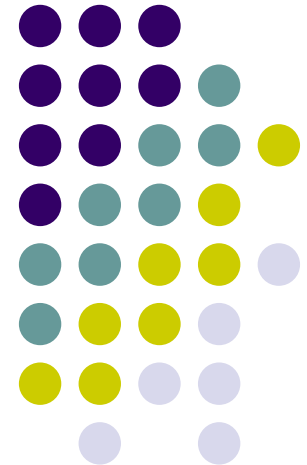


Evaluation of Pen-Shaped and Conventional Mouse Designs

Chia-chen Chao and Alan Hedge

Cornell University, NYS College of Human Ecology
Department of Design and Environmental Analysis,
Ithaca, NY 14853, USA



Acknowledgements

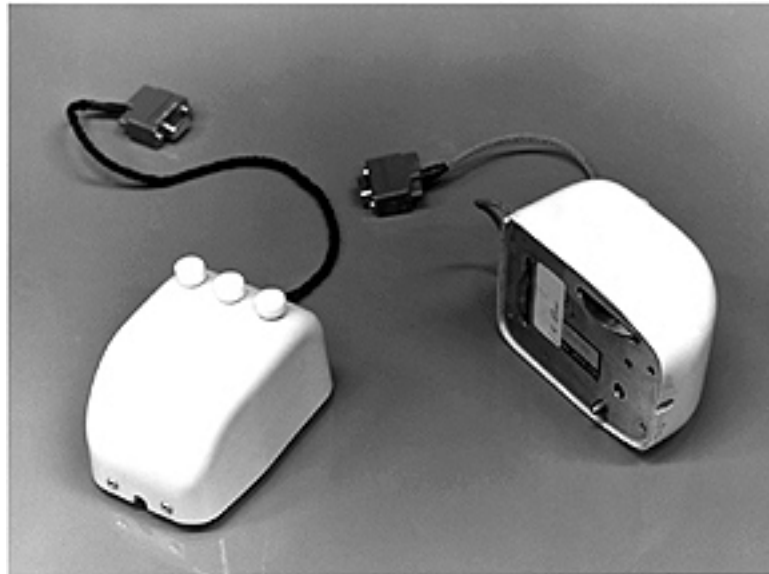


- Salient for the V-mouse.
- WorkRite (Steve Owles) and LINAK (Ann Hall) for the worksurface.
- WorkRite (Steve Owles) for the PenClic mouse.
- This work was supported by a grant from the NYS College of Human Ecology, Cornell University.

The mouse



- Invented by Douglas Engelbart (1968)
- Many design advances since then

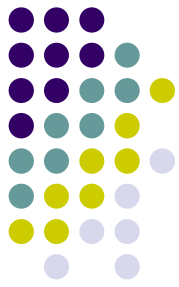




Mouse Use and MSDs

- Mouse use: 2/3 of the time (Johnson et al., 1993; CTD News, 1996)
- Claims: 0 to 325,000 from 1988 to 1993 (Fogelman & Brogmus, 1995)
- Sustained muscle loads in the forearm => musculoskeletal disorders (Karlqvist et al., 1996; Jensen et al., 1998; and Cooper & Straker, 1998)
- Musculoskeletal disorders associated with:
 - Forearm pronation (Zipp et al., 1983; Aaras & Ro, 1997; Gustafsson & Hagberg, 2003)
 - Radial/Ulnar deviation $>15^\circ$ or sustained deviated posture => biomechanical load problems (Johnson et al., 1994; Rempel et al., 1994)
 - Wrist Extension/Flexion $>20^\circ$ increases risk to wrist and hand (Rempel et al., 1994)

The Pen



● Pen history

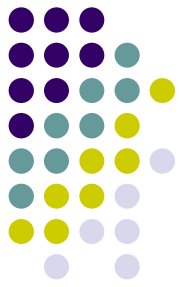
- 4000 BC – first pen/stylus use
- Ink invented by the Chinese philosopher, Tien-Lcheu (2697 B.C.)
- Egyptian "Puisse Papyrus" written in ink ~ 2000 B.C.
- 1300 -1200 BC – widespread use of ink pen
- 1879 in Providence, Rhode Island, Alonzo T. Cross invented the stylographic fountain pen, a precursor of the ball-point pen.
- Hungarian László Jozsef Bíró (1899-1985) from Budapest, invented a ball-point pen with a pressurized ink cartridge in 1938.
- In 1954, Parker Pens introduced its first ballpoint pen called "The Jotter".

Pen Use and MSDs



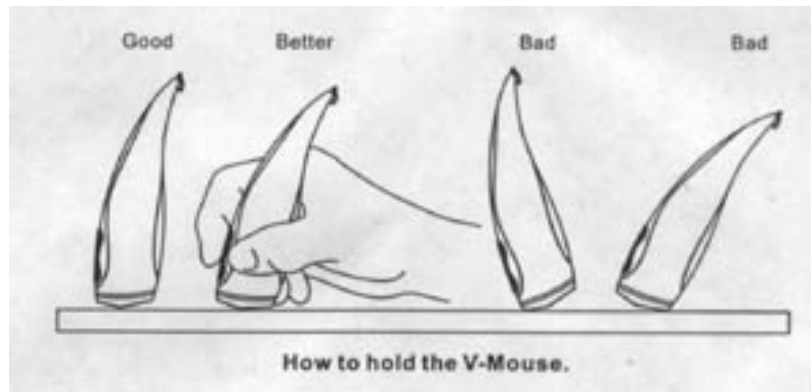
- **Writer's cramp:**

- A form of task-specific focal dystonia.
- Dystonia is an involuntary, sustained muscle contraction causing twisting movements and abnormal postures; focal dystonia means only one body part is affected.
- Writer's cramp is the most common focal dystonia among repetitive movement disorders.
- In normals, when an agonist muscle is contracted the antagonist muscle relaxes.
- In patients with dystonia there is simultaneous contraction of both groups of muscles. Spinal reciprocal inhibition, a process that inhibits the antagonist muscles when the agonist muscles are active, is reduced in patients with writer's cramp.
- In the US the estimated the prevalence rate is 69 per 100,000; this is thought to be an underestimation because a high percentage of patients never seek medical assistance.
- Prevalence is slightly higher in men; the male-to-female ratio is 1.3:1.
- Typically, patients present in the third to fifth decades, and women usually present earlier than men. (<http://www.emedicine.com/neuro/topic614.htm>)

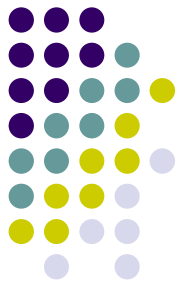


Pen-shaped mouse (A)

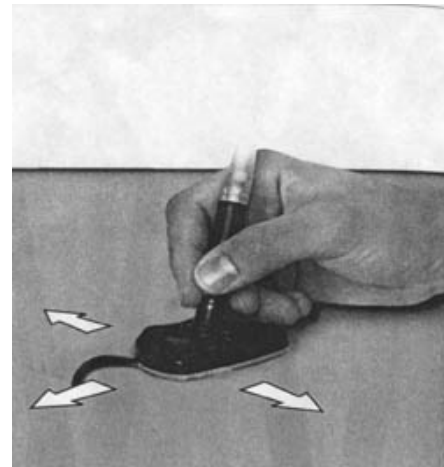
- Salient V-Mouse

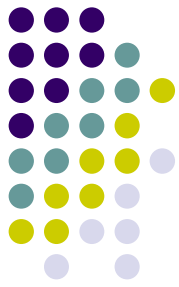


Pen-shaped mouse (B)



- Ullman PenClic Mouse





Research Objectives

- Compare wrist posture (ulnar/radial; flexion/extension; wrist pronation/supination) between two pen-shaped mice and a conventional mouse design.
- Compare task performance (cursor movement speed and accuracy) on various computer based mousing tasks for the two pen-shaped mice and a conventional mouse.
- Compare self-reports of comfort, preference and usability after using all three mouse designs.

Methods and Procedures

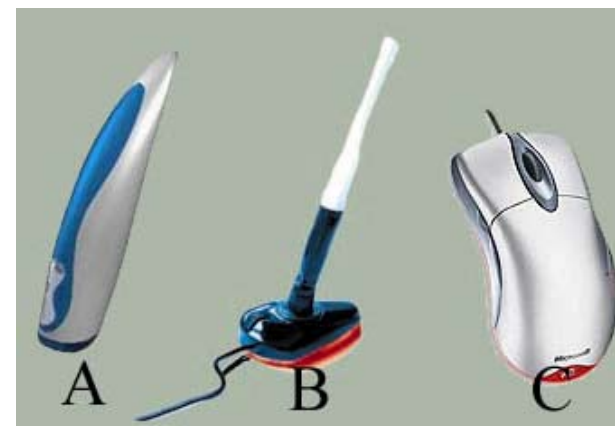


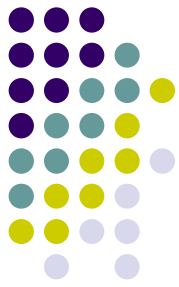
- **Subjects**

- 16 (8 male; 8 female), right-handed
- Professional administrative assistants, graduate students or under graduate students at Cornell University
- No cumulative trauma disorder history

- **Apparatus**

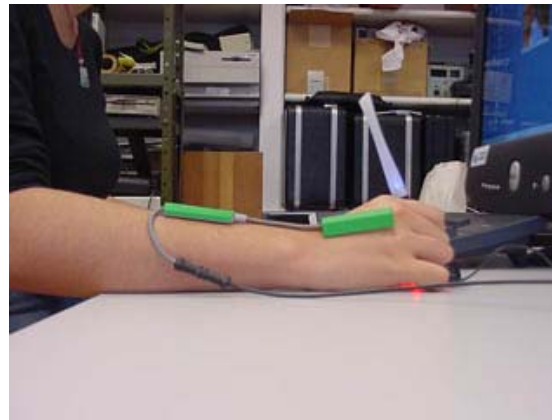
- Cornell University's Human Factors and Ergonomics Laboratory (Ithaca, NY) in November 2003
- DELL Optiplex GX400 with Windows®2000 OS and 20" CRT monitor
- Motorized height adjustable table (WorkRite)
- Adjustable ergonomic chair (Steelcase Leap)
- Mice
 - Mouse A :Salient V-mouse
 - Mouse B :Ullman PenClic Mouse
 - Mouse C (Microsoft® IntelliMouse® Explorer)





Wrist Posture




- Electrogoniometer instrumented glove (Greenleaf Medical Systems)
- Torsiometer (NexGen Ergonomics Q110)



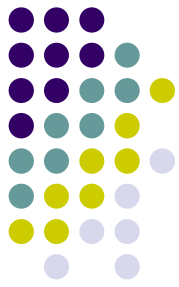
Hedge, A. and Chen, C.C. (2004) Evaluation of pen-shaped and conventional mouse designs, Proceedings of the Human Factors and Ergonomics Society 48th Annual Meeting, New Orleans, Sept. 20-24, HFES, Santa Monica, 818-822.



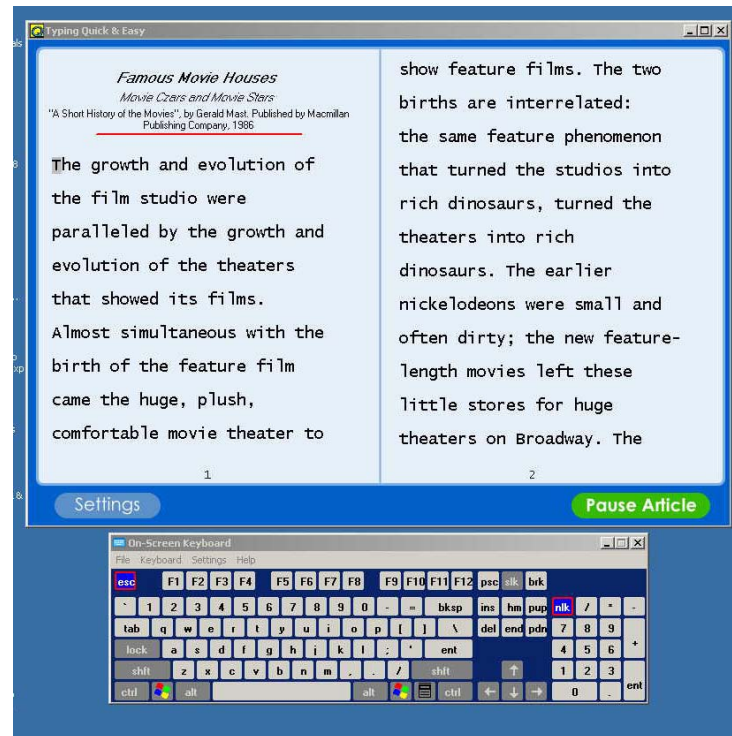
Procedure

	Donning & Calibrating Equipment	Familiarization	Task 1		Task 2		Task 3		TOTAL
			Practice	Test	Practice	Test	Practice	Test	
Mouse A 	10 min	10 min	1 min	2 min	1 min	2 min	1 min	2 min	29 min
Mouse B 	10 min	10 min	1 min	2 min	1 min	2 min	1 min	2 min	29 min
Mouse C 	10 min	5 min	1 min	2 min	1 min	2 min	1 min	2 min	24 min
TOTAL	30 min	25 min	9 min		9 min		9 min		82 min

Familiarization Trial



- Typing Quick and Easy v.14 (10 minutes for pen mice, 5 minutes for conventional mouse)

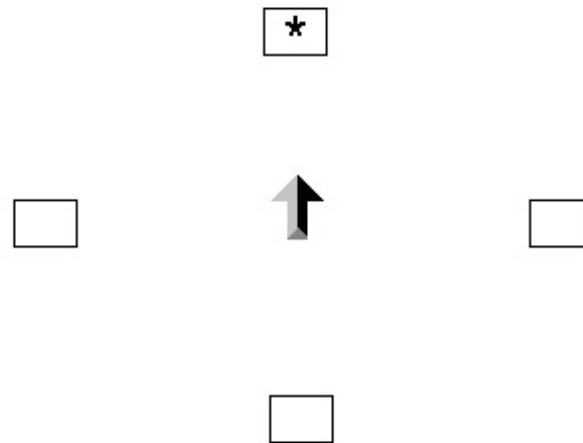


Task 1 - Cursor Positioning

(vertical/horizontal movements)



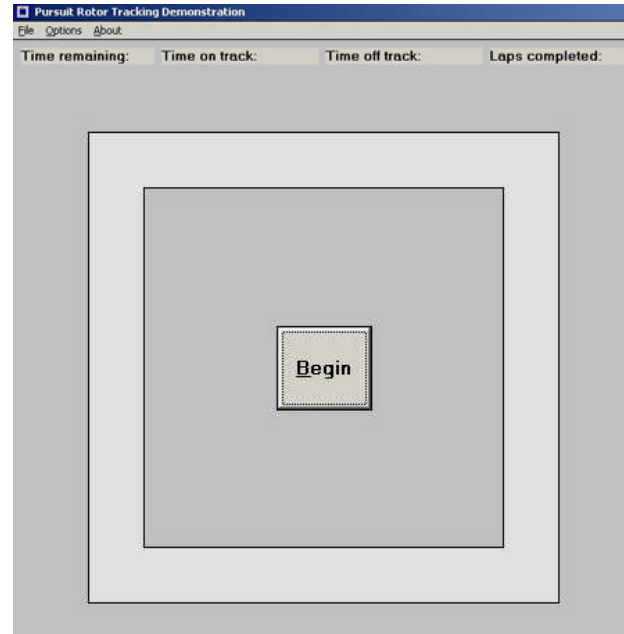
- Task based on Fitt's law (Fitts & Seeger, 1953)
- E-prime (Psychology Software Tools Inc. v1.1, 2002)
- Benchmark test (Plant, et al., 2003)



Task 2 - Cursor Positioning

(clockwise movements)

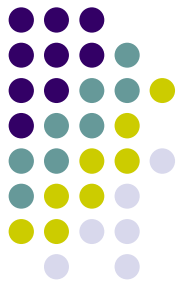
- Track task (Porter, 2000)



Task 3 - Cursor Positioning

(random movements)

- Target acquisition task



Subjective ratings



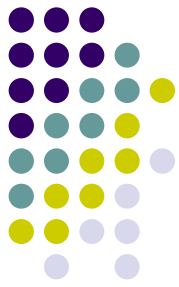
- 1. Difficulty of each task with each mouse
- 2. User's preference for each mouse for each task
- 3. Overall comfort rating for each mouse

Results



- **Subjects characteristics**

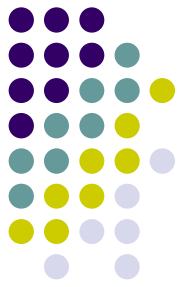
- Mean age: 25.8(\pm 3.9) years (range 19 to 32 years);
- Female: 23.9 (\pm 3.1) years (range 19 to 29 years);
- Male: 27.6 (\pm 4.0) years (range 20 to 32 years)
- Overall mean number of years of mousing experience 9.9 (\pm 3.8) years, 9.4 (\pm 3.5) years for female and 10.4 (\pm 4.3) years for male.
- No significant difference between male and female in age and mousing experience.



Results

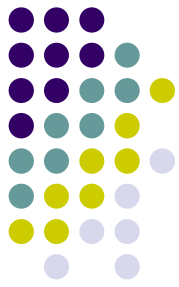
- Mean wrist pronation
 - Pen mice required less pronation posture than conventional mouse ($F_{2,28} = 22.895$, $p=0.000$: $A = +3^{\circ}$; $B = 0^{\circ}$; $C = +11^{\circ}$)
 - Women had less pronation than men ($F_{1,14} = 9.713$, $p=0.008$: men = $+5^{\circ}$; women = 0°)
- Mean wrist extension
 - Mouse B increased wrist extension ($F_{2,28} = 5.415$, $p=0.01$: mean wrist extension: $A = 5.6^{\circ} \pm 2.8^{\circ}$; $B = 7.4^{\circ} \pm 2.5^{\circ}$; $C = 0.9^{\circ} \pm 2.1^{\circ}$)
- Mean wrist ulnar deviation
 - Use of pen-shaped mice decreased ulnar deviation ($F_{2,28} = 18.443$, $p=0.000$; mean radial deviation: $A = 2.1^{\circ} \pm 2.3^{\circ}$; $B = 1.8^{\circ} \pm 2.3^{\circ}$; mean ulnar deviation: $C = 11.0^{\circ} \pm 3.1^{\circ}$).
 - Significant interaction between mouse and gender ($F_{2,28} = 5.154$, $p=0.012$)

Results



- Task 1 - Vertical/horizontal movements
 - Overall, no significant differences in mean response times between mouse designs or gender.
 - Pen-shaped mice were rated as slightly less easy to use ($F_{2,28} = 3.469$, $p = 0.045$: $A = 4.1 \pm 0.4$; $B = 3.8 \pm 0.3$; $C = 5.1 \pm 0.3$)
 - 56.5% of subjects preferred using the conventional mouse C; 31% preferred the pen-mouse A and 12.5% preferred the pen-mouse B.

Results



- Task 2 - Clockwise movements

- Overall, no significant differences in performance (mean number of circuits) or errors.
- Significant gender effect on performance: men completed more laps than women ($F_{1,14} = 11.271$, $p=0.005$: men = 8.0 ± 0.6 ; women = 4.9 ± 0.6).
- Significant gender effect on errors: men made more errors than women ($F_{1,14}=5.764$, $p=0.031$: men = 952.1 ± 179.2 ; women = 343.8 ± 179.2)
- Significant interaction between mouse and gender for difficulty of use ($F_{2,28} =5.343$, $p=0.011$) – men rated pen-mice as easier, women rated conventional mouse as easier.
- 31% preferred pen-mouse A for this task; 38% preferred pen-mouse B; and 31% preferred the conventional mouse.

Results



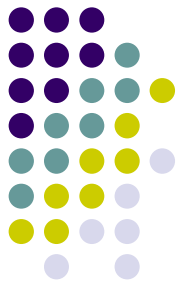
- Task 3 - Random movements
 - Mouse C performed significantly better than the pen-mice ($F_{2,28} = 2.304$, $p=0.022$: pen-mice A and B= 20.9 ± 2.4 ; mouse C= 25.8 ± 1.8)
 - No significant effect for mouse designs on difficulty of use.
 - 50% preferred pen-mouse A; 25% preferred pen-mouse B; and 25% preferred the conventional mouse C.

Results



- **Reports of overall comfort**

- Marginal main effect of mouse design on overall comfort ratings ($F_{2,28} = 3.257$, $p = 0.054$), mouse C was slightly rated more comfortable than mouse A and B (A = 3.8 ± 0.5 ; B = 4.1 ± 0.3 ; C = 5.0 ± 2.8)



Conclusions

- **Wrist posture**

- In this short-term study there was evidence that pen-mice reduced wrist pronation and ulnar deviation, but increased wrist extension compared with a conventional mouse design.

- **Task Performance**

- In this short-term study there the pen-mice performed at the same level as a conventional mouse design.

- **Subjects' Preference and overall comfort**

- Preferences for the mice varied with the task. Overall, the conventional mouse design generally was favored by subjects