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

University of Wisconsin–Madison, Department of Computer Sciences

Fall 2011 — Monday, September 19, 2011

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** 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. *Study Design & Data Analysis*

You are employed by a company that develops educational apps for K-12 students. The company will be releasing a new algebra tutor app as a competitor to three existing products. Your boss asks you, as the company's HCI researcher, to evaluate the effectiveness of the new app, because they would like to claim that it improves learning. Your boss wants to show the effectiveness of the product but wants to avoid making any false claims. She also thinks that the product might facilitate learning in girls and boys and different age groups differently and asks you to consider these factors.

(a) Design an experiment in which you test the effectiveness of the app in teaching different algebra topics. Describe your experimental design, dependent and independent variables, factors and their levels, random and control variables.

(b) Describe how you will ensure your boss that your findings will not involve false claims.

(c) Describe the data analysis method you will employ to test for effectiveness and construct a statistical model that shows how each variable will be considered in the analysis. Exact mathematical expressions are not necessary in describing the statistical model, but describe how each variable is treated as consistent with your answer in part (a).

Question 2. *Usability Evaluation*

As novel interactive technologies such as speech interfaces, virtual agents, and robots become viable products for end users, designers of these technologies have to evaluate their usability using *formative* evaluation methods.

(a) Discuss the differences between summative and formative evaluation in the context of designing such systems, justifying the need for formative evaluation methods.

(b) Describe the advantages and disadvantages of *three* existing formative methods (that are in use to evaluate conventional interfaces) in evaluating usability of these novel technologies.

(c) Consider three stages of the design process, *user research*, *iterative design*, and *usability evaluation*, and describe how you would adapt an existing formative evaluation method to support each stage of the process.

Question 3. *Keystroke-level Modeling*

Card et al. (1980) developed a set of operators to model user actions and predict user performance with a computer. In particular, they devised the **K** (keystroking), **P** (pointing), **H** (homing), and **D** (drawing) physical operators, **M** (mental) cognitive operator, and **R** (response) system operator. Their predictions closely matched observations of real user actions.

(a) What are the limitations of this set of operations in modeling user actions in touch-based interfaces?

(b) If you were to add an operator to the original set of operators developed by Card et al. (1980) to model *swipe* and *drag*, (1) what existing model, principle, or operator would serve as a good approximation for this operator and (2) what would the parameters of such model be?

(c) Using this new operator predict the time it would take to sequentially drag three items from one edge of the screen and drop on the other edge.

Assumptions: Swipe and drag to require physically and mentally similar operations. Use middleman. Use constants and other parameters that you set for the operators in your prediction (e.g., **K** = 0.08 sec).

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.

Question 4. *Models of Interaction*

Consider a novel computer-mediated communication system that allows users to construct avatars that resemble them, place them in a virtual environment, channel their behaviors to the avatar in real time, and see and interact with the avatars of other people (e.g., Avatar Kinect).

(a) Discuss how such a system might or might not support the main tenets of *distributed cognition* (Hollan et al., 2000).

(b) Describe *three* theories of computer-mediated communication (Whittaker, 2003) that might apply to such a system and discuss how such a system might or might not support these theories.

(c) Consider the use of such as a system in the context of an organization, describe and discuss *three* challenges (Grudin, 1994) that the designers of such a system might face.

Hollan, J., Hutchins, E., & Kirsh, D. (2000). Distributed cognition: toward a new foundation for human-computer interaction research. *ACM Transactions on Computer Human Interaction*, 7 (2), 174–196.

Whittaker, S. (2003). Theories and methods in mediated communication. In Graesser, A., Gernsbacher, M., and Goldman, S. (Ed.) *The Handbook of Discourse Processes.* Mahwah, NJ: Lawrence Erlbaum Associates, pp. 243–286.

Grudin, J. (1994). Groupware and social dynamics: eight challenges for developers. *Communications of the ACM*, 37 (1), 92–105.

Question 5. *Research Design*

Edmondson and McManus (2007) suggest that qualitative research methods would be more appropriate for areas in which theory is *nascent*, while research in *mature* areas would most benefit from the use of quantitative research methods—what they call "methodological fit."

(a) What are some *exceptions* to this proposition?

(b) Provide justification and examples for these exceptions.

(c) Describe *three* example research questions and study designs—from the literature or of your own construction—with good methodological fit for *nascent*, *intermediate*, and *mature* areas.

Edmondson, A. C., & McManus, S. E. (2007). Methodological Fit in Management Field Research. *The Academy of Management Review*, 32 (4), 1155–1179.

Question 6. *Interaction Design*

Consider three interactive systems, (1) a humanlike social robot, (2) a multi-touch surface, and (3) an avatar-based computer-mediated communication system, and provide examples of the following *design elements* for each of the three systems:

(a) Perceptible, false, *and* hidden affordances (Gaver, 1991; Cooper et al., 2007)

(b) Constraints (Norman, 1999)

(c) Conventions, metaphors, *or* idioms (Norman, 1999; Cooper et al., 2007), choosing one and identifying which element the example represents

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Gaver, W. W. (1991) Technology affordances. In *Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI '91)*, pp. 79–84.

Norman, D. A. (1999) Affordance, conventions, and design. *Interactions* 6 (3), 38–43.

Cooper, A., Reimann, R., & Cronin, D. (2007) *About Face 3 (Chapters 13-14)*. Wiley, pp. 269–320.