Sex differences in hypertext navigation during E-learning
Christa van Mierlo, Paul Kirschner & Liesbeth Kester

Centre for Learning Sciences and Technologies
Open Universiteit
celstec.org
Sex differences in exploration and storing of information

- Meyers-Levy and Maheswaran (1991) demonstrated that for processing advertising messages females often engage in comprehensive processing of all available information, whereas males tend to focus their attention on a fewer number of topics.

- Roy and Chi (2003) found that teenage boys, when using search engines on the Internet, oscillated between submitting searches and scanning only the first few document excerpts returned as search results (i.e., horizontal searchers), whereas girls opened and browsed entire linked document excerpts or documents (i.e., vertical searchers) without going through a preliminary filtering step of scanning. Their correlation analysis showed that this pattern of variability was responsible for boys outperforming the girls.

- Pan, Hembrooke, Gay, Granka, Feusner and Newman (2004) showed that when scanning web pages, males exhibited significantly longer mean fixation durations than females, fixating longer on a smaller number of items than females.
Males’ mental model construction

Bottom-up approach: from leaves to trunk

• deepening their understanding in one practical application of the knowledge first
• then gradually moving on to topics that share a lot of original topic’s information (i.e. adjacent items)
• any new information encountered is used to create new branches in the model
Females’ mental model construction

Top-down approach: from trunk to leaves

- starting off to gain as much general information on the topic as possible
- thus defining the overall size and layout of their mental model in the first few stages of learning,
- and then gradually detailing the branches as the model becomes more complete.
Sex differences in motor coordination, perception and navigation

• Tasks that require fine motor ability typically favour females, whereas tasks requiring gross motor ability usually favour males (Kimura, 1999). For instance, whereas females master writing much faster than males, they have more trouble with the catching balls compared to males.

• Part of males' advantage for such gross motor movements might stem from a higher oculomotor precision in smooth pursuit (Wilner & Nakayama, 2006), i.e. they can track the trajectory of the ball with greater precision, making it easier to perform the calculations of interception.

• Additionally, numerous studies found profound differences in spatial abilities between males and females (for a review see Voyer et al., 1995) in that males are much more efficient in route finding and remembering and orientating in novel environments than females are.
Sex differences in navigation through electronic environments

- Cognitive?
- Biomechanical?
- Both?
Plan of attack

- Pilot experiment to measure sex differences in basic execution of eye & hand movements and in responses to variations in perceptual load so that we can take these into account when interpreting the mouse and eye movement data that we measure in e-learning situations.

- Two experiments to measure sex differences in hypertext navigation:
  - “Cognitivism and Instruction” e-course for 24 first year Bachelor students at the Faculty of Psychology and Pedagogies University of Gent.
  - Hypertext environment with information on the effects of Alcohol (Ab)use on the body for high school students (24 students Sophianum, Gulpen).
Pilot: Sex differences in morphology and dealing with perceptual load

- Tracking of a translating or rotating ball: fast or slow, with or without distracters
- Clicking on 10 in sequence appearing randomly positioned disks.
- Measurement of eye movements, mouse movements and experienced cognitive load (Paas measure)

  - Sex differences in scan paths?
  - Sex differences in mouse paths?
  - Sex differences in eye-hand coordination?
  - Sex differences in responses (in both scan & mouse paths and eye-hand delay) to variation in perceptual load?
  - Is perceptual load reflected in eye-hand coordination (delay & error)? If so we will use this to measure cognitive load (mental effort) in the e-learning experiments

Vector paths fitted and compared using MultiMatch (Jarodzka, Holmqvist & Nyström, 2010)
E-learning experiments

- Pretest
- Time in hypertext learning environment (IMS-LD, content created in Recourse)
- Posttest
- Questionnaire
Methods

- Measuring gaze positions (Tobii 50 Hz), mouse pointer positions (50 Hz Matlab application Psychophysics Toolbox) and taken route (sequence of opened pages, measured by Tobii eye tracker)

- Relating scan paths, mouse paths and route to learning outcomes (post-test – pretest performance) using vector path distances (MultiMatch) for the scan and mouse paths and Levenstein distances for the routes.
Analysis:
Relating Gaze and Mouse Pointer Positions to Sex and Performance

- Fitting vectors to (X,Y) position data to generate scan and mouse paths (MultiMatch)
- Calculating Dijkstra distances between vector paths on the same page based on the angle and length of corresponding vectors in the paths:
  - between each scan path and a randomly chosen scan path: bigger distance for comparisons across sexes than within?
  - between each mouse path and a randomly chosen mouse path: bigger distance for comparisons across sexes than within?
  - between scan and mouse paths within a subject and then compare this distance across sexes
- Relating paths to performance:
  - grouping subjects based on their distance to a randomly chosen path and testing whether these groups had different learning outcomes
Analysis:
Relating Navigation to Sex and Performance

• Coding window sequences with letters/numbers and calculating the Levenshtein distance of each route to a randomly chosen route:
  o distances bigger between sexes than within sexes?
  o grouping routes based on their distance to a randomly chosen route and then testing whether different groups had different learning outcomes.
Status of Project

- Pilot data and E-learning Experiment 1 data collected.
- Analyzing pilot data: implemented MultiMatch vector fitting of the position data and calculation of Levenshtein distances for the routes. At the moment running the comparisons.
- Same analysis can be used for E-learning position data.
Blue lines = Mouse path males
Green lines = Scan path males
Pink lines = Mouse path females
Red lines = Scan path females
Results of Project

• Body of knowledge on sex differences in navigation and learning outcomes in e-learning
• Guidelines how to make adaptable hypertext learning environments that take sex into account
Future Directions:
static HLE

- Force females and males to take a particular route through the information, based on the route that for each group resulted in the best performance in pilot experiments.
- Highlight the AIO that were visited by females and males in the pilot experiment so that they are easier to locate.
- Layout of page: order information from abstract to practical or vice versa depending on the sex of the learner.
Future directions:
Fully adaptable HLE based on gaze, mouse positions and/or logdata

• Adjust next page that is loaded in the environment based on scan and mouse paths
• Adjust next page that is loaded in the environment based on history of previously opened pages.
• Adjust difficulty of new material, amount of information and layout of the next page based on eye-hand distance

Do these result in better learning outcomes for both females and males?
Thank you for your attention!

You can contact me for further questions at:

christa.vanmierlo@ou.nl