

PhD Qualifying Examination: **Human-Computer Interaction**

University of Wisconsin–Madison, Department of Computer Sciences

Spring 2014 — Monday, February 3, 2014

General Instructions

- ★ This exam has **7** numbered pages including this page.
- ★ Answer each question in a separate book.
- ★ Indicate on the cover of each book **the area** (HCI) of the exam, your **code number**, and the **question number** answered in that book. On one of your books, list the numbers of all the questions answered. Do not write your name on any answer book.
- ★ Return all answer books in the folder provided. Additional answer books are available if needed.

Specific Instructions

- ★ Answer all **6** questions.

Policy on Misprints and Ambiguities

The Exam Committee tries to proofread the exam as carefully as possible. Nevertheless, the exam sometimes contains misprints and ambiguities. If you are convinced that a problem has been stated incorrectly, mention this to the proctor. If necessary, the proctor can contact a representative of the area to resolve problems during the *first hour* of the exam. In any case, you should indicate your interpretation of the problem in your written answer. Your interpretation should be such that the problem is nontrivial.

Question 1. *Measurement Design*

Each semester, the Department of Computer Sciences uses a questionnaire to evaluate the courses offered by the Department. The Department is interested in redesigning this questionnaire to better capture student experience and to serve as a more valid and reliable measure of teaching quality. The questionnaire is intended to measure the course in dimensions of the instructor's teaching performance, the overall organization, quality, and usefulness of the course, and the overall student experience in the class. Based on Lazar et al.,¹ respond to the following considerations regarding the process of redesigning this measurement.

- (a) Describe the types of *questions* and *response types* that such a questionnaire might include, discussing their advantages and disadvantages.
- (b) List three of the common *problems* in survey questions that the designers of the new questionnaire must avoid.
- (c) Provide the Department with recommendations on how they should assess the *validity* and *reliability* of the new questionnaire.
- (d) Finally, discuss the advantages and disadvantages of administering the questionnaire *online* and *on paper*.

¹ Lazar, J., Feng, J. H., & Hochheiser, H. (2010). *Research Methods in Human-Computer Interaction*. Wiley.

Question 2. *Human-Performance Modeling*

The Keystroke-Level Model (KLM) developed by Card et al.² involved a set of physical operators, including *keyboard*, *pointing*, *homing*, and *drawing*, a *mental* operator for the user, and *response* operator for the system. A colleague of yours is interested in using the KLM to predict operator performance in a visual search task that involves monitoring a radar screen for targets to appear and choose from an interface the appropriate response and is finding the *mental* operator to be limited in capturing the variability how long mental operations take in his task domain. You would like to help your colleague in defining a more detailed set of operators for the non-physical, non-system processes in the task at hand.

- (a) Describe to your colleague the *subsystems* involved in Model Human Processor (MHP)³ that would be pertinent to the task and how they might serve you in extending the mental operator.
- (b) Based on these subsystems, propose a set of *new operators* to further detail the mental operator for the task that your colleague is considering.
- (c) Provide a back-of-the-envelope calculation of the *predicted time* it will take the user to respond to three targets appearing in the radar screen, assuming that three seconds pass between appearances, with the original mental operator and your proposed set of mental operators.⁴

² Card, S. K., Moran, T. P., & Newell, A. (1980). The keystroke-level model for user performance time with interactive systems. *Communications of the ACM*, 23 (7), 396–410.

³ Card, S. K., Moran, T. P., & Newell, A. (Eds.). (1983). *The psychology of human computer interaction*. Routledge. Also described in Card, S., & Moran, T. (1986, January). User technology—from pointing to pondering. In *Proceedings of the ACM Conference on The history of personal workstations* (pp. 183-198). ACM.

⁴ Use middleman. It is not necessary to use exact constant and parameter ranges used in KLM or MHP, but provide assumed values in your answer.

Question 3. *Interface Usability and Design*

Consider the popular text editor Emacs.⁵ Identify violations of three of the usability evaluation *heuristics* proposed by Nielsen,⁶ describing each heuristic and how the design of the text editor violates it. Propose design recommendations for these violations considering the three *interface paradigms* discussed by Cooper et al.,⁷ outlining what these paradigms are and how they might help you improve the design of the text editor.

⁵ If you are not familiar with Emacs, consider TextEdit on Mac OS X, Notepad on Windows, or gedit on Ubuntu.

⁶ Nielsen, J. (1993) *Usability Engineering*. Morgan Kaufmann.

⁷ Cooper, A., Reimann, R., & Cronin, D. (2007) *About Face 3*. Wiley.

Question 4. *Data Analysis*

You are asked to serve in a Ph.D. dissertation committee for your expertise in study design and data analysis. The student is planning a study in which she will evaluate the different visualization techniques she has developed for providing users with feedback on their energy use. She is weighing different study designs and qualitative and quantitative measures for her evaluation, but she is not sure what type of data analysis they will involve. She comes to you for advice.

- (a) The first option that she is considering is to deploy her system in a number of homes and use *open-ended interviews* with participants to better understand how people make sense of the information her system is presenting. If she follows this option, provide her with two methods for *qualitative data analysis*, discussing their advantages and disadvantages.
- (b) The second option she is considering is to deploy different versions of the system at different homes and comparing the effects of different feedback mechanisms on participants' energy use. If she follows this path, provide her with examples of energy-use measures of *nominal*, *ordinal*, *interval*, and *ratio* data types and describe what *statistical data analysis* method would be appropriate for each type of measure.
- (c) Another thought that comes up in your discussions with her is following the second option, but also collecting data using open-ended interviews. She asks you whether it would be possible to quantify data from the interviews and use statistical methods for analysis. Provide her with recommendations on methods for quantifying textual data and an appropriate statistical method for data analysis.

Question 5. *Experimental Design*

Experimental design involves a number of consideration about what variables should be manipulated, how these manipulations should be presented to participants, what should be controlled for, and so on. Based on Lazar et al.,⁸ provide answers to the following questions about experimental design in HCI research.

- (a) Describe *simple*, *factorial*, and *split-plot* designs, discussing their advantages and disadvantages.
- (b) What is a *covariate*, and how is it factored into these designs?
- (c) Discuss the advantages and disadvantages of *between-subjects*, *within-subjects*, and *mixed-model* designs.
- (d) Explain *random errors* and *systematic errors*, providing examples of sources for such errors.
- (e) Describe the five common sources of systematic error and common methods for controlling for these errors.

⁸ Lazar, J., Feng, J. H., & Hochheiser, H. (2010). *Research Methods in Human-Computer Interaction*. Wiley.

Question 6. *Statistical Data Analysis*

Hypothesis testing involves a careful consideration of a number of factors to determine whether our data provides support for our research hypothesis. Provide answers to the following questions based on Hinton.⁹

- (a) Describe the concepts *significance level*, *statistical power*, and *effect size*.
- (b) Explain how *statistical power* is affected by *alpha level* and *sample size*.
- (c) Describe the different *types of errors* involved in hypothesis testing and their relationship with *alpha level*.
- (d) Explain the differences between *one-tailed* and *two-tailed* predictions and their relationship with *significance level*.

⁹ Hinton, P.R. (2004). *Statistics Explained*. 2nd Edition. Routledge.