Contents

Welcome

Dear Colleague,

We are happy to welcome you to the 45th annual meeting of the *Society for Mathematical Psychology* being held at the Hyatt Regency, Columbus, Ohio. This years conference features plenary addresses from Gregor Schöner, Roger Ratcliff, and the 2011 winner of the William K. Estes Early Career Award, Charles Kemp. There are also 4 invited symposia, 103 accepted talks and 32 posters.

Before the start of the conference, there will be a half-day workshop on July 21th on Building Human Cognitive Models Using Quantum Probability and Dynamics followed by the Women's symposium in the afternoon.

We would especially like to acknowledge the generous financial support of the Air Force Office for Scientific Research (AFOSR), and the National Science Foundation (NSF). Their support made an important contribution to many aspects of this year's conference, including especially support for students, our invited speakers, and the poster session..

Best regards, The organizing committee: Simon Dennis, Trisha van Zandt, Richard Golden, Michael Lee, Annemarie Zand Scholten, Mark Pitt, Roger Ratcliff and Eric-Jan Wagenmakers.

Program Booklet Credits

General content; figures 1 – 3:	Conference Committee
Abstracts; figure 4:	Their respective authors
LaTeX-code generation, lay-out, cover:	Timo Kluck, Infty Advies (www.infty.nl) & MLC Inc.

General Information

Locations

The conference will be held at the Hyatt Regency Columbus, 350 North High Street. Registration will be available on the second floor outside the meeting rooms (Farfield, Knox and Marion) and also at the reception which will be held in Peppercorn. The venues for the different activities are:

- *County Foyer*: Continental breakfasts and coffee breaks
- *Fairfield*: Workshop: Building Human Cognitive Models Using Quantum Probability and Dynamics
- *Fairfield*: Women's Symposium: Bridging the "Gaps"
- *Peppercorn*: Reception
- *Fairfield*: Keynotes
- *Fairfield*: Session A
- *Knox* : Session B
- *Marion*: Session C
- *Clark*: Journal of Mathematical Psychology meeting
- *Morrow*: Poster Session
- *Clark* : Society for Mathematical Psychology executive meeting
- *Franklin CD*: Banquet

Quantum Workshop

A pre-conference workshop on "Building Human Cognitive Models Using Quantum Probability and Dynamics" will be held on Saturday the 21st of July starting at 9am. The organizers are Jerome Busemeyer and Zhang Weng.

Women's Symposium

A pre-conference women's symposium on "Bridging the Gaps" will be held on Saturday the 21st starting at 1pm. The keynote will be Betty Tuller, who is a program officer of the Perception, Action and Cognition panel of the National Science Foundation.

Reception

The reception is from 7pm to 9pm in the Peppercorn Room.

Funding Opportunities

On Sunday at 5pm there will be a session discussing funding opportunities for mathematical psychology. The speakers will be Betty Tuller (NSF), Jay Myung (AFOSR) and Scott Brown, who will be outlining opportunities in Australia. The session will run concurrently with the first half hour of the poster session.

Presentation Guidelines

Talks

Except for the plenary addresses, all the talks will be in one of three concurrent sessions. Many people will wish to hear specific talks and to shuttle among the parallel sessions. Consequently, it is essential for each session to run strictly on schedule and for the sessions to begin on time. For all the regular talks, the presentation time will be limited to a total of 20 minutes, which includes a five minute period for discussion. Talks will be strictly timed. We ask either the author or the coauthor of the last paper in each session to be the session Chair and to keep time for the session. Each session is relatively short and has either four or five talks. Please install your talk on the computer in the room well before the beginning of the session. There will be some assistance if needed for loading the talks on the computer. The computers in each presentation room will be a PC.

Posters

Poster presentations will be held on Sunday July 22nd between 5:00 pm to 6:30 pm. The posters will be in Morrow. Each poster board will have the first author's name attached and posters will be organized alphabetically.

Conference Dinner

The conference dinner will be on Monday July 23rd starting at 6:30pm in Franklin. A cash bar will begin at 6pm.

Breakfast

A breakfast which will be provided Sunday, Monday, and Tuesday from 8am-9am in the County Foyer.

Lunch

A food court is housed within the hotel complex and will be available for lunch. If you would like to leave the building, the section labeled Places to Eat below provides a list of possibilities in the Arena district.

Places to Eat

You'll discover many great restaurants, bars and entertainment venues in Columbus, Ohio's Arena District, a popular urban destination located very close to our downtown Columbus hotel. The Arena District in Columbus is a mixed-use space featuring contemporary design, a slick urban atmosphere and plenty of diversions for both locals and travelers alike.

- Boston's The Gourmet Pizza
- Cotters Restaurant
- BD's Mongolian BBQ
- Buca di Beppo
- Gordon Biersch Brewery Restaurant
- Max & Erma's
- R Bar Arena
- O'Shaughnessy's Public House
- Ted's Montana Grill
- W.g. Grinders
- Rodizio Grill
- Sunny Street Caf
- The Three-Legged Mare

Internet Access

Wireless internet will be available in guest rooms and for presenters in the session rooms. Internet will not be available for registrants in the session rooms, but is available in the hotel lobby. If you wish to use the internet during your presentation please see one of the student volunteers and they will be able to supply you with the approrpiate access code.

Travel

An interactive map to the hotel can be found at `columbusregency.hyatt.com`

- From I-71 North Bound: Take I-71 to I-70 East and exit on Fourth St. Follow Fourth St to Nationwide Blvd. Turn Left at Nationwide Blvd. Hyatt Regency Columbus is on the Right.

- From I-71 South Bound: Exit on Spring St (the exit is to the Left). From Spring St turn Right onto Fourth St (get into the far Left lane). Turn Left on Nationwide Blvd. Hyatt Regency Columbus is located on the Right.

- From I-70 East or West Bound: Exit on Fourth St. Follow Fourth Street to Nationwide Blvd. Turn Left on Nationwide Blvd. Hyatt Regency Columbus is located on the Right.

- From Rte #33 North/West Bound: Exit to I-70 West Bound. From I-70 exit at Fourth St. Follow Fourth St to Nationwide Blvd. Turn Left on Nationwide Blvd. Hyatt Regency Columbus is located on the Right.

- From U.S. Rte #33 South/ East Bound: Take U.S. Rte. #33 South or East (depending where you are on U.S. Rte. #33). (Rte. #33 is also known as Riverside Dr in the Dublin/Upper Arlington area, or as Long St once you are in the Downtown area). Once you reach Downtown, turn Left onto High St (U.S. #23 North). Follow High Street to Nationwide Blvd. Turn Right on Nationwide Blvd. Hyatt Regency Columbus is located on the Left.

- From U.S. Rte #23 (High Street) North Bound: Take U.S. #23 (High Street-within Rte. #270) North until you reach I-270 By-pass. Take I-270 West. Follow I-270 West to I-71 North. Follow I-71 North to I-70 East. Follow I-70 East to Fourth St exit. Follow Fourth St to Nationwide Blvd. Turn Left on Nationwide Blvd. Hyatt Regency Columbus is located on the Right.

- From U.S. Rte #23 (High Street) South Bound: Take U.S #23 (High Street - within I-270) South to I-270. Take I-270 East. Follow I-270 East to I-71. Take I-71 South to the Spring St exit (exit is to the Left). Follow Spring St to Fourth St. Turn Right onto Fourth St and get into the far Left lane. Follow Fourth St to Nationwide Blvd. Turn Left onto Nationwide Blvd. Hyatt Regency is located on the Right.

- From Port Columbus Int'l Airport: Departing from the terminal at the Port Columbus International Airport, you are on International Gateway Drive. Go through the traffic light at Stelzer Rd. Follow the signs to Rte. #670 West. Follow Rte #670 West until you come to Third St./Convention Center

exit. Take the Third St. exit and follow to Chestnut St. Turn Left on Chestnut St. Turn Left on to Fourth St. Turn Left onto Nationwide Blvd. Hyatt Regency Columbus is located on the Right.

- From Rte #315 South Bound: Follow 315 South to 670-East to the Neil Ave. exit. At stoplight turn Right onto Neil Ave. Turn Left onto Nationwide Blvd. Nationwide will cross over High St. The Hyatt Regency Columbus is located on the Left.

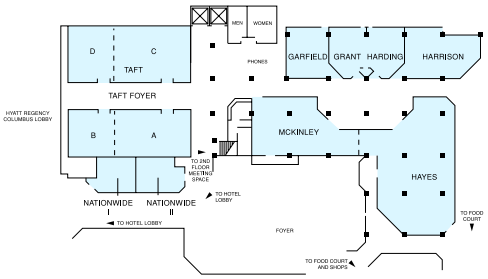
Floorplan

Hyatt Regency Columbus

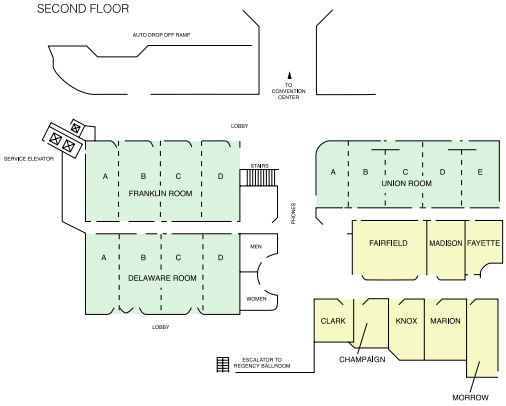
DIRECTIONS

From Port Columbus International Airport (7 miles): Take I-670 West to the Third St. Exit. Turn right at the first stoplight (Chestnut St.), turn right at High St. and right at Nationwide Blvd. Hotel is on the left.

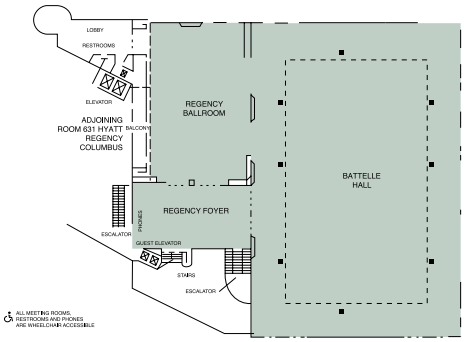
MEETING ROOMS
FIRST FLOOR



MEETING ROOMS
SECOND FLOOR



REGENCY BALLROOM
AND EXHIBIT ROOM
THIRD FLOOR



11.09

Abstracts For Plenary Talks

(Plenary abstracts organized by day)

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Saturday, 1:00

Session A

Staying in the academic pipeline (despite detours and delays). Betty Tuller, *National Science Foundation*. For many decades, an increasing number of women have obtained STEM doctoral degrees, however, women, particularly women of color, continue to be significantly underrepresented in almost all STEM academic positions. While the degree of underrepresentation varies across disciplines, women's advancement to senior professorial ranks and leadership roles is an issue in all fields. In this talk, I will discuss research showing that women's representation and advancement in academic positions are affected by many external factors that are unrelated to their ability. Such factors include, but are not limited to, stereotype threat, societal impacts, organizational constraints of academic institutions, differential effect of work and family demands, implicit and explicit bias, and lack of women in academic leadership and decision-making positions. I will also discuss what women can do to attenuate these infrastructural barriers, at home and in the university, using scenarios from my own experiences.

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Sunday, 1:45

Session A

Dynamic Field Theory as a mathematical framework for understanding embodied cognition. Gregor Schoener, *Ruhr-Universitaet Bochum*. Dynamical Systems thinking has been influential in the way psychologists, cognitive scientists, and neuroscientists think about sensori-motor behavior and its development. The initial emphasis on motor behavior was expanded when Dynamic Field Theory (DFT) provided access to embodied cognition. DFT is a famework for thinking about representation-in-the-moment that is firmly grounded in both Dynamical Systems thinking and neurophysiology. Dynamic fields are formalizations of how neural populations represent the continuous dimensions that characterize perceptual features, movements, and cognitive decisions. Dynamic fields evolve dynamically under the influence of inputs as well as strong neuronal interaction from which elementary forms of cognition like detection, selection, and working memory emerge through dynamical instabilities. I will show how DFT establishes links between brain and behavior in paradigms in which behavioral signatures of neural mechanisms can be observed. I will illustrate how models based on DFT provide quantitative accounts of behavior and make testable predictions, but also how these process models may be linked to sensory and

motor systems to actually generate behavior in autonomous robots. Finally, I will explore how an embodied approach to cognition based on DFT can be scaled to understand cognitive architectures.

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Monday, 1:45

Session A

Psychological theories of the middle range. CHARLES KEMP, *Carnegie Mellon University*. Psychologists have developed theories at many levels of generality, including theories of specific phenomena (e.g. models of categorization) and general-purpose cognitive architectures (e.g. ACT-R). A theory of the middle range lies between these extremes and provides a unifying view of a class of specific phenomena. I will present three such theories that focus on structure learning, inductive reasoning, and concept learning. The first theory helps to explain how humans learn qualitatively different representations for different domains. The second is a taxonomy of inductive problems that helps to clarify the relationships between familiar problems such as property induction, categorization, and generalization, and that introduces new problems for psychological investigation. The third theory aims to explain how humans learn about kinship systems and other systems of objects, features and relations.

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Tuesday, 12:15

Session A

Modeling confidence and multichoice decisions in memory and perception. ROGER RATCLIFF, *Ohio State University*, JEFF STARNS, *University of Massachusetts at Amherst*, CHELSEA VOSKUILEN, *Ohio State University*, VICTOR INTERMAGGIO, *Ohio State University*. We apply a new version of the Ratcliff & Starns (2009) diffusion model for confidence judgments to a variety of tasks in memory and perception. The model has previously been fit to quantile reaction times and confidence judgments from item recognition memory experiments. We first present results from fits to manipulations in item recognition including number of response options, item strength, and speed and accuracy emphasis. We also present applications of the model to associative recognition and to perceptual brightness discrimination tasks. Much of the research examining various models of memory has focused on differences in the locations and shapes of zROC curves across tasks. In both item and associative recognition our model was able to fit and explain a variety of zROC shapes as well as individual differences in these shapes. Additionally, for the perceptual task, we added known variability to conditions and this allowed us to examine how the model accounts for variance in latent distributions of evidence. Finally, we adapted the model and applied it to a 3 choice motion discrimination task. In the item recognition and motion discrimination tasks, we were able to discriminate between the new model and three competing models with decay in evidence (including the leaky competing accumulation model)

Abstracts For Symposium Talks

(Symposium abstracts organized by day and presentation order)

Big Data

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Sunday, 9:00

Session A

The recurrence structure of context and its effect on memory performance. Vishnu Sreekumar, *Ohio State University*, Simon Dennis, *Ohio State University*, Yuwen Zhuang, *Ohio State University*, Mikhail Belkin, *Ohio State University* . With the advent of sensor technology, it is now possible to measure people's lives outside of the laboratory and provide better ecological validity for studies of episodic memory. We analyzed the geometry, dynamics and network structure of text corpora (for semantic contexts) and images (for visual contexts) that were taken automatically by an android phone worn around the neck. The results suggest that the contexts people experience are highly repetitive and exist in a low dimensional manifold, which may explain why interference in memory is dominated by confusion between contexts. We had subjects segment and tag streams of their visual contexts. At the end of the month-long data collection phase, a week discrimination test is administered after a retention interval of 5 days. Both accuracy and reaction time data are collected. Preliminary data suggest that visual contexts are fairly discriminable between weeks but performance is affected due to recurrence of contexts. We also find a negative point biserial correlation between accuracy and average fan of the cue set. Finally, we attempt to model the data using a version of the Context, Occurrence, Cooccurrence and Order (COCO) model (Osth& Dennis, in prep).

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Sunday, 9:40

Session A

Dimensional information-theoretic measures of affective expressivity. Jihun Hamm, *Ohio State Univeristy*, Christian Kohler, *University of Pennsylvania*, Ruben Gur, *University of Pennsylvania*, Ragini Verma, *University of Pennsylvania* . Objective: Abilities in recognition and expression of emotions have crucial impact on social lives of individuals. While several objective measures of affect recognition are available, measures of deficits in expressivity are mostly observer-based. We present two dimensional measures of facial expressivity ' ambiguity (vs consistency) and distinctiveness (vs inseparability) ' computed objectively from information-theory. We use these measures to study expressivity deficits in schizophrenia compared to a healthy comparison group. Method: The sample included 28 schizophrenia patients without tardive dyskinesia or acute extrapyramidal symptoms and 26 healthy controls matched

by gender, race, age, and parental education. Subjects were administered facial emotion recognition tests for assessing recognition accuracy, and were administered evoked emotion video acquisition procedures for assessing expression ability of basic emotions (happiness, sadness, anger, fear, and disgust). The videos were then analyzed using information-theoretic measures and clinician-rated flatness and inappropriateness. Results: Patients performed more poorly on affect recognition, but had even greater deficits in expressivity, with highest effect sizes demonstrated by ambiguity and distinctiveness. Ambiguity and distinctiveness were positively and negatively correlated with inappropriateness, and distinctiveness was negatively correlated with flatness. Conclusions: The information-theoretic measures provide equal or better power of differentiating schizophrenia with the advantage of being fully automated and without inter-rater reliability issues. It offers more focused targets for intervention, and efficient means for assessing its effects. The proposed analysis is general and applicable to other populations and experimental settings for quantitative and objective measures of emotion expression deficits.

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Sunday, 9:20

Session A

Automatic Annotation of Daily Activity from Smartphone-based Multisensory Streams. Jihun Hamm, *Ohio State Univeristy*, Benjamin Stone, *Ohio State University*, Mikhail Belkin, *Ohio State Univeristy*, Simon Dennis, *Ohio State Univeristy* . We present automatic annotation methods of daily experience for lifelogging systems. Our approach differs from previous approaches in that 1) we use smartphones as platform to facilitate naturalistic data collection, 2) we predict high-level tags that cover activity, place, and people, instead of a few posture or locomotion types, and 3) we use image and audio streams along with the usual motion and location, with a flexible fusion framework that incorporates heterogeneous sensory modalities. Using 43 days of real-life data, we made a systematic comparison of annotation accuracy of different modalities. Image and audio (0.90) were more accurate than accelerometer or GPS (0.81 and 0.79) in spite of reduced information to address privacy. Furthermore, the proposed fusion methods were consistently accurate while individual modalities failed to recognize certain activities. Our work brings us closer to accurate and practical solution to automatic annotation for lifelogging system.

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Sunday, 10:00

Session A

A Simple Model for Social Media. Xiangen Hu, *The University of Memphis*, Tai Wang, *Central China Normal University*, Usef Faghihi, *The University of Memphis*, Tianhai Tian, *Monash University* , Zhiqiang Cai, *The University of Memphis*. We present a simple model for social media. The goal of this model is to understand how social media such as twitter, facebook, or corporate internal messaging system work. The basic components of this model are memes and agents. The model is created based on the idea of a popular book "Virus Of The Mind" (Richard Brodie, 2008). In this model, Memes are implicit semantic dimensions contained in text messages and agents are senders and receivers of messages. With these assumptions, an agent in a social media is uniquely specified by its activities such as sending

and receiving messages, liking or disliking posts, etc. Similarly, a meme in a social media is implicitly determined by the messages sent and received by the agents. We will present some basic analysis of the model with simulations. We believe this intuitive approach may eventually help us better understand social media.

Bayesian Methodology

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Sunday, 10:45

Session B

Blending Generative and Discriminative Models: A Bayesian Framework for Prediction and Classification. Brandon Turner, *University of California, Irvine*, Mark Steyvers, *University of California, Irvine*. Often psychologists are interested in examining the properties of generative models because they provide key insight to the underlying structure of the data. However, we are sometimes faced with the task of predicting or classifying "unlabeled" data from training data with known labels. We first illustrate the hybrid modeling approach that blends generative models with discriminative ones. We then show in a series of applications, that the hybrid modeling approach is useful for converting generative models (e.g., the Linear Ballistic Accumulator model) into prediction and classification tools.

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Sunday, 11:05

Session B

Why your mom was wrong about playing with your food: Bayesian nonparametric methods. Joseph Austerweil, *University of California, Berkeley*. A fundamental problem in Bayesian modeling is defining a model with an appropriate structure and prior distribution. Bayesian nonparametrics solves this issue by defining a prior distribution over models that are potentially infinitely complex, but penalizes models that are more complex. This results in a model that creates the minimal amount of structure to adequately capture its observations. In this talk, I outline the use of Bayesian nonparametrics as psychological models of categorization and feature learning. In particular, I address common misconceptions, relations between Bayesian nonparametrics and standard parametric models, and different constructions of Bayesian nonparametric models (culinary metaphors and stick-breaking). Finally, I discuss Bayesian nonparametric models from the unifying perspective of the Poisson process.

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Sunday, 11:25

Session B

A diffusion model account of the relationship between the emotional flanker task and rumination and depression. Joachim Vandekerckhove, *University of California, Irvine*, Madeline Pe, *University of Leuven, Belgium*, Peter Kuppens, *University of Leuven, Belgium*. We apply a pragmatic combination of Bayesian hierarchical modeling and simulation-based model comparison to investigate the relationship between a behavioral measure of cognitive interference and two trait variables: depression and tendency to ruminate. We demonstrate that the data analysis strategy that is common in this area fails to yield a pattern that is consistent with cognitive theories of depression. We then apply a hierarchical diffusion model and do recover the expected relationships. We additionally apply a novel simulation-

based model fitting technique with which we evaluate the need for a process model that assumes attentional shifting or spotlighting in our emotional flanker task.

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Sunday, 11:45

Session B

Some Bayesian re-analyses acknowledging uncertainty. Michael Lee, *UC Irvine*. Many attempts to draw inferences from data in the psychological sciences are not Bayesian, and so often fail to incorporate the uncertainty that should surround measures and conclusions. We present three Bayesian re-analyses of exsiting studies, exploring to what extent acknowledging uncertainty changes the conclusions we reach. The first example deals with correlation between variables, where the values of those variables themselves are subject to measurement uncertainty. The second example deals with splitting subjects into high and low groups based on their accuracy, and looking for differences in reaction times between these two groups. The third example deals with individual differences in a signal detection study, using a small number of trials to look at differences in discriminability between reasoning tasks.

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Sunday, 12:05

Session B

ABCDE: A practical likelihood-free Bayesian analysis technique with applications to mathematical models of cognition. Per Sederberg, *Ohio State University*, Brandon Turner, *University of California, Irvine*. Many cognitive models derive their predictions through simulation. This means that it is difficult or impossible to write down a probability distribution or likelihood that characterizes the random behavior of the data as a function of the model's parameters. In turn, the lack of a likelihood means that standard Bayesian analyses of such models are impossible. In this presentation we demonstrate a procedure called approximate Bayesian computation (ABC), a method for Bayesian analysis that circumvents the evaluation of the likelihood. Although they have shown great promise for likelihood-free inference, current ABC methods suffer from two problems that have largely prevented their mainstream adoption: long computation time and an inability to scale beyond models with few parameters. We introduce a new ABC algorithm, called ABCDE, that includes differential evolution as a computationally efficient genetic algorithm for proposal generation. ABCDE is able to obtain accurate posterior estimates an order of magnitude faster than a popular rejection-based method and scale to high-dimensional parameter spaces that have proven difficult for the current rejection-based ABC methods. To illustrate its utility we apply ABCDE to a number of well-established simulation-based models of memory and decision-making that have never been fit in a Bayesian framework.

Nonlinear Dynamics

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Sunday, 4:10

Session A

Dynamics of Coupling Explains Entrainment and Coordination in Human Activity. John Holden, *CAP Center for Cognition, Action and Performance*. Human cognition and action viewed through the lens of coupled system dynamics. Oscillatory systems, whether physical or biological, have a natural affinity to co-

ordinate their behavior if linked by a physical or informational medium. This basic principle informs an understanding of behavioral systems. Multi-agent examples explain cooperation expressed across distributed tasks, and in anticipation of a dynamic environment. Intra-individual coupling is illustrated in the control of goal directed movement, and the dynamics of speeded word naming. Likewise, the emergent dynamics of ensembles of neurons are modeled using similar principles. Steven Harrison discusses how cooperative tasks, distributed between two or more agents, can be understood and predicted using coupled oscillator theory. Nigel Stepp introduces a general framework for anticipatory coupling motivated by the behavior of certain classes of coupled differential equations that exhibit anticipation. How does a many-degrees-of-freedom behavioral system compress them to express a particular activity? Nikita Kuznetsov demonstrates how so-called coordinative synergies, reciprocal linkages among system components, resolve this problem. Principal components analysis reveals coordinative synergies in a behavioral system. Jay Holden discusses how pronunciation time distributions from large speeded word-naming data sets express patterns consistent with multiplicative and reciprocal feedback dynamics entailed in coordinative synergies. Chris Kello introduces a critical branching network model of neural spiking. The model's self-tuning dynamics account for the patterns of 1/f scaling observed in speech and cued response behaviors. The presentation focuses on interactions emerging across time scales, and their relation to multi-scale biological and cognitive interactions.

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Sunday, 3:10

Session A

Dynamics of Coupling Explains Entrainment and Coordination in Human Activity. Steven Harrison, *CAP Center for Cognition Action and Performance*. See general symposium abstract.

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Sunday, 3:30

Session A

Dynamics of Coupling Explains Entrainment and Coordination in Human Activity. Nigel Stepp, *HRL Laboratories, Malibu, CA*. See general symposium abstract.

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Sunday, 3:50

Session A

Dynamics of Coupling Explains Entrainment and Coordination in Human Activity. Nikita Kuznetsov, *CAP Center for Cognition, Action and Per*. See general symposium abstract.

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Sunday, 4:30

Session A

Dynamics of Coupling Explains Entrainment and Coordination in Human Activity. Christopher Kello, *University of California, Merced*. See general symposium abstract.

Neural Models of Cognition

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Tuesday, 10:45

Session A

Inhibitory control in mind and brain 2.0: A blocked input model of saccadic countermanding. Gordon Logan, *Vanderbilt*. Motonori Yamaguchi, ,

Thomas J. Palemeri, *Vanderbilt*, Jeffrey D. Schall, . Boucher, Palmeri, Logan and Schall (2007) proposed an interactive race model of saccadic countermanding that accounted for behavioral data and single neuron activity in monkeys, which assumed that a stop unit representing fixation cells in frontal eye fields inhibited activation in a go unit representing movement cells in the same area. To fit the data, inhibition had to be asymmetrical; stronger from stop to go than from go to stop. We propose an alternative model in which countermanding is accomplished by blocking the inputs to the movement cells, which prevents them from reaching threshold. We show that the blocked input model accounts for behavioral data and neural data as well as the interactive race model. Then we extend the models so they address the steady-state period before a saccade begins in which fixation cells are active (maintaining fixation) and movement cells fire at baseline. When we model the fixation activity as well as the movement, the blocked inpu! model fits behavioral data much better than the interactive race model and accounts for the neural data just as well.

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Tuesday, 11:05

Session A

Using the Context Maintenance and Retrieval model to interpret the neural phenomena of memory search. Sean Polyn, *Vanderbilt University*. The Context Maintenance and Retrieval (CMR) model describes how an internally maintained context representation, sensitive to the temporal, semantic, and source characteristics of studied material, is constructed, and is then used as a retrieval cue to guide memory search. I will present a series of free-recall studies (using scalp EEG, ECoG, and fMRI) in which neural activity patterns were recorded during study and recall periods. In each of these studies, multivariate pattern analysis techniques are used to relate neural phenomena to the cognitive dynamics characterized by the CMR model. In particular, the model provides an explanation of organizational phenomena in free recall, whereby similar items are clustered during memory search. Neural signals observed during study predict subsequent recall organization, and neural signals at recall track clustering behavior. According to the model, these study-period effects may reflect the formation of associations between items and a retrieval cue, and the recall-period effects may reflect the deployment of that cue. Bringing neural data into contact with a computational model benefits both neural and cognitive theories: The model provides a functional interpretation for a number of neural phenomena, and in turn, the details of the neural phenomena can be used to constrain the form of the model.

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Tuesday, 11:25

Session A

Spiking neuronal circuit model of decision-making: From neurotransmitters to psychophysics and behavioral disorders. Kongfatt Wong-Lin, *University of Ulster*. Biophysical modeling of cognition requires a balance between incorporating the amount of biological details and computational efficiency. The "integrate-and-fire neuronal type models seem to be the right level to bridge from neurotransmitters to cognition. Here, I shall discuss such modeling approach to understand the neural mechanisms underlying simple decision-making. Specifically, I will discuss a cortical microcircuit model of decision-making that consists of spiking

neurons coupled with realistic synaptic dynamics. The model can mimic neuronal spike rates and behavioral performance (accuracy and reaction time) recorded in behaving animals. The reduced form of the model can allow theoretical analysis of its emergent dynamics, provide conceptual understanding, and relate to other more abstract decision-making models. The model can be subjected to learning and adaptation through synaptic plasticity and neuromodulation. Under different levels of neuromodulation, it can exhibit symptoms of abnormal decision-making. As the neurons that emit the neuromodulators can also be similarly modeled, it may eventually lead to the integration of large-scale, sufficiently realistic neural models of cognition constrained by neurophysiology and behavior. This type of models also has the potential to provide systems level understanding of brain and behavioral disorders related to abnormal decision-making.

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Tuesday, 11:45

Session A

Electrophysiology of Encoding and Retrieval in Memory Search. Michael Kahana, *University of Pennsylvania*. Using the free recall paradigm we have investigated the neural correlates of memory encoding and retrieval using electrocorticographic and single neuron recordings in neurosurgical patients and using scalp EEG in healthy young and older adults. A major focus of this effort has been to understand how spectral features of the time-series of the brain's electrical activity correlate with memory encoding and retrieval processes. I will present an update on this program of research and discuss the role of these types of neural measurements in the further development and testing of cognitive theories of memory.

Abstracts For Talks

(Symposium abstracts organized alphabetically by last name of presenting author)

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Monday, 11:45

Session B

A Statistical Development and Comparison of Two Useful Recognition Memory Models. Gregory Alexander, *University of California, Irvine*, William Batchelder, *University of California, Irvine*. It's been fifty plus years since James P. Egan (1958) wrote his famous technical report, 'Recognition Memory and Operating Characteristics', and yet recognition memory modelers are still debating over the 'Correct Theory' of recognition memory. We believe all recognition models are wrong, but several of them have been very useful in such areas as medical science, ethnography, forensic psychology, memory and psychophysics. In particular, we believe there are more things going on in recognition memory than the few degrees of freedom available to a modeler. In this spirit, we take a new look at the Gaussian Signal Detection model (SDT) and the Double High-Threshold (DHT) models for Old/New recognition memory data. Advocates of SDT do not like the restriction of equal variance for Old and New items, and advocates of the DHT model do not like the assumption that the detection probabilities for Old and New items are equal. We add a third response option, 'Unsure', and modify both models accordingly. The new models are saturated with four parameters in a product trinomial data structure, but either one or both models can't fit many possible data tables. To handle the sampling assumptions we develop Bayesian hierarchical versions of both models, and we fit both models to data allowing heterogeneity in both subjects and items. Our focus is not on proving one of the models is better than the other, but instead we focus on when both models give the similar stories about sensitivity and bias.

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Tuesday, 10:00

Session B

Cultural Consensus Theory for Multiple Consensus Truths. Royce Anders, *University of California, Irvine*, William Batchelder, *University of California, Irvine*. Cultural Consensus Theory (CCT) is a popular methodology used in the social and behavioral sciences to determine consensus knowledge shared by a group of informants (respondents), and to better understand the individual informant properties within the group (e.g. degree of cultural knowledge, response biases). Before the present paper, a central assumption for most CCT models has been the single truth assumption, namely that there is a single consensus answer key applicable to all informants. The single truth assumption has restricted CCT applications from being applied to data sets where subgroups of infor-

mants may have a different sense of shared truth on some of the items. The present paper resolves this restriction by developing the primary CCT model for dichotomous True/False response data, known as the General Condorcet Model (GCM), to accommodate more than one consensus answer key. This extended GCM is developed axiomatically, and notable properties of the model are derived. Novel data-exploratory tests that help to detect multiple answer keys are presented. Comparisons of the extended GCM under different numbers of consensus answer keys are made on both simulated and real data. Inference for the models is performed using hierarchical Bayesian methods with Markov Chain Monte Carlo samplers. It is found that the extended GCM can achieve a strong recovery of the generating parameters on simulated data that have multiple answer keys, as well as provide interesting and new interpretations of real data sets that the classical, single-truth GCM fails to handle.

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Sunday, 3:50

Session C

Bayesian Hierarchal Parameter estimation in Forgetting. Lee Averell, *University of Newcastle*, Andrew Heathcote, *University of Newcastle*. Understanding of the processes of forgetting is usually gained by modeling data with simple 2 or 3 parameter non-linear functions (Averell and Heathcote, 2011). Parameters in these models capture different aspects of the loss of information over time. Predominantly, an analysis of which, of several competing models, best describes forgetting data is the focus of studies. A somewhat less well studied area is whether it is necessary to allow the parameters in these models to vary over experimental conditions which, according to theory, should affect memory performance. A rigorous investigation of parametric variability across experimental conditions can assist in understanding the processes of both memory and forgetting. However, a combination of methodological and statistical shortfalls has arrested progress in this area. We make use of advances in Bayesian estimation to investigate parametric variability in forgetting models as a function of encoding and retrieval manipulations. Results are discussed with reference to the depth of encoding and multiple memory systems debates.

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Sunday, 11:25

Session A

Auditory Goodness of Pattern Judgments. Karina-Mikayla Barcus, *Ohio University*, Ronaldo Vigo, *Ohio University*, Yu Zhang, *Ohio University*. What makes some patterns of discrete sounds more pleasing than others? Garner (1971) proposed that with respect to visual stimuli, spatial symmetries were good predictors of "goodness of visual pattern judgments." In the current study, we investigated this question empirically from the standpoint of the dimensional structure of sets of auditory stimuli defined over the dimensions of timbre, tone, and duration. The results indicate that auditory goodness of pattern judgments follow a clear preference ordering that is well accounted for by the categorical invariance model (Vigo, 2009, 2011, 2012). Furthermore, they point the way towards a simple explanation as to why humans have certain types of aesthetic musical and visual arts preferences: namely, that there is an implicit additive tradeoff between the perceived degree of "patternfulness" of a stimulus and its perceived degree of complexity. We express this relationship mathemat-

ically.

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Sunday, 10:00

Session B

Comparing complexity measures. Annelies Bartlema, *University of Leuven*, Sara Steegen, *University of Leuven*, Wolf Vanpaemel, *University of Leuven*. A key aspect of any model is its complexity, which is tightly coupled to its fit, its informative content and its falsifiability. To adequately assess complexity, a series of stand-alone complexity measures have been proposed in the literature (such as Parametric complexity, Effective Parametric complexity, Geometric complexity, Parameter Space Partitioning-based complexity and Prior Predictive complexity). Quite surprisingly, the relative performance of these measures has never been systematically evaluated, making it unclear whether different measures lead to similar results. In this talk, we will present results from a systematic comparison of the relative performance of these complexity measures across a set of cognitive models (such as memory retention, information integration and category learning) and across a range of different designs.

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Sunday, 9:40

Session C

Associations and the Accumulation of Preference: A Model of Choice Set and Reference Dependence. Sudeep Bhatia, *Carnegie Mellon University*. I explore the determinants of attribute sampling in a multi-alternative preferential choice task. I assume that the associations between the available alternatives and their component attributes determine the attentional weights on the attributes. These associations are assumed to be increasing functions of the amounts of the attributes in the alternatives. Adding or removing irrelevant alternatives, or altering the salience of alternatives can influence the attentional weights on the attributes. This can bias their integration into preferences, and generate preference reversals. This mechanism is formalized using a dynamic stochastic preference accumulation process, embedded in a linear feed-forward neural network. The resulting model provides a unitary explanation for a large range of choice set dependent behaviors, including context effects (such as the asymmetric dominance, compromise and similarity effects), alignability effects, and less is more effects. The model also generates a gain/loss preference asymmetry relative to especially salient options. This asymmetry accounts for all the reference dependent anomalies explained by loss aversion, as well as reference dependent phenomena not captured by loss aversion. Finally, this model requires fewer parameters than previous models of preference accumulation, and is simple enough that most of its properties can be demonstrated analytically, without simulations.

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Monday, 9:20

Session B

Using Neural Synchronization Models to Bridge the Gap between Sensory Integration and Sensory Binding Theory. Vincent Billock, *NRC, U.S. Air Force Research Laboratory*, Brian Tsou, *U.S. Air Force Research Laboratory*. Sensory integration and sensory binding are similar problems separated by a vast methodological gulf. The dominant paradigm of binding theory is neural synchronization, while sensory integration is

built on observations of bimodal neurons. These cells show large increases in firing rates for bimodal presentation of weak stimuli, but little improvement for strong stimuli, a finding known as the Principle of Inverse Enhancement. It would be useful to link these two fields so that methods from each could be used by the other. The best case for such a bridge is the rattlesnake, which has two dissimilar visual systems, one for light and one for heat. Although this sounds like a binding problem, the rattlesnake has been studied using the methods of sensory integration. Many cells in rattlesnake optic tectum are sensitive only to light but can be strongly modulated by heat stimuli, or vice versa. We modeled these cells by assuming that they are members of synchronized pairs of excitatory-coupled neurons. We replace the usual weak coupling assumption with Goldilocks *** coupling: coupling is kept as strong as possible without distorting spike amplitudes. The same synchronized neuron model, without any parameter changes, accounts for a population of cells in cat visual cortex whose firing rates are enhanced by auditory stimuli. It also produces enhancements quite similar to those described psychophysically in humans and can be used to model some previously mysterious human color vision transformations; we present models of ***yellowness*** and chromatic brightness generated from oscillatory synchronization of known neural mechanisms.

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Sunday, 11:45

Session C

Functional Principal Components Analysis of the Capacity Coefficient. Devin Burns, *Indiana University Bloomington*, Joseph Houpt, *Indiana University Bloomington*, James Townsend, *Indiana University Bloomington*. The efficiency of an information processing system across changes in workload (i.e number of items to be processed) is particularly important in cognitive science. The capacity coefficient (Townsend& Nozawa, 1996; Townsend& Wenger 2004) is an empirical measure of workload efficiency based on estimated reaction time distributions. The capacity coefficient is a function of time, so different values can be assessed for fast and slow responses. This level of description affords many possibilities for comparing among subjects or conditions, but can also lead to difficulty in interpreting the results. In this talk I describe how a functional extension of principal components analysis, which we call fPCA, can be applied to workload capacity analysis. I will demonstrate its use as a tool for dimensionality reduction, to obtain a finite set of values that maximally distinguish the functions. This reduced description, usually only a couple of factor loading values, can be used for purposes such as structural equations modeling or other approaches designed for a discrete number of dependent variables. I will also discuss how fPCA is an appropriate tool for studying the meaning of changes in capacity across time, an underexploited source of information inherent in the capacity coefficient. The applications of fPCA to workload efficiency in other research goals will also be highlighted.

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Satuday, Pre Conference

Workshop

To Build Human Cognitive Models Using Quantum Probability and Dynamics. Jerome Busemeyer, *Indiana University, Bloomington*, Zheng Wang, *Ohio State University, Columbus*. The cognitive revolution in the 1960's was based on

classical computational logic and the connectionist/neural network movements in the 1970's were based on classical dynamical systems. These classical assumptions remain at the heart of both cognitive architecture and neural network theories. They are so commonly and widely applied that they are taken for granted and presumed to be true. However, in recent years, quantum probability and dynamics have been successfully used to explain many important anomalies in human cognition that resist classic explanations, including applications to perception of ambiguous figures, associative memory, conceptual combinations, probability judgments, decision making under uncertainty, survey research, and game theory. Our workshop will compare fundamental differences between the two types of probability theories and dynamic systems. The logic and mathematical foundation of classic and quantum theory will be laid out. We will emphasize the process to develop quantum models to account for experimental findings which are puzzling from the perspective of classic cognitive models using real research examples. References and resources are available at the web site below. `http://mypage.iu.edu/~jbusemey/quantum/QuantumCognitionNotes.htm`

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Monday, 3:30

Session B

List Length and Word Frequency Effect on Cued Recall. Rui Cao, *the Ohio State University*, Simon Dennis, *the Ohio State University*, Adam Osth, *the Ohio State University*. The list length effect is a phenomenon in which performance improves when the number of studied items decreases. This effect is present in most memory tasks. However, Dennis and Humphreys (2001) showed that the list length effect can be eliminated in recognition memory tasks if controls for retention interval, attention, rehearsal and contextual reinstatement are employed. In some unpublished data we have also found a null-list length effect in cued recall experiments, when it is presented in an experiment set that contains cued recall, associated recognition, and single item recognition. Therefore we would like to single out the cued recall experiment to see if we can replicate this finding. Word frequency effects (high frequency advantages on recall and low frequency advantages on recognition) represent another disassociation between recognition and recall. We are also interested in the word frequency effect in cued recall and examine it separately for cue and target items. In the experiment, we manipulated both the list length and word frequency effects with a filler task between study and test. We found that there is a small difference between list length but not statistically significant. There are also low frequency advantage for cues and high frequency advantage for targets. These findings place critical constraints on viable models of cued recall. The experiment is a critical component for the COCO model.

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Sunday, 3:50

Session B

A Bayesian Analysis of the Transitivity of Preference Axiom. Daniel Cavagnaro, *California State University, Fullerton*, Clintin Davis-Stober, *University of Missouri*. Few measurement axioms have garnered as much attention within the decision sciences as transitivity of preference. Yet, there is little agreement within the literature on how best to translate this algebraic axiom into a probabilistic one suitable for

modeling human behavior. Regenwetter et al. (2011) endorsed the use of a 'mixture model of transitive preference', and validated it against new experiment data using a frequentist statistical methodology. One shortcoming of this approach is that the frequentist methodology can only report the outcome of a goodness-of-fit hypothesis test and is not easily applied to non-nested model comparisons. Thus, it is possible that other models of transitivity, such as 'moderate stochastic transitivity' or 'strong stochastic transitivity', could describe human behavior even better. In this study, we reanalyze the data from 8 different experiments, using two different Bayesian model selection methodologies, to place four major models of transitivity in direct competition with one another. Our results confirm the assertion by Regenwetter et al. that violations of transitivity are rare. However, we find that no one model of transitivity best describes the behavior of all decision makers. It seems that most people's preferences are transitive, but they are transitive in different ways.

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Sunday, 4:30

Session C

Separate Probability Estimates for Explicit and Implicit Memory. Richard Chechile, *Tufts University*, Lara Sloboda, *Tufts University*, Jessica Chamberland, *Unilever Research and Development*. The research on model-based measurement of explicit and implicit memory is reviewed. As opposed to using the more traditional process dissociation model model, we discuss the reasons for using the more recent Implicit/Explicit Separation (IES) model. The IES model is a multinomial processing tree model that results in separate probability measures for explicit storage, implicit storage, fractional storage, and non-storage. A number of experiments are presented in terms of the IES model. Beyond providing evidence for validation, the experiments also point to a different conceptualization of implicit and explicit memory. Rather than treating implicit and explicit memory as separate memory systems, we advance the idea that implicit memory more likely to be a faint residue of memory representation that previously was explicitly stored.

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Sunday, 11:45

Session A

Top-down control modulates the effect of exogenous attention on the process of detecting the redundant targets. Hsu Ching-Chun, *National Cheng Kung University*, Yang Cheng-Ta, *National Cheng Kung University*. Attention can be automatically guided to a particular location by an exogenous spatial cue. Information at the cued location would be accumulated faster with a stronger representation. Decision based on the item at the cued location, hence, would be more accurate. However, no prior studies have investigated the effect of the knowledge of the cue validity on accumulating the cued and uncued items that are both task-relevant for decision-making. Thus, the current study manipulated the cue validity in two experiments to examine its effect on the processing order of the cued and uncued items. We followed the suggestions of the systems factorial technology (SFT) to design experiments, analyze data, and make inferences regarding the process characteristics of a decision mechanism. In a redundant-target detection task, the participants were required to detect whether there was a signal on the right or left

side (single-target condition) or on the both sides of the screen (redundant-target condition). The cue was 50% valid in Experiment 1 and 100% valid in Experiment2. Results showed that the participants adopted parallel self-terminating processing in Experiment 1, without difference between RTs in the valid and invalid conditions. All the participants altered their decision strategies to serial self-terminating processing in Experiment 2 since they knew the target always followed the cue. These results highlight the role of top-down control in modulating the effect of exogenous attention on the decision process of detecting multiple targets.

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Tuesday, 10:45

Session B

Ultrametric Fechnerian Scaling of Discrete Object Sets. Hans Colonius, *Oldenburg University*, Ehtibar Dzhafarov, *Purdue University*. Universal Fechnerian Scaling (UFS) is a principled approach to computing subjective distances among objects (stimuli) from their pairwise discrimination probabilities. It is based on the general concept of 'dissimilarity function' leading to a locally symmetrical quasimetric in the context of Dissimilarity Cumulation (DC) theory developed by Dzhafarov and Colonius (JMP 2007) and Dzhafarov (JMP 2008a,b). For a finite set of objects, a *dissimilarity* is a function that assigns to every pair of objects (points) a nonnegative number vanishing if and only if the two points are identical. A dissimilarity need not be symmetric and need not satisfy the triangle inequality. A dissimilarity satisfying the triangle inequality is called a *quasimetric*. A quasimetric G is *induced* by a dissimilarity D through the Dissimilarity Cumulation procedure: for each ordered pair of points (a, b), a dissimilarity $D(a, b)$ is replaced by the minimum of the sums of dissimilarity values across all finite chains of points from a to b. Here we show that the replacement of Dissimilarity Cumulation by a Dissimilarity Maximization procedure, i.e., replacing $D(a, b)$ by the minimum of the maximum value of the dissimilarities across all finite chains of points from a to b, results in a quasimetric satisfying the quasi-ultrametric inequality which is a basic requirement underlying many cluster-analytic procedures for embedding subjective distances in a hierarchical tree structure. Properties of this new procedure in the context of UFS will be discussed and illustrated with empirical data sets.

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Monday, 11:05

Session B

Priming and Fluency Within a Dynamic Model of Recognition. Gregory Cox, *Indiana University*, Richard Shiffrin, *Indiana University*, Nicholas Lewis, *Indiana University*. Recently, Cox& Shiffrin (2012) introduced a dynamic model that jointly predicts accuracy and response time in recognition memory. Within this model, recognition decisions (whether a test item had or had not been recently studied) are based on the accumulation of changes in familiarity over time as features are sampled from the test item: Old items tend to result in more positive changes in familiarity than new items. For both old and new items, however, the model predicts a slight decrease in familiarity early on, as the first few sampled features tend not to match most of the recently stored memory traces (even for an old item, the number of mismatching traces overwhelms the match to the target until enough features are sampled). This implies that, if the

recognition process begins with a few features already sampled, these early negative changes may be "skipped", resulting in a bias to say "old". This prediction is in accord with the fluency results of Jacoby& Whitehouse (1989), in which unconscious identity priming (which results in the recognition process beginning with a few features of the test item) produces a bias to respond "old". The dynamic model also predicts a novel empirical result (although hinted at in Jacoby& Whitehouse, 1989), that an unconscious non-identity prime results in an increased tendency to say "old" to studied items. This is a function of well-matching features of the studied item replacing the poorly-matching features of the prime, resulting in positive changes in familiarity.

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Sunday, 10:45

Session C

A comparison of stochastic models of intertemporal choice. Junyi Dai, *Indiana University, Bloomington*, Jerome Busemeyer, *Indiana University, Bloomington*. Most theoretical and empirical research on intertemporal choice assumes a deterministic perspective, leading to the widely adopted delay discounting paradigm. As a form of preferential choice, however, intertemporal choice might well be probabilistic in nature. Two empirical studies were conducted to demonstrate this property, in which the delay amount effect, common difference effect and magnitude effect in intertemporal choice were revealed in a probabilistic manner. The results, especially those associated with the delay amount effect, challenge the traditional deterministic view and call for alternative approaches. Consequently, a number of probabilistic models were explored and fitted to the choice response data, including one alternative-wise random utility model, two alternative-wise diffusion models, and six attribute-wise diffusion models employing the general framework of decision field theory. The alternative-wise models were derived from the traditional hyperbolic discount function while the attribute-wise models were built upon direct and/or relative differences in money and delay amounts. Furthermore, response times for intertemporal choice were recorded for the first time and the diffusion models, which assume a dynamic structure, were also fitted to the response time data so that more information can be utilized to find a better model. The results showed that attribute-wise diffusion models involving only direct differences performed the best and were able to account for all three intertemporal effects. In addition, the empirical relationships between choice proportions and response times are consistent with diffusion models and thus favor a dynamic instead of static model structure.

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Monday, 11:25

Session C

The Random Estimator Paradox. Clintin Davis-Stober, *University of Missouri*, Jason Dana, *University of Pennsylvania*. Dating back to the seminal work of Gauss and Legendre, the technique of least squares has served as a primary method of knowledge accumulation across the behavioral and life sciences. We demonstrate via analytic proof and simulation study that, under effect sizes and samples sizes common to the behavioral sciences, the Ordinary Least Squares estimator is less accurate than an estimator that determines the relative weights and signs among coefficients uniformly at random. Our

analysis includes the special case of sample means. Under these specified conditions, estimating population means via randomly determined weights is more accurate than using sample means. We demonstrate that these conditions can occur even if statistical power and sample size are adequate by current standards in the field of psychology.

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Monday, 12:05
Session C

On Some Misconceptions about Signal Detection Theory and Forced Choice. Lawrence DeCarlo, *TC, Columbia University*. The standard textbook derivation of the forced choice model in terms of signal detection theory (SDT) uses a differencing approach. Here I note that this approach is not consistent with basic ideas underlying SDT. In particular, if observers have information about the magnitude of their underlying perceptions, then they can base their decisions directly on their perceptual magnitudes, without having to take differences. The SDT approach to forced choice is simply to choose, as the signal, the alternative with the largest perceptual magnitude. The model that follows from this approach is shown. For two alternative forced choice (2AFC), the model is equivalent to a model that follows from the differencing approach, however this is not the case for distributions other than the normal, or for situations where the number of alternatives is greater than two (mAFC). Another complication is that the differencing approach gives a value of d' that is multiplied by $\sqrt{2}$, which has led to some confusion as to whether detection is better in 2AFC. The model shown here does not involve a $\sqrt{2}$ term, and clarifies that d' should be invariant across forced choice and detection, and is not better by a factor of $\sqrt{2}$. A general conclusion is that, although choosing the maximum of two random variables is equivalent to basing a decision on the difference between the random variables, the associated psychological processes are not the same. Approaches to fitting the models with maximum likelihood estimation and Bayesian estimation are noted.

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Monday, 4:30
Session B

A chaining-based model of serial recall. Simon Dennis, *Ohio State University*. Henson (1996) has argued that several results including fillin effects, patterns of protrusions and performance on lists of alternating similar and dissimilar items (the sandwich effect) preclude a model of serial recall that relies on chaining associations between items. However, this conclusion is at odds with other data showing that serial recall improves dramatically when study lists approximate language at the letter and word levels and also is improved when spin lists that maintain chaining information, but confound positional information are repeated. I demonstrate that the objections to chaining models can be overcome if one assumes that associations act as constraints on a whole of list resolution process, rather than acting in a purely feedforward fashion. Furthermore, by resolving the chaining issue in this fashion one can create a model that is more similar to models of other episodic tasks.

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Sunday, 11:05
Session C

On the Structural Equilibrium of Choice Sets. Charles Doan, *Ohio University*, Ronaldo Vigo, *Ohio University*,

Jinling Zhao, *Ohio University*. We introduce the notion of the structural equilibrium of a choice set to address a long standing problem in decision science: namely, given a choice set with n items, how does human choice behavior differ as a function of the structural changes to the set introduced by replacing or removing its items? Structural equilibrium is defined using categorical invariance theory (Vigo, 2009, 2011, 2012) and is roughly characterized as the state when all the dimensions of a choice set play approximately the same structural role. We distinguish between 'good' and 'bad' structural equilibrium and propose quantitative relationships between these two conditions and the nature of choice reaction times on the members of choice sets. The structural equilibrium model, without free parameters, accounts for most of the variance in our three contextual choice experiments. We also introduce a parameter-free model for predicting choice reaction times (Vigo & Doan, 2012) that is based on categorical invariancetheory. The model accounts for over 90% of the variance in our three contextual choice experiments.

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Monday, 9:00

Session C

Parametric and non-parametric capacity: An application to aging. Chris Donkin, *University of New South Wales*, Ami Eidels, *University of Newcastle*, Boaz Ben-David, *University of Toronto*. In the redundant target effect, participants respond faster with two (redundant) targets. We compared the magnitude of this effect in younger and older adults, with and without distractors, in a simple visual-detection task. We employed additional measures that allow non-parametric assessment of performance (Townsend's capacity coefficient) and parametric estimates (Linear Ballistic Accumulator). Older participants' latencies were slower, and their capacity indicator increased with distractors. A parametric analysis of capacity revealed that older participants were slower largely because of longer non-decision times (and not evidence accumulation rate), and that older participants had particular difficulty inhibiting distracting information.

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Sunday, 12:05

Session A

Fine visual discriminations and spatial attention. Barbara Anne Dosher, *TBA*, Shia-hua Liu, *National Dong-Hwa University*, Zhong-Lin Lu, *Ohio State University*. Visual attention often improves the accuracy of perception. Fine discriminations may demand more attention and require distinct processing heuristics. Attention has a special role in filtering visual noise. In addition, models of optimal decision predict a role for off-channel weighting of the tails of the evidence distribution for high precision judgments. Fine discrimination is shown to incorporate both attention-based noise filtering and off-channel weighting. Off-channel tuning in finer discriminations accounts for readout in discrimination. An opponent model of orientation discrimination provides a theoretical framework for both effects.

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Tuesday, 11:25

Session B

Re-reading Fechner and correcting historical misconceptions. Ehtibar Dzhafarov, *Purdue University*, Hans Colonius, *Oldenburg University*. From the principle that subjective dissimilarity between two stimuli

is determined by their ratio Fechner derives his logarithmic law in two ways. In one derivation, ignored and forgotten in modern accounts of Fechner's theory, he formulates the principle in question as a functional equation and reduces it to one with a known solution. In the other derivation, well-known and often criticized, he solves the same functional equation by differentiation. Both derivations are mathematically valid (the much-derided 'expedient principle' mentioned by Fechner can be viewed as an inept way of pointing at an elementary property of differentiation). Neither derivation uses the notion of just-noticeable differences. But if Weber's law is accepted in addition to the principle in question, then the dissimilarity between two stimuli is approximately proportional to the number of just-noticeable differences that fit between these stimuli: the smaller Weber's fraction the better the approximation, and Weber's fraction can always be made arbitrarily small by an appropriate convention. For details, see Dzhafarov, E.N.,& Colonius, H. (2011). The Fechnerian idea. American Journal of Psychology, 124, 127-140.

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Monday, 10:45

Session C

The psychology of replication and replication in psychology. Gregory Francis, *Purdue University*. Many scientists believe that repeated successful replications of an experiment are the best way to demonstrate the validity of an empirical finding. Although this belief is often described as a foundation of an empirical science, it is wrong. When success is measured by rejecting a null hypothesis, the replication rate should follow the rules of probability. The probability of replication can be measured with power; and given the relatively low power of most experiments in psychology, even true effects should often produce a failure to replicate. There are two important corollaries of this observation. First, a failure to replicate a previously published finding often ignites a heated debate, including claims of researcher incompetence. But often times the findings are consistent with the inherent uncertainty of the experimental measures. Second, it is possible to have too much replication success. If the frequency of rejecting the null hypothesis is inconsistent with the power of reported experiments, then there is some type of publication bias. Regrettably, when there is publication bias, the set of experiments should be considered non-scientific. I will demonstrate how to test for too much successful replication and will provide examples of how publication bias contaminates important studies in experimental psychology. I will also outline data analysis methods that avoid some of the temptations to introduce publication bias.

(73)

Monday, 9:40

Session B

Is multimodal information integrated optimally under time pressure? Juan Gao, *Stanford University*, James McClelland, *Stanford University*. Studies in perceptual decision making have revealed that the formation of a perception resembles a dynamical process whose outcome, the accuracy of the perception, increases and asymptotes as the exposure to stimulus lengthens. Such behavior is believed to result from gradual accumulation of noisy sensory information over time. While most of such studies are limited to unimodal stimuli, or more specifically

mostly to visual stimuli, some studies have began to show that humans, given enough time, are able to integrate multimodal sensory information in an optimal manner. However, little is known about whether subjects can optimally combine information across modalities in a dynamic environment (i.e., under time pressure) and if so, how this is accomplished. Do subjects accumulate noisy information from multimodal sources simultaneously (independent parallel processing) or do they work on one channel at a time and switch to another channel when no additional information can be gained from the current channel (serial or resource-limited parallel processing)? We attempt to answer these questions using human participants in a two-alternative perceptual decision making task with auditory and visual stimuli. The time available to process the stimulus is controlled via a 'go' cue, and duration varies randomly from trial to trial in the 75 msec to 2000 msec range. We found that in such conditions, only some participants can optimally combine information from the two modalities. For those participants, the stimulus sensitivity in the bimodal condition tends to asymptote slower than in the unimodal condition, suggesting serial or parallel-resource-limited processing.

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Monday, 11:05

Session C

Generalized Information Matrix Tests: A Unified Theory for Goodness-of-Fit Analysis.
RICHARD GOLDEN, *University of Texas at Dallas*, STEVEN HENLEY, *Martingale Research Corporation*, MICHAEL KASHNER, *Loma Linda University School of Medicine*.
A 'specification test' is a goodness-of-fit test that tests the null hypothesis that the researcher's probability model contains the data generating process (DGP). If this hypothesis is rejected, then the presence of model misspecification is detected. An Information Matrix test (IMT) is a type of model specification test (White, 1982) that tests the null hypothesis that the Hessian and OPG (Outer-Product-Gradient) asymptotic covariance matrices of the quasi-maximum likelihood estimates are equal. If this null hypothesis is rejected, then it follows directly from the Fisher Information Matrix Equality that model misspecification is present. In this talk, we establish the basis for developing new specification tests by introducing a general mathematical theory based upon testing the null hypothesis that a smooth function of the Hessian asymptotic covariance matrix is equal to the same smooth function of the OPG asymptotic covariance matrix. Furthermore, we introduce a new family of large sample test statistics called GIMTs (Generalized Information Matrix Tests) for testing this null hypothesis and provide explicit regularity conditions for characterizing a GIMT's asymptotic distribution when the null hypothesis holds. We also show that the Type II error converges to zero. GIMTs are applicable to a large class of smooth probability models including the exponential family nonlinear probability models. Although the main results presented in this talk are new theorems and proofs, we illustrate the application of the mathematical theory with empirical applications to a typical epidemiological data analysis problem Involving binary logistic regression modeling.

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Tuesday, 9:20

Session A

Replacing Maslow Needs Hier-

archy with Stage and Value. William Joseph Harrigan, *Dare Institute*. An all-encompassing model of value and stage is applied to Maslow's "needs" hierarchy model. "Needs" may be understood as primary and secondary reinforcers that change with stage. Primary reinforcers are biologically built-in, such as food, sleep and social stimuli. Secondary reinforcers are learned when paired with a primary reinforcer. For example, money is a powerful reinforcer when paired with objects it can purchase. As one moves up in stage, secondary reinforcers become more complex. Reinforcers may change from simple to more abstract such as adhering to moral principles and searching for the truth. In addition to changes of reinforcers, what contingencies make contact with behavior also change. A contingency is the predictive relationship between two events, such that the occurrence of one event predicts the probable occurrence of another. e.g. a child receives a balloon every time she goes to the dentist. Individuals who understand complex contingencies may be more likely to act on long term benefits. Contingencies may not make contact with behavior in three circumstances. They may not make contact because the consequence a) requires too high a stage to appreciate or b) it is not of interest to the person or more typically, c) when they occur too far away in time, and more short term consequences are perceived as more valued. Individuals who score higher on Maslow's hierarchy should also show higher stage social perspective taking skill.

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Monday, 4:10

Session C

Accumulator models for consumer preference and response times. Guy Hawkins, *University of Newcastle*, Scott Brown, *University of Newcastle*, Anthony Marley, *University of Victoria*, Andrew Heathcote, *University of Newcastle* , Terry Flynn, *University of Technology, Sydney*, Jordan Louviere, *University of Technology, Sydney*. Consumer preferences for goods or services are increasingly examined using the method of best-worst scaling, where people are asked to select both the best option and the worst option from a set of choice alternatives. The data from best-worst choices are typically analysed with random utility models. These models provide a good account of data and are useful for measurement purposes, but they provide limited insight into the underlying cognitive processes. Random utility models also do not account for response times, which have proven valuable in other areas of psychology for obtaining a deeper understanding of decision processes. We explore a new, tractable evidence accumulation model, previously used to explain simple perceptual decisions, as a process interpretation of the complex multi-attribute decisions involved in best-worst choice tasks. The accumulator model provides convergent parameter estimates to the random utility models, after integrating out response times to produce marginal choice probabilities. We illustrate this point in two data sets: one involving patient preferences for dermatology appointments, and another involving preference for attributes of mobile phones. Three variants of the accumulator model all provide good accounts of the data, but make different assumptions about the cognitive processes in best-worst choices. We conclude that response time data are required to further understand decision processes in best-worst choice tasks.

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Monday, 10:45

Session A

Modeling the formation of and interaction between perceptual features during category learning. Andrew Hendrickson, *Indiana University*, Robert Goldstone, *Indiana University*. Though the evidence that new perceptual features can be learned is growing, the field so far has focused only on learning situations in which no clear features exist before learning or the initial features are unknown. Previous work has not addressed how existing perceptual features interact with and shape the learning of new features or what learning mechanisms underlie this process. In an experiment and a mathematical model we begin to answer the questions of how new features are learned – not only from novel objects without existing features but also how new features are learned in the presence of existing, conflicting features and if the processing of existing features changes. Learners were taught to categorize novel objects into one of two category structures in which individual object properties were diagnostic of category membership either independently or when combined. Mathematical modeling of individual learner data confirms the predictions of an ideal observer analysis: learning different category structures led to learning different sets of features despite the objects being identical. This was assessed by modeling the probability of responding same or different to whole-part perceptual discrimination judgments before and after category training. After an initial learning phase, the category structure was switched, learners were re-trained, and then re-assessed on discrimination judgments. Data suggests that the order of category training led to learners acquiring significantly different sets of features.

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Monday, 9:20

Session A

Violations of Consequentialism in Dynamic Decision Making. Jared Hotaling, *Indiana University*, Jerome Busemeyer, *Indiana University*. Human are often faced with complex choices involving many interrelated events. Achieving one's goals usually requires planning a sequence of actions, rather than a single decision. Despite the importance of considering entire sequences when planning, rational choice theories state that individuals should be consequential, in that choices should be unaffected by past events and focused only on the potential future outcomes. We present data collected in a dynamic decision making paradigm showing that individuals' risky choices are influenced by past events. In the experiment multistage decision were represented as branching decision trees. At decision nodes, participants chose which path to take through the tree. At chance nodes, a marble was randomly drawn from an urn to determine the path. Each branch of the tree terminated with an outcome node representing the amount of points a participant could win. We found that the choices made at decision nodes depended on the preceding chance event. This violation of consequentialism suggests that one's current prospects are judged relative to counterfactual ones. Decision Field Theory-Dynamic, a recently developed cognitive model of sequential decision making, is used to account for this finding.

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Sunday, 12:05

Session C

Bayesian Approaches to Assessing Architecture and Stopping Rule. Joseph Houpt, *AFRL*, Andrew Heathcote, *University of Newcastle*, Ami Eidels, *University of Newcastle*, James Townsend, *Indiana University* . Much of scientific psychology and cognitive science can be viewed as a search to understand the mechanisms and dynamics of perception, thought and action. Two processing attributes of particular interest to psychologists are the architecture, or temporal relationships between sub-processes of the system, and the stopping rule, which dictates how many of the sub-processes must be completed for the system to finish. The Survivor Interaction Contrast (SIC) is a powerful tool for assessing the architecture and stopping rule of a mental process model. Thus far, statistical analysis of the SIC has been limited to null-hypothesis-significance tests. In this talk we will demonstrate two Bayesian approaches to assessing the architecture and stopping rule of a process. The first is a nonparametric Bayesian model that examines posterior distributions over SIC forms. This model is based on Dirichlet process priors for the response time distributions. The second is a parametric approach in which we compare hierarchical Bayesian models of the sub-process completion time distributions using varying architecture and stopping rule possibilities.

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Monday, 3:30

Session A

A Procedure for Modeling Coupled Latent Differential Equations with Moderators. Yueqin Hu, *University of Virginia*, Steven Boker, *University of Virginia*, Michael Neale, *Virginia Commonwealth University*, Kelly Klump, *Michigan State University* . Latent Differential Equations (LDE) is an approach to estimate characteristics of an oscillation and interactions between oscillators. Due to its recent development, many theoretical and practical issues critical to performing an LDE model remain. This article recommends a procedure to implement a coupled LDE model with moderators. Issues discussed include 1) a novel method to select a smoothing parameter and its advantage over classic criteria -2LL and AIC; 2) a demonstration of the coupling effect by studying simulated coupled processes or uncoupled processes with plausible synchronizations; 3) an exploration of the boundary conditions for model parameters; and 4) a demonstration of how to add moderators to an LDE model. An example data set modeling the interaction between ovarian hormone cycles and eating behavior is analyzed using the procedure. Results indicated that eating behavior follows the cycle of the hormone estradiol by 1/4 period, around seven days. The average level of negative affect moderates the frequency of eating oscillation and the coupling strength between eating and estradiol. People with a higher average level of negative affect oscillate faster in eating, and their eating behavior is more strongly coupled with hormone estradiol. Permutation tests on this empirical data supported the reliability of using LDE models to detect internal and external dynamics.

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Tuesday, 11:05

Session B

Representing Symmetric ROCs. Geoff Iverson, *UC Irvine*, Don Bam-

BER, *UC Irvine*. An ROC is symmetric if it is invariant under reflection in a mirror placed on the line "Hits"+"False Alarms"=1. For a given symmetric ROC there are very many signal and noise sources that generate that ROC. However, we show that among these multiple random representations there always exists an especially simple one in which both signal and noise values are concentrated on the same interval symmetric about zero, and such that signal values are distributed as the negative of noise values.

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Monday, 4:30

Session C

On the (Un)falsifiability of Models of Choice RT. MATT JONES, *University of Colorado*, EHTIBAR DZHAFAROV, *Purdue University*. The predictive content of a cognitive model can depend far more on incidental parametric assumptions than realized or intended. For example, Grice (1968) proposed a model of choice RT in which deterministic evidence processes race to stochastic thresholds. Grice's choices for the functional forms of the processes were rather arbitrary, but Dzhafarov (1993) proved that if the forms are unconstrained then the model becomes unfalsifiable. We extend this result to architectures in which evidence processes are stochastic and thresholds deterministic: the diffusion model (Ratcliff, 1978) and ballistic accumulators (Brown& Heathcote, 2005, 2008). Both models assume multiple sources of variability across trials, including stochasticity in growth rates and starting points of the evidence processes. The forms of the associated distributions (Gaussian for drift rates, uniform for starting points) are considered incidental implementational details, but we prove that relaxation of either assumption can make the models unfalsifiable. Thus, the explanatory or predictive content of these models is determined not by their architectures but by their parametric assumptions. To understand the import of these parametric assumptions, we develop means for translating them among different modeling frameworks, i.e. starting with a parametrically constrained model in one framework and deriving an equivalent model in a different framework. Our results suggest that current models are more complex than necessary, and that comparisons of model fits to data do not always answer the theoretical questions they are intended to answer.

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Sunday, 3:30

Session C

A Continuous Holographic Vector Model of Semantic Representation. BRENT KIEVIT-KYLAR, *Indiana University*, MICHAEL JONES, *Indiana University*. We explore an extension of the BEAGLE model (Jones& Mewhort, 2007, Psyc Rev) of lexical semantic representation to infinite-dimensional spaces. BEAGLE learns lexical representations from text by using holographic vectors to represent words and functions over these vectors represent relations between words (cf. Murdock's 1992 TODAM). A major limitation of the model is its use of finite discrete vectors. We test the implications of replacing finite vectors with continuous functions and using analog continuous space manipulations to replace the functions over these vectors. The computational limits of these systems are analyzed under different constraints on the functions used for each referent, proving infinite theoretical capacity for both word co-occurrence information as well as word order dependent relation for certain classes

of initial functions. In addition to quantifying the limits and extremes of the system, we show that varying initial functions from a spectrum of distribution spaces affects the generalizability of the model in a lawful way. Finally, we discuss the implications of the transition from discrete to continuous in the options for physical instantiation of the computational system required to implement the model. Digital computers are capable of modeling the performance of the continuous vector model, however, computations quickly become intractable for extremely large corpora and for sufficiently complex initial function representations. Analog systems are easily capable of performing such operations linearly scaled to the size of the number of distinct tokens in a corpus (words) regardless of the function complexity.

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Sunday, 9:40

Session B

Optimal Experimental Design for Model Discrimination: A Nonparametric Extension. Woojae Kim, *Ohio State University*, Jay Myung, *Ohio State University*, Mark Pitt, *Ohio State University*. Discriminating among competing theoretical explanations is a vital issue in psychology. While it has been adequately demonstrated that psychological modeling can benefit from the methods of statistical model comparison, the issue of finding an optimal experimental design for effective model discrimination is a relatively new topic in the field (Myung& Pitt, 2009). Quite typical in the process of experimentation and modeling of cognitive tasks is a complex decision-making task in which it is desirable to find not only optimal levels of an independent variable in an experiment but also an optimal number of such levels as well as suitable sample sizes in each condition. In the present study, a procedure is developed for optimizing all such design variables jointly through sequential experiments in an adaptive fashion. To that end, the Dirichlet process (Ferguson, 1973) is adopted as a prior on the design space and integrated into the sampling-based optimization algorithm for nonlinear models (Mueller, 1999; Amzal et al., 2006). The method's effectiveness is demonstrated through a few modeling examples in cognitive science.

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Monday, 10:00

Session C

Response dynamics reveal evidence accumulation in decision making. Gregory Koop, *Miami University*, Joseph Johnson, *Miami University*. Recently, decision research has witnessed an exciting shift from utility-based models focused on outcomes and the maintenance of choice axioms to computational models that make specific predictions about the underlying cognitive processes (Johnson& Busemeyer, 2010). Unfortunately, the methods for discriminating among these models have not advanced at the same pace. Specifically, although response time analyses and information search data have complemented analysis of choice patterns, experimental tasks still only collect discrete choice responses. This prevents testing of process predictions generated by several popular theories concerning the dynamic nature of the buildup of preference. We have remedied this glaring deficiency by developing a unique paradigm to collect this dynamic preference data in decision tasks, drawing from successful application of the paradigm in other cognitive science domains (see Freeman, et al., 2011,

for a review). Specifically, we analyze the response dynamics associated with a choice by simply tracking the real-time spatial coordinates of the response device (e.g. computer mouse). In application to three studies, we show how this paradigm produces novel, meaningful, interpretable information about the decision process. For example, we find evidence for 'online preference reversals' during a single trial, clear dissociations in the response patterns for gains/losses and risky/safe choices, and characteristic trends in derivative measures such as velocity and acceleration. We discuss these results in terms of their support for various formal decision models. Finally, in one study, we pair response dynamics with eye-tracking of information acquisition to formalize and evaluate an evidence accumulation model of decision making.

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Tuesday, 9:00

Session A

A Model of Stage and Value to Predict Behavior. Michael Lamport Commons, *Harvard Medical School*. This paper proposes an all-encompassing mathematical model of behavior that coordinates a) a theory of measurement applied to the difficulty of tasks, and b) a model of value and how it is discounted. The theory of measurement part of the model explains how the hierarchical complexity of tasks that an individual successfully addresses predicts their social perspective-taking, that is the extent to which the relationship between self and other is appreciated. The increase in social perspective taking seen in normal development has been shown to be correlated with the increasing difficulty of tasks to be solved; these performance changes are called stages of development. The second sub-model describes the effect of value and how it is discounted. First, behaviors may be reinforced due to consequences of the behavior. For example, when a child picks up toys, an adult immediately gives them a cookie. The child's behavior may be reinforced due to the value of the cookie. With increases in stage, what is valued changes from built in biological reinforcers, such as food and comfort, to what can be considered secondary reinforcers, such as honor and money. Discounting of value may also influence behavior. For example, a student studies to pass a course to qualify for the next course in a sequence. The student may discount the value of studying because the consequence is too far in the future and instead go partying with friends. Increases in stage of development will also be shown to affect the extent of discounting.

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Monday, 9:40

Session C

Accounts of two diffusion-process models to stimulus frequency and payoff manipulations. Fabio Leite, *The Ohio State University at Lima*. I analyzed response time and accuracy data from a numerosity-discrimination experiment in which both stimulus frequency and payoff structure were manipulated. The numerosity discrimination encompassed responding 'low' or 'high' to the number of asterisks in a 10 x 10 grid, based on an experimenter-determined decision cutoff (fixed at 50). In the stimulus-frequency condition, there were more low than high stimuli in some blocks and more high than low stimuli in other blocks. In the payoff condition, responses were rewarded such that the relative value of a stimulus mimicked the rela-

tive frequency of that stimulus in the previous manipulation. I modeled the data using two sequential-sampling models in which evidence was accumulated until either a low or high decision criterion was reached and a response initiated: a single-stage diffusion model framework and a two-stage diffusion model framework. In using these two frameworks, the goal was to examine their relative merits across stimulus-frequency and payoff-structure manipulations. In the models, I found that shifts in starting point in a single-stage diffusion framework and shifts in the initial drift rate in the two-stage model were able to account for the data across conditions. I also found, however, that these shifts in the two models produced similar changes in the random walk that described the decision process, and discussed the similarities and differences between the two models in terms of assumptions and parameter interpretation.

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Monday, 9:00

Session B

A new definition of shape. Yunfeng Li, *Purdue University*, Yun Shi, *Purdue University*, Tadamasa Sawada, *Purdue University*, Zygmunt Pizlo, *Purdue University* . Shape is an intrinsic characteristic of an object, which allows its identification. However, there is no widely acceptable definition of shape. This led to a lot of controversy in shape perception research. It is commonly agreed that shape refers to something that is 'invariant under some transformation'. Therefore, shape researchers defined shape by using the similarity of one object to another (invariant) in the sense of a rigid motion, similarity, affine, projective, or topological transformation. These definitions are either too strict to allow a small change of shape, or too loose to agree with our commonsense about shape perception. We propose a shape definition that is based on the object's self-similarities (symmetries). Namely, shape is invariant under symmetry mapping (transformation) of one of its parts onto another. Put simply, the symmetrical objects have shape. Otherwise they are shapeless. Our definition could easily be used to account for (1) the shape of 'non-rigid' and 'piece-wise rigid' objects, (2) the veridical shape perception, (3) construction of informative shape priors for unfamiliar shapes, and (4) fast recognition of familiar shapes based on the types of symmetry. We analyzed the algebraic invariants for three basic types of 3D symmetry: translational, mirror and rotational. Next, we identified invariants of the transformation between the similar parts of an object in a 2D perspective image. Geometrically, these invariants correspond to either fixed points or fixed lines under the symmetry mapping. These invariants can be used to identify, recover and recognize shapes.

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Monday, 3:50

Session A

A monotone item characteristic curve estimator based on kernel non parametric regression. Mario Luzardo, *Universidad de la Republica, Uruguay*, Dario Padula, *Universidad de la Republica, Uruguay*, Diego Forteza, *Universidad de la Republica. Uruguay*, Nelson Chaves, *Universidad de la Republica. Uruguay*. An usual assumption of Item Response Theory (IRT) is that the relationship between the performance of an examinee on an item and the underlying features of the item can be described by a monoton-

ically increasing function called item characteristic curve (ICC). This function specifies that as the ability of an individual increase also increases the probability of answering correctly. The item characteristic curve estimates using nonparametric regression proposed by Ramsay do not comply with this postulate. We perform a transformation on Ramsay's estimates to obtain a monotone curve. The new estimate is obtained in two steps and is computationally convenient and does not require constrained optimization. Consider without loss of generality an uniform [0,1] latent variable θ and a monotone ICC $P_m(\theta)$. First consider a grid $0, \frac{1}{T}, .., \frac{i}{T}, .., 1$, two kernels K_r, K_d and two bandwidths h_r, h_d. The usual Ramsay's estimator of the ICC in each poin is $\widehat{P}(\frac{i}{T}) = \frac{\sum_{j=1}^{N} K_r(\frac{\frac{i}{T}-\widehat{\theta}_j}{h_r})Y_j}{\sum_{j=1}^{N} K_r(\frac{\frac{i}{T}-\widehat{\theta}_j}{h_r})}$

The estimator of $P_m^{-1}(\theta)$ is $\widehat{P_m^{-1}}(\theta) = \frac{1}{Th_d}\int_{-\infty}^{\theta}\sum_{i=1}^{T} K_d(\frac{\widehat{P}(\frac{i}{T})-u}{h_d})du$

Then the estimator of $\widehat{P_m}$ is obtain by reflection of $\widehat{P_m^{-1}}$ in the line $y = x$. We also present a simulation study to illustrate the method and an application to a dichotomous items in a mathematical test.

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Tuesday, 11:45

Session B

Conceptual Relations Between Expanded Rank Data and Models of the Unexpanded Rank Data. Anthony Marley, *University of Victoria*, Towhidul Islam, *University of Guelph*. Louviere et al. (2008. J. of Choice Modelling, 1, 126-163) present two main empirical examples in which a respondent rank orders the options in various choice sets by repeated best, then worst, choice. They expand the ranking data to various "implied" choices in subsets and fit the expanded data in various ways; they do not present models of the original rank data, except in one case (that of the rank ordered logit). We build on that work by constructing models of the original rank data that are consistent with the "weights" implied by the data expansions. This results in two classes of models: the first includes the reversible ranking model and has useful "score" properties; the second includes the rank ordered logit model and has natural "process" interpretations. We summarize known and new results on relations between the two classes of models and present fits of the models to the data of a case study concerning microgeneration of electricity using solar panels - that is, where individual households generate electricity using a renewable energy technology.

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Monday, 4:10

Session B

Hierarchical Multinomial Processing Tree Models for the Pair-Clustering Paradigm with Heterogeneity in Participants and Items. Dora Matzke, *University of Amsterdam*, Conor Dolan, *University of Amsterdam*, William Batchelder, *University of California, Irvine*, Eric-Jan Wagenmakers, *University of Amsterdam* . The pair-clustering multinomial processing tree (MPT) model (Batchelder& Riefer, 1980, 1986) allows the estimation of the encoding and retrieval processes in the free recall of semantically related word pairs. Statistical analysis for the pair-clustering model is traditionally carried out on aggregated data, assuming homogeneity in items and participants. If this assumption is violated, the analysis of aggregated data may lead to misleading parameter estimates and flawed conclu-

sions. Various methods are now available to incorporate parameter heterogeneity in MPT models. Here we focus on a crossed-random effects extension of the latent-trait pair-clustering model (Klauer, 2010) that accounts for heterogeneity in items as well as participants. The model assumes that the item and participant effects combine additively on the probit scale and postulates independent and multivariate normal distributions for the random effects. The method relies on Markov chain Monte Carlo sampling to obtain posterior distributions for the model parameters. We provide WinBUGS implementations of the latent-trait pair-clustering model and its crossed-random effects extension and report the results of applying these models to experimental data.

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Sunday, 9:20

Session C

Prior distributions for Random Choice Structures. William McCausland, *Universit de Montral*, Anthony Marley, *University of Victoria*. We study various axioms of discrete probabilistic choice, measuring how restrictive they are, both alone and in the presence of other axioms. We do this by formulating a class of prior distributions over the set of random choice structures and using Monte Carlo simulation to numerically estimate the implied prior probabilities that various axioms hold, including conditional probabilities that one axiom holds given that other axioms hold. The reciprocal of the prior probability that an axiom holds is an upper bound on the Bayes factor in favour of a restricted model, in which the axiom holds, against an unrestricted model. For example, across a wide range of prior distributions, the probability of the triangle inequality holding for binary choice probabilities is many orders of magnitude higher than the probability of random preference rationalisation (random utility). The high prior probability of the triangle inequality limits the strength of evidence that data from a single decision maker can provide in favour of the axiom. For most pairs of axioms we study, the probability that both hold is greater than the product of their marginal probabilities of holding. The reverse is usually true when one of the two axioms is Sattath and Tversky's (1976) multiplicative inequality. In this sense, it is complementary to other axioms.

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Monday, 4:30

Session A

The impact of scoring rule on forecast comparison. Edgar Merkle, *University of Missouri*. This paper generally considers the scoring of multiple forecasters across a common set of events, in order to rank/compare pairs of forecasters. Such comparisons are commonly made using proper scoring rules, with choice of a specific scoring rule potentially influencing the comparison. To circumvent this issue and study its prevalence, we employ a recently-introduced family of proper scoring rules that contains many common rules as special cases. We show how the family can be used to determine whether or not forecaster comparisons will change based on the scoring rule. The proposed methods are illustrated and tested using data from the Aggregative Contingent Estimation System, a web-based environment for eliciting and aggregating subjective forecasts on a variety of world events.

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Monday, 4:10

Session A

Improving Group Forecasts Using Individual Performance History. Brent Miller, *University of California, Irvine*, Mark Steyvers, *University of California, Irvine*, Dirk Warnaar, *Applied Research Associates*, Youngwon Shin, *Applied Research Associates* . The average of individuals' estimates for an unknown quantity has often been shown to be generally more accurate than those of the individuals themselves. This works well for problems where subjects' error is distributed randomly, allowing individual errors to cancel out. Averaging yields worse results when many subjects share a common bias or lack crucial information, however, as in estimating the likelihood of future events. In this study, we report the performance of subjects for a series of probabilistic forecasting tasks given over a period of time. We examine whether the accuracy of averaging can be improved by re-weighting individual estimates based upon subject characteristics, such as accuracy, from previously completed tasks. We also discuss improvement gains that can be achieved by measuring subject performance using several different scoring methods, including Brier scores. Responses were provided on a voluntarily basis from subjects online, who were free to respond to as many or as few questions as they wanted. We show how the resultant sparsity in our dataset can be overcome when using individual differences to improve averaging.

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Tuesday, 9:40

Session A

How Stage Explains Bias in Expert Witnesses. Patrice Marie Miller, *Harvard Medical School*. When experts are hired to give an opinion in a court, it is ideal that they issue unbiased opinions. How do expert witnesses perceive the possible biases of their fellow expert witnesses, and how do they perceive the degree to which situations may lead to bias? Participants were attendees at a workshop at the American Association of Psychiatry and the Law. They were asked to rate the biasing potential of a number of situations that might affect the behavior of an opposing expert. A Rasch Analysis produced a linear scale as to the perceived biasing potential of these different kinds of situations from the most biasing to the least biasing. A factor analysis was conducted to investigate the underlying dimensions. Items were also scored to obtain their Orders of Hierarchical Complexity. The results showed that items rated as the most biasing were working for only one side in both civil and criminal cases; these had large scaled Rasch values. They were also the first factor in 'the factor analysis. Interestingly, two items, a) an opposing expert also serving as the litigant's treater and b) an opposing expert being viewed as a "hired gun" (supplying an opinion only for money) were viewed as not very biasing. In a regression analysis, the Order of Hierarchical Complexity of an item predicted the perceived bias of the items from the 1st, 2nd and 3d factors, suggesting that hierarchically complex situations and behaviors are more likely to be perceived as less basing and biased.

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Sunday, 4:10

Session C

Associations and manipulations in the mental lexicon: A model of word-stem completion. Shane Mueller, *Michi-*

gan Technological University, KEJKAEW THANASUAN, *Michigan Technological University*. Word-stem completion, a process by which a complete word is generated from a fragment, has been used extensively in psychological studies of implicit memory, verbal fluency, and related tasks such as the "Tip-of-the-tongue" phenomena, and forms the basis for many popular word games. However, no mathematical or computational models of the ability have been widely investigated. We will report a series of models of word stem completion. Initial models based on an associative hypothesis can account well for the fact that very few (e.g., about 10%) of the possible completions can easily be generated, and for the fact that initial stem letters produce many more completions than matched end-of-word stem letters. However, these associative models fail to predict differences in short versus long word stems, or stems with many versus few legal completions. Both of these additional phenomena are explained when we the model assumes that once a proper response is generated, it is used as a new stem to help generate and check candidates for the initial stem. Together, this suggests the difficulty for human lexical access is generating candidates that match patterns. We will also use the model to examine relative experts in the task, to propose mechanisms and structures that account for their improved performance.

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Tuesday, 9:00

Session B

Quantitative Clinical Cognitive Science, Cognitive Neuroimaging, and Tacks to fMRI Signal Analysis: The Case of Encoding Deficit in Schizophrenia. JIM NEUFELD, *Western University*. In event-related clinical neuroimaging, 'events of interest' are clinically significant cognitive functions. Identifying the latter, and delineating their time course within cognitive-task trials, arguably requires dynamical stochastic modeling of function abnormalities. A key abnormality in the case of schizophrenia entails elongated encoding of presenting stimulation, such as a probe in a memory search task, into a cognitive format facilitating collateral processes, such as memory scanning (e.g., Neufeld (2007), Schizophrenia Bulletin). Stochastic modeling of encoding deficit has pointed to brain regions of measurement interest in schizophrenia fMRI studies, but also to intra-trial times of interest. Identifying candidate neurocircuitry, on which encoding deficit supervenes, has recruited the method of time-series covariance (TSC)– between measured MRI-voxel signals, and those of 'seed voxels' preliminarily ascertained as involved in task transaction. Encoding related deviations in neurocircuitry have been estimated by isolating TSC values whose magnitude during epochs with heightened encoding surviivor functions significantly exceed TSC values of other intra-trial epochs. Considerable TSC temporal resolution has been required, and moreover obtained empirically. Explanation exploits TSC's quantitative relation to 'brought forward' fMRI signals, conveyed by the time derivative of the fMRI Blood Oxygen Level Dependent measure. The present developments are presented as a 'proof of principle' demonstration that quantitative clinical cognitive science stands to inform 'where to measure' in clinical neuroimaging studies; when to measure, by targeting modeled time windows of pathognomonic functions; and how to measure, by guiding selection of signal-analysis methods from among the array of those available in the fMRI lit-

erature and shareware.

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Tuesday, 9:40

Session B

Bayesian hierarchical Cultural Consensus Theory. Zita Oravecz, *University of California, Irvine*, William Batchelder, *University of California, Irvine*. Cultural Consensus Theory (CCT) relies on formal cognitive and measurement models to discover the nature of respondents' shared cultural knowledge. In the last two decades basic CCT models have been extensively applied in ethnographic studies of various topics to learn about shared belief systems. Many of the applications have involved dichotomous True/False response data; however, CCT models have been developed for other response requirements as well. In this talk we broaden the range of applicability of CCT models by extending them in two ways. First, we extend the dichotomous model to better represent the decision process when respondents are unwilling to commit to any of the response alternatives. Second, we formulate hierarchical versions of the extended model to explore variability that arises among respondents, moreover we aim to explain interindividual variability by introducing covariate information. Statistical inference in the Bayesian framework for these models will also be presented. We demonstrate the merits of the new models through an application.

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Monday, 12:05

Session B

A unified model of episodic memory: Application to item and associative recognition. Adam Osth, *The Ohio State University*, Simon Dennis, *The Ohio State University*, Per Sederberg, *The Ohio State University*. In recent years, episodic memory modeling has become splintered, resulting in models that address benchmark findings from only one or two episodic memory tasks. This is a major departure from the global memory models of the 1980's that were designed to address episodic memory as a whole and were successful in modeling results from a variety of tasks. We present an extension of the matrix model of Humphreys, Bain, and Pike (1989) which uses three separate representations: An occurrence matrix that stores item-context bindings, a co-occurrence tensor that stores symmetric inter-item bindings within a context, and an order tensor that stores asymmetric inter-item bindings within a context. Separate representations for each of these forms of information allows the advantage of differential weighting of these sources of information in different tasks. Memory strength is calculated by the match between the available cues and the respective representations. In item and associative recognition, decisions are made on the basis of a likelihood ratio transform used by Glanzer, Hilford, and Maloney (2009). For both item and associative recognition, the model is capable of producing mirror effects, null list length and list strength effects, linearity and curvilinearity in associative recognition zROCs, as well as the appropriate changes in the false alarm rate with changes in associative strength.

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Sunday, 4:30

Session B

Folk Choice Theory: Consequences of gambling in a structured environment. Timothy Pleskac, *Michigan State University*, Ralph Hertwig, *University of Basel*. In life risk is reward. Almost al-

ways the big rewards we seek to gain (and the big losses we seek to avoid) are relatively unlikely to occur. The reason this relationship emerges is because the economics of the situation constrain the gambles that we are offered in life: When was the last time you were offered a 90% chance for$1 million? The relationship between risk and return may seem obvious to the financial community and to lay people alike. Nevertheless descriptive theories of risky choice have largely ignored the impact of this relationship on choice. During this talk, I will show that gambles constructed under typical economic constraints will give rise to a power law relationship between outcomes and probabilities. I will then develop an alternative descriptive theory of risky decision-making ' folk choice theory – that takes as a central premise that agents have a lay understanding of this risk/return relationship and use it to make more effective decisions in all types of risky situations. I will show that in decisions made under uncertainty decision makers use this risk/return relationship to infer the probability of an outcome. I will also show that this process level hypothesis offers an explanation for several phenomena including the so-called Ellsberg paradox, and phenomena relating to a presumed non-linear probability weighting function. Finally, I will discuss the theoretical and methodological implications of this ecological dependence between probabilities and payoffs in how we study risky decision making.

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Monday, 3:50

Session B

A correction and some extensions of the SIMPLE model for free recall. James Pooley, *UC Irvine*, Michael Lee, *UC Irvine*. This work concerns the SIMPLE (scale-invariant memory, perception, and learning) model, which is either mentioned or applied in many contemporary theoretical accounts of free recall. In this work, we first correct a previously unreported error in the formal translation of SIMPLE to a free recall setting, and also discuss issues with the common interpretation of the model parameters in such a setting. Following this discussion, we use hierarchical Bayesian methods to explore various extensions of SIMPLE, including various assumptions about the dynamics of the free recall process (which is assumed static in the original version of SIMPLE). These explorations take place within the context of a variety of classic data sets from the free recall literature, as well as a "real world" clinical data set concerning the neuropsychological assessment of dementing disorders.

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Monday, 10:45

Session B

Variability due to study-test lag in recognition memory. Melissa Prince, *University of Newcastle*, Lee Averell, *University of Newcastle, Australia*, Andrew Heathcote, *University of Newcastle, Australia*. Explanations of the latent structure underlying recognition memory performance are often based on signal detection models, where studied (old) and unstudied (new) items are represented as two Gaussian distributions located on single memory strength dimension. A common finding is that the old distribution is more variable than the new distribution (zROC slope = 0.8). Ratcliff, Sheu and Gronlund (1992) suggested that this greater variance might in part be due to variations in the time between study and test positions ('lag') among old items. We examined this explanation by manipulating variabil-

ity in lag through the order in which study items were tested relative to the order in which they were studied, either minimizing lag variability (same order), maximising it (reversed order), or through two different random orders that produced intermediate levels of lag variability. Data were analysed with Bayesian hierarchical models that accounted for variability in lag, items and participants: (Pratte, Rouder& Morey, 2010). The two simpler models assumed either the same (equal variance signal detection theory) or functionally related new and old variance, whereas the two more complex models (unequal variance signal detection theory and dual-process signal detection theory) estimated the relationship. We discuss the results in terms of posterior parameter estimates and different approaches to model selection.

(114)

Tuesday, 11:05

Session C

How do people to make fast decisions? Scott Brown, *University of Newcastle, Australia*, George Kachergis, *Indiana University*, Chris Donkin, *University of New South Wales*, Andrew Heathcote, *University of Newcastle, Australia* , Babette Rae, *University of Newcastle*. One of the most fundamental aspects of decision making is the speed-accuracy tradeoff – people can choose to make fast, but error-prone decisions or slow and careful decisions. This tradeoff has been extensively studied at the empirical level, the cognitive level, and the neural level. A fundamental assumption for cognitive models is that the tradeoff has a unitary mechanism. This mechanism posits that people make slower and more accurate decisions by waiting for more evidence to accumulate before deciding. Using experiments and model-based analyses, we investigate the possibility that there are deeper changes involved in the speed-accuracy tradeoff, such as changes on the perceptual side.

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Sunday, 10:00

Session C

The Integrative Theory of Anchoring. Dan Schley, *The Ohio State University*, Brandon Turner, *University of California Irvine*. We present the Integrative Theory of Anchoring (ITA), which splits the anchoring effect into a memory process and an information integration process. ITA contends that individuals have some prior representation of a target item, constructed from the availability of information in memory. When an anchor is presented, the anchor provides information by increasing the accessibility of anchor relevant information in memory, and by serving as an informational source itself. These two sources of information (i.e., the prior information and anchor) are differentially integrated into a posterior representation of the target, from which a judgment is elicited. By splitting the anchoring effect into two simple components, we can approximate the ITA by developing a model to account for the integration of the information provided by the anchor with the prior representation. In three experiments, we show that our model can account for both classical effects and previously unexplained phenomena. Whereas previous theories have been qualitative in nature, ITA and its accompanying model are the first to provide quantitative predictions about individuals' judgments, given a range of prior knowledge and anchors.

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Sunday, 11:25

Session C

Reaction Time Predictions for Factors Selectively Influencing Processes in Processing Trees. RICHARD SCHWEICKERT, *Purdue University*, HYE JOO HAN, *Purdue University*. Processing trees are useful models for a variety of tasks, including perceptual identification, recall, and social judgments. In these tasks, responses fall into different categories, say, correct and incorrect. Processing trees have successfully accounted for the probabilities of different responses. We present predictions processing trees make for reaction times. In a processing tree, a process involved in carrying out a task is represented by a vertex, and the possible outcomes of the process are represented by arcs descending from the vertex. Associated with each arc are the probability the outcome occurs and the time required for the outcome to occur. Processing starts at a special vertex, the root, and continues until a vertex with no descending arcs is reached. A vertex with no descending arc is called a terminal vertex. Each terminal vertex is associated with a category of response; when a terminal vertex is reached a response in its category is made. An experimental factor, such as whether a to-be-remembered item is a word or not, selectively influences a process if it changes probabilities and times associated with arcs descending from a single vertex, leaving all else invariant. Two vertices can be arranged in two ways: Either there is a path from the root to a terminal vertex containing both vertices, or there is not. We present necessary and sufficient conditions for both reaction times and response probabilities to be accounted for by two factors selectively influencing two different processes in either of these ways.

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Sunday, 9:00

Session C

Coping with Stress through Decisional Control: The Mixture Model Side of a Quasi Game-Theoretic Account. MATTHEW J. SHANAHAN, *Western University - Canada*, PETER NGUYEN, *Western University - Canada*, JIM NEUFELD, *Western University - Canada*. Coping with stress through Decisional Control entails positioning oneself in a multifaceted stressing situation so as to minimize the probability of an untoward physical or social event (Shanahan& Neufeld, 2010, British Journal of Mathematical and Statistical Psychology). Maximizing the threat reduction availed by Decisional Control is cognition intensive, requiring exhaustive analysis of situation options using predictive judgments of threat. As options increase, so too does potential threat reduction, but so again does requisite cognitive load, demonstrably stressing in its own right. These associations are converted into sentential statements expressing the architecture of decisional stress control, and the structure of its negotiation. Formal developments issue in a hierarchical discrete mixture model of stressor occurrence. Exploitation of mixture-model properties includes multinomial likelihood based model testing, and Bayesian individual profiling of one's stressor environment. These offshoots are illustrated numerically both with conjectured and real data. Extensions incorporating Beta-distributed levels of threat are previewed, and relevance of contemporary cognitive science (notably Townsend Systems Factorial Technology) to studying the for-

mulation of threat judgments is discussed. The presented account is situated within an expanded context conveyed by a nonlinear dynamical systems model of stress and coping (Neufeld, (1999), Psychological Review; Levy, et al, (in press), Nonlinear Dynamics, Psychology and Life Sciences). Finally, a possible taxonomy of individual differences in predilection toward Decisional Control is proposed.

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Monday, 3:10

Session C

Time matters: rational impatience underlies the Go bias in Go/NoGo compared to 2AFC decision-making. PRADEEP SHENOY, *University of California, San Diego*, ANGELA YU, *University of California, San Diego*. Two-alternative forced choice (2AFC) and Go/NoGo (GNG) paradigms are sometimes used interchangeably to study sensory and cognitive processing. While GNG is thought to isolate the decisional component by eliminating response selection, experimental data suggest a systematic bias toward the Go stimulus in GNG (more and faster Go responses), compared to the same two stimuli used in 2AFC (e.g., Bacon-Mace, 2007). We postulate that this "impatience" to go is due to the implicit asymmetry in the GNG cost structure. Using a Bayesian risk-minimization framework, we show how minimizing both response error and delay leads to the Go bias: the NoGo response must wait longer to register, while a Go response immediately terminates the trial. This optimal policy is equivalent to a drift-diffusion model (DDM) with a time-varying threshold that decreases backwards toward stimulus onset, as the temporal cost of choosing NoGo increases when further away from the response deadline. Counterintuitively, previous work directly fitting a fixed-threshold DDM to behavioral data (Gomez et al., 2007) found the threshold to be higher in GNG than 2AFC. We show how fitting a fixed-threshold DDM to the optimal model produces the same effects. The optimal model also makes two experimentally verifiable predictions: (1) error rate decreases as a function of response time (the constant-threshold approximation predicts a constant error rate independent of RT), (2) lengthening the response deadline exacerbates the Go bias.

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Sunday, 3:30

Session B

Aggregating subjective probabilities via statistical learning algorithms. YOUNGWON SHIN, *Applied Research Associates, Inc.*, EDGAR MERKLE, *University of Missouri*, DIRK WARNAAR, *Applied Research Associates, Inc.*, MARK STEYVERS, *University of California, Irvine* . Statistical learning algorithms have shown impressive performance in a variety of domains. We examine the abilities of out-of-the-box supervised learning algorithms to aggregate subjective probabilities across diverse sets of judges and forecasting problems. The algorithms are applied to data from the Forecasting Ace project (forecastingace.com), a web-based environment that allows volunteer contributors to forecast a variety of world events. Along with subjective probabilities, the algorithms can make use of a rich set of behavioral features from the website, including contributors' self-reported topic knowledge, their performance on previous forecasting problems, and the amount of time they spent on a particular forecast. Results indicate that the algorithms' performance is no better than aggregation methods that employ simple psychological con-

structs. Reasons for these results are discussed, highlighting unique characteristics of the data and shortcomings of the algorithms.

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Monday, 3:50

Session C

A drift-diffusion account of temporal discrimination. PATRICK SIMEN, *Oberlin College*, FUAT BALCI, *Koc University*. Temporal bisection is a commonly used psychophysical procedure in the study of interval timing. Subjects retrospectively categorize experienced time intervals ('probes') as short or long based on their perceived similarity to two, remembered reference intervals. Researchers have historically assumed that subjects use a comparator mechanism to make such decisions, but the dynamics of the mechanism's operation and the response times it predicts have received relatively little attention. The drift-diffusion model of two-choice perceptual decisions, however, may provide a framework for modeling retrospective temporal decision-making that can reveal these dynamics. To explore this possibility, we tested 35 human subjects on the temporal bisection task with multiple sets of test intervals over multiple sessions. We fit response time and choice data with a nested sequence of twelve drift-diffusion models of increasing complexity. In all models, a two-stage, sequential diffusion process was assumed, in which the first stage times intervals, and the second makes decisions about the first-stage temporal representation. Fits demonstrated that model parameters were related to probe durations in a manner consistent with reward rate maximization by a drift-diffusion decision process, applied to a drift-diffusion-based representation of time. Results support an extension of Ratcliff's diffusion model of two choice decision making to the domain of temporal decisions.

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Monday, 10:00

Session B

A Neurocomputational Theory of Attentional Selection in Multielement Displays. PHILIP SMITH, *The University of Melbourne*, DAVID SEWELL, *The University of Melbourne*. We generalize the integrated system model of Smith and Ratcliff (Psychological Review, 2009) to obtain a new theory of attentional selection in multielement visual displays. The theory proposes that attentional selection occurs via competitive interactions among detectors that signal the presence of task-relevant features at particular display locations. The outcome of the competition, together with attention, determines which stimuli are selected into visual short-term memory (VSTM). Decisions about the contents of VSTM are made by a diffusion-process decision stage. The selection process is modeled by coupled systems of shunting equations, which perform gated where-on-what pathway VSTM selection. The theory provides a neurocomputational account of key findings from attention tasks with near-threshold stimuli. These are: (1) the success of the MAX model of visual search and spatial cuing; (2) the double-target detection deficit; (3) redundancy costs in the post-stimulus probe task; (4) the joint item and information capacity limits of VSTM, and (5) the object-based nature of attentional selection. We argue that these phenomena are all manifestations of an underlying competitive VSTM selection process, which arise as a natural consequence of our theory.

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Monday, 11:25

Session B

Response-time distributions support the unequal-variance assumption in recognition memory. Jeffrey Starns, *University of Massachusetts Amherst*, Roger Ratcliff, *Ohio State University*. For the past couple of decades, many memory researchers have tried to use zROC data to test hypotheses about the evidence underlying recognition decisions. We have recently suggested that further progress can only be made by considering response time (RT) data in addition to zROC data (Ratcliff& Starns, 2009; Starns, Ratcliff,& McKoon, 2012). In the current project, we eliminated the zROC data entirely and used RT distributions alone to address a central question in the zROC literature. zROC slopes less than 1 typically have been explained by either appealing to a threshold recollection process or by assuming that evidence values for targets are more variable than evidence values for lures. Recollection theorists see the unequal-variance explanation as an ad hoc data-fitting exercise, but here we test a true prediction of the account. The diffusion model estimates between-trial variation in evidence using differences in the location and spread of RT distributions for correct and error responses. If the unequal-variance explanation is correct, this between-trial variability should be higher for targets than for lures. Previous applications of the diffusion model assumed an equal-variance model, but we re-fit the data from 15 existing datasets (376 subjects) with free parameters for target and lure variability. All 15 datasets showed higher variability for targets, and the difference reached significance for 12 datasets. Thus, RT distributions support the unequal-variance explanation independent of zROC data.

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Sunday, 9:00

Session B

Where is the log? A comparison of the Prior Information Criterion and the Bayes Factor. Sara Steegen, *University of Leuven*, Francis Tuerlinckx, *University of Leuven*, Wolf Vanpaemel, *University of Leuven*. Priors, while often maligned for supposedly introducing subjectivity, can also be viewed more beneficially as opportunities to capture theory in a model. A logical consequence of this perspective is that model selection methods should be sensitive to the prior. Most existing model selection methods, however, pride themselves as being insensitive to the prior, the most notable exception being the Bayes Factor (BF). Another example is the recently proposed Prior Information Criterion (PIC), a modification of the Deviance Information Criterion for evaluating (in)equality constrained hypotheses (Van de Schoot, Hoijtink, Romeijn& Brugman, 2012). PIC is closely related to the BF, in the sense that the latter averages the likelihood as weighted by the prior, whereas PIC averages the log-likelihood as weighted by the prior. While in some situations PIC and BF behave similarly and result in identical conclusions, we show that in other situations PIC can lead to conclusions that not only widely differ from the conclusions based on the BF, but are also highly questionable. Van de Schoot, R., Hoijtink, H., Romeijn, J-W& Brugman, D. (2012). A Prior Predictive Loss Function for the Evaluation of Inequality Constrained Hypotheses. Journal of Mathematical Psychology, 56, 13-23.

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Monday, 10:00

Session A

A Parameter Space Partitioning Analysis for Reinforcement Learning Models of the Iowa Gambling Task. HELEN STEINGROEVER, *University of Amsterdam*, RUUD WETZELS, *University of Amsterdam*, ERIC-JAN WAGENMAKERS, *University of Amsterdam, The Netherlands*. The Iowa gambling task (IGT) is one of the most popular tasks to study decision-making deficits in clinical populations. In order to decompose performance on the IGT in its constituent psychological processes, several cognitive models have been proposed (e.g., the Expectancy Valence and Prospect Valence Learning models). Here we present a comparison of these models based on parameter space partitioning. This method allows us to assess the choice patterns predicted by the models across the entire parameter space. Our results show that the EV model is unable to account for the frequency-of-losses effect, a prominent feature of IGT performance for healthy participants. The PVL model, in contrast, can handle the frequency-of-losses effect, but underpredicts choice pattern characterized by a preference of bad decks as often shown in clinical populations. Overall, our results suggest that the search of an appropriate IGT model has not yet come to an end.

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Monday, 11:45

Session C

Estimating Test Reliability with One Observation per Subject. HOBEN THOMAS, *Penn State University*. Spearman's latent variables random effects model for interpreting reliability correlation coefficients for two parallel tests, formalized in 1908 by Yule, remains extensively used in application settings far beyond Spearman's imagination. In 1951 Cronbach's alpha essentially extended the model to any number of parallel tests. But there are many venues in which obtaining two assessments is expensive, difficult, or impossible. Can test reliability be estimated with one assessment? The following fictitious story illustrates that in some settings this can be achieved.Imagine a setting of focus in which everyone lives in one of two equally-sized cities. The IQ mean of one city is 80, the other 120 with $\sigma^2 = 25$ in each. To estimate reliability of an IQ test: a) Obtain a random sample of, say, $n = 100$ IQ scores. b) Pair-up the observations randomly. c) If the absolute within-pair difference exceeds 15 points, discard the pair. d) Correlate the remaining pairs; the resulting r estimates the IQ test's "unknown" population reliability of .94. Theory will be developed and examples provided.

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Monday, 9:20

Session C

The Multi-attribute Linear Ballistic Accumulator Model of Context Effects in Multi-alternative Choice. JENNIFER TRUEBLOOD, *Indiana University*, SCOTT BROWN, *University of Newcastle*, ANDREW HEATHCOTE, *University of Newcastle*, JEROME BUSEMEYER, *Indiana University* . When decision-makers are faced with a choice among multiple options that have several attributes, preferences are often influenced by how the options are related to one another. For example, consumer preferences can be influenced and even reversed by the context defined by available products. Three standard context effects found in the preferen-

tial choice literature will be discussed: the attraction, similarity, and compromise effects. In the literature, there are two different stochastic models that account for the three effects: multi-alternative decision field theory (MDFT) (Roe, Busemeyer,& Townsend, 2001) and the leaky competing accumulators (LCA) model (Usher& McClelland, 2004). Although these models have provided insight into multi-alternative choice behavior, they are difficult to fit to data because they require computationally intensive simulations. The models also have other limitations such as using loss aversion and attention switching to account for context effects. The current work introduces an extension of the Linear Ballistic Accumulator model (Brown& Heathcote, 2008) called the multi-attribute linear ballistic accumulator (MLBA) model as an alternative framework for studying multi-alternative choice. Unlike MDFT and the LCA model, the MLBA model has an analytical solution making it easier to fit to experimental data. It also introduces a new psychological theory about context effects that does not rely on concepts such as lateral inhibition, attention switching, or loss aversion. Fits of the MLBA model to data from new experimental studies will also be discussed.

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Monday, 9:00

Session A

How to Collect Information in Uncertain Decision Environments? A Hierarchical Bayesian Modeling Approach. Don van Ravenzwaaij, *University of New South Wales*, Chris Moore, *University of New South Wales*, Michael Lee, *University of California Irvine*, Ben Newell, *University of New South Wales* . When making decisions people are often confronted with a plethora of information. Deciding what information to gather and what to ignore is no small feat. How do decision makers determine in what sequence information cues are collected and when to stop? In this study, we administered a version of the German Cities task, in which participants have to decide which of two unknown cities is the largest. Decision makers can collect different kinds of cues for both response alternatives (e.g., "Does this city have a university?") and have to make a decision as soon as they encounter one discriminating cue. Using a novel Hierarchical Bayesian model (Lee& Newell, 2011), we demonstrate that the data can be explained by two parameters: a weight parameter w, which quantifies the importance decision makers attach to the validity of the cue relative to the discrimation rate, and a response consistency parameter γ which quantifies decision makers' consistency in acting on the information provided by the discriminating cue.

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Tuesday, 11:25

Session C

Estimating the parameters of decision models without explicitly modeling the non-decision component of reaction time. Stijn Verdonck, *University of Leuven*, Francis Tuerlinckx, *University of Leuven*. In most decision models (e.g., the Ratcliff diffusion model), reaction times are considered to have a stimulus dependent decision part and a residual, stimulus independent non-decision part. While a lot of attention is generally given to the modeling of the decision part, the residual part is (if at all) mostly modeled in terms of very basic distributions, such as the uniform distribution. However, the non-decision part of reaction time is often esti-

mated to be responsible for up to one third of the total choice reaction time, suggesting it may require a more careful treatment. Based on the symmetry assumption that the non-decision time does not depend on the stimulus condition, we develop a non-parametric technique that estimates the parameters of the decision model without explicitly modeling the non-decision part of the RT. Simply put, we look for those parameters that result in a non-decision distribution (which can be obtained by deconvolving the decision model distribution out of the observed distribution) with minimal differences across stimulus conditions. A slightly modified version of this criterion circumvents the necessity of actually performing the tricky deconvolution step. In a second stage and if desired, the resulting non-decision distribution can then be calculated. It is shown that, using simulated data, we can recover the parameters of the Ratcliff diffusion model under a variety of non-decision distributions without any parametric assumptions about these distributions. The respective non-decision distributions can also be recovered.

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Monday, 11:05

Session A

How Informative are Concept Cues? Predicting Informativeness Judgments. Ronaldo Vigo, *Ohio University*, Basawaraj Basawaraj, *Ohio University*, Mark Gould, *Ohio University*. Many investigations on human categorization behavior aim to determine how humans form concepts based on knowledge about their exemplars; on the other hand, no studies have been conducted that attempt to determine the perceived degree of information conveyed by a concept cue (a subset of the set of known exemplars) about its associated concept. We propose that concept cues elicit information judgments about their associated concept that are not consistent with a prototype representation of the concept. One of the reasons is the inability of prototype theories to capture many of the contextual effects exhibited in situations involving multiple stimulus-objects. According to Representational Information Theory (Vigo, 2011) such contextual effects determine the degree of subjective information conveyed by each concept cue. Two experiments on information judgments using the well-known family of concept types with categorical stimuli consisting of three dimensions and four stimulus-objects support this view, suggesting that subjective information judgments are modulated by the human conceptual system.

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Monday, 11:45

Session A

Bias in Speeded Decision-Making: An Analysis with the Drift Diffusion Model. Eric-Jan Wagenmakers, *University of Amsterdam*. Even in elementary cognitive tasks, prior information can exert a powerful influence on performance; prior information increases speed and accuracy for decisions consistent with expectations, and decreases speed and accuracy for decisions inconsistent with expectations. Despite a recent surge of interest on this topic, the neural and computational mechanisms that subserve the biasing effect of prior information are still shrouded in mystery. In particular, it is not known whether bias is qualitatively similar when it is induced by advance knowledge about probability of occurrence or about amplitude of reward; it is unclear what brain mechanisms implement bias; there is disagreement on how an op-

timal decision-maker should adjust processing when confronted with prior information; and, finally, the extent to which people approximate the optimal ideal has been assessed only rarely. In this presentation I will attempt to address these issues with model-based neuroimaging techniques that involve the drift diffusion model, the linear ballistic accumulator model, and functional MRI.

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Sunday, 4:10

Session B

Entangling Beliefs and Actions during Interpersonal Interactions. Zheng Wang, *Ohio State University*, Jerome Busemeyer, *Indiana University, Bloomington*. Markov theory and quantum theory are two mathematical frameworks to build probabilistic-dynamical systems of human cognition. Markov models have been well established in psychology. However, converging empirical data have shown violations of the law of total probability, which Markov models must obey. Thus, alternative models based on quantum theory which do not obey the law of total probability have been explored. Quantum models share great similarity with Markov models, but they also profoundly differ in some of their psychological premises and are rooted from different probability theory (Busemeyer, Wang,& Townsend, 2006). Using a categorization-decision experimental paradigm, we show that beliefs about others and actions towards them become entangled during interactions, where beliefs and actions become interdependent, and changes in one cause changes in the other. This quantum entanglement state explains experimental findings which are puzzling from the perspective of Markov models. An initial conceptual and empirical comparison of Markov vs. quantum models to explain the findings are reported by Busemeyer, Wang, and Lambert-Mogiliansy (2009). This paper reports three additional experiments to further test the Markov vs. quantum models. Violation of the law of total probability was observed in all the experiments. The quantum model, called Belief-Action Entanglement Model (BAEM), was estimated using hierarchical Bayesian method using data across all experiments (total N = 481). The distribution of the entanglement parameter suggests that quantum, rather than Markov, dynamics can better describes the interpersonal categorization-decision process.

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Sunday, 3:10

Session B

Quantifying expertise based on past performance. Dirk Warnaar, *Applied Research Associates, Inc.*, Youngwon Shin, *Applied Research Associates, Inc.*, Mark Steyvers, *University of California, Irvine*. Expertise is a poorly defined and subjective characteristic. It is often implied that expertise applied to similar tasks produces similar results. We examine whether this can be applied to aggregate predictions of global events from a wide range of volunteer contributors. These predictions take the form of probabilistic judgments of problem statements related to world events. Weighting judgments based on the individual's level of knowledge or expertise is difficult for many reasons; e.g. prior to the outcome of the event it is not known what topic knowledge would contribute to making an accurate forecast. We propose an objective method for establishing an expertise profile based on past performance on similar forecast problems. This method relates one event to the oth-

ers through a set of similarity measures between events that are obtained by extracting unique keywords from the descriptions of two events, and analyzing the web-search engine results for combinations of keywords and general topic words. The paper discusses how the similarity measures can also be used to develop forecast problem profiles. Individuals can then be up- or down-weighted based on the extent that the individual's profile matches the problem profile.

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Sunday, 3:10

Session C

Bias in Simple Decisions. Corey White, *University of Texas at Austin*, Russell Poldrack, *University of Texas at Austin*. The ability to adjust bias for one option over others is a critical component of decision making that allows for great behavioral flexibility. Choice response time (RT) models like the drift-diffusion model (DDM) assume that bias can be induced by adjusting the evaluation of the stimulus, which produces changes in the value of decision evidence (i.e., drift rates), or by adjusting expectations about the upcoming response, which produces changes in how much evidence is needed for each response (i.e., the starting point of evidence accumulation; Ratcliff et al., 1999, Psych Rev). Importantly these biases can be dissociated behaviorally because they produce different effects on the distributions of RTs. We manipulated both types of bias independently in perceptual and recognition memory tasks to assess their behavioral effects across different decisions. Effects of expectancy manipulations were most pronounced for fast responses, consistent with changes in the starting point in the DDM. However there was some evidence of expectancy bias for slow responses, consistent with the dynamic biasing signal introduced by Hanks et al. (2011, J Neurosci). Effects of evaluation manipulations were fairly consistent across different response speeds, consistent with changes in the value of decision evidence. The DDM separated these biases into distinct parameters, offering a promising methodological approach to interpreting decision bias. The results highlight important considerations regarding how response expectation and stimulus evaluation interact to influence bias, how they relate to other aspects of the decision process, and how their effects can be identified in the behavioral data.

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Sunday, 9:20

Session B

Some boundary likelihood ratio tests and confidence intervals in psychological models. Hao Wu, *Virginia Commonwealth University*, Mike Neale, *Virginia Commonwealth University*. It is well known that the likelihood ratio test (LRT) usually requires a non-boundary true value and a non-singular information matrix. Unfortunately these regularity conditions are not met in many cases and the test need to be amended. Such cases include the test of variance components or random effects, as a zero covariance matrix of the random effects is a boundary value. In this presentation I will review the theory of correcting LRTs based on conic approximations and apply it to the problem of testing variance components and some other tests in twin studies. A confidence interval will also be constructed for a bounded parameter to give consistent result to the LRT.

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Monday, 3:10

Session B

A Multinomial Processing Tree Model for List Method Directed Forgetting in Free Recall. ZHUANGZHUANG XI, *Purdue University*. In the list method directed forgetting paradigm, subjects are presented with two lists of items one after the other. Between the two lists a cue is presented and subjects are instructed to forget or keep remembering List 1 before proceeding to List 2 presentation. Memory of List 1 is poorer if subjects are asked to forget the list; this is called the directed forgetting effect. An experiment is reported to examine whether sleep can differentially affect memory of the to-be-remembered and to-be-forgotten items. Results are analyzed using a Multinomial Processing Tree (MPT) model. The proposed model assumes there are two paths via which an item can be recalled: generate-then-recognize or automatic recall. An item can be generated from a serial position in the list and then be recognized, or it can be recalled in a less elaborate way and then the list membership determined. The effect of directed forgetting and possible effects of sleep are discussed in the MPT model.

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Sunday, 11:05

Session A

Examining the effect of payoffs on stimulus detection in a redundant-target detection task. CHENG-TA YANG, *National Cheng Kung University*, YUAN HU, *National Cheng Kung University*. A redundant-target detection task has been widely used to study how participants detect signals from spatially independent channels. For example, using the systems factorial technology (SFT), Townsend and Nozawa (1995) found that participants adopted parallel processing and followed a self-terminating rule to detect redundant signals. However, it is still unclear whether the decision process is affected by the top-down factors, i.e., payoffs, which can affect the perceived relative salience between signals from different spatial channels. In the present study, we followed Townsend and Nozawa's (1995) study and conducted two experiments. Participants had to detect whether there was a signal on the right or left side (single-target condition) or on the both sides of the screen (redundant-target condition). In addition, the payoff matrix was manipulated. Results showed that no matter when an unbiased payoff matrix (i.e., right correct: +1; right incorrect: -1; left correct: +1; left incorrect: -1) or a biased payoff matrix (i.e., right correct: +5; right incorrect: -5; left correct: +0; left incorrect: -0) was applied, participants adopted parallel self-terminating processing to detect redundant targets. The manipulation of payoffs only affected the allocation of attentional weight on different spatial channels, which in turns affected the processing speed on different channels. The results suggest that relative saliency does not affect the processing structure when signals are from spatially independent channels and highlight that processing spatially distinct information is of unlimited capacity.

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Tuesday, 9:20

Session B

Early word learning through associations in context. HYUNGWOOK YIM, *The Ohio State University*, XIN YAO, *The Ohio State University*, SIMON DENNIS, *The Ohio State University*, VLADIMIR SLOUT-

SKY, *The Ohio State University* . Early word learning is often considered as a difficult problem to solve since it requires both mapping a word to the exact meaning while generalizing the meaning beyond that of the learned context. Mainly there have been three views to solve the problem. One view argues that early word learning involves hypothesis testing and there are certain innate biases that facilitate the process (e.g. Markman, 1989), while another view sets probabilistic hypothesis spaces and sampling process for evaluating the hypotheses for word learning (Xu and Tenenbaum, 2007). On the other hand, a third view argues that early word learning is accomplished by a simple but powerful associative mechanism (i.e. associative and attentional learning) that stands on lesser assumptions than the previous views (e.g. Colunga& Smith, 2005). The current study is based on the last view. Especially we argue that early word learning could be explained by encountering the to-be-learned words in a context where the context provides syntagmatic (i.e. association between the words that co-occurred) and paradigmatic (i.e. associations of words having the same role in a similar context) associations between the words. We propose a model based on these associations, where the syntagmatic association is greater for children (Brown, 1957). Therefore, for children, it could be predicted that associative generalizations would be stronger than taxonomic generalizations during word learning. Conducting a series of experiments using a modified word learning task (i.e. label extension) supported the proposed model that could not be explained by models based on hypothesis testing.

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Monday, 3:30

Session C

The time course of processing retrospective confidence judgments. SHULI YU, *Michigan State University*, TIMOTHY PLESKAC, *Michigan State University*, MATTHEW ZEIGENFUSE, *Michigan State University*. There are several hypotheses about what information people use to make confidence judgments and the time course of confidence after a choice is made: (1) Confidence and choice may be derived simultaneously based on the same information, which implies that confidence should not change after a choice is made; (2) Confidence may be developed after choice by accumulating confirming evidence to justify the success of the decision, which predicts that confidence in both corrects and incorrect choices should strengthen with more time; or (3) Confidence may be developed after choice based on accumulating evidence about the choice options. This two-stage hypothesis is consistent with recent sequential sampling models of confidence judgments and predicts that confidence in correct responses should strengthen while confidence in errors should weaken. Hence, confidence accuracy should improve with time. We present results from two studies that test these different hypotheses by manipulating the time people take between making a choice and making a confidence judgment. Consistent with the two-stage hypothesis, results show that increased post-decisional processing time improved confidence resolution with stationary and dynamic stimuli. However, the improved resolution was due to reduced confidence in errors with time while confidence in correct responses remained relatively constant.

This pattern is not consistent with a two-stage model assuming a constant rate of evidence accumulation. Rather evidence accumulation after a choice appears to be state dependent where confirming evidence has a decreasing impact on confidence, but disconfirming evidence has increasing impact on confidence.

(96)
Monday, 9:40
Session A

A rational account of contextual effects in preference choice: what is fair? Angela Yu, *University of California San Diego*, Pradeep Shenoy, *University of California San Diego*. Choosing among multiple options requires humans to decode and compare the relative value of the available options. This valuation is particularly challenging when the options differ along multiple attribute dimensions, with no universal mapping among the different dimensions, or from them to a shared value dimension. Human choice behavior exhibits several idiosyncrasies in these multi-attribute contexts. For example, subjects consistently exhibit contextual effects in preferential choice: the attraction effect, the similarity effect, and the compromise effect. Each of these effects involve an "irrational" shifting of the relative preference between two options when a third option is introduced. We propose a normative Bayesian model of preference choice, and demonstrate that these apparently irrational contextual effects naturally arise from two simple assumptions: (1) humans make preferential choices based not on intrinsic value of the options, but relative value anchored with respect to the "fair market value", (2) the fair market value is not directly accessible or universally agreed upon, but rather inferred by each individual based on both subjective preference and observed data. In particular, the range of values for an attribute in the choice proposal is itself used by the subject to infer the mean and variance of fair market value, and to map each attribute to a scalar value function based on the perceived relationship to fair market value. We show that this relative framing effect accounts for all three of the contextual effects found in the preference choice literature, and also predict novel types of contextual effects.

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Tuesday, 10:00
Session A

Gaps between Orders and Equal Spacing of Orders of Hierarchical Complexity. Eva Yujia Li, *Harvard Graduate School of Education*. This study investigates whether the Model of Hierarchical Complexity (MHC) is an equally spaced scale with gaps between orders. The model is an analytic tool to study the a priori difficulty of tasks. In an instrument, participants were asked to answer questions about whether the laundry would be dirty or clean under a set of conditions. Items were designed to have different Orders of Hierarchical Complexity. The higher order items non-arbitrarily coordinated the lower order tasks. Participant responses were coded and Rasch Analysis was conducted to calculate the difficulty of items. Firstly, the data showed that the Order of Hierarchical Complexity was an ordinal scale, as the Rasch Scaled Item difficulty of items were consistent with their Orders of Hierarchical Complexity. Secondly, it is shown that the gaps between the highest Rasch-scaled item scores at a lower order and the lowest scores at the next higher order exist. We found there was no overlap between the Rasch-scaled item scores at one order of complexity, and those of the adjoining orders.

Hence, there are 'gaps' between the stages of performance on those items. Second, we tested for equal spacing between the Orders of Hierarchical Complexity. We found that the means for Rasch performance on each order's items were equally spaced. To deviate significantly from the data, the orders had to deviate from linearity by over .25 of an order. This would appear to be an empirical and mathematical confirmation for the equally spaced stages of development.

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Monday, 3:10

Session A

The Rasch model and stochastic resonance. ANNEMARIE ZAND SCHOLTEN, *University of Amsterdam*. In the Rasch model item responses are characterized as a logistic function of the difference of item difficulty and person ability. Item discrimination is not allowed to differ between items in the model. Objections to interval level measurement claims associated with the Rasch model (Michell, 2008, 2009) have given rise to the conceptualization of an item discrimination parameter that varies, not between items, but between forms of administration of the items (e.g. speeded vs. non-speeded). The increase of item discrimination is supposed to correspond to an increase in measurement precision. However, removing error does not necessarily result in higher precision; a certain amount of error can be informative. This phenomenon, known in other fields as stochastic resonance, will be demonstrated using data obtained from respondents who were asked to solve simple arithmetic problems under varying amounts of time pressure.

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Tuesday, 10:45

Session C

Accumulating Reward Information During Risky Decisions. MATTHEW ZEIGENFUSE, *Michigan State University*, TIMOTHY PLESKAC, *Michigan State University*, TAOSHENG LIU, *Michigan State University*. When sequential sampling models are applied to risky decisions they assume as individuals deliberate they imagine or simulate possible payoffs coming from the options. Here we investigate this assumption with a task that requires active integration of reward information over time. During the task subjects made repeated choices between two displays filled with a large number of dots valued$0.003 each. One display was a sure thing with a fixed number of dots. The other was a risky option where the number of dots changed quickly and were draws from a normal distribution. After each choice subjects were rewarded with a draw from the chosen option. Choice behavior was sensitive to the average difference in reward between the two options, but not the variability. We also had a second perceptual group of subjects see the same displays, but were told to identify which display had more dots on average. Objectively both the gambling and perceptual groups should have the same goal, but we find differences in choice proportions and response times between the two groups. Drift diffusion model analyses isolate differences between the gambling and perceptual groups to differences in the drift rates, not bias or threshold. In particular, subjects in the gambling group extracted information favoring the risky alternative at faster rate, but were less sensitive to changes in reward rate. Overall, our results suggest sequential sampling

models can provide a good framework for understanding risky decisions, but the nature of the evidence during deliberation requires further investigation.

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Tuesday, 11:45

Session C

Drift Diffusion Model with Converging Boundaries. Shunan Zhang, *University of California, Irvine*, Michael Lee, *University of California, Irvine*, Joachim Vandekerckhove, *University of California, Irvine*, Gunter Maris, *University of Amsterdam* , Eric-Jan Wagenmakers, *University of Amsterdam*. Drift diffusion models are popular accounts of the time course of decision-making, and can provide a process account of accuracy, response time and also confidence of human decisions in many tasks. We consider the situations where the drift diffusion model have converging instead of constant boundaries. In the first situation, allowing converging boundaries will lead to model equivalence between the diffusion model and other models that use different information integration methods, such as the accumulator model. In the second situation, converging boundaries are necessary to maintain optimality with respect to sensible utilities when decision has to be made under time pressure.

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Sunday, 10:45

Session A

Perceptual Separability through Selective Influence. Ru Zhang, *Purdue University*, Ehtibar Dzhafarov, *Purdue University*. Perceptual separability of stimulus dimensions is a widely used intuitive notion. Several approaches were utilized to make this notion operationally and mathematically rigorous, e.g., within the framework of MDS, General Recognition Theory, and generalized Fechnerian Scaling. We propose a new approach to perceptual separability, which may depict another aspect of this intuitive notion. Let stimulus dimensions (properties) D1 and D2 be judged/assessed by responses R1 and R2, respectively, generally random variables. Then D1 and D2 are perceptually separable if changes in the values of D1 and D2 selectively influence R1 and R2, respectively. In this approach therefore the notion of perceptual separability may depend on the judgments R1 and R2 being used. Selective influence is understood as the representability of R1 as a function of D1 and C, and of R2 as a function of D2 and C, where C is a common source of randomness. Several computational procedures (tests for selective influences) have been previously developed to ascertain if this representability is possible. We have developed an experimental procedure in which R1 and R2 are the values of D1 and D2 in a stimulus adjusted by an observer to match a target stimulus (which makes the choice of D1-D2 flexible and unknown to the observer). We report the results of "test-driving" this procedure and subsequent computations (linear feasibility and cosphericity tests for selective influences) using as D1 and D2 simple geometric properties of dots and line drawings.

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Monday, 11:25

Session A

Some Answers to Luce's Challenge for Decision Researchers. Chris Zwilling, . Michel Regenwetter, , Yun-shil Cha, , Ying Guo, , Anna Popova, . Many times over his illustrious career, Duncan Luce has highlighted

a two-fold challenge for researchers who study decision theories (e.g., 1959, 1995, 1997). First, find probabilistic specifications of algebraic decision theories. Second, develop appropriate statistical methodology to test these probabilistic specifications. Regarding the first challenge, we discuss a unified probabilistic framework that reconciles error models, modal choice, Luce's choice axiom, logit and probit models, as well as distribution-free random utility and mixture models. Some of these models posit fixed unique binary preferences or a unique utility function in a decision maker, with an allowance made for committing errors. Some of these models specifically treat preference as uncertain or variable. In regards to Luce's statistical challenge, our group has recently developed, and presented, frequentist (Math Psych, 2010) and Bayesian (Math Psych, 2011) methodologies. We expand our analyses to test multiple decision theories, different functional forms of the same decision theory and to test different data sets. More than 50 years after Duncan Luce proposed his influential choice axiom, there are now a whole range of different approaches to reconciling variable choice behavior with deterministic decision theories.

Abstracts For Posters

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Sunday, 5:00-6:30

poster session

Item strength and associative information: Examining the role of item repetition on subsequent cued recall. William Aue, *Syracuse University*, Amy Criss, *Syracuse University*. In cued recall, Aue, Criss,& Fischetti (2012) observed an increased level of responding for word-face pairs that were composed of repeated items relative to pairs composed of items that were not repeated. That is, both correct responses and incorrect responses were higher when the studied pair was composed of repeated items, but the pair itself was studied just once. In the current experiments, we investigated whether this increase is the result of cue strength, target retrieveability, or both. This is accomplished by separately manipulating the strength of items that later served as cues or as targets and by manipulating whether the repetitions were in the form of single items or pairs. Implications for models of episodic memory are discussed.

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Sunday, 5:00-6:30

poster session

An Evaluation of Behavioral Similarities Between Human Coders and an Automated System for Coding Free Response Data. Alexander Bichler, *University of Texas at Dallas*, Shahram Ghiasinejad, *University of Central Florida*, Richard Golden, *University of Texas at Dallas*. The problem of coding free response data arises frequently in the analysis of talk-aloud, recall, and summarization data in behavioral studies. AUTOCODER is a graphical-user-interface tool intended to facilitate reliable and replicable coding of free response data. The essential idea of AUTOCODER is the concept of a Hidden Markov Model where the system learns the emission probability of a particular word given a word-sense as well as the transition probability that one word-sense follows another given a particular proposition. Using these statistics, the best-fitting HMM is assigned to a given subsequence of words. In order to evaluate the effectiveness of the AUTOCODER system, a statistical template environment was created that used sentence templates to generate a wide variety of English sentences involving ambiguous words that could only be disambiguated using sentence context (i.e., the sequence of word-senses). The generated sentences were then corrupted by systematically violating syntactic structure and replacing select words with pseudowords. Thirty-nine human participants were then asked to identify the propositions associated with the corrupted sentences. Next, after learning the statistical template environment, the AUTOCODER classified the propositions associated with the same corrupted sentences. The performance of the AUTOCODER in coding the corrupted

sentences was comparable to human participants using a Kappa agreement measure in order to assess the reliability of coding. To assess coding validity, both precision and recall measures of performance were used. The results of this study suggest the AUTOCODER approach is a promising methodology for aiding and documenting free response data coding procedures.

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Sunday, 5:00-6:30

poster session

Individual differences in free recall and intelligence. Patrick Crutchley, *University of Pennslyvania*, Karl Healey, *University of Pennslyvania*, Michael J. Kahana, *University of Pennslyvania*. Much existing work on individual differences in memory has focused on the ability of overall recall probability on memory tasks to predict performance on tests of fluid intelligence. Recall probability, however, is determined by multiple underlying memory processes. To study individual differences in these processes we collected multiple (7+) sessions of free recall data from each of 102 participants and used sophisticated measures that provide indices of how participants initiate recall and how they make transitions between items. Probability of recall was positively correlated with both temporal clustering and semantic clustering. The two clustering measures were negatively correlated with each other, however, suggesting a tradeoff in strategy. Furthermore, the tendency to initiate recall with the final list item was negatively correlated with overall probability of recall. These correlations are robust across several experimental manipulations. Full-scale Wechsler Adult Intelligence Scale IQ was collected for a subset of 68 participants. Recall probability was positively correlated with full-scale IQ scores. We explore how recall initiation and clustering contribute to the positive correlation between recall probability and full-scale IQ.

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Sunday, 5:00-6:30

poster session

People's estimation of probabilities in football (soccer) games. Irina Danileiko, *University of California, Irvine*, Michael Lee, *University of California, Irvine*. People's estimation of probabilities is often studied in tasks that are artificially created (like gambling games) or difficult to control (like real-world prediction tasks). We collected statistics from more than 6000 first-division football (soccer) games played over the last decade, and measured a set of interesting probabilities in this real-world environment. We then asked people to estimate these probabilities: "What is the probability a game has a 0-0 scoreline at half time?", "What is the probability a team leading after 80 minutes will win a game?", and so on. The questions were constructed to span the full range of probabilities from 0 to 1, allowing us to infer a calibration curve relating people's probabilities and the true empirical probabilities, in this structured environment.

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Sunday, 5:00-6:30

poster session

Confirming construct validity across literacy and income levels using a higher-order invariance factor model. Geneva Dodson, *University of Virginia*, Steven Boker, *University of Virginia*, Michele Evans, *National Institute on Aging*, Alan Zonderman, *National Institute*

on Aging . To establish construct validity in a model, one must identify a sound theoretical basis and establish that the model contains invariant relationships. Traditionally, researchers establish invariance at the level of factor loadings on manifest variables. However, if factor loadings were variable across people, invariance could be established on the level of factor covariances. Such higher-order invariance would allow for interindividual differences without compromising the latent model. In this study, using both the traditional and higher-order invariance methods, we investigated the construct validity of a cognitive battery across groups of varying income and literacy levels. In a Monte Carlo simulation, we found that a higher-order invariance factor model was able to establish well-fitting models when the groups a) had identical factor loading patterns or b) shared two factors with other groups. In our application of the method, we found that we could establish a model confirming invariance via factor loadings conditional on forcing the data to conform to a sub-optimal model; however, a higher-order invariance model fit the data well, allowing the subgroups to have varying factor loading patterns while still substantiating the latent constructs via identical second-order factors.

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Sunday, 5:00-6:30

poster session

Learning in Unknown Dynamic Environments: A Quantum Reinforcement Learning Approach. PEGAH FAKHARI, *Indiana University*, JEROME BUSEMEYER, *Indiana University*. Human lives are characterized by series of decisions they make in an environment that changes both spontaneously and as a result of their earlier actions. Unlike simple and conventional one-time decisions, dynamic decision tasks with multiple controllable and uncontrollable steps are more similar to real life situations. In these tasks subjects choose one or multiple actions among a set of possible actions they have per step and receive the environments' feedback untill they reach the final goal. Many researchers developed models like a production rule model (Anzai, 1984), an instance based model (Dienes and Fahey, 1995) and neural networks (Gibson, Fichman,& Plaut, 1998) to understand human learning processes in various dynamic decision tasks. The reinforcement learning model is another type of model for learning dynamic systems (Sutton& Barto, 1998) which has been used in robotic applications (Miller, Sutton,& Werbos, 1991), but not yet been tested for human performance in dynamic decision tasks. The goal of this algorithm is to maximize the future cumulative reward through interacting with environment. It doesn't need to know the model of the environment and optimization is based on the agent's on-line samples from environment. While there are many algorithms in reinforcement learning framework which have been proposed to solve dynamic decision making in complex environments, still exploration-exploitation trade off, learning speed and sensitivity to environment's variation remain under debate. In this study, we use a new quantum reinforcement learning model to explore these difficulties by simulating a dynamic grid world environment. Results demonstrate that the performance of Quantum Reinforcement Learning isn't sensitive to the selection of the exploration-exploitation parameter and therefore is more robust.

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Sunday, 5:00-6:30

poster session

Graphic-Processing-Units based Adaptive Parameter Estimation of a Visual Psychophysical Model. Hairong Gu, *Ohio State University*, Jay Myung, *Ohio State University*, Mark Pitt, *Ohio State University*, Zhong-Lin Lu, *Ohio State University* . The applicability and effectiveness of adaptive design optimization (ADO) in selecting the maximally informative values of stimulus and design variables to present on each experimental trial have been well demonstrated in several content areas of cognitive psychology (Myung& Pitt, 2009; Cavagnaro et al, 2010). On the other hand, heavy computational costs associated with the implementation of ADO have been a major challenge in applying ADO for real-time, online experiments with human participants, such as in a psychophysical experiment with clinical patients. In the present study we explore ways of speeding up the computation of ADO by taking advantage of more powerful hardware. Given the recent surge of interest and use of parallel computing enabled by graphics processing units (GPUs), the purpose of this study is to examine the feasibility and performance of GPU-based ADO estimation of the threshold and slope of the visual psychometrical model of Kontsevich and Tyler (1999), in relation to that of the standard, CPU-based ADO computation. Because it is easy to parallelize, a GPU-based grid search algorithm was implemented and compared with the same algorithm run on a single CPU chip. The results showed that GPU computing provided dramatic reduction in compute time. Another goal of such experiments is to reduce the number of trails to meet required measurement criteria. The efficiency of grid search (with variable grid resolution) and sequential Monte Carlo were compared in terms of accuracy and precision in parameter estimation. Both algorithms worked similarly well.

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Sunday, 5:00-6:30

poster session

A survey of observed power in a large sample of published articles in psychology. Maime Guan, *University of California, Irvine*, Joachim Vandekerckhove, *University of California, Irvine*. Statistically significant results are more likely to be published than non-significant results. This form of publication bias inflates the estimated replication probability of a study. Recently, an extension of statistical power analysis has been applied to identify evidence of publication bias in individual articles in several peer-reviewed psychological journals. In the present project, we apply this extension to a large random sample of published articles in three leading journals in psychology: "Psychological Science", "Journal of Personality and Social Psychology", and "Journal of Experimental Psychology: Learning, Memory, and Cognition". The first 30 articles in the 2008 editions of these journals were previously selected for replication by the collaborative "Reproducibility of Psychological Science" project. We identify a subset of this representative sample that is eligible for post hoc power analysis, report on the observed power of those studies and identify the minimal sample size required to replicate each reported result with 80% probability. We also compute the likelihood of each set of outcomes under the assumption of unbiased publishing.

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Sunday, 5:00-6:30

poster session

The shortest path as a spatially global interpolation of contours in images. Shweta Gupte, *Purdue University*, Yunfeng Li, *Purdue University*, Zygmunt Pizlo, *Purdue University*. Extracting meaningful contours in a 2D image in an unsupervised way is still an unsolved problem. By 'meaningful' we mean occluding contours, as well as internal contours representing symmetrical features in the 3D space. The main challenge is the large amount of irrelevant contours. We applied the shortest path algorithm in two representations: (i) the retinal image, and (ii) the area V1 of the cortex, which is known to be a log-polar transformation of the retina. The log-polar transformation of the retinal image is well suited for detecting closed contours because a straight line in area V1 corresponds to a circle on the retina. We set the fixation point inside the image of the object and randomly choose a starting point in the log-polar representation, which is also the end point. The shortest path corresponds to a closed contour that circumscribes the fixation point in the original image. A point is more likely to be on the occluding contour if more short paths pass through this point. We threshold the probability of a point being on the occluding contour to produce an approximation of the occluding contour. Once the occluding contour of an object is identified, we chose pairs of points on the contour and compute the shortest path in the retinal image to identify the meaningful internal contours inside the object. Our model is the first spatially global method for contour interpolation in images.

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Sunday, 5:00-6:30

poster session

The effect of continuous word frequency, context variability and OLD across memory tasks. Pernille Hemmer, *Syracuse University*, Amy Criss, *Syracuse University*. Understanding the properties of words that contribute to successful memory is an important empirical and theoretical question. However, progress has been difficult in part because continuous properties of words have often been treated as discrete categories (low and high) and because the same property often has opposite effects in different memory tasks. For example, low frequency words are better recognized but poorly recalled compared to high frequency words. The goal of this project was to understand the complex relationship between task characteristics and word properties that lead to successful memory. To do so, we developed a large stimulus set including 924 words (from the Touchstone Applied Science Associates (TASA) corpus) and identified the normative word frequency, context variability, and OLD (orthographic Levenshtein distance 20) values for each word. We then collected data from 396 subjects in each of 5 memory tasks (single item recognition, associative recognition, cued recall, free recall, and lexical decision). Our analysis focuses on identifying factors across tasks, across word properties, and across participants that best predict performance. The data will be used to inform models of memory.

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Sunday, 5:00-6:30

poster session

Parameter identifiability in models of perceptual decision making.

Arash Khodadadi, *Indiana University*, James Townsend, *Indiana University*. In recent years, several models have been proposed that can account for the behavioral data in perceptual decision-making tasks. Each of these models uses different mechanisms to explain the processes underpinning subjects' performance. In general, one can classify these models based on their assumptions about temporal integration (with or without temporal integration), threshold (constant vs. time-varying threshold), interaction between channels, and variability in the parameters across trials. In this study, we consider a general model that comprises all of these mechanisms. Each of the previously proposed models can be obtained by fixing some of the parameters of this general model at specific values. The goal of the study is to assess the practical identifiability of the parameters of this model for different shapes of the stimulus (step, pulse etc.). In doing so, we fit the model to subjects' data collected from a visual decision-making task with different stimuli. We then exploit a recently developed method for investigating identifiability of nonlinear dynamic systems based on analyzing their profile likelihood. This method takes the maximum likelihood estimation of the parameters as its input and provides the sensitivity of the maximum likelihood function to the changes in each of the parameters of the system. We investigate how different forms of the stimulus affect the sensitivity and, as a result, the identifiability of the parameters. This analysis provides important information about how the shape of the stimulus can determine the falsifiability of different models of perceptual decision making.

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Sunday, 5:00-6:30

poster session

Adopting a Support Vector Machine in Psychological Studies to Detect Group Differences. Bommae Kim, *University of Virginia*, Timo von Oertzen, *University of Virginia*. A likelihood ratio test is widely used in social science and known as the most powerful statistical test if collected data is normally distributed and a research model is properly defined. If the data or the model violates the assumption, the likelihood ratio test may not lead to a proper conclusion due to alpha inflation. As a distribution-free and model-free statistical test, a new alternative available is a support vector machine. A support vector machine is a statistical classification method in machine learning that can predict group membership based on the data itself, without any assumption about distribution or models. Support vector machines can be useful when we test whether there are any differences between two groups. Here, we present simulation results that examine the Type I error and the power of both likelihood ratio tests and support vector machines to detect group differences in latent growth curve models. The simulation conditions are varied in sample size, effect size, the number of measurement occasions, and violation of normal distribution. The likelihood ratio test shows better performance overall, but the support vector machine shows advantages when the data does not follow normal distribution. We discuss how to improve the support vector machine as a statistical test and suggest how to use classification methods as statistical tests.

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Sunday, 5:00-6:30

poster session

A Nonparametric Ability Measure. Nan Kong, *ETS*. This paper defines a new measure of examinees' abilities using additivity, one of the fundamental properties of a measure. By employing mathematical proofs, other fundamental properties of the new measure are demonstrated. This paper also shows that shared ability and unique ability can be determined with this new measure. Finally, the paper looks at subscales and partial credits for the ability measure.

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Sunday, 5:00-6:30

poster session

Beyond process tracing: The response dynamics of preferential choice. Gregory Koop, *Miami University*, Joseph Johnson, *Miami University*. The ubiquity of process models of decision making requires an increased degree of sophistication in the methods and metrics that we use to evaluate models. In this paper, we capitalize on recent work in cognitive science on analyzing response dynamics (or action dynamics). We propose that, as information processing unfolds over the course of a decision, the bearing this has on intended action is also revealed in the motor system. This decidedly 'embodied' view suggests that researchers are missing out on potential dependent variables with which to evaluate their models, specifically the motor response associated with choice. We first validate this method for use in the domain of decision making generally, and preferential choice specifically, using widely normed stimuli from the International Affective Picture System (Experiment 1). After demonstrating that curvature in response trajectories provides a metric of the competition between choice options, we further extend the method to risky decision making (Experiment 2). In this second study, both choice (discrete) and response (continuous) data correspond to the well-known idea of risk-seeking in losses, and risk-aversion in gains, but the continuous data also demonstrate that choices contrary to this maxim may be the product of at least one online preference reversal. Finally, we discuss how characteristics of these continuous process data can be formalized within the multiattribute dynamic decision model (Experiment 3). In sum, we validate response dynamics for use in preferential choice tasks and demonstrate the unique conclusions afforded by response dynamics over and above traditional methods.

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Sunday, 5:00-6:30

poster session

Utilizing the inherent properties of fractional anisotropy in DTI with correspondence analysis. Michael Kriegsman, *University of Texas at Dallas*, Ehsan Shokri-Kojori, *University of Texas at Dallas*, Dan Krawczyk, *University of Texas at Dallas*, Amy Pinkham, *Southern Methodist University* , Herve Abdi, *University of Texas at Dallas*. Research on brain structural connectivity has advanced rapidly with the advent of diffusion tensor imaging (DTI), a non-invasive MRI method that measures the direction and intensity of preferred water diffusivity within small brain volumes (called voxels). For each voxel, water diffusivity is measured from several directions, which are then integrated into a 3 by 3 positive semi-definite (psd) matrix whose eigen-decomposition gives three eigenvalues that represent the magnitude

of diffusivity for three directions. The most common output metric of DTI, fractional anisotropy (FA), is computed from these three eigenvalues, and is proportional to the sum of the squared deviations of the eigenvalues, normalized by the sum of the squared eigenvalues. FA ranges from 0 (spherical diffusion) to 1 (linear diffusion), and is widely used in neuroimaging as a measure of directionality. We found that FA as a measure could be inherently problematic because widely different patterns of diffusivity (i.e. cylindrical to planar), represented by different combinations of eigenvalues, can generate similar FA values. To investigate if an approach other than FA could alleviate this problem, we compared the standard computation of FA to a novel application of correspondence analysis (CA) performed on the eigenvalues. CA was selected because it is a PCA-based technique designed for positive data (such as eigenvalues of a psd matrix) in the form of frequencies or proportions. Using relevant examples from neuroimaging experiments, we contrast a traditional approach using FA with the new CA approach.

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Sunday, 5:00-6:30

poster session

Human recovery of the shape and size of a 3D indoor scene. Taekyu Kwon, *Purdue University*, Yunfeng Li, *Purdue University*, Tadamasa Sawada, *Purdue University*, Yun Shi, *Purdue University* , Zygmunt Pizlo, *Purdue University*. Little is known as to how humans recover 3D scenes based on the information provided by 2D retinal images. Previous studies reported that human visual space is systematically distorted. However, these studies cannot be generalized beyond impoverished viewing conditions. The present study investigated how humans perceive a layout of an indoor scene under natural viewing conditions. When the subject was asked to draw a top view of a scene, she reconstructed the shape of the scene accurately. The reconstructed overall size varied from trial to trial due to a response bias. There was little or no evidence for an affine or projective distortion of the visual space. To test the intrinsic geometry of the visual space, Foley's (1972) right isosceles triangle experiment was replicated under natural viewing conditions. Unlike Foley's subjects, our subjects adjusted the right isosceles triangle very accurately. The same task was repeated in several viewing conditions: bright vs. dark room, stimuli on the floor vs. at the eye level, and 2 vs. 3 objects (when two objects were used, the subject, herself, was the third vertex of the triangle). The subject formed the right isosceles triangle more accurately in a bright room than in a dark room, with 3 objects than with 2 objects. Natural environment provides several effective priors such as gravity, horizontal ground, symmetry of objects, and known height of the observer. These constraints were implemented in a computational model. A robot using this model recovers the 3D scenes as well as our human subjects.

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Sunday, 5:00-6:30

poster session

Expanding the scope of memory search: Modeling intralist and interlist effects in free recall. Lynn J. Lohnas, *University of Pennsylvania*, Sean Polyn, *Vanderbilt University*, Michael J. Kahana, *University of Pennslyvania*. Abstract: In modeling human memory, theorists often make the

simplifying assumption that memory is cleared at the start of each experimental trial. As a result, the explanatory scope of most memory models has been limited to intralist phenomena, such as the effects of primacy, recency, contiguity, and similarity on memory search. To account for interlist effects, such as prior-list intrusions, and proactive and retroactive interference, models must allow for the continuity of memory across lists. Building on the Context, Maintenance and Retrieval model (CMR; Polyn, Norman and Kahana, 2009), we propose a model of both intralist and interlist effects in free recall (CMR2). We show that CMR2 can account for the patterns of prior-list intrusions in free recall and the ability of participants to selectively target retrieval of items on prior lists in the list-before-last paradigm (Shiffrin,1970; Jang and Huber, 2008).

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Sunday, 5:00-6:30

poster session

Cognitive Modeling Repository: Status update. Mark Pitt, *Ohio State University*, Yun Tang, *Ohio State University*. The purpose of the Cognitive Modeling Repository (cmr.osu.edu) is to assist scientists in their modeling efforts, and to promote cognitive modeling research. The repository contains data sets and computer programs for cognitive models published in peer-reviewed journals. The repository was completed and opened to the public in early 2012 after several evaluation phases. Significant feedback from the cognitive modeling community and other audiences has greatly improved the final design and the functionality of the website. Researchers have begun to contribute models and data sets in a variety of content areas, including recognition memory, categorization, sematic analysis, and judgment and decision making. An overview of the repository will be presented, together with demonstrations of the browsing and submitting procedures. Creation of the repository was funded by the Mathematical and Computational Cognition program of the Air Force Office of Scientific Research.

(118)

Sunday, 5:00-6:30

poster session

Deriving Cognitive Maps from Brain and Behavior: Do They Agree? Erin Semple, *Miami University*, Robin Thomas, *Miami University*. Cognitive mapping reveals how observers perceive certain stimuli. By using observed similarities between pairs of objects, psychologists construct spatial representations of objects such that the pair-wise distances in the map agree with the observed pair-wise similarities. Early research in sensory neuroscience suggested that objects that are perceived as similar send sensory information to topologically related areas in the brain. Hence, Abdi, et al., (2010) attempted to relate fMRI data to a derived cognitive map from observed similarities. fMRI techniques identify which regions in the brain are active during a given task with very poor temporal resolution implying that location equals representation in the brain. In contrast, a growing perspective stemming from research in animals argues that the neural correlate of representation is in the electrical activity of neural ensembles. These ensembles could be widely distributed in location but their coordinated oscillation patterns visible in the electrical activities (spiking and field potentials) signal 'objectness'. We compare a behaviorally derived cognitive map with maps derived from data obtained by an electroencephalogram (EEG).

Specifically, three classes of metrics have been proposed to measure the similarity between EEG (or time-series data, in general): those based on the Euclidean distance between the averaged waveforms in the time-domain, those based on the Fourier representation in the frequency-domain, and those based on dimension-reduction techniques such as PCA or ICA. We compare the relative efficacy of each class to construct a cognitive map of colors that best approximates the behaviorally derived map.

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Sunday, 5:00-6:30

poster session

Recovering the 3D shape of a generalized cone from a single 2D image. Yun Shi, *Purdue University*, Tadamasa Sawada, *Purdue University*, Yunfeng Li, *Purdue University*, Taekyu Kwon, *Purdue University* , Zygmunt Pizlo, *Purdue University*. Recovering a veridical 3D shape of an object from a single 2D image is an ill-posed inverse problem. In order to solve this problem, a priori constraints must be applied to the solution space. Previous studies showed that mirror symmetry is used by the human visual system as an a priori constraint. In this study, we explore the role of translational symmetry in human 3D shape recovery. Objects characterized by translational symmetry are called Generalized Cones (GCs). Last year we presented the results of a shape recovery experiment. The results showed that subjects perceive 3D shapes of GCs accurately, which suggested that translational symmetry is used as an a priori constraint in human 3D shape recovery. This year, we propose a computational model which can recover the 3D shape of a GC from a single 2D orthographic image. The model uses three implicit constraints: all cross sections of a GC are planar shapes, the axis is a planar curve and all cross sections are perpendicular to the axis. Two explicit constraints are used in a cost function. The first term minimizes the dissimilarity between the shapes of the two end cross sections. The second term biases the recovered 3D shape towards maximum 3D compactness. The model produced similar performance compared to the subjects. The correlation between the performance of each subject and the performance of the model is similar to the correlation between the performance of the two subjects.

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Sunday, 5:00-6:30

poster session

Framing and Adaptation in Optimal Stopping Problems. Andrew Silva, *University of California, Irvine*, Alvin Lee, *University of California, Irvine*, Maxim Gorbunov, *University of California, Irvine*. Optimal stopping problems are a set of exercises in which one must choose the best alternative under uncertain circumstances. We used a modification of Lee and Campbell's (2006) optimal stopping paradigm in which subjects selected the highest or lowest number from a serially presented set of five. without the ability to backtrack. Subjects encountered numbers that were sampled from symmetric high or low skewed distributions. Half of the subjects encountered an unexpected change in distribution at the midpoint of the experiment. The symmetry between a high-skewed search for the largest and a low-skewed search for the smallest allowed for examination of framing effects within our paradigm. We found that subjects were able to adapt well to an unexpected change in distribution but found no significant main effect for framing, suggesting that subjects behave similarly when faced with numbers

near a known maximum or minimum bound.

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Sunday, 5:00-6:30

poster session

Evaluating the Flexibility of Likelihood Ratio Signal Detection Models of Recognition Memory. Troy A. Smith, *The Ohio State University*, Brandon Turner, *University of California Irvine*, Per Sederberg, *The Ohio State University*. Recently Glanzer, Hilford, and Maloney (2009) showed analytically that using likelihood ratios as the decision axis in signal detection theory (SDT) allows SDT models to capture the mirror effect and two other "regularities" in recognition memory, at least when particular assumptions are made with regard to the shape and parameters of the underlying strength distributions. We evaluated the effects of these assumptions using an approximate Bayesian computation (ABC) algorithm to conduct model comparisons and cross-fits. This allowed us to visualize the basic behavior of the models by examining the joint posteriors of the model parameters when being fit to data generated from competing models. Results show that the likelihood ratio transformation adds a layer of complexity to the models that make them overly flexible when being fit to outcomes from 2 AFC experiments (e.g., hit and false alarm rates), such that a likelihood ratio SDT model may not be able to successfully recover its own data any better than data from an alternative model. However, when confidence rating data are used, the likelihood ratio constrains the models, such that likelihood ratio SDT models recover their own data and reject data from alternative models better than strength-based SDT models do. Additionally, we show that Glanzer et al.'s restrictions on parameter ranges when calculating likelihood ratios for the unequal variance model fundamentally changes the behavior of the model. Implications for computational models of recognition memory are discussed.

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Sunday, 5:00-6:30

poster session

Adaptive Design Optimization for Model Discrimination under Model Misspecification. Yinghao Sun, *The Ohio State University*, Jay Myung, *The Ohio State University*, Mark Pitt, *The Ohio State University*. An experiment in cognitive science is often conducted with the goal of discriminating multiple models of a cognitive process. Adaptive Design Optimization (ADO: Cavagnaro, Myung,Pitt& Kujala, 2010) is a statistical methodology for selecting the values of the critical design variables (e.g., presentation schedule, stimulus structure) to present on each experimental trial based on responses from the preceding trials such that the chosen values are most informative in differentiating between models under consideration. In this work-in-progress study we explore performance characteristics of ADO under model misspecification, in which the data-generating model differs from any of the models being discriminated. Specifically, we examine whether ADO would choose the one, among a set of candidate models, that is most similar, in some defined sense, to the data-generating model. Two candidate models of retention memory, power and exponential, were compared in which the misspecified, data-generating model was varied in a systematic manner, from a 'power-like' model at one end of the spectrum to an 'exponential-like' model at the other end.

The simulation results showed that ADO favored the 'closest' model in the sense of the Kullback-Leibler distance to the data-generating model.

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Sunday, 5:00-6:30

poster session

Optimal Experimental Design for the Decision-from-Experience Experiments. Yun Tang, *Ohio State University*, Jay Myung, *Ohio State University*, Mark Pitt, *Ohio State University*. In this study we explore an optimal experimental design approach for a class of sequential decision-making problems. The decision-from-experience paradigm (a.k.a. bandit problem) is used to study risky decision-making under a dynamic setting, which requires the decision-maker to explore the environment and learn the payoff distribution associated with the options. The paradigm focuses on the acquisition and integration of information, as well as the mechanism of risky choice behavior. In the present study we develop a model that decomposes the decision-making process into exploration and exploitation components. The model also quantifies the risk probability experienced by the decision maker and associates this probability with the decision maker's choices. In addition to the experienced probability, the objective risk probability implemented in the task design could be appended to the model, thus allowing the adaptation of a previously developed design optimization (DO) procedure. DO can help find the optimal task designs and increase the model's prediction performance. We will demonstrate the model and the design optimization procedure using the Technion Prediction Tournament data (Erev, Ert,& Roth, 2008) as well as in simulation. We will also discuss the potential implication of the DO procedure in connecting static and dynamic decision-making.

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Sunday, 5:00-6:30

poster session

Gaze and Information Processing During Category Learning: Evidence for an Inverse Law. Ronaldo Vigo, *Ohio University*, Derek Zeigler, *Ohio University*, Phillip Andrew Halsey, *Ohio University*. The general relationship between information and the dynamics of visual processing has so far been elusive. This is unfortunate because such a finding would have profound implications for research in economics and the decision sciences. In this paper, we report such a relationship in data from a study that uses eye-tracking during a simple object classification paradigm. Results indicate a surprising quantitative law: namely, that the average fixation time per object during learning is inversely proportional to the amount of information that object conveys about its category. This inverse relationship may seem counterintuitive; however, objects that have a high-information value are inherently more representative of their category. Therefore, their generality captures the essence of the category structure relative to less representative objects. As such, it takes relatively less time to process these objects than their less informative companions.

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Sunday, 5:00-6:30

poster session

Structural Manifold Analysis: A New Nonparametric Framework for Continuous and Dichotomous Multivariate Data Analysis. Ronaldo Vigo, *Ohio University*, Basawaraj Basawaraj,

Ohio University. In this report we introduce a new, straightforward, and intuitive nonparametric framework for: 1) reducing the number of dimensions in binary and continuous multivariate data, 2) determining the discriminability of each such dimension, and 3) measuring the structural complexity of such datasets. The framework, referred to as structural manifold analysis or SMA, is partly based on logical manifold theory, a framework developed by Vigo (2009, 2011a, 2011b, 2012) as the basis for a mathematical theory of human classification performance. SMA determines the degree of "diagnosticity" or classification potential of each of the dimensions in a multidimensional dataset up to a pre-specified resolution threshold value. Using a simple heuristic, and without free parameters, SMA was able to reliably identify sets of highly diagnostic dimensions in real and synthetic multidimensional datasets as verified by an exhaustive search using linear discriminant analysis and using more recent dimensionality reduction methods on data generated by Monte Carlo simulations. In addition, SMA offered a clear advantage over each of these alternative methods.

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Sunday, 5:00-6:30

poster session

The 2N-ary choice tree model for N-alternative preferential choice: Formal derivations and predictions of choice probabilities and choice response times. Lena Wollschlaeger, *Jacobs University Bremen*, Adele Diederich, *Jacobs University Bremen*. The 2N-ary choice tree (2NCT) model is an approach developed for multi-alternative and multi-attribute decision problems which takes into account both the dynamic and stochastic nature of decision making. Its goal is to describe the motivational and cognitive mechanisms that guide the deliberation process in decisions under uncertainty. Formally the model is based on a random walk on a 2N-ary tree in which the transition probabilities depend on comparison of the alternatives on the given attributes, leakage of already sampled information and noise. The 2NCT model provides a mechanism to determine expected choice probabilities and response time distributions in closed form for optional and fixed stopping times. Here we show how the model can be implemented to determine choice probabilities and choice response times in closed form and discuss the problems arising from limited machine precision.

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Sunday, 5:00-6:30

poster session

Accuracy and the Survivor Interaction Contrast. Haiyuan Yang, *Indiana University Bloomington*, Joseph Houpt, *Indiana University*, James Townsend, *Indiana University Bloomington*. While both common and informative measures in cognitive psychology, reaction time and accuracy are not always used together. Often, either on or the other is ignored, or they are each analyzed separately. A variety of parametric models have proposed to allow the joint analysis of accuracy and response time, but little work has been done using nonparametric approaches. We will discuss the use of the Kaplan-Meier (KM) estimator, a common, nonparametric estimator of the cumulative distribution function from survival analysis, as a partial solution to the problem. We do so in the context of the survivor interaction contrast (SIC), a measure used to analyze the characteristic underlying information processing sys-

tems. We demonstrate the use of the KM estimator on simulated SIC data from existing models of response time and accuracy as well as on data from a recent experiment.

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Sunday, 5:00-6:30

poster session

New metrics and measurement for information search in decision making. Xiaolei Zhou, *Miami University*, Joseph Johnson, *Miami University*. Contemporary decision models have shifted away from focusing solely on choice outcomes, additionally making claims about the processes assumed to underlie these observable responses. Furthermore, experimental paradigms have been developed that allow for the collection of high resolution process data regarding the information acquired en route to making a decision, such as mouse-tracking (e.g. Payne, et al., 1993) and especially eye-tracking (e.g., Franco-Watkins& Johnson, 2011). However, the metrics that have been deployed in summarizing and analyzing these rich data have not advanced at the same pace. We present work that goes beyond the typical use of summary statistics such as number of acquisitions, or acquisition time, to better understand the dynamic patterns of information search. The study of transitions has been severely limited to crude measures such as relative direction (row- vs. column-wise) or the frequency of a select set of multi-step transitions (Ball, 1997), defined for the trial as a whole. We augment such analyses by considering two distinct, new approaches. First, we analyze the entire (first order) transition matrix, which provides a more sophisticated and complete treatment of search dynamics and allows for the assessment of properties such as stationarity. Second, to compare acquisition streams across conditions, we make novel use of string edit distance techniques. The utility of these techniques is illustrated through application to a vast data set from probabilistic inference tasks under varying conditions, using either mouse- or eye-tracking for information acquisition. Contributions of these methods to strategy identification and classification are also discussed.

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Sunday, 5:00-6:30

poster session

Relating EEG/ERP measures of visual working memory capacity to behaviorally derived measures in a visual change detection task. Li Zhou, *Miami University*, Robin Thomas, *Miami University*. Various behaviorally based measures of visual working memory capacity have been proposed and studied extensively (Pashler, 1988; Cowan, 2005; Rouder et al., 2008). In addition, several measures based upon EEG and ERP data have also been explored as correlates of various concepts of cognitive load and/or working memory capacity based on spectral representation of EEG data (Gevins& Smith, 2003), nonlinear time-series analysis (Lamberts, et al., 2000), and measures based on ERPs (Luck, 2005). We explore several of these EEG/ERP measures in their relative ability to relate to the different behaviorally derived measures of working memory capacity in the visual change detection paradigm.

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Sunday, 5:00-6:30

poster session

Metric Based Automatic Event Segmentation. Yuwen Zhuang, *Ohio State University*. This paper describes a metric-based model for event segmentation of sen-

sor data recorded by a mobile phone worn around subjects' necks during their daily life. More specifically, we aim at detecting human daily event boundaries by analysing the recorded triaxial accelerometer signals and images sequence (lifelog data). In the experiments, different signal representations and three boundary detection models are evaluated on a corpus of 2 subjects over total 24 days. The contribution of this paper is three-fold. First, we find that using accelerometer signals can provide much more reliable and significantly better performance than using image signals with MPEG-7 low level features. Second, the models using the accelerometer data based on the world's coordinates system can provide equally or even much better performance than using the accelerometer data based on the device's coordinates system. Finally, our proposed model has a better performance than the state of the art system.

Author Index

We ask that the last presenter in each session act as chair, and keep time for the session.

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9:20	**Hamm:** Automatic Annotation of Daily Activity from Smartphone-based Multisensory Streams	**Wu:** Some boundary likelihood ratio tests and confidence intervals in psychological...	**McCausland:** Prior distributions for Random Choice Structures
9:40	**Hamm:** Dimensional information-theoretic measures of affective expressivity	**Kim:** Optimal Experimental Design for Model Discrimination: A Nonparametric Extension	**Bhatia:** Associations and the Accumulation of Preference: A Model of Choice Set and Reference...
10:00	**Hu:** A Simple Model for Social Media	**Bartlema:** Comparing complexity measures	**Schley:** The Integrative Theory of Anchoring
10:20		***coffee break***	
10:45	**Zhang:** Perceptual Separability through Selective Influence	**Turner:** Blending Generative and Discriminative Models: A Bayesian Framework for Prediction...	**Dai:** A comparison of stochastic models of intertemporal choice
11:05	**Yang:** Examining the effect of payoffs on stimulus detection in a redundant-target...	**Austerweil:** Why your mom was wrong about playing with your food: Bayesian nonparametric...	**Doan:** On the Structural Equilibrium of Choice Sets
11:25	**Barcus:** Auditory Goodness of Pattern Judgments	**Vandekerckhove:** A diffusion model account of the relationship between the emotional flanker...	**Schweickert:** Reaction Time Predictions for Factors Selectively Influencing Processes in Processing...
11:45	**Ching-Chun:** Top-down control modulates the effect of exogenous attention on the process...	**Lee:** Some Bayesian re-analyses acknowledging uncertainty	**Burns:** Functional Principal Components Analysis of the Capacity Coefficient
12:05	**Dosher:** Fine visual discriminations and spatial attention	**Sederberg:** ABCDE: A practical likelihood-free Bayesian analysis technique with applications...	**Houpt:** Bayesian Approaches to Assessing Architecture and Stopping Rule
12:25		***lunch break (jmp meeting)***	
1:45	**Schoener:** Dynamic Field Theory as a mathematical framework for understanding embodied cognition		
2:45		***coffee break***	
3:10	**Harrison:** Dynamics of Coupling Explains Entrainment and Coordination in Human Activity	**Warnaar:** Quantifying expertise based on past performance	**White:** Bias in Simple Decisions
3:30	**Stepp:** Dynamics of Coupling Explains Entrainment and Coordination in Human Activity	**Shin:** Aggregating subjective probabilities via statistical learning algorithms	**Kievit-Kylar:** A Continuous Holographic Vector Model of Semantic Representation
3:50	**Kuznetsov:** Dynamics of Coupling Explains Entrainment and Coordination in Human Activity	**Cavagnaro:** A Bayesian Analysis of the Transitivity of Preference Axiom	**Averell:** Bayesian Hierarchal Parameter estimation in Forgetting
4:10	**Holden:** Dynamics of Coupling Explains Entrainment and Coordination in Human Activity	**Wang:** Entangling Beliefs and Actions during Interpersonal Interactions	**Mueller:** Associations and manipulations in the mental lexicon: A model of word-stem completion
4:30	**Kello:** Dynamics of Coupling Explains Entrainment and Coordination in Human Activity	**Pleskac:** Folk Choice Theory: Consequences of gambling in a structured environment	**Chechile:** Separate Probability Estimates for Explicit and Implicit Memory
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We ask that the last presenter in each session act as chair, and keep time for the session.

Time	Monday, Fairfield	Monday, Knox	Monday, Marion
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9:20	**Hotaling:** Violations of Consequentialism in Dynamic Decision Making	**Billock:** Using Neural Synchronization Models to Bridge the Gap between Sensory Integration...	**Trueblood:** The Multi-attribute Linear Ballistic Accumulator Model of Context Effects in...
9:40	**Yu:** A rational account of contextual effects in preference choice: what is fair?	**Gao:** Is multimodal information integrated optimally under time pressure?	**Leite:** Accounts of two diffusion-process models to stimulus frequency and payoff manipulations
10:00	**Steingroever:** A Parameter Space Partitioning analysis for reinforcement learning models ...	**Smith:** A Neurocomputational Theory of Attentional Selection in Multielement Displays	**Koop:** Response dynamics reveal evidence accumulation in decision making
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10:45	**Hendrickson:** Modeling the formation of and interaction between perceptual features during...	**Prince:** Variability due to study-test lag in recognition memory	**Francis:** The psychology of replication and replication in psychology
11:05	**Vigo:** How Informative are Concept Cues? Predicting Informativeness Judgments	**Cox:** Priming and Fluency Within a Dynamic Model of Recognition	**Golden:** Generalized Information Matrix Tests: A Unified Theory for Goodness-of-Fit Analysis
11:25	**Zwilling:** Some Answers to Luce's Challenge for Decision Researchers	**Starns:** Response-time distributions support the unequal-variance assumption in recognition...	**Davis-Stober:** The Random Estimator Paradox
11:45	**Wagenmakers:** Bias in Speeded Decision-Making: An Analysis with the Drift Diffusion Model	**Alexander:** A Statistical Development and Comparison of Two Useful Recognition Memory Models	**Thomas:** Estimating Test Reliability with One Observation per Subject
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1:45		**Kemp:** Psychological theories of the middle range	
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3:10	**Zand Scholten:** The Rasch model and stochastic resonance	**Xi:** A Multinomial Processing Tree Model for List Method Directed Forgetting in Free...	**Shenoy:** Time matters: rational impatience underlies the Go bias in Go/NoGo compared...
3:30	**Hu:** A Procedure for Modeling Coupled Latent Differential Equations with Moderators	**Cao:** List Length and Word Frequency Effect on Cued Recall	**Yu:** The time course of processing retrospective confidence judgments
3:50	**Luzardo:** A monotone item characteristic curve estimator based on kernel non parametric...	**Pooley:** A correction and some extensions of the SIMPLE model for free recall	**Simen:** A drift-diffusion account of temporal discrimination
4:10	**Miller:** Improving Group Forecasts Using Individual Performance History	**Matzke:** Hierarchical Multinomial Processing Tree Models for the Pair-Clustering Paradigm...	**Hawkins:** Accumulator models for consumer preference and response times
4:30	**Merkle:** The impact of scoring rule on forecast comparison	**Dennis:** A chaining-based model of serial recall	**Jones:** On the (Un)falsifiability of Models of Choice RT
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We ask that the last presenter in each session act as chair, and keep time for the session.

Time	Tuesday, Fairfield	Tuesday, Knox	Tuesday, Marion
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9:40	**Miller:** How Stage Explains Bias in Expert Witnesses	**Oravecz:** Bayesian hierarchical Cultural Consensus Theory	
10:00	**Yujia Li:** Gaps between Orders and Equal Spacing of Orders of Hierarchical Complexity	**Anders:** Cultural Consensus Theory for Multiple Consensus Truths	
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10:45	**Logan:** Inhibitory control in mind and brain 2.0: A blocked input model of saccadic...	**Colonius:** Ultrametric Fechnerian Scaling of Discrete Object Sets	**Zeigenfuse:** Accumulating Reward Information During Risky Decisions
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11:25	**Wong-Lin:** Spiking neuronal circuit model of decision-making: From neurotransmitters to...	**Dzhafarov:** Re-reading Fechner and correcting historical misconceptions	**Verdonck:** Estimating the parameters of decision models without explicitly modeling the...
11:45	**Kahana:** Electrophysiology of Encoding and Retrieval in Memory Search	**Marley:** Conceptual Relations Between Expanded Rank Data and Models of the Unexpanded...	**Zhang:** Drift Diffusion Model with Converging Boundaries
12:05	***quick break***		
12:15	**Ratcliff:** Modeling Confidence and Multichoice Decisions in Memory and Perception		
1:05	***end of meeting***		