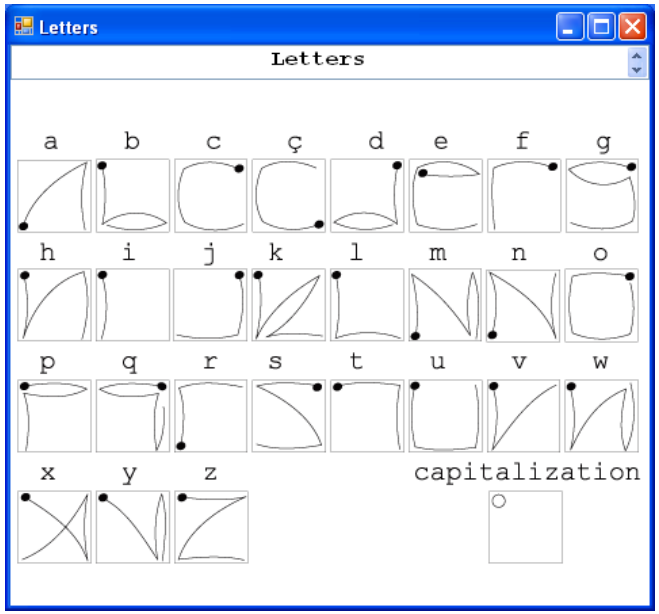
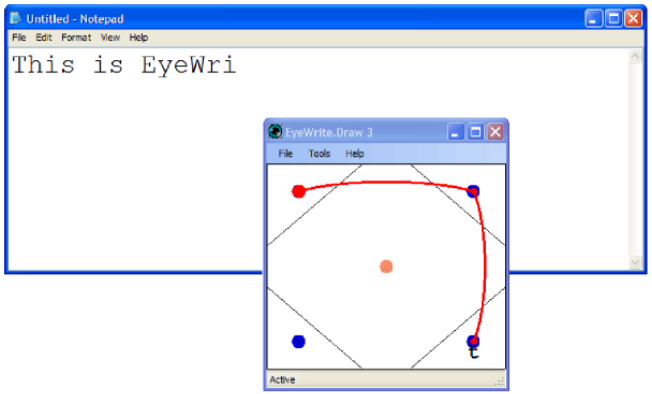
Design

- Based on four corners
- Similar to Isokoski's (2000) MDITIM but EyeWrite's alphabet resembles handwritten letters





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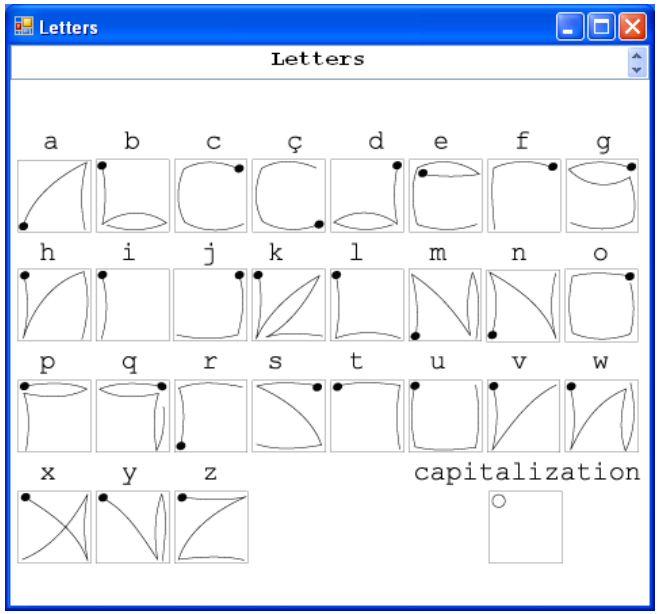

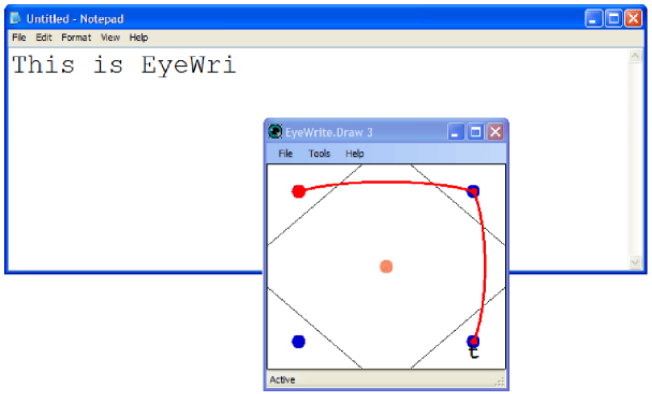

Comparison with Click-N-Type

- Click-N-Type settings:
  - resized for height to match that of EyeWrite
  - width squeezed in as far as app would allow (> 400)
  - dwell time set to 330 ms
- Longitudinal study spanned 15 sessions
  - Participants performed no more than 2 sessions per day
  - If 2 sessions in one day, at least a 2 hour break required
  - No more than 48 hours could elapse between sessions
  - Participants paid $5 at the end of each session
  - $50 bonus paid out if all sessions completed
- Hypothesis assumed learning effect and better EyeWrite typing performance once the alphabet was learned

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Experimental Details

- Data captured with TextTest and analyzed with StreamAnalyzer (Wobbrock & Myers, 2006a)
- Real-time (x, y) POG calculated as average of valid (validity code 0) left and right gaze points, smoothed over last 5 data points
- Eight participants (4 M, 4 F), age range [20-25], mean 21.8
- Participants asked to balance speed and accuracy during input (e.g., try character twice before moving on)
- Apparatus was the Tobii ET-1750
- Experimental design was within-subjects with one two-level factor for input technique (EyeWrite, Click-N-Type)

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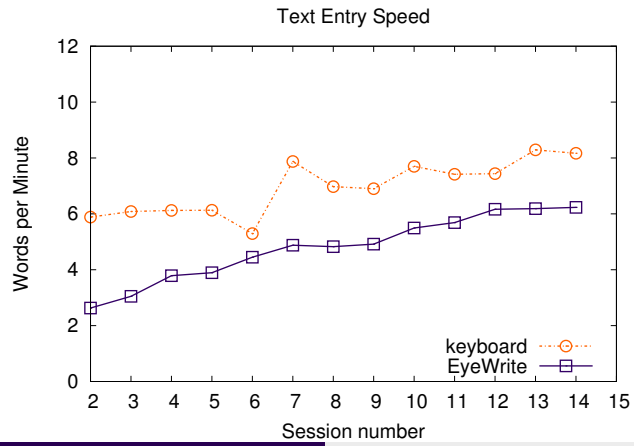
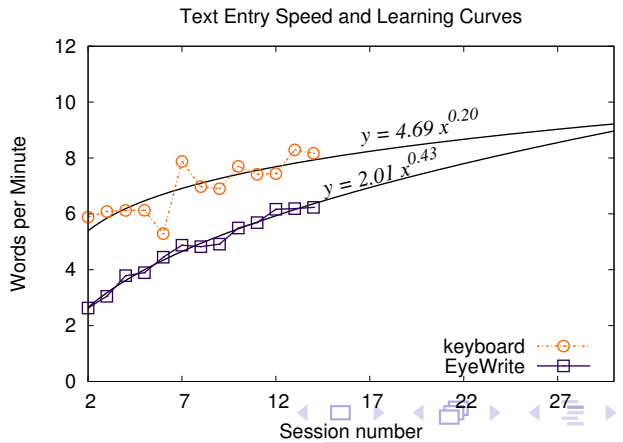
Speed

- Speed measured as words per minute
- Input technique as well as session used as fixed factors in 2-way repeated measures ANOVA (with subject as random factor; see Baron and Li (2007) for examples in R)
- Over last 14 sessions, average speed for EyeWrite was 4.87 wpm and 7.03 for Click-N-Type ($F(1,189) = 113.42$, $p < 0.01$)
- Session also significant ($F(13,189) = 7.52$, $p < 0.01$)
- Each method improved about equally, with no technique $\times$ session interaction ($F(13,189) = 0.74$, $p = 0.74$, n.s.)





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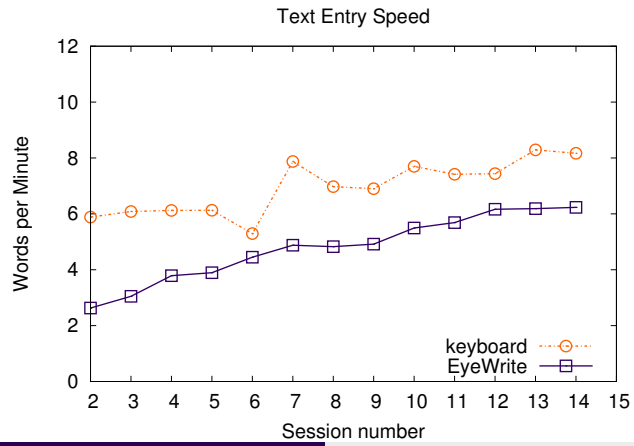

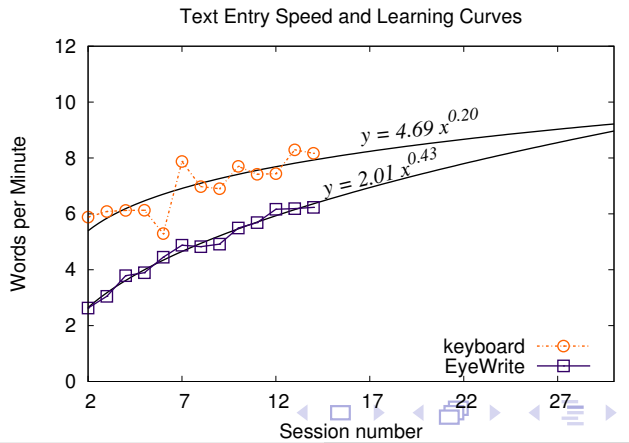

Speed

- Speed measured as words per minute
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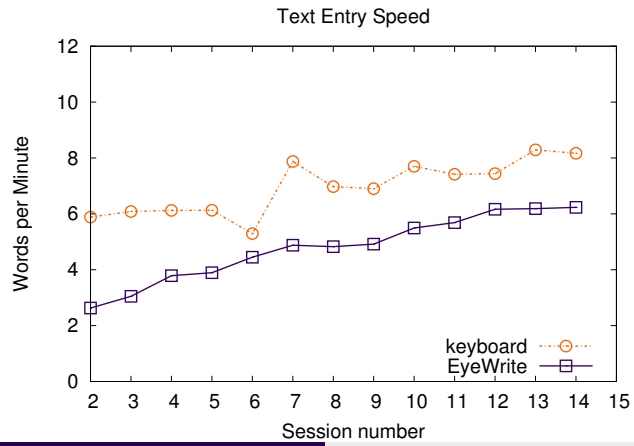

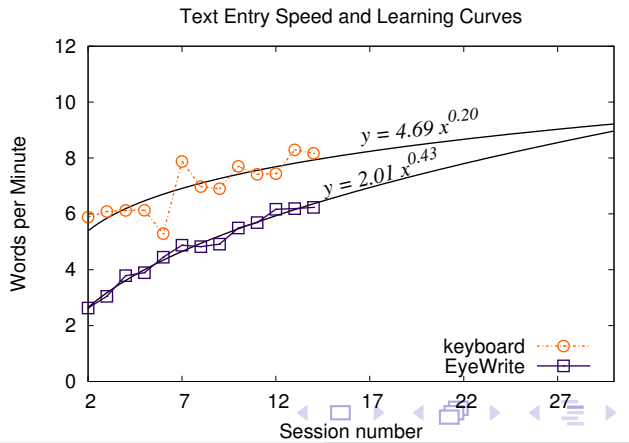

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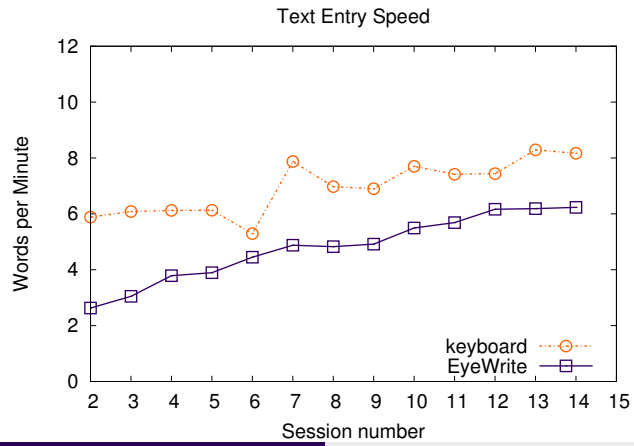

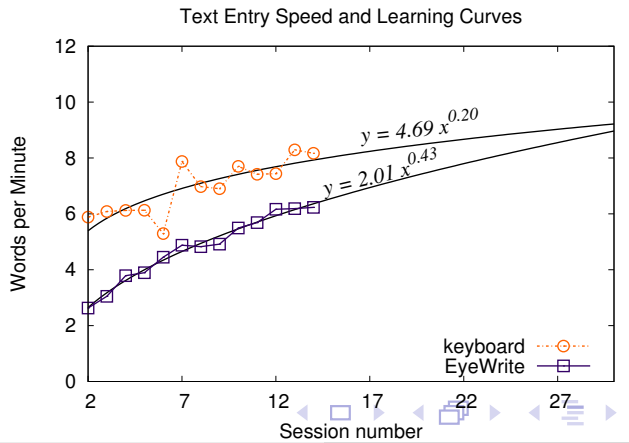

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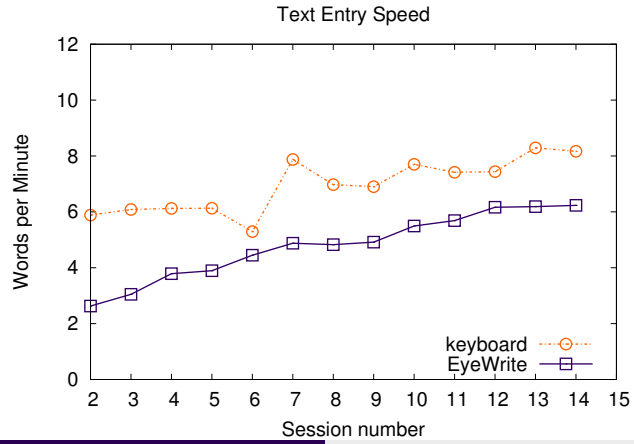
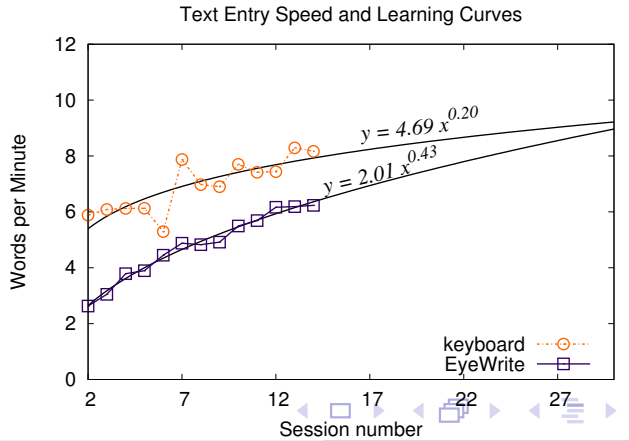
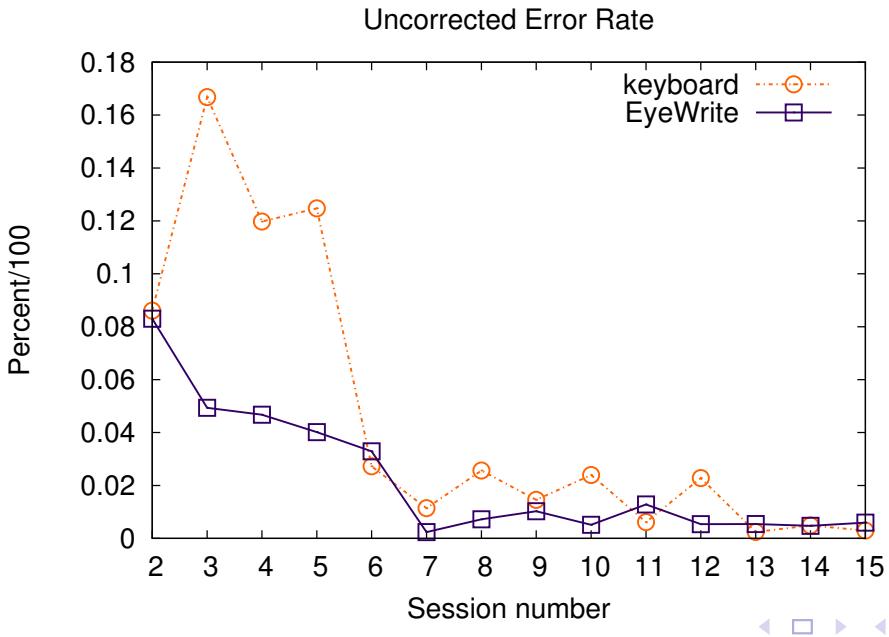




Accuracy: Uncorrected Errors

- Uncorrected errors are ones left in final text entry
- They are precisely at odds with speed
- Over last 14 sessions, average uncorrected error rate for EyeWrite was 2.21% and 4.62% for Click-N-Type ($F(1,189) = 3.83$, $p = 0.05$)
- Effect is seen mainly in the first 5 sessions; effect no longer significant over last 9 sessions



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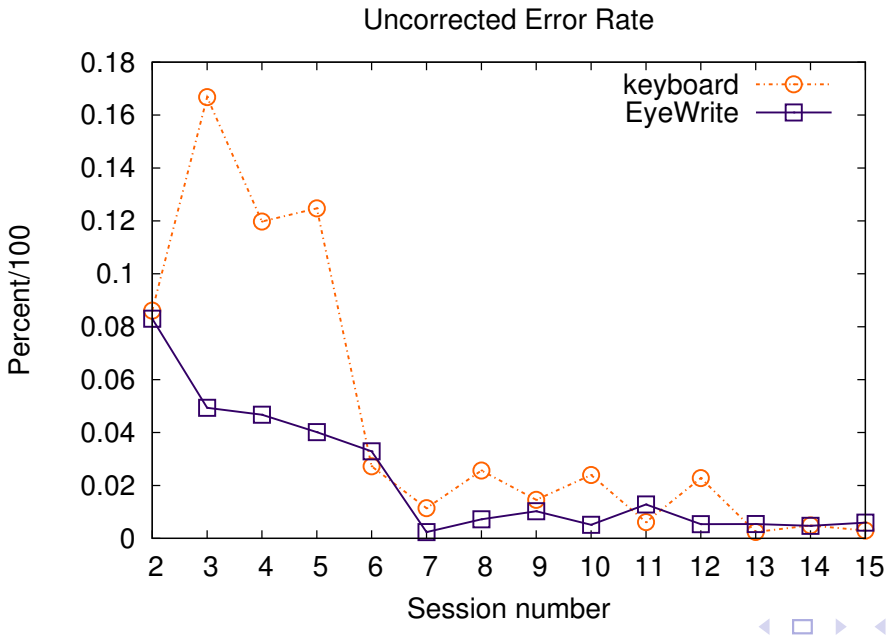

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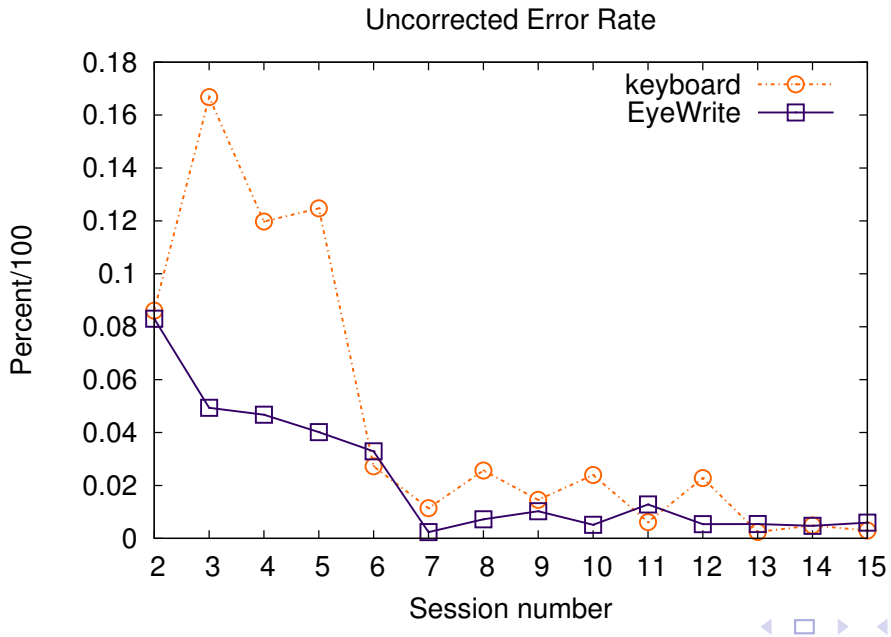

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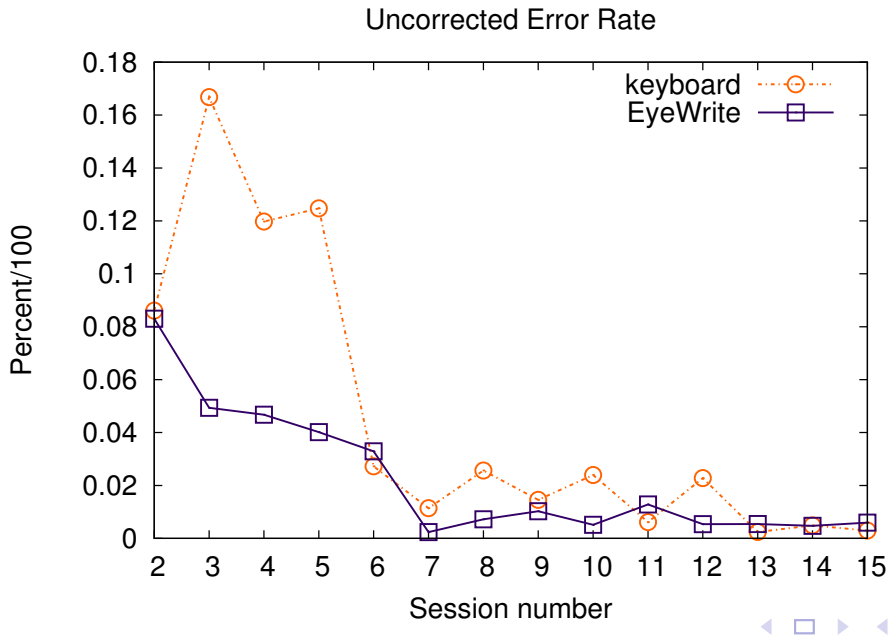

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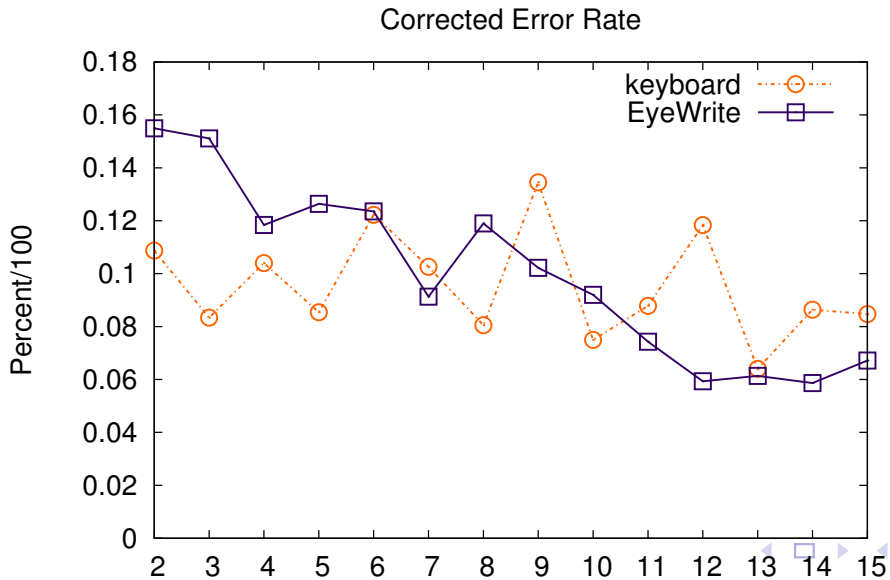

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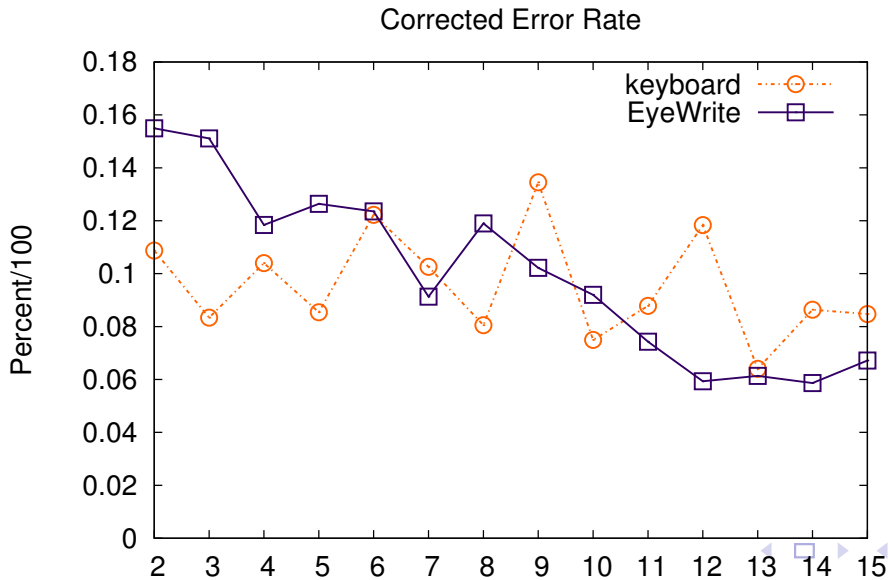

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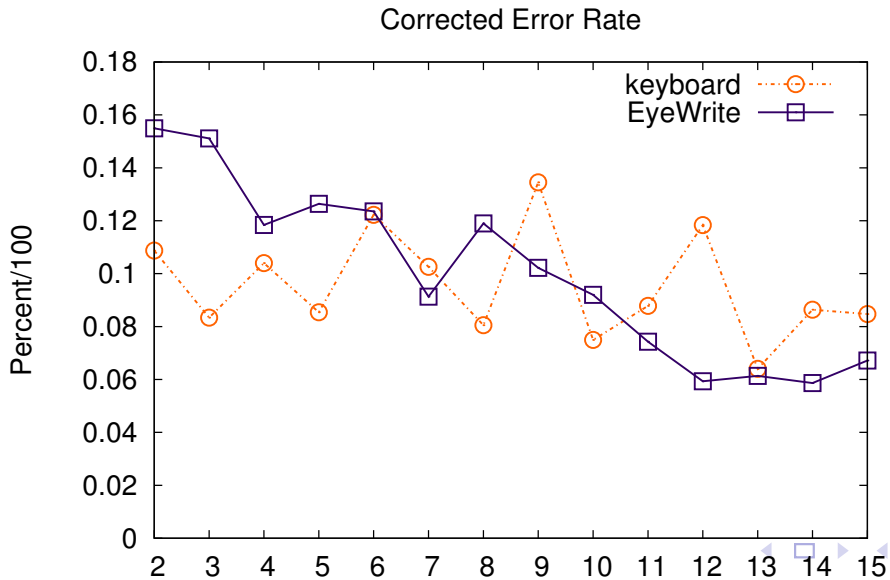

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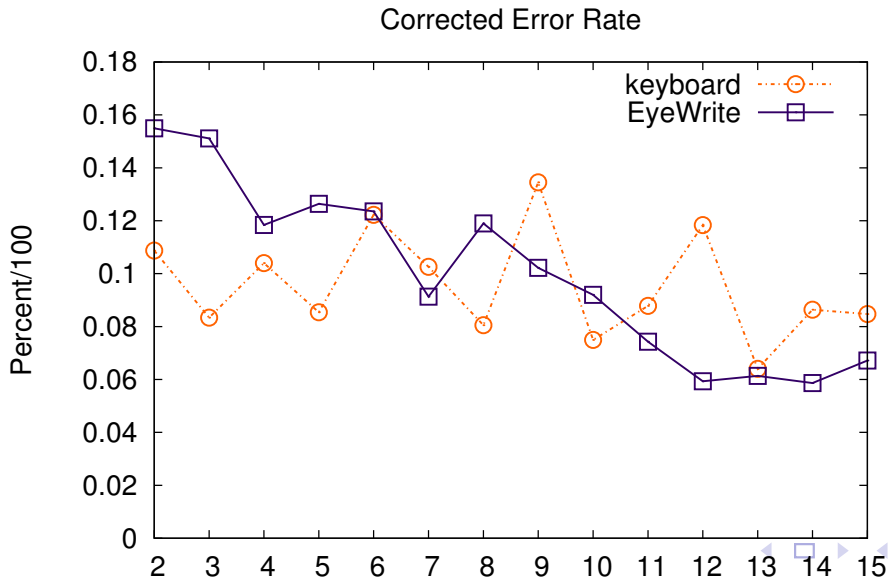

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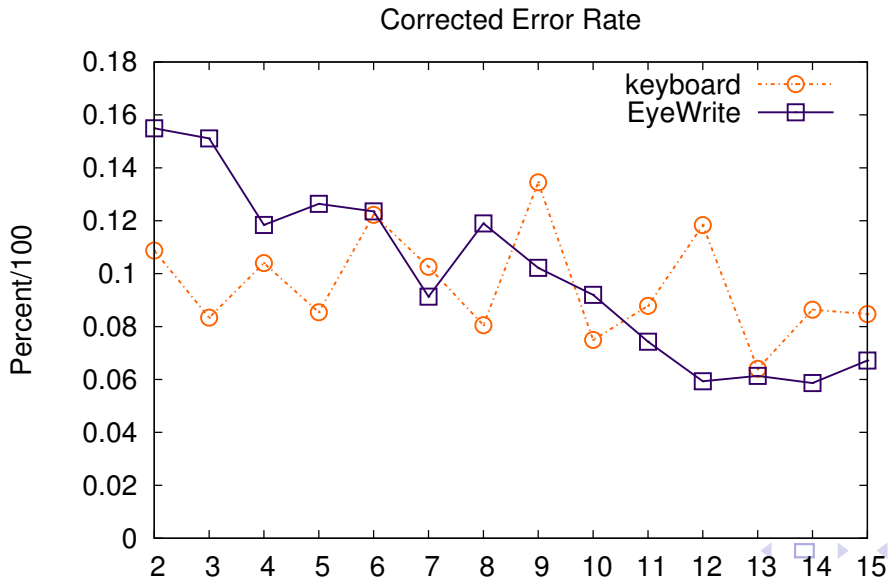

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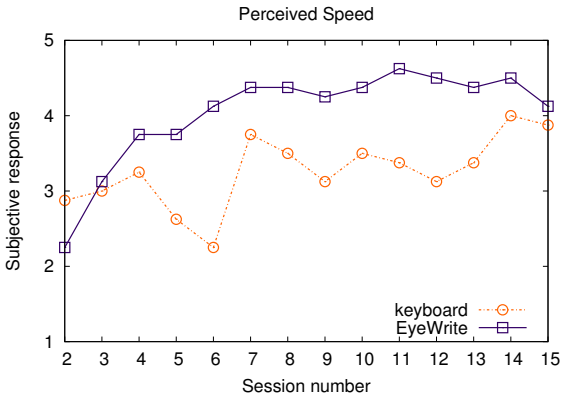
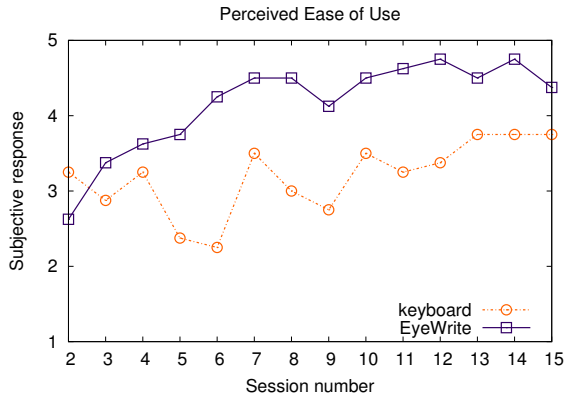
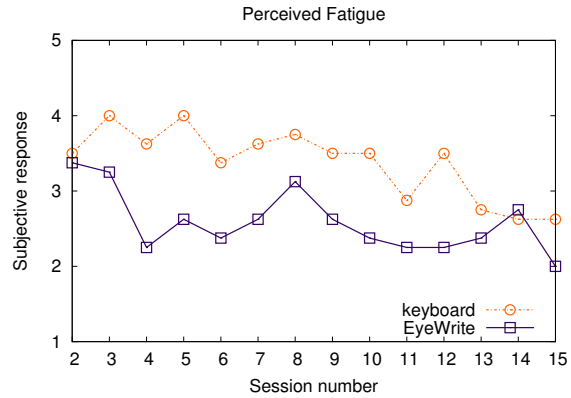
- Participants noted significant preferences for EyeWrite in terms ease of use ($z = 49.00$, $p < .001$), perceived speed ($z = 47.00$, $p < .01$), and fatigue ($z = -51.00$, $p < .001$)
- Perceived ease of use and speed increased over sessions for both methods while perceived (ocular) fatigue decreased
- EyeWrite was thought more difficult only during 1st session
- It is remarkable that a gestural alphabet would be so quickly learned and thought as easier to use than an on-screen keyboard







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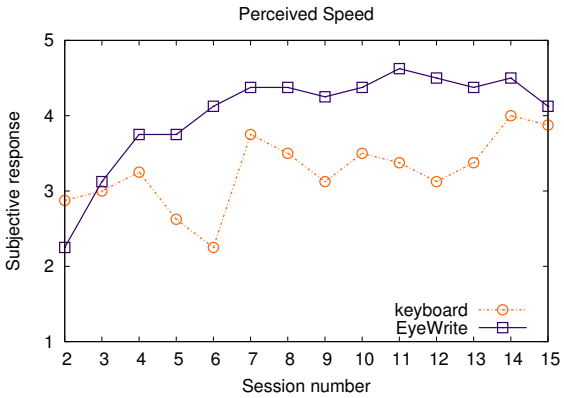

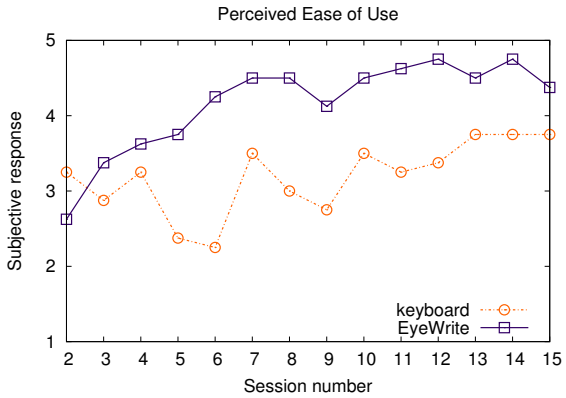

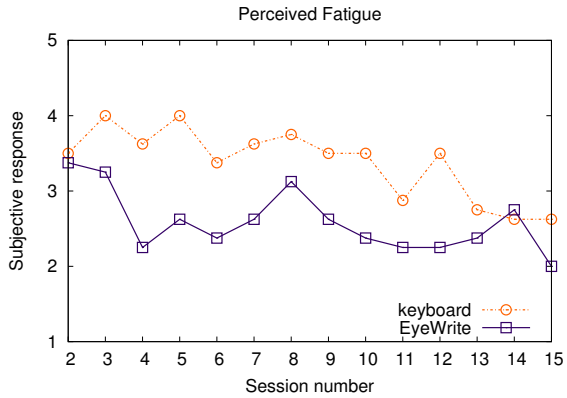

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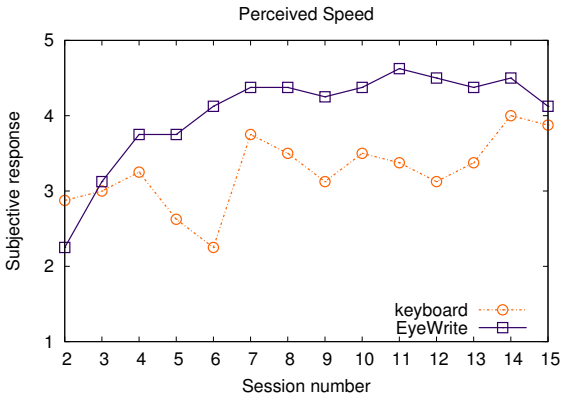

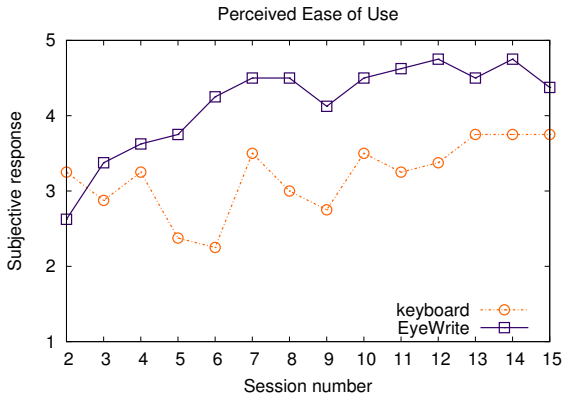

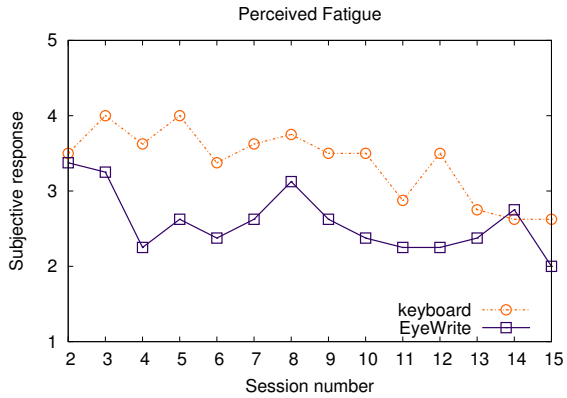

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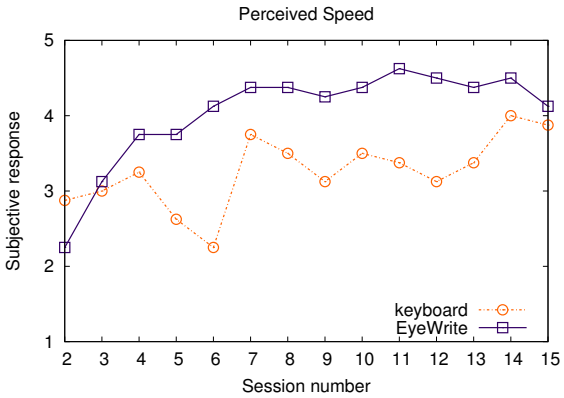

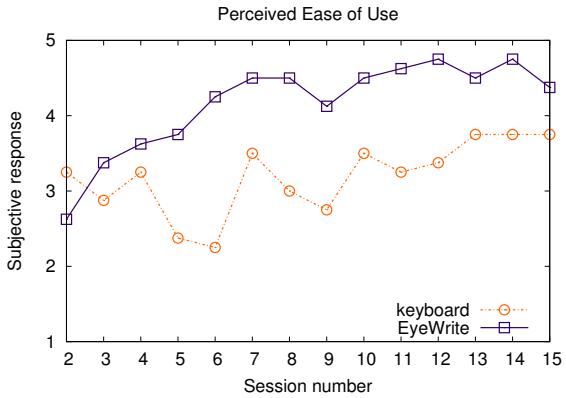

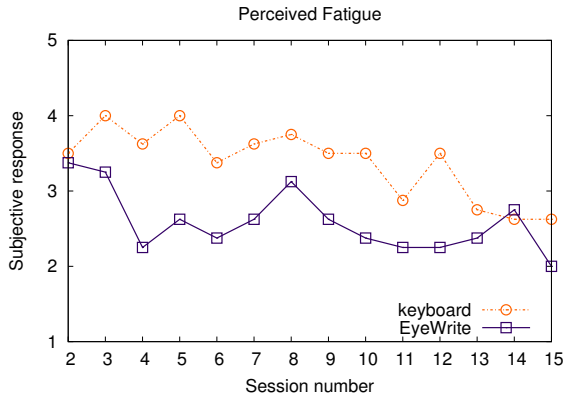

Discussion

- Click-N-Type is faster than EyeWrite, at the expense of accuracy
- Thus, a speed-accuracy tradeoff is observed
- It seems that once familiar with gestures, participants were more willing to correct errors with EyeWrite than with Click-N-Type
- It is plausible they did so because they perceived EyeWrite the faster input modality even though it was not
- EyeWrite's small screen footprint may be an advantage over off-screen targets due to smaller saccade requirement
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- Other applications may include web browsing, as per Moyle and Cockburn's (2005) study showing 11%–18% speed increase over mouse gestures (on certain tasks)

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For Further Reading I

Baron, J., & Li, Y. (2007, November 09). *Notes on the use of R for psychology experiments and questionnaires.* Online Notes. (URL: <http://www.psych.upenn.edu/∼baron/rpsych/rpsych.html> (last accessed December 2007))

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For Further Reading III

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Wobbrock, J. O., & Myers, B. A. (2006b). Trackball Text Entry for People with Motor Impairments. In *Human Factors in Computing Systems: CHI 06 Conference Proceedings* (p. 479-488). ACM Press.

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For Further Reading IV

Wobbrock, J. O., Rubinstein, J., Sawyer, M., & Duchowski, A. T. (2007, 3-4 September). Not Typing but Writing: Eye-based Text Entry Using Letter-like Gestures. In *Conference on Communication by Gaze Interaction (COGAIN)* (p. 61-64). Leicester, UK.

Wobbrock, J. O., Rubinstein, J., Sawyer, M., & Duchowski, A. T. (2008, March 26-28). Longitudinal Evaluation of Discrete Consecutive Gaze Gestures for Text Enry. In *Eye Tracking Research & Applications (ETRA).* Savannah, GA.