Tutorials

Quantum models of cognition and decision

Dr. Jerome R Busemeyer, Indiana University
Dr. Zheng (Joyce) Wang, Ohio State University

The cognitive revolution that occurred in the 1960's was based on classical computational logic, and the connectionist/neural network movements of the 1970's were based on classical dynamical systems. These classical assumptions remain at the heart of both cognitive architecture and neural network theories, and they are so commonly and widely applied that they are just taken for granted and presumed to be obviously true. What are these critical but hidden assumptions upon which all traditional theories rely? Quantum information processing theory provides a fundamentally different approach to logic, reasoning, probabilistic inference, and dynamical systems. For example, quantum logic does not follow the distributive axiom of Boolean logic; quantum probabilities do not obey the Kolmogorov law of total probability; quantum reasoning does not obey the principle of monotonic reasoning. Nevertheless Mother Nature seems to rely heavily on quantum computing principles in many domains of science.

This tutorial provides an exposition of the basic assumptions of classic versus quantum information processing theories. These basic assumptions are examined, side by side, in a parallel and elementary manner. For example, classical systems assume that measurement merely observes a pre existing property of a system; in contrast, quantum systems assume that measurement actively creates the existence of a property in a system. The logic and mathematical foundation of classic and quantum theory is laid out in a simple and elementary manner that uncovers the mysteries of both theories. Classic theory is seen to emerge as a possibly overly restrictive case of the more general quantum theory. The fundamental implications of these contrasting assumptions are examined closely with concrete examples and applications to cognition. New research programs in cognition based on quantum information processing theory are reviewed.

Prerequisite knowledge: No prior knowledge beyond basic familiarity with cognitive psychology is needed.

Jerome Busemeyer is a Provost Professor at Indiana University in Psychological and Brain Sciences and Cognitive Science.

Zheng (Joyce) Wang is a professor at the Ohio State University in Communications.

Modeling Human Performance in C3TRACE

Dr. Walter Warwick, Alion Science and Technology

This half-day tutorial will present the fundamentals for modeling human performance using C3TRACE (Command, Control, and Communication Techniques for Reliable Assessment of Concept Execution). As a task network modeling environment, C3TRACE shares common assumptions and representational strategies with other tools (e.g., Micro Saint Sharp, IMPRINT). Unlike those other tools, however, C3TRACE has been extended to support the modeling and analysis of information flow across a command and control structure (Plott, Quesada, Killduff, Swoboda & Allender, 2004; Swoboda &

Plott, 2012). Our main focus in this tutorial will be to present the basic components of a C3TRACE mode in the task network, the operators, and the communication events.

By working though simple examples that demonstrate how the task network, the operators and the communication events are defined, I will provide attendees with a solid understanding of the scope and limits of human behavior representation in C3TRACE. I will also discuss the various methods used to analyze results from a C3TRACE simulation. This discussion is intended to provide the attendee with a better understanding of the typical applications of a C3TRACE model. Finally, if time and interest permit, I will briefly introduce some advanced (and non-typical) uses of C3TRACE to model human performance from the perspective of network science. These uses include both social network an

Prerequisite knowledge: No prior knowledge is needed.

Walter Warwick is a scientist with Alion Science and Technology.

The Soar Cognitive Architecture

John Laird, University of Michigan

The tutorial provides a whirlwind tour of Soar, starting with its historical background and the motivation for cognitive architecture, but focusing on how and why Soar works the way it does. We will the details of Soar, and it will be a combination of hands-on, where participants create simple Soar programs, and lecture. In the morning we will cover the syntax and structure of the original aspects of Soar (working memory, productions, subgoals and chunking), and participants will learn to run, modify, and debug small demonstration programs that illustrate the various parts of Soar. In the afternoon, we will present the new components of Soar (reinforcement learning, semantic memory, episodic memory, and mental imagery) using running programs. We guarantee to exhaust all participants and presenters, with plans for a debrief and further discussion at a bar of the participants' choice following the tutorial.

Prerequisite knowledge: Tutees should bring laptops, but laptops may be shared.

John Laird is the John L. Tishman Professor of Engineering at the University of Michigan, where he has been since 1986. He received his Ph.D. in Computer Science from Carnegie Mellon University in 1983 working with Allen Newell. From 1984 to 1986, he was a member of research staff at Xerox Palo Alto Research Center. He is one of the original developers of the Soar architecture and leads its continued evolution, including the recent development and integration of reinforcement learning, episodic memory, semantic memory, visual and spatial mental imagery, and appraisal-based emotion. He was a founder of Soar Technology, Inc. and he is a Fellow of AAAI, AAAS, ACM, and

How to analyze verbal protocols to support cognitive modeling

Dr. Thora Tenbrink, Bangor University, UK

This tutorial will support researchers who consider using, or have already collected, verbal protocols as data to inform cognitive models. After discussing the extent to which language can be useful to identify cognitive processes and principles, we will examine each step of the process from data collection via transcription, analysis, and triangulation towards specification for modeling purposes. The main emphasis will lie on the systematic analysis of linguistic choices. Besides a thorough understanding of what people say in a task setting, linguistic analysis should include specific aspects of how they formulate their ideas. Specific effort therefore needs to be placed on identifying linguistic indicators for specific cognitive phenomena that are of interest for the research purpose at hand. This tutorial will address the kinds of linguistic indicators that may support cognitive modeling, targeted towards the research interests of its audience. Participants are encouraged to contribute actively to this tutorial by bringing ideas and samples from their own research, pertaining to each step of the research process as just outlined. Email-based communication in advance of the tutorial will ensure a lively and highly interactive tutorial, supporting ongoing research in a practical way rather than theorizing about potential benefits. Related publication.

Prerequisite knowledge: There is no prerequisite for taking this tutorial.
Participants who have already collected natural language data are encouraged to bring examples as handouts or on their computers.

Thora Tenbrink is a Senior Lecturer in Cognitive Linguistics at Bangor University (UK), and a principal investigator in two projects in the SFB/TR 8 Spatial Cognition (Germany). Her main interest concerns complex cognitive processes and their representation in language. She is the author of Space, Time, and the Use of Language (Mouton de Gruyter, 2007), and co-editor of Spatial Language and Dialogue (Oxford, 2009) and Representing space in cognition: Interrelations of behavior, language, and formal models (Oxford, in press). Current research addresses cognitive strategies in various problem solving tasks, spatial communication in complex built environments, cognitive transformation processes, and inferences derived by problem solvers from situational clues, experience, and verbal and graphical information. Although not a cognitive modeler herself, Thora has a thorough understanding of the prerequisites for implementing insights about cognition in a cognitive architecture (ACT-R and other frameworks). Her main overarching research goal is to specify cognitive processes and principles sufficiently precisely to allow for such an implementation. This is achieved by systematic linguistic analysis of verbal data collected along with cognitively complex tasks, informed by insights about the cognitive import of specific linguistic choices. See http://knirb.net for further information.

Measuring simulation-observation fit: An introduction to ordinal pattern analysis

Prof. Warren Thorngate, Carleton University

As cognitive simulations and their outputs become more complex, it becomes more important to develop simple means of measuring how closely they match empirical observations. Current goodness-of-fit tests based on the General Linear Model are restrictive. Simulation research would be better served by alternative methods that are (1) easy to calculate and understand, (2) forgiving of missing and non-normal data, (3) designed to examine time series and other statistically dependent measurements, and that (4) allow us to analyze individual cases before aggregating them. Such a method was invented by Denys Parsons in the mid-1970s to encode musical tunes. I have adapted it to measure and compare simulation-observation fits. This workshop will introduce the method, which can be done on your fingers, demonstrate how it works with a short, voluntary sing-along, and show participants how to use it with the freely-available computer programme provided.

The content of this workshop will be similar to the content of Thorngate & Edmonds' recent article in the Journal of Artificial Societies and Social Simulation (http://jasss.soc.surrey.ac.uk/16/2/4.html), but with examples drawn from cognitive psychology and decision-making simulation research.

Prerequisite knowledge: Some knowledge of modeling and sequential data would be helpful but is not required.

Warren Thorngate is a failed classical guitarist and emeritus professor of psychology at Carleton University, specializing in research on human judgment and decision making, social and cross-cultural psychology, statistics and research methods. Most of his recent work has focussed on the social and economic consequences of assorted judgment and decision making processes. He is the first author ofJudging Merit (with Robyn Dawes & Margaret Foddy), a recently-published book on the pathologies of competitions and contests. He has also undertaken several education and development projects in what was once called the Third World, and is currently producing videos of ordinary people telling stories about their extraordinary lives. Works in progress include a book on the economics of attention and the marketplace of ideas, and another on the ecology of problems and the limits of time.