Speed-accuracy Trade-off in Dwell-based Eye Pointing Tasks at Different Cognitive Levels

Xinyong Zhang[◇], Pianpian Xu[◇], Qing Zhang[◇] and Hongbin Zha[§]

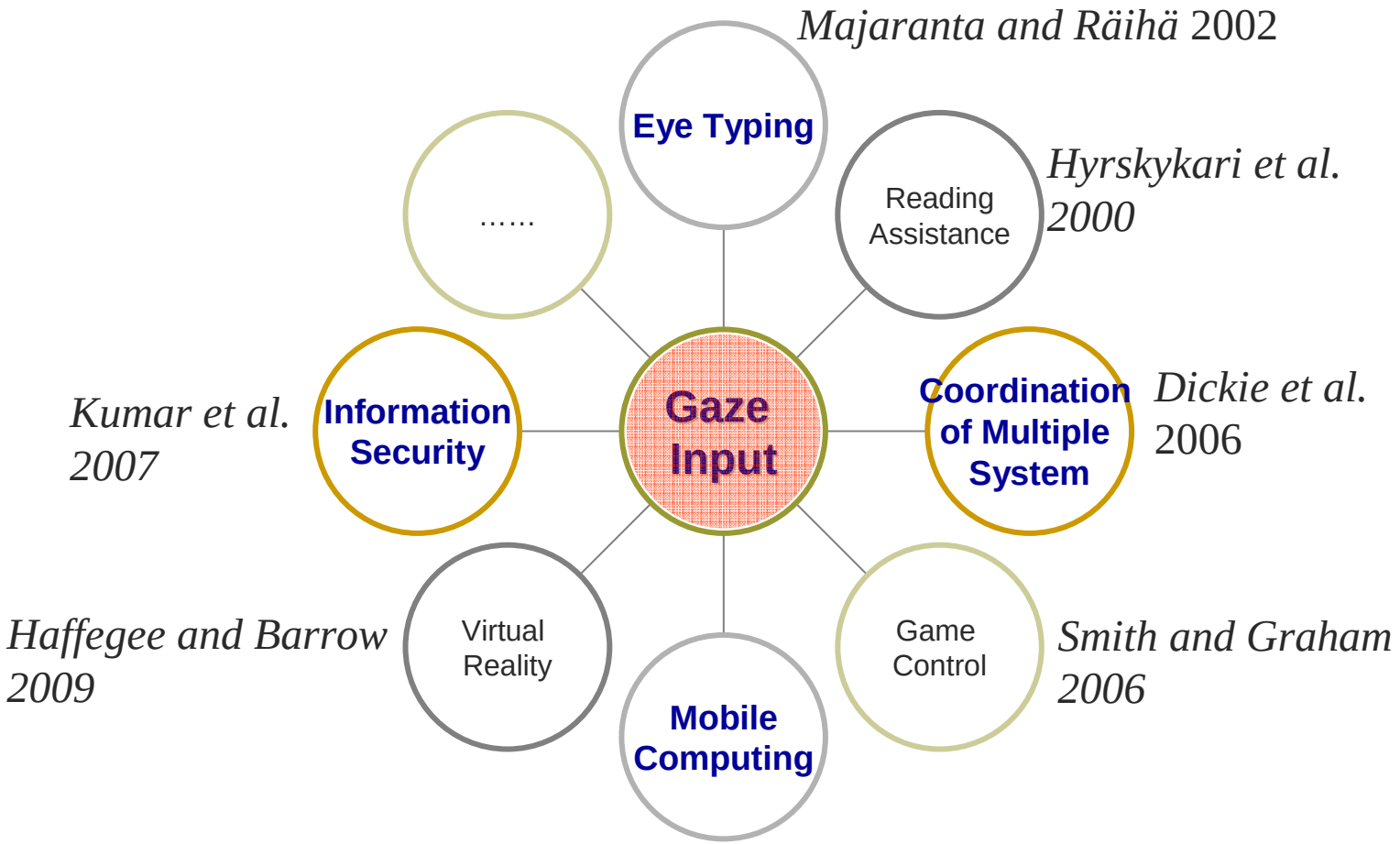
[◇] **Renmin University of China**

[§] Peking University

中国人民大学
RENMIN UNIVERSITY OF CHINA

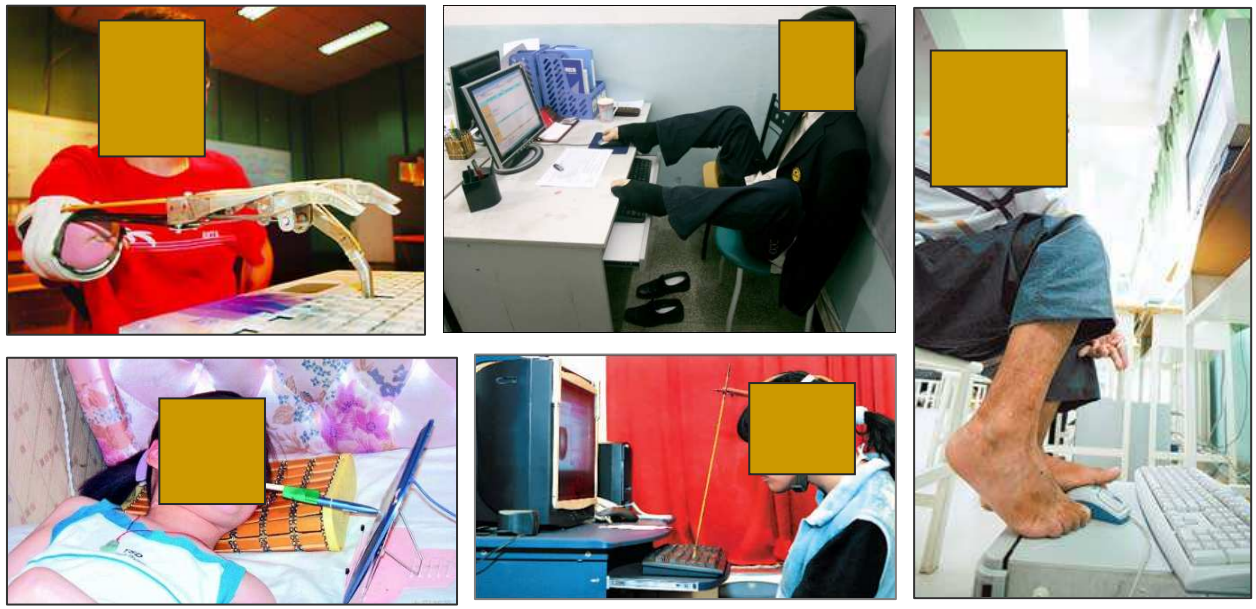
北京大学

Applications of Gaze Input



Benefits of Gaze Input

——for the situations of hands unavailable

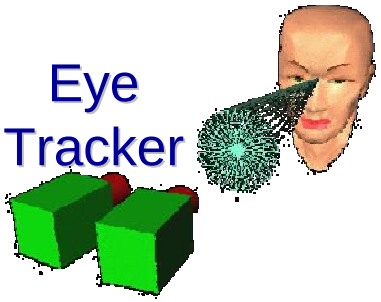


The Problem of Gaze Input

- The eyes: ***Perception*** vs. ***Control***
  - The eyes inherently are organs for perception, not for control;
  - Eye gaze input can cause wrong commands, i.e. the Midas Touch problem, when used as an independent input channel;
  - Gaze input needs specific command activation methods.

Related Methods for the Midas Touch Problem

- Multimodal input



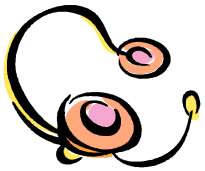
+

Mouse

MAGIC Pointing, Zhai *et al*. 1999

Keyboard

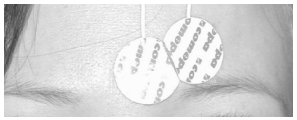
Eyepoint, Kumar *et al*. 2007



Microphone

Gaze and speech, Zhang *et al*. 2004

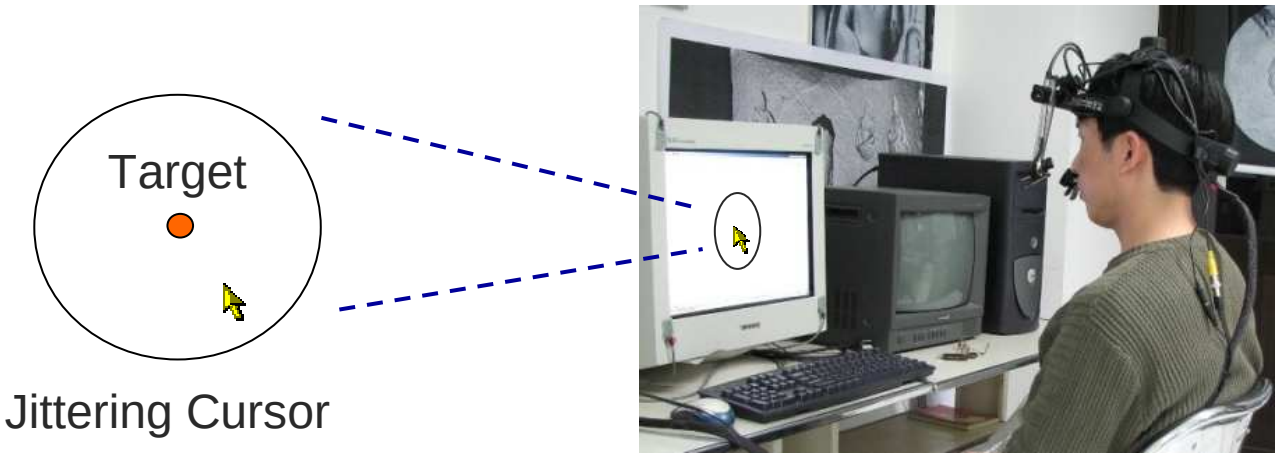
Skin Electrode



Gazing and frowning,
Surakka *et al*. 2004

Related Methods for the Midas Touch Problem

- Dwell Time
  - the most dominant method



Predictive Model Constructed

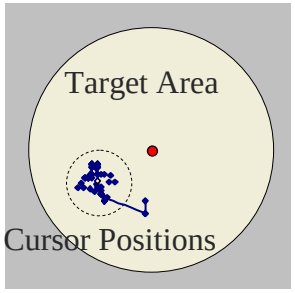
for the Performance of **Dwell-based Eye Pointing**

Zhang *et al*. CHI2010:

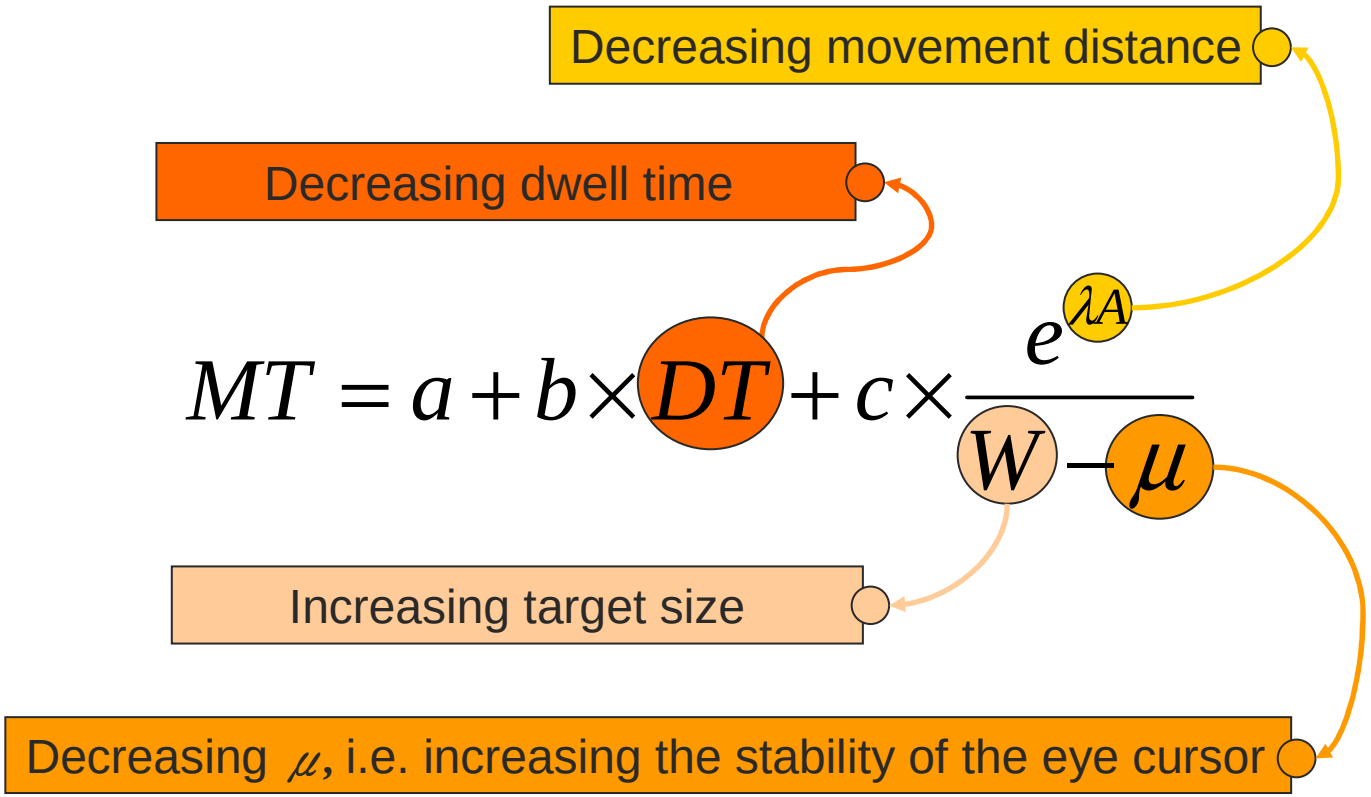
$$MT = a + b \times DT + c \times \frac{e^{\lambda A}}{W - \mu}$$

Defined as the Index of difficulty for Dwell-based eye pointing task

a, *b*, *c*: Regression coefficients;
DT: **dwell time**;
A: movement distance;
W: target size (diameter);
λ: **an empirical constant,** which is a small decimal reflecting the fast speed of saccades;
μ: **an empirical constant,** which reflects the jittering feature of the eye cursor.



Implications of the model



Dwell Time

- Different dwell times were used in different studies, for example
  - Ware and Mikaelian (1987), **400 ms**
  - Sibert and Jacob (2000), **150 ms**
  - Majaranta et al. (2004, 2006), short dwell time **450 ms** ; long dwell time **900 ms** for eye typing

Dwell Time

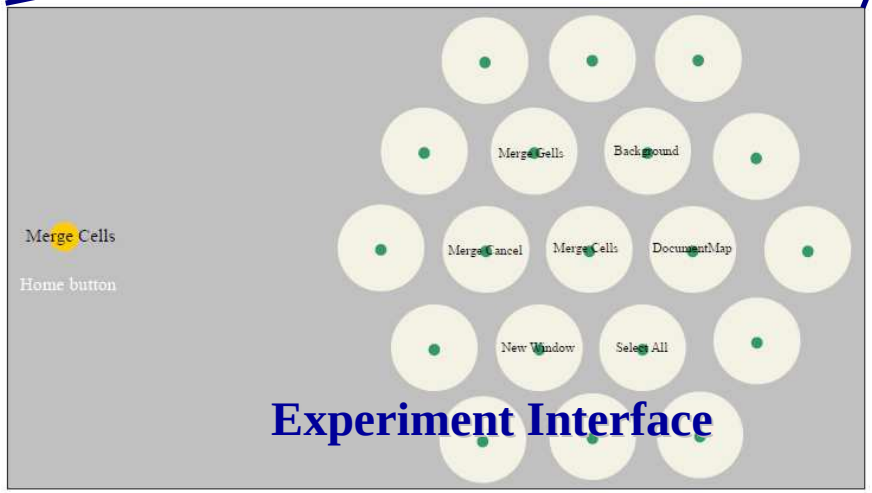
- A common feature of the experiments in previous studies:
  - Visual searching was eliminated from the corresponding tasks, without the need to
  - recognize and make decision for the desired target in advance. That is to say,
  - Cognitive load was absent from the experiments,
  - Being different from the reality

Dwell Time

- Visual searching is **indispensable** in real interfaces
  - Short dwell time can maintain the advantage of fast target acquisition, but with high risk of the Midas-Touch problem.
  - Long dwell time can efficiently avoid wrong selections, but with low efficiency.
  - **How long is long enough for the user to safely acquire targets under different cognition conditions?**

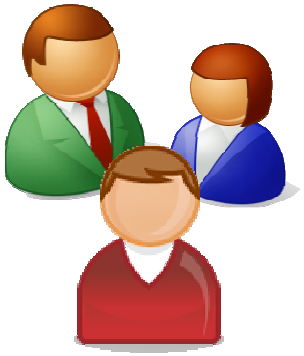
Searching Task: to find the answer

- Experiment



Experiment Interface

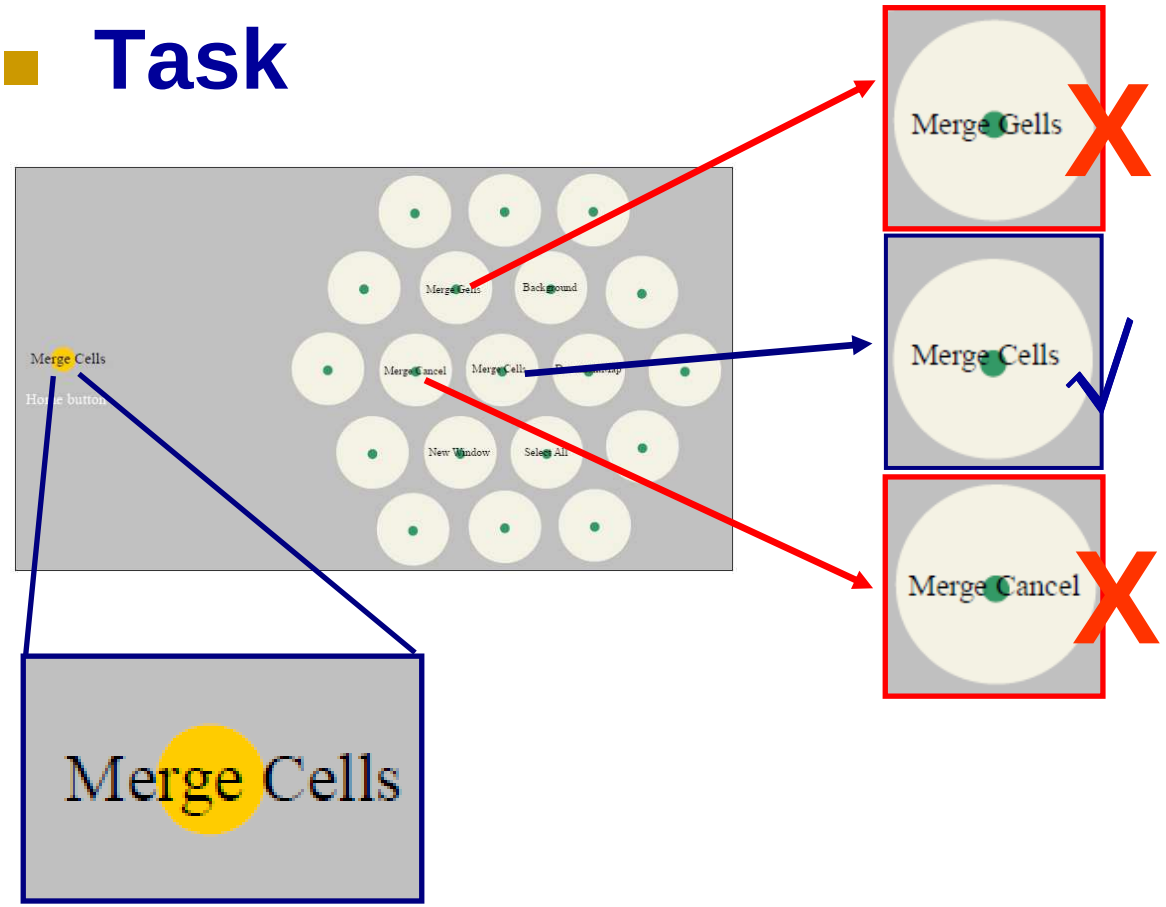
Eyelink II



21 able-bodied participants, including 10 females and 11 males, successfully completed this experiment

Searching Task (cont.)

- **Task**



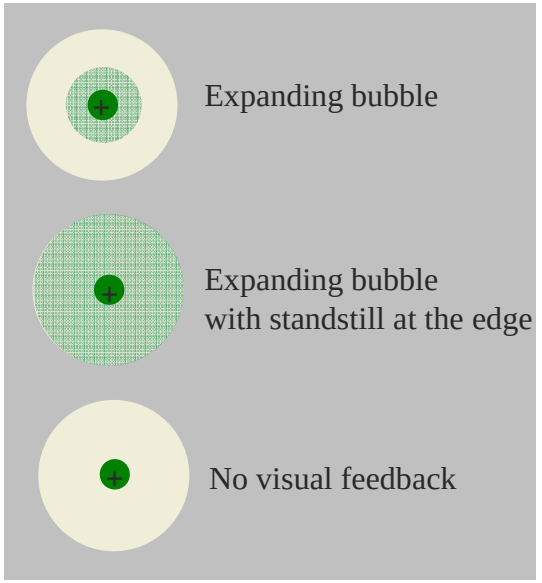
Level	Labels
I	11, 12, 13, 14, 15, 51, 52, 53, 54, 55
II	**O**pen, Close, Pic Font, Tabs, Then Table, Tools, Wir Delete, Bullets, S
III	**T**ext Direction, Background, Aut Time, Hyperlink, Thumbnails, Coll Cells, Paragraph; **N**ew Window, Ar

Label sets used for target searching with different levels of cognitive complexity

Searching Task (cont.)

- **Design**
  - Three factors :

- **T**ask **C**omplexity:
  digit, short label, long label
- **D**well **T**ime:
  450, 650, 850, 1100 ms
- **V**isual **F**eedback:



A fully crossed design resulted in 36 combinations
(3*TC*×**4***DT***)** ×2 trials ×9 blocks ×3*VF*

Searching Task (cont.)

Searching Task (cont.)

Eye searching time *was defined as the time from the beginning of the trial to the time of locating the desired target.*

- Results
  - Eye searching time (**speed**)

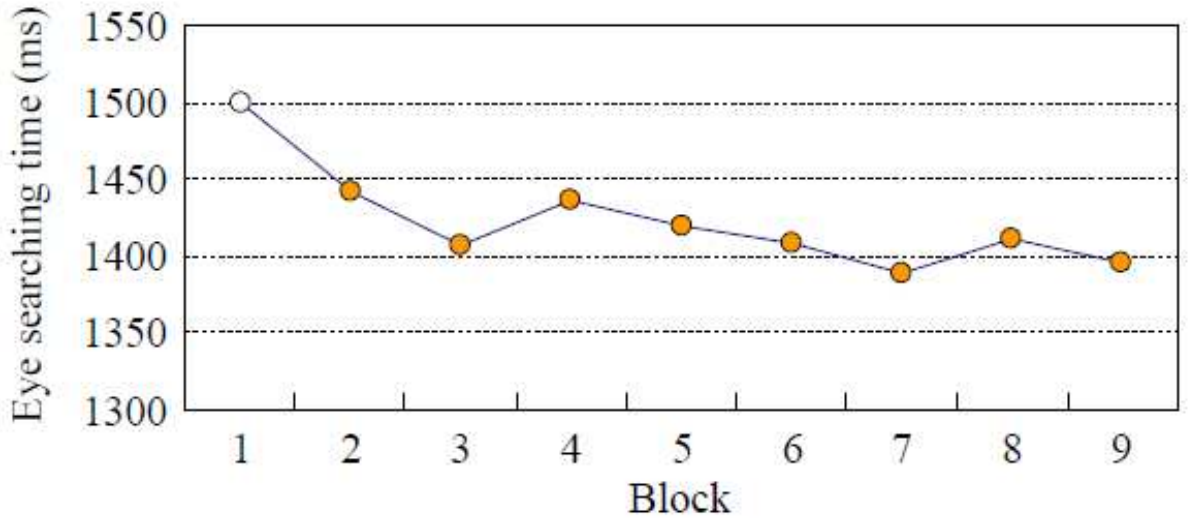


Figure 2. Average eye searching time by block.

Searching Task (cont.)

$$Error\ Rate\ (\%) = 100 \times \frac{Failed\ Trials}{18 + Failed\ Trials}$$

- Results
  - Error Rate (**accuracy**)

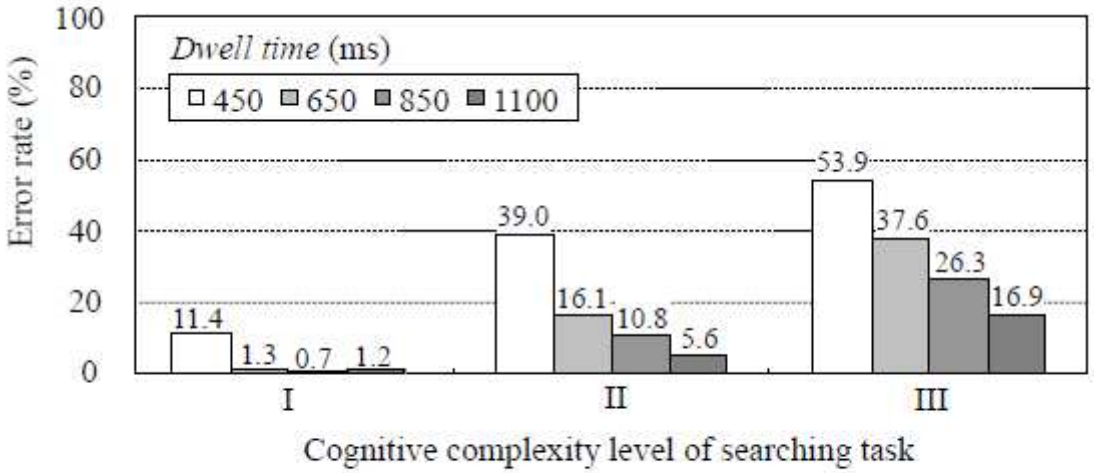


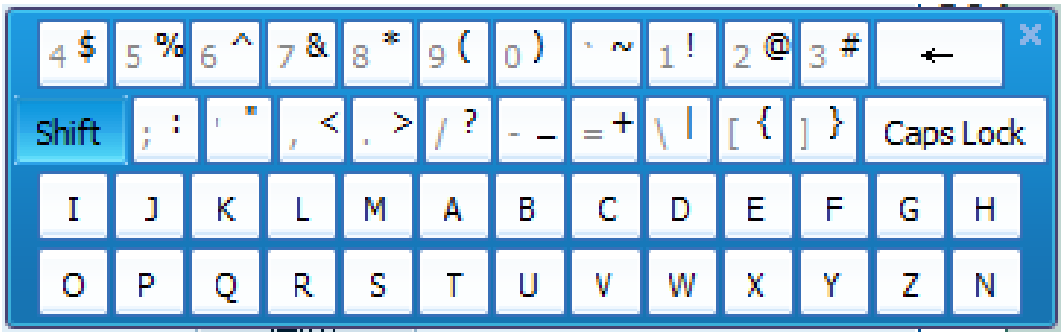
Figure 4. Error rate by combination of task complexity and dwell time.

Searching Task (cont.)

- The factor of **task complexity** had a significant main effect on both eye searching time and error rate.
- **Dwell time** significantly affected error rate.
- The **feedback modes** we used had no significant effect to improve the visual search.

Design Implications of the Results

- With respect to **simple user interfaces**, such as the interfaces of digit calculators and on-screen keyboards, it is suitable to set dwell time approximate to **600 ms**.



Design Implications of the Results

- When the target is labeled using a simple **short word**, we can set dwell time **around 1000** ms.
- Within an interface, if the targets are labeled using **different texts** with **different cognitive complexities**, they should be individually set using **different dwell times**.

Design Implications of the Results

- When the user's **short term memory** has transformed into **long term memory**, the cognitive load of target searching can be decreased;
- Therefore, the interactive system should be **adaptive** to automatically adjust the dwell time according to the state of the user or be **adaptable** for the user herself/himself to do so.

Thanks for your attending
Q/A