MathPsych 2009

August 1—4, 2009
University of Amsterdam

Joint Annual Convention of the
Society for Mathematical Psychology
and the
European Mathematical Psychology Group

Program

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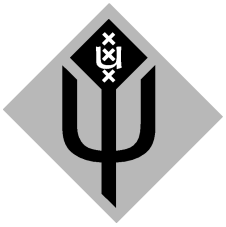

Universiteit van Amsterdam
www.uva.nl

Contents

Welcome

Dear colleague,

We are happy to welcome you at the joint annual meeting of the *Society for Mathematical Psychology* and the *European Mathematical Psychology Group*. Almost 250 participants registered for the conference, many of whom were also eager to present. As a result, we now have a three-stream program that is both varied and focused – varied, because it features many different topics and symposia; focused, because most topics are addressed by at least three or four speakers. This is a program that should have something in it for everybody. Of course, this conference has more to offer than just the formal presentations. As you will notice, we have made an effort to facilitate more informal interactions. Couches, coffee, and tea are available in the main hall throughout the conference; a poster session is organized on Monday, from 18:00 till 19:30; and, for those of you who opted in, we arranged for lunches, a canal cruise, and a conference dinner.

During your visit here, you might want to explore Amsterdam's many attractions, such as the beautiful parks, scenic canals, and famous museums. If so, we recommend that you do this by bike – Amsterdam is a small city without hills, and biking is generally more convenient than public transportation. We hope that you will experience Amsterdam at its best, that is, when the weather is nice. Unfortunately, this could not be arranged in advance. A seven-day weather forecast predicts that you will experience some clouds and some sun.

Should you have any questions, please don't hesitate to talk to us or to the students that help us – orange name badges and orange shirts make us easy to recognize. Please enjoy the conference, and please enjoy your time in Amsterdam.

Best regards,
The organizing committee: Annemarie Zand Scholten, Don van Ravenzwaaij, Gilles Dutilh, Ruud Wetzels, & 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)

General Information

Registration & Reception

The conference will take place in the Psychology building of the University of Amsterdam, located at Roetersstraat 15 (see Figure 1 for a map and nearby hotels). Conference registration will be available at the information desk in the main hall starting on August 1st at 9:30. The conference itself will start with a reception at 18:00 in the main hall, immediately following the workshop on Bayesian modeling that takes place on August 1st, from 10:00 to 18:00. For those who will not attend this workshop, registration is available during the reception until 21:00 on Saturday. On the remaining conference days, registration is possible from 8:30 to 17:00.

MathPsych Time

In order to allow people to visit presentations in different streams we need to keep a tight schedule. For this reason we will be timing each presentation according to MathPsych time. MathPsych time is determined by the clock above the information desk in the main hall. Please synchronize your watches!

Presentation Guidelines

Talks

For talks, presentation time will be limited to a total of 20 minutes, which includes five minutes for discussion. Talks will be strictly timed. Students are available to upload your presentation and help you with the audio-visual equipment.

Posters

Poster presentations have the advantage of longer discussion time, less formality, and closer audience contact. The "status" associated with poster presentations will be equal to that associated with oral presentations. The poster session will be held on Monday, August 3rd, from 18:00 to 19:30. Poster boards allow for posters on A0-format, landscape orientation. Posters can be attached to the poster boards in the main hall starting at 16:40.

Conference Dinner

The conference dinner will be held on Tuesday, August 4th at the "Miranda paviljoen" located at the Amsteldijk 223. We will travel to the dinner location by canal boat. Drinks and snacks will be available during the boat trip through the canals. We will get on the canal boat behind the venue

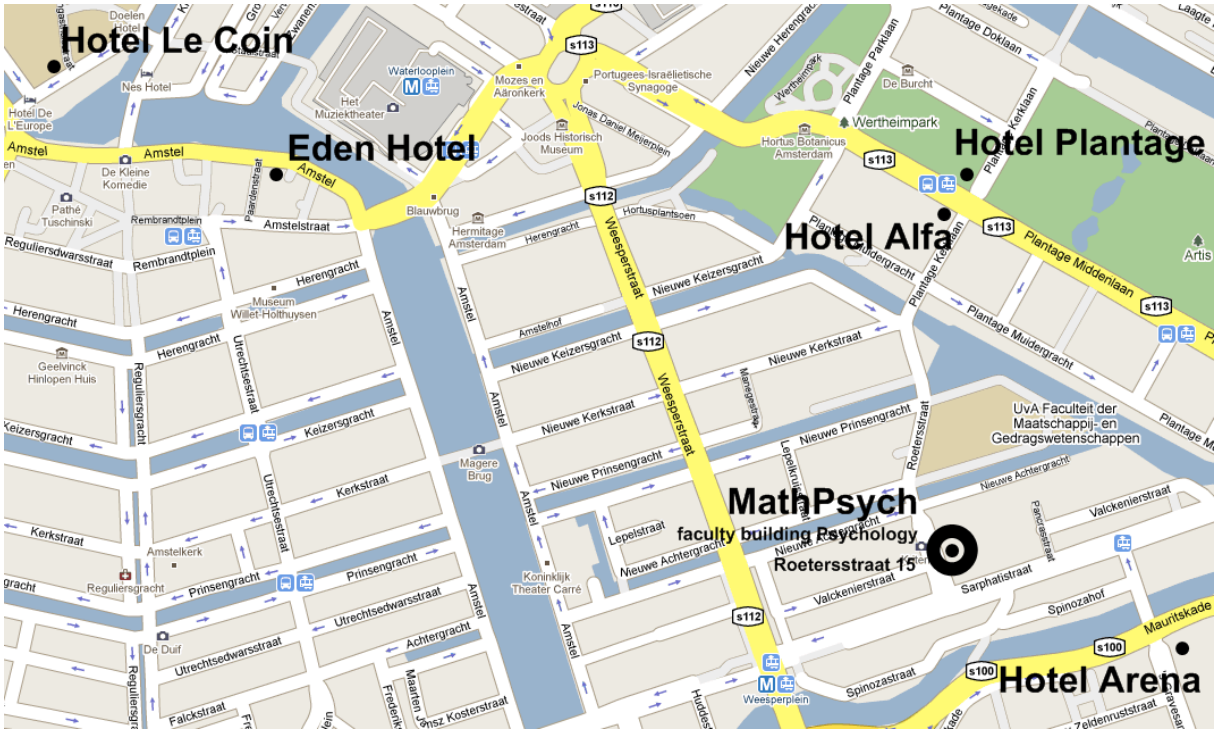

Figure 1: Map of the conference venue and nearby hotels.

building. Directions to the departure point will be given immediately after the New Investigator Address in lecture Hall A. Students will be available to guide you to the correct location. Travel back to the conference venue is arranged by bus. The first bus leaves at approximately 22:30.

For those who want to join the conference dinner, but skip the canal cruise, here's how to get to the restaurant directly from the venue building: Exit the Faculty building through the main entrance, cross the street and turn left. At the end of the street turn right. Keep walking until you get to a large cross-road. Numerous stairways going down indicate you have just reached the metro-station. Take metro 51 (direction: Westwijk), metro 53 (direction: Gaasperplas) or metro 54 (direction: Gein) which are all going in the same direction and exit at Amstel Station (about a three minute ride). From there, take bus 62 (direction: Station Lelylaan). Exit at President Kennedylaan/Waalstraat (about a seven minute ride). Now, walk to the Amsteldijk 223, where you will find the Miranda Paviljoen. For directions on how to walk, see the Google Maps picture below. The dinner starts at 19.30, so you will need to leave the faculty building somewhere around 19.00.

Conference Lunch

A conference lunch will be provided for those who registered for this option. Lunch

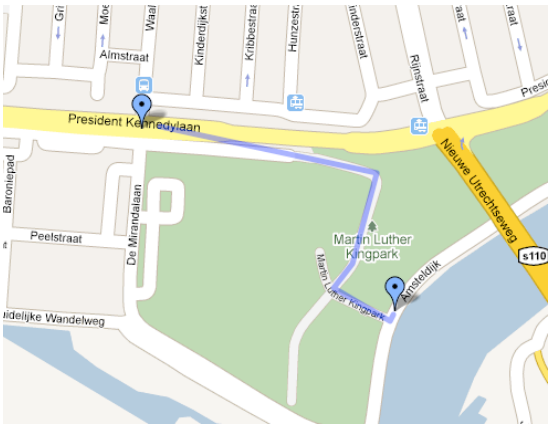

Figure 2: How to walk from the bus stop to the Mirandapaviljoen.

will be served on Sunday, Monday and Tuesday in the mensa Agora. The mensa can be reached by exiting the building and turning right. After crossing the bridge the mensa entrance is in the next block, just before cafe de Krater. The mensa can also be reached by going to the elevator hall on the first floor (one flight of stairs), walking through the glass hallway and then taking a left into the broad hallway crossing the canal below. At the end of this hallway, walk down the stairs and cross the foyer. The mensa entrance is to your left. There are signs to help you find your way. The special Editorial Board and Executive Committee lunches will be held in the Senaatszaal (room number 2.20), which is in the main hall on the second floor at the front of the building overlooking the street.

Internet Access

Wireless Internet will be available at the venue during the entire conference. The network to connect to is called **congres** and the password is **acce552a15**. More detailed instructions on how to log in will be provided at registration. There are also seating areas with tables and electrical outlets available on the second floor near the entrance to lecture hall C, there is a study hall with seats and electrical outlets on the first floor overlooking the street, and there will be extra electrical outlets available in the main hall. The computer room 1.06 on the first floor (at the end of the glass doorway on the right of the entrance to Lecture Hall A) has 24 computers with internet access. You can log in with username **10072009** and password **hondbijtkat**.

Travel

Schiphol - Amsterdam CS

To get to Amsterdam Central Station from Schiphol airport, the easiest (and cheapest!) way is to take a train. Trains depart towards Central Station every 10-15 minutes from platforms 1/2. The train-trip takes 19 minutes.

Amsterdam CS - The Lab

From Amsterdam Central Station, you take any of the three subways (51, 53 or 54) to station "Weesperplein" (the third stop). From there, you take exit "Valckeniersstraat", and you walk into this street, which is on your right, heading straight towards the large glassy building at the end of the street. This is the Psychology building, located at Roetersstraat 15, where the Math Psych 2009 conference will be held (see Figures 1 and 3).

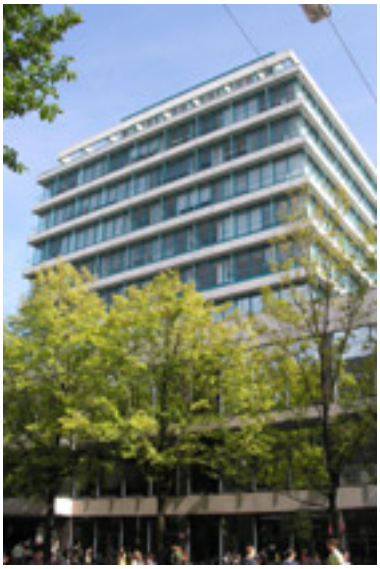

Figure 3: Roetersstraat 15, the conference venue.

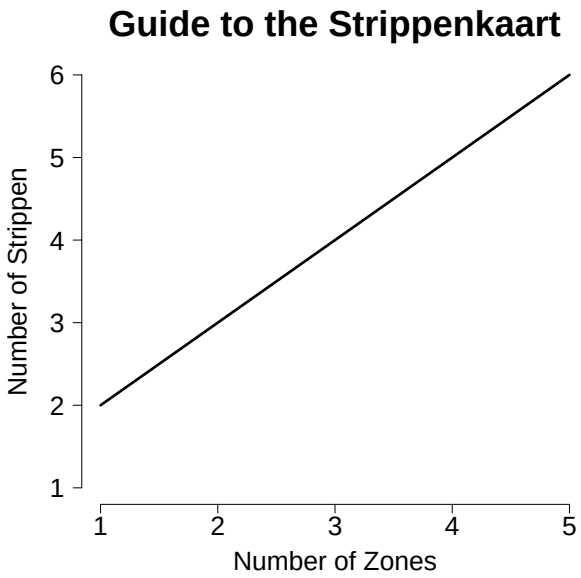

Figure 4: Guide to the *strippenkaart*.

Strippenkaart

When traveling by bus, tram or subway, you will need a 'strippenkaart' for travel fare. A 'strippenkaart' can be bought at any kiosk, magazine store, or train ticket booth. You need to stamp a number of 'strippen', namely the number of zones you travel through plus one (see Figure 4). When traveling by bus or tram, you can ask the driver to stamp (just tell him where you need to go). When traveling by subway, you need to stamp at the platform.

Places to Eat

Amsterdam has many restaurants, some of which serve excellent food. In general, we advise you to stay clear of the tourist areas. More detailed advice is available on www.iens.nl (select "English", and "Amsterdam").

Right opposite the conference venue you will find eating cafe De Roeter. Not the most fancy place to eat, but if you're looking for good food at a reasonable price and a nice atmosphere, this is the place to be.

When you exit the conference venue through the main entrance, turn right and continue down the road for 5 minutes until you cross the Plantage Middenlaan, you will find yourself across from Cafe Koosje at number 37– Koosje serves special season courses, vegetarian dishes, and they have a good house wine. Koosje is also an excellent place for lunch.

If you prefer oriental food, you can visit the Indonesian restaurant Taman Sari at the Plantage Kerklaan 32, the Chinese restaurant New Happy Corner at Plantage Kerklaan 30, or the Japanese restaurant Tempura at Plantage Kerklaan 26; all of these restaurants, and more, are about a 5 minute walk away.

Aug 2 2009			Stream A: Lecture Hall A			Stream B: Lecture Hall B			Stream C: Lecture Hall C
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09.20 - 09.40		2	**Usher:** Contrasting Models of Perceptual Choice		17	**Malmberg:** A Process Model of Associative Recognition		33	**Zeigenfuse:** Finding the Features that Represent Stimuli
09.40 - 10.00		3	**Ditterich:** Perceptual Decisions between Multiple Alternatives: Data and Computational Models		18	**Chechile:** Storage and Retrieval Modeling with Amnesic Populations		34	**Quesada:** A Graph- Theoretic Approach to Statistical Semantics: Explaining both Similarity and Frequency Judgments
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10.40 - 11.00						*coffee*			
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16.40 - 17.00						*coffee*			
17.00 - 18.00						**Keynote Address by Michael Frank**			

Aug 3 2009			Stream A: Lecture Hall A		Stream B: Lecture Hall B		Stream C: Lecture Hall C
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17.00 - 18.00					**Keynote Address by Gordon Logan**		
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Aug 4 2009			Stream A: Lecture Hall A			Stream B: Lecture Hall B			Stream C: Lecture Hall C
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16.40 - 17.00						*coffee*			
17.00 - 18.00						**New Investigator Address by Scott Brown**			
18.00 - 23.00						**Conference Dinner**			

Abstracts For Talks

(1)
Aug 02, 09:00–09:20
Lecture Hall A

Robust versus Optimal Strategies for Two-Alternative Forced-Choice Tasks. Philip Holmes, *Princeton University*, Miriam Zacksenhouse, *Technion - Israel Institute of Technology*, Rafal Bogacz, *University of Bristol*. The drift-diffusion model predicts a speed-accuracy tradeoff that maximizes reward rate in two-alternative forced-choice tasks. This can be expressed as an optimal performance curve that relates normalized decision times to error rates under varying task conditions. Human behavioral data indicate that 30% of subjects achieve optimality, and in this talk we propose that, in allowing for uncertainties, subjects might exercise robust instead of optimal strategies. We describe two such strategies: maximin and robust-satisficing. The former supposes maximization of guaranteed performance under a presumed level of uncertainty; the latter assumes a required performance level and maximizes the uncertainty under which it can be assured. We show that maximin performance curves for uncertainties in response-to-stimulus interval match data for the lower-scoring 70% of subjects well, and are more likely to explain them than robust-satisficing or alternative optimal performance curves that emphasize accuracy. For uncertainties in signal-to-noise ratio, neither maximin nor robust-satisficing performance curves adequately describe the data. We discuss implications for decisions under uncertainties, and suggest further behavioral assays.

(2)
Aug 02, 09:20–09:40
Lecture Hall A

Contrasting Models of Perceptual Choice. Marius Usher, *Tel-Aviv University*, Konstantinos Tsetsos, *University College London*, Andrei Teodorescu, *Tel-Aviv University*. A number of neurocomputational models have been proposed to account for the algorithm used by the brain to make decisions when faced with ambiguous information. Here we examine shared and diverging assumptions that some models of choice, such as race, diffusion and leaky competing accumulators, make in accounting for choice patterns. We show that the models make different predictions on how the increase in evidence in favor of a weak alternative, affects choice time, and on how the time course of the evidence (early/primacy vs late/recency) affects the choice. We then present experimental data in a choice task that manipulated the evidence in favor of each choice alternative, independently, and in a task that manipulated the time-course of the evidence. The implications for contrasting between the models will be discussed.

(3)
Aug 02, 09:40–10:00
Lecture Hall A

Perceptual Decisions between Multiple Alternatives: Data and Computational Models. Jochen Ditterich, *University of California*. The 2AFC version of the random dot motion direction discrimination task has been very helpful in advancing our understanding of the neural and computational mechanisms underlying binary perceptual decisions.

To address potential mechanisms of perceptual decision making between multiple alternatives, I will present data from a task where subjects are watching a random dot stimulus containing up to three coherent motion components with different directions. They are asked to pick the dominant direction of motion out of three alternatives. The viewing duration is controlled by the subjects. Response times (RTs) and the subject's choice are measured. The advantage of this task is that it provides the experimenter with full control over the sensory evidence provided for each of the alternatives.

The human behavioral data (probabilities of particular choices as well as RT distributions) are well explained by a computational model assuming a race to threshold between three (independent) integrators, one for each alternative. Each integrator accumulates the net sensory evidence for a particular alternative. The net sensory evidences are calculated as linear combinations of the activities of three relevant pools of sensory neurons with a positive weight assigned to the pool providing evidence for a particular choice and negative weights assigned to the pools providing evidence against a particular choice.

In addition to such an independent integrator model with feedforward inhibition, the behavioral data can also be captured by an integrator model with lateral/feedback inhibition. I will address how neurophysiological data might help us narrowing down the computational mechanism.

(4)
Aug 02, 10:00–10:20
Lecture Hall A

Optimal Decision Making in the Cortico-Basal-Ganglia Circuit. Rafal Bogacz, *University of Bristol*, Kevin Gurney, *University of Sheffield*. It is well established that the patterns of reaction times and accuracy from a wide range of tasks involving choice between two alternatives are well described by the diffusion model. It assumes that during the choice process the brain integrates the difference between the sensory evidence supporting the two alternatives until a criterion of confidence is reached. The model has a statistical interpretation, as it is equivalent to a statistically optimal test that minimizes decision times for any given accuracy. However, it is not clear how the diffusion model can be generalized to multiple alternatives, and how it is implemented in neural decision circuits.

It has been proposed that during choice tasks based on sensory information cortical regions integrate evidence supporting alternative responses, and the basal ganglia act as a central switch resolving the competition between the cortical areas. This talk will show that many aspects of the anatomy and physiology of the circuit in-

volving the cortex and basal ganglia are exactly those required to implement the computation defined by an optimal statistical test for decision making between multiple alternatives. In particular, it will be shown that the equation describing this test can be mapped onto the functional anatomy of the basal ganglia. This theory provides many precise and counterintuitive experimental predictions, ranging from neurophysiology to behaviour. Some of these predictions have been already validated in existing data. Furthermore, it offers a possible neural implementation for the diffusion model.

(5)
Aug 02, 10:20–10:40
Lecture Hall A

Interactive Dynamics between Frontal Cortex and Subthalamic Nucleus in Conflict-Based Decisions. Michael Frank, *Brown University*. The frontal cortex and basal ganglia (BG) interact intimately to facilitate adaptive motor plans and suppress others. Our neural models of this system suggest two BG mechanisms that can affects response time parameters. First, dopamine plays a critical role in BG circuitry by modulating both the learning of adaptive actions and the speed at which they are selected. It does so by increasing the relative output of striatonigral vs striatopallidal neurons, which encode the positive and negative evidence that a given action will yield a reward, respectively. Second, the subthalamic nucleus (STN) provides a "Hold your Horses" signal that transiently increases the decision threshold and prevents the DA mechanisms from facilitating a response too swiftly during difficult decisions. This STN signal is dynamically modulated by the degree of decision conflict represented in dorsomedial frontal cortex, leading to an initial STN activation surge that subsequently subsides due to feedback inhibition and neural accommodation. Further, frontal conflict-related activity can itself vary both within and across trials. Thus this model suggests that the "decision threshold" is not fixed and can be regulated at multiple time scales. Evidence for this proposal will be briefly presented from neuroimaging and STN deep brain stimulation studies.

(6)
Aug 02, 11:00–11:20
Lecture Hall A

An Overview of Models for Bounded Scales. Jay Verkuilen, *City University of New York*, Michael Smithson, *Australian National University*. Bounded responses are quite common in experimental psychology. Examples include judged probabilities, confidence ratings, or proportions computed from time allocation. Results by Schoenemann (1983) suggest that the boundaries in the response space may create systematic distortions in subject responses that adversely affect the performance of models when standard statistical methods for unbounded sample spaces are used to estimate model parameters from data. Knowledge about statistical models for bounded responses is relatively limited. This talk will provide an overview of different error models on the unit interval. These include the well-known beta distribution, but also less well-known distributions such as the Jorgensen/Barndorff-Nielsen simplex distribution, the Johnson SB distribution,

etc. The underlying commonalities for generating distributions on the unit interval will be discussed.

(7)
Aug 02, 11:20–11:40
Lecture Hall A

Beta Regression Finite Mixture Models of Polarization and Priming. Michael Smithson, *The Australian National University*, Jay Verkuilen, *City University of New York*. For doubly-bounded scales, finite mixture GLMMs based on the beta distribution can model heterogeneous response styles and related phenomena in attitudes and judgments that are inaccessible via conventional approaches. These GLMMs, in turn, enhance our capacity for explicitly testing hypotheses and theories regarding attitudinal extremity and polarization, priming effects, additivity, and probability weighting models. After describing the GLMMs and appropriate estimation methods, theory-testing potential is outlined and illustrated with several examples. The primary focus is on polarization and priming effects.

(8)
Aug 02, 11:40–12:00
Lecture Hall A

Bayesian Beta Models of Confidence. Ed Merkle, *Wichita State University*, Jay Verkuilen, *City University of New York*, Michael Smithson, *Australian National University*. Probabilistic confidence judgments are bounded and often skewed, meaning that statistical models with normal error are unrealistic and potentially misleading for such data. The beta distribution is more realistic in these situations because it is bounded and flexible in shape. In the talk, we will develop Bayesian models of confidence using the beta distribution. The models can be used to assess the effects of experimental conditions on confidence and to account for individual differences across judges. Further, the models can be used to study psychological processes underlying confidence and accuracy. We will illustrate these uses with confidence data from a two-alternative test of financial knowledge.

(9)
Aug 02, 12:00–12:20
Lecture Hall A

When Extreme Responses are Substantial: Application of a Generalized Beta Response Model to Behavior Change Data. Yvonnick Noel, *University of Brittany, Rennes 2*. One of the potential advantages of using continuous response scales, by contrast with binary responses, is that bimodality in the (conditional) response density is likely to become apparent, if truly present in the data. We present a generalized beta response model, based on the interpolation response mechanism (Noel & Dauvier, 2007) that leads straightforwardly to a beta distribution for the response on a continuous scale. As the beta can take bimodal shapes for some parameter values, this makes it possible to directly model bimodal response densities. That this class of models is realistic is illustrated on smoking cessation data, where bimodality is interpreted as readiness-to-change. It is argued that when smokers are ready to change, their responses on processes of change items are likely to suddenly bifurcate from one extreme to the other of the response scale. A parallel is made with cusp models of behavior change.

(10)

Aug 02, 14:00–14:20

Lecture Hall A

Formalizing Intuitive vs. Deliberative Decision-Making in Sports. Markus Raab, *German Sport University Cologne*. Intuition is often defined as a fast and effective manner for decision making in sports. However scientific research in that area is almost absent. In this study we investigate if the preference for intuitive (in contrast to deliberative) decisions (measured by the Preference for Intuition and Deliberation, PID-questionnaire, Betsch, 2004) results in faster and better lab-based choices in team handball attack situations. It is assumed that intuitive choices, due to their affective and experienced nature, are faster in situations with multiple options available such as in option-generation tasks. We used a video-based option-generation paradigm, measuring choice time and quality of choices (Raab $p < .05$). Results support, and are discussed in the context of, a mathematical choice model that describes intuitive choices in terms of how options are searched for, how option-generation is stopped and how an option is chosen. In this framework, similarity relations among options are of central importance in determining the number and type of options generated. An individual's preference for a particular decision-making style can be implemented as a priori specification of model parameters.

(11)

Aug 02, 14:20–14:40

Lecture Hall A

Modeling Intention from Attention. Joe Johnson, *Miami University*. We illustrate, via a simple mathematical model, the ability for predicting decision behavior based solely on perceptual data and therefore a decidedly embodied view of decision making. In particular, we employ eye-tracking data as a proxy for visual attention and show how it can predict individuals' intuitive decisions in an ill-defined task. Typically, process data serve as dependent variables used to provide a degree of converging evidence in support of theoretical models. In the current work, we instead use visual attention as measured by eye-tracking as an independent variable to predict subsequent decision behavior. We use a simple evidence accumulation model with a ratio choice rule to predict athletes' intuitive, initial choice in a realistic game situation. We presented a video clip of a handball team's offensive possession which ended in a freeze frame, at which point participants were asked to name the first ball allocation option that came to mind (where to pass the ball, or to shoot on goal). Visual attention was measured through eye-tracking, and models related gaze region to initially-selected options. A parameter-free summation model was significantly better than chance and better than a baseline model in both fitting and cross-validation. Adding a single parameter to represent the degree of primacy vs. recency in evidence accumulation significantly increased predictive accuracy further. These results support the strong link between perception and cognition, highlighting the ability to predict choice behavior directly from perceptual inputs, even in the absence of detailed assumptions about mental representations or transformations thereof.

(12)
Aug 02, 14:40–15:00
Lecture Hall A

Decision-Making as Transitions in a Course of Interaction in Sport. Duarte Araujo, Ana Diniz, *Technical Universiy of Lisbon*, Pedro Passos, *ULHT, Portugal*, Keith Davids, *Queensland University of Technology*, Sofia Fonseca, *ULHT, Portugal*. In dynamical systems such as sport games, decision-making is considered to emerge from interaction of the different system components (Davids et al., 2006). The existent models of transitions of this kind explain task dynamics characterized by two attractors. In this presentation we model a three attractors task. A dyad conceived as a system can be described by the angle x between the line connecting the subjects and the try line. The collective behavior of the system is defined by the changes in x over time and can be expressed by the equation $dx/dt = -dV/dx$, where $V = V(x)$ is a potential function. The minima of V correspond to the stable states of the system. There is empirical evidence that this kind of system has three stable attractors, namely $x = -\pi/2$, $x = 0$, and $x = \pi/2$. This suggests a potential function of the form $V(x) = -k_1 x + k_2 a x^2/2 - b x^4/4 + x^6/6$, where k_1 and k_2 are two control parameters, $a = (\pi/4)^2 \cdot (\pi/2)^2$, and $b = (\pi/4)^2 + (\pi/2)^2$. Note that k_1 is the parameter of the linear term linked to the attractors $-\pi/2$ and $\pi/2$, and k_2 is the parameter of the quadratic term related to the attractor 0. There is also evidence of random fluctuations in the behavior of the system which can be modeled as a white noise e_t. This leads to the more general equation $dx/dt = -dV/dx + Q^{0.5} e_t$, where Q is the noise variance. The model successfully predicted outcomes from the dyadic system.

(13)
Aug 02, 15:40–16:00
Lecture Hall A

An Extended Signal Detection Theory Model Accounts for Order Effects in Forced-Choice Detection Tasks. Rocío Alcalá-Quintana, Miguel Angel García-Pérez, *Complutense University of Madrid*. The popularity of two-interval forced-choice (2IFC) tasks in psychophysics is motivated by the belief that they are criterion-free. Their use is ultimately justified by the assumption that presentation order is immaterial, but empirical data from detection experiments frequently show order effects (Yeshurun et al., 2008, Vis Res, 48, 1837-1851). In this study we reinterpret 2IFC tasks under an extended Signal Detection Theory (SDT) model along the lines suggested by Kaernbach (2001, Percept & Psychophys 63, 1377-1388) and we show that the model can account for order effects without postulating that sensitivity varies across intervals. The extended SDT model considers an indifference region around the null value of the random decision variable D such that the observer 'guesses' when D on a given trial lies in this region. Under this framework, 2IFC tasks are not criterion-free and they should be modified so that observers either indicate which interval contains the stimulus or indicate that they would have to guess on that trial. There are three parameters in the model (sensitivity, width of the indifference region and finger error rate) that can be estimated when 'catch' 2IFC trials (i.e., trials with-

out a stimulus) are intermixed with regular 2IFC trials presenting the stimulus in one interval. Simulation results show that the extended SDT model allows accurate estimation of a unique sensitivity parameter for both intervals. Finally, we present empirical results from a contrast detection experiment showing that order effects can be eliminated when the data are analyzed under the extended model.

(14)
Aug 02, 16:00–16:20
Lecture Hall A

A Nonparametric Model for Signal Detection. Brandon Turner, Trish Van Zandt, *Ohio State University*, Scott Brown, *University of Newcastle*.

Signal detection theory (SDT) forms the basis of many current models of memory, choice, categorization, and so forth. However, the classical SDT model presumes the existence of fixed stimulus representations, usually Gaussian distributions, even when the observer has no experience with the task. Furthermore, the classical SDT model requires the observer to place a response criterion along the axis of stimulus strength and this criterion is fixed and independent of the observer's experience. We will present a new nonparametric, dynamic model that addresses these two long-standing issues. Our model describes how the stimulus representation is built by modifying a rough subjective prior of the task and thereby explains changes in signal detection performance over time. The model structure also provides a basis for the signal detection decision that does not require the placement of a criterion. We will also present data from an experiment designed to test the predictions of the model. In particular, the model makes predictions about sequential dependencies across repeated trials in a signal detection task.

(15)
Aug 02, 16:20–16:40
Lecture Hall A

New Mechanisms for the Less-is-More Effect: A Signal Detection Approach. Konstantinos Katsikopoulos, *Max Planck Institute*. A strong and interesting prediction of the theory of heuristics is that less information leads, under some conditions, to more accuracy. Without recognition errors, the 'less-is-more' effect is predicted if and only if the validity of the recognition cue exceeds the accuracy of the knowledge used for comparing two recognized objects (Goldstein, B) The less-is-more effect is predicted if additionally (1) the hit rate is medium and the false alarm rate is low, or (2) the false alarm rate is high and the hit rate is low. As more objects are experienced, in (1) guessing is used instead of experience or knowledge, and in (2) erroneous recognition is used instead of guessing or experience. In (1) accuracy first increases and then decreases, and in (2) accuracy first decreases and then increases - a new kind of less-is-more effect.

(16)
Aug 02, 09:00–09:20
Lecture Hall B

Separating Memory, Confidence, and Correlation: A Stochastic Detection and Retrieval Model. Yoonhee Jang, David Huber, *University of California, San Diego*, Thomas Wallsten, *University of Maryland, College Park*. We present a new detection model termed the Stochas-

tic Detection and Retrieval Model (SDRM) that allows for multiple sources of processing variance when relating two different kinds of criterial responses. Such situations include, but are not limited to, judgments of learning (JOLs) in relation to recall, response confidence in relation to recognition, and the relation between different statement verifications. The SDRM includes 3 separate mechanisms, one criterial process for memory retrieval, a second one for confidence, and a bivariate normal distribution for the relationship between the two responses, which may explain distinct patterns of relationships between recall and JOLs. We tested the usefulness of the SDRM both with parametric bootstrap simulations and through its application to a new experiment that simultaneously examined the delayed-JOL effect and the testing-JOL effect (greater accuracy with delay and with more testing experience, respectively). Through a nested model comparison, the SDRM revealed that a reduction in the variability of confidence judgments is the most likely explanation of the delayed-JOL effect, and that a change in the sources of information under the two responses is the most likely explanation of the testing-JOL effect.

(17)
Aug 02, 09:20–09:40
Lecture Hall B

A Process Model of Associative Recognition. Kenneth Malmberg, *University of South Florida*. Associative recognition involves the discrimination of the pairs of items that were studied together from pairs of item that were studied but not studied together. In this talk, I will describe a model of the processes, representations, and decisions involved in associative recognition. The model of retrieval combines sequential sampling with stochastic retrieval processes. As such, the model attempts to account for both the accuracy and the latency of performance, as well as retrieval dynamics. Data that challenge the variants of the model will be presented.

(18)
Aug 02, 09:40–10:00
Lecture Hall B

Storage and Retrieval Modeling with Amnesic Populations. Richard Chechile, *Tufts University*. In this paper, the Chechile (2004) 6P model is used to study several types of amnesia. The 6P model has separate measures for storage and retrieval. The resulting group estimate for model parameters depends on the method of examining the multinomial frequency data, i.e. grouping the frequencies first before fitting the model versus fitting the model to each subject and averaging the parameter estimates for the group. Monte Carlo studies examined the relative accuracy of the two methods. The sampling studies showed that the pooling of frequencies resulted in more accurate parameter estimates. Yet, in clinical assessment there is requirement to have accurate measures on an individual basis. In order to recover information about individuals from pooled frequency information, a modified jackknife method was examined. The jackknife method is based on a contrast between the overall pooled frequency information and the pool frequency without the observations from a single individual. Another series of Monte Carlo simulations demonstrate that the new jackknife method

resulted in more accurate recovery of the individual parameter values than just fitting the model to the individuals. The 6P model was then used to examine the data from two previously reported studies involving amnesia. One study dealt with the effects of alcohol-induced amnesia, and the other study dealt with Korsakoff amnesia. In both cases the pattern of storage and retrieval measurements resulted in a clarification of the storage and retrieval differences between the amnesic group and the control group.

(19)
Aug 02, 10:00–10:20
Lecture Hall B

A Declarative Memory Model for Episodic Sequence Categorization: Utilizing Findings from the Mammalian Biological Archetype.
Peter Michael Goebel, *Vienna University of Technology*, Markus Vincze, *Technical University of Vienna*. Humans remember their experiences in terms of events over time, hence, the "where", the "when" and the "whos" involved when they appear. The memory, which is accounted for this, is termed episodic memory, which together with semantic memory is subsumed as declarative memory. Episodic memory describes a sequence of states that appears within a particular situation. The sequential information is used then together with contextual information to build up semantical information. Thus, episodic memory utilizes temporal association between events and its recall, whereas semantic memory organizes how general knowledge is constructed and retrieved. This also applies to vision processes for object reconstruction and categorization. However, although artificial pattern and object categorization have reached certain maturity, the achieved intelligence level is still more or less at "insect-like" mechanics. State-ofStream-the-art computer vision is still too inflexible and lacks self-understanding. Human perception can do a great deal in about 200 milliseconds. It is obvious that the recognition of faces, words and objects, can be achieved within this short time. Furthermore, humans can generalize, thus, they detect similarities with ease; they can also judge between the essential and unessential features of visual patterns. They also take account of context and use that context to complete percepts in order to resolve ambiguities such as shown as by Fig. 5.

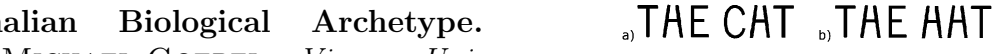

Figure 5: Humans take account of context to resolve ambiguities: a) one reads "THE CAT" with success, b) the context is insufficient and one reads rather "THE AAT" than "THE HAT", because 'H' followed by 'H' is uncommon to English language use.

In this work, we propose a new artificial declarative memory model which archetype is the topology of the mammalian temporal lobe. We apply stochastic learning and use recent findings from neuropsychology research. The model utilizes the brain formation for visual episodic sequence categorization by including context information to the building of semantic representation. We show first results from applying the approach to linguistic and visual object sequences, figuring out the prospective high

flexibility of the approach.

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Aug 02, 10:20–10:40
Lecture Hall B

Short-Term Memory: Evidence Against a Role of Time and a New Model. Stephan Lewandowsky, *University of Western Australia*. Human cognition would be unthinkable without a 'short-term' or 'working' memory that provides ready access to task-relevant information, for example during mental arithmetic or processing of spoken language. What are the mechanisms and processes that characterize this memory? In particular, what explains its extremely transient nature and its very limited capacity? Two opposing explanations exist that are encapsulated by the distinction between temporal decay and interference-based forgetting. This talk reviews some recent evidence and modeling that addresses this issue. In particular, I review arguments and data that increasingly challenge the decay notion and review one particular theory, known as SOB (e.g., Farrell & Lewandowsky, 2002, PB&R), that handles a variety of phenomena within an interference approach. I conclude that time per se need not contribute to forgetting over the short term and that SOB provides a strong alternative model.

(21)
Aug 02, 11:00–11:20
Lecture Hall B

Validation of Three Knowledge Contexts Representing an Assessment Tool for the Obsessive-Compulsive Disorder. Andrea Spoto, Luca Stefanutti, Giulio Vidotto, *University of Padua*. Although Knowledge Space Theory (KST; Doignon & Falmagne, 1985) has been developed referring to knowledge domains, the authors have hypothesized some different fields of application. In the present study KST has been applied, jointly with Formal Concept Analysis (Wille, 1982), as a tool to evaluate the goodness of a formal representation of the relations between the items of the short form of the Maudsley Obsessive-Compulsive Questionnaire (Hodgson & Rachman, 1977; Sanavio & Vidotto, 1985). Each item has been analyzed on the basis of the presence-absence of the diagnostic criteria included in the DSM-IV-TR for the Obsessive-Compulsive Disorder (OCD). Three formal contexts have been built, one for each of the three subscales of the questionnaire. The objects of each formal context were the items of the sub-scale, the attributes were the diagnostic criteria. Since the collection of the intents of a formal context is $\cap$-closed, its dual is $\cup$-closed (Rusch & Wille, 1996). From the dual of the obtained contexts, we derived three structures representing the relations among the attributes and the items of each sub-scale. A data-set of 33 patients with a diagnosis of OCD has been used to validate the structures. The parameters of the Basic Local Independence Model (BLIM; Doignon & Falmagne, 1999) have been estimated for each structure. The fit of the three models has been tested by parametric bootstrap. The results showed a good fit for the three models. The obtained structures could be used to build an automatic adaptive procedure for the assessment of patients.

(22)
Aug 02, 11:20–11:40

Lecture Hall B

Mosaic Visualization for Knowledge Space Theory. Ali Uenlue, *University of Augsburg*. Mosaic plots are state-of-the-art graphics for multivariate categorical data (Hofmann, 2008). A mosaic plot consists of groups of rectangular tiles. Each tile corresponds to one cell of a contingency table. The tile's area is proportional to the cell's count. Knowledge structures are mathematical models that belong to the theory of knowledge spaces (Doignon & Falmagne, 1999). Knowledge space theory provides a theoretical framework for the modeling, assessment, and training of knowledge. This theory utilizes the idea that some pieces of knowledge may imply others, and is based on order and set theory. In this talk I present an application of mosaic plots to psychometric data arising from underlying knowledge structure models. Tiles of the mosaic plots now correspond to knowledge states of the knowledge structures. In simulation trials, the scope of this graphing method in knowledge space theory is investigated.

Key words: Mosaic plot; Knowledge space theory; Visualization

References: Doignon, J.-P., & Falmagne, J.-C. (1999). Knowledge spaces. Berlin: Springer. Hofmann, H. (2008). Mosaic plots and their variants. In C. H. Chen, W. Haerdle, & A. R. Unwin (Eds.), Handbook of data visualization (pp. 617-642). Heidelberg: Springer.

(23)

Aug 02, 11:40–12:00

Lecture Hall B

Matroids Associated with a Medium. Reinhard Suck, *Univesity of Osnabrueck*. Several possibilities are investigated of how to characterize a medium in the sense of Eppstein, Falmagne & Ovchinnikov (2008) "Media Theory" as a matroid. Clearly, the mediatic graph which is equivalent to a medium gives rise via its cycles to a graphic matroid. But which are the the additional and charateristic properties of this matroid? These and related questions are are the subject of this paper.

(24)

Aug 02, 12:00–12:20

Lecture Hall B

Parsimonious Probabilistic Assessment of Competences. Cord Hockemeyer, *University of Graz*, Thomas Augustin, *KNOW-Center Graz*, Dietrich Albert, *University of Graz*. Recently, procedures for the assessment of competences in the application area of game-based learning have been proposed. Current applications, however, reach very large sizes for competence spaces thus requiring different approaches to assessment procedures. The new procedures have to be parsimonious not only with respect to computational load but also to memory load. We propose a probabilistic assessment procedure for quasi-ordinal competence spaces which uses the underlying surmise relation as its representation of the competence space. The suggested procedure will be compared with the classical procedure (Falmagne & Doignon, 1988) in two ways. On a theoretical side, we will show proximities and differences between the two approaches. On a practical side, we will present simulation results comparing the correctness of the different procedures

as well as comparing their efficiency. The efficiency of assessment procedures has two dimensions, the computational efficiency and the assessment efficiency, i.e. the number of questions that have to be asked for a complete assessment.

(25)
Aug 02, 14:00–14:20
Lecture Hall B

The Effects of Alcohol: A Diffusion Model Decomposition. Don Van Ravenzwaaij, Gilles Dutilh, Eric-Jan Wagenmakers, *University of Amsterdam*. Alcohol consumption is known to impair both cognitive and motoric skills (e.g. Maylor & Rabbitt, 1987). However, the precise effect of dosage on those skills is as yet unknown. In this research, we have administered three different amounts of alcohol to participants on different days: a placebo dose (0 per mille), a moderate dose (.5 per mille) and a high dose (1 per mille). Following this, participants performed a moving dot task, in which a group of moving dots is presented on screen. Two-thirds of them move randomly, while one-thirds are moving either to the right or to the left. Participants have to indicate whether the cloud of dots seems to be moving to the left or to the right. To test the effects of alcohol on performance, we analysed data using the Ratcliff diffusion model. The diffusion model accounts for proportion correct as well as the shape of RT distributions for both correct and error responses. Moreover, the estimation of the model parameters allows a decomposition of the alcohol effect in terms of its constituent components. The results show that alcohol consumption negatively affects the speed of information accumulation. The impact of alcohol on response caution and motor processes is negligible.

(26)
Aug 02, 14:20–14:40
Lecture Hall B

Perceptual Discrimination In Static and Dynamic Noise. Roger Ratcliff, *Ohio State University*, Philip Smith, *University of Melbourne*. The diffusion model for simple two-choice decision making has proved very successful at fitting all aspects of experimental data (accuracy and response time distributions for correct and error responses) as well as interpreting effects of independent variables and subject groups of processing. Here we present data that pose problems for the usual way the model is applied to data. Stimuli in letter discrimination and brightness discrimination tasks were degraded with static and dynamic noise. The onset and the time course of decision making were quantified by fitting the data with the diffusion model. Dynamic noise and, to a lesser extent, static noise, produced large shifts in the leading edge of the RT distribution in letter discrimination but had little effect in brightness discrimination. These shifts are inconsistent with the idea that noise reduces the rate of evidence accumulation. Instead, they imply that noise delays the time at which evidence accumulation begins. The shifts in the RT distributions are shown not to be the result of strategic processes or the result of using different stimuli in different tasks. These results imply that decision making is time locked to the perceptual processing of the stimulus features needed to do the task.

They also show that it is important to address the issue of what is the signal that turns on the accumulation of evidence in the decision process.

(27)
Aug 02, 14:40–15:00
Lecture Hall B

Optimal Response Initiation in Diffusion Decision Models. Matt Jones, Michael Mozer, *University of Colorado*. Diffusion processes have been highly successful as models of human decision making, and they have a rational justification via their close relationship to sequential likelihood-ratio tests. However, when there are more than two responses, optimal responding cannot be based directly on accumulated evidence. Instead, one needs to calculate the posterior probability over which response is correct. This in turn requires knowledge of the drift rate of the correct response. We show that the drift rate acts as an inverse temperature parameter in the posterior response distribution, so that, for example, overestimation of the drift leads to premature and error-prone responding. We then develop a hierarchical Bayesian model in which the drift rate is unknown, with a hyper-prior derived from previous decision trials. This model predicts sequential effects in decision times that closely match human data.

(28)
Aug 02, 15:00–15:20
Lecture Hall B

The Over-Constraint of Response Time Models. Chris Donkin, *University of Newcastle*. Theories of choice response time provide insight into the psychological underpinnings of simple decisions. Evidence accumulation (or sequential sampling) models are the most successful theories of choice response time. All of these models all have the same scaling property that a subset of their parameters can be multiplied by the same amount without changing their predictions. This property means that a single parameter must be fixed to allow estimation of the remaining parameters. We show that the traditional solution to this problem has been over-constraining the models, unnecessarily restricting their ability to account for data and implicitly making unjustified psychological assumptions. We look at data from Gould, Wolfgang and Smith (2007) which cannot be fit by over-constrained versions of leading exemplars of two classes of evidence accumulation models, the diffusion model (Ratcliff, 1978) and the linear ballistic accumulator model (Brown & Heathcote, 2008). Properly (i.e., minimally) constrained versions of these models provide a more accurate fit to these data with parameters that provide a sensible account of the underlying psychological processes.

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Aug 02, 15:40–16:00
Lecture Hall B

Differentiation and Response Bias in Episodic Memory: Evidence from Reaction Time Distributions. Amy Criss, *Syracuse University*. In differentiation models, the processes of encoding and retrieval produce an increase in the target distribution and a decrease in the foil distribution as the amount of encoding increases. This produces an increase in the hit rate and decrease in the false alarm rate for a strongly encoded compared to

a weakly encoded list, consistent with empirical data. Other models assume that the foil distribution is unaffected by encoding manipulations or the foil distribution increases as a function of target strength. They account for the empirical data by adopting a stricter criterion for strongly encoded lists relative to weakly encoded lists. The differentiation and criterion shift explanations have been difficult to discriminate using accuracy measures. In this paper reaction time distributions and accuracy measures are collected in a list strength paradigm and in a response bias paradigm where the proportion of test items that are targets was manipulated. Diffusion model analyses showed that list strength affects the rate of accumulation of evidence (e.g., drift rate) for both targets and foils but not response bias (e.g., starting point). Manipulating the proportion of targets affects response bias but not the accumulation of evidence. The diffusion model analyses is consistent with a priori predictions of the differentiation models where subjective memory strength is mapped directly onto drift rate and criterion placement is mapped onto starting point. Criterion shift models require ad hoc assumptions to account for these findings.

(30)
Aug 02, 16:00–16:20
Lecture Hall B

A Diffusion Model of Processing in the Flanker Task: Attention and Overlapping Spatial Representations.
Corey White, Roger Ratcliff, *Ohio State University*. The flanker task has been extensively used to investigate spatial attention and conflict resolution. In the task, a central target must be identified in the presence of flanking stimuli that are either congruent or incongruent with the target. Results show that flanking stimuli influence the decision, but their impact decreases over time. Dual process models account for this by assuming an automatic route where all stimuli are processed, and a slower, attention-controlled route where only the central target is processed (e.g., Gratton, Coles, & Donchin, 1992). Alternatively, single-process models have been proposed where attention boosts the impact of the central target relative to the flankers (e.g., Cohen, Servan-Scheiber, & McClelland, 1992). We propose a single-process model in which a diffusion decision process is driven by the interplay between attention and the perceptual representation of the stimulus. Each stimulus is assumed to have a distribution of spatial uncertainty, leading to overlapping spatial representations (i.e., overlap model, Ratcliff, Gomez, & Perea, 2007). Over time, attention serves to focus in on the center of the perceptual representation, minimizing the impact of the flanking stimuli. This process provides the evidence (drift rate) for the diffusion process. To test the model, several experiments were performed that included the standard conditions, congruent (>>>>>) and incongruent (>><>>), as well as two intermediate incongruent conditions (><<<>) and (<><><). The model captures the patterns of behavioral data with relatively few free parameters. Results are discussed in relation to existing models and model-based interpretations of empirical phenomena.

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Aug 02, 16:20–16:40

Lecture Hall B

Applying the Linear Ballistic Accumulator model to implicit sequence learning. Ingmar Visser, *University of Amsterdam*, Tom Marshall, *Cognitive Science Center Amsterdam*. Sequence learning studies the acquisition of sequential structure in forced-choice reaction time paradigms. Such learning is expressed in an increasing difference between predictable and unpredictable trials, where the predictable trials form a complex sequence. This kind of learning is typically considered a basic and automatic process which occurs largely outside participants' awareness as tested by subsequent recognition tasks. One of the major theoretical frameworks on implicit learning states that there are no or hardly any individual differences between participants; this is partly confirmed by the absence of correlations with for example IQ and age. A common problem in these studies is that the dependent measure is a reaction time difference or ratio, which is hence very noisy. Moreover, reaction times themselves could be different due to different speed-accuracy trade-offs; the latter is certainly likely in developmental comparisons. To alleviate this, in the current paper we apply the linear ballistic model (Brown & Heathcote, 2008) to implicit learning data so as to arrive at stable individual measures of the learning process. Our goals are three-fold. One, to establish which parameters change while participants are acquiring sequence knowledge. Drift rate, boundary separation and starting point distribution are all candidates for explaining reaction time effects in sequence learning. Second, to establish whether there are reliable individual differences. Third, to establish if such differences are correlated with other cognitive measures such as IQ. Preliminary results indicate that at least the starting point distribution and the boundary separation parameters are affected in a typical sequence learning task.

(32)

Aug 02, 09:00–09:20

Lecture Hall C

Applications of the Loss Signals Risk Hypothesis. Eldad Yechiam, Guy Hochman, Ariel Telpaz, *Technion - Israel Institute of Technology*. The Loss Signals Risk hypothesis argues that losses increase the subjective significance of global outcome patterns and thus signal the existence of environmental risk. To risk takers losses are an attraction signal and to risk-averse individuals they are an avoidance signal. The current presentations reviews recent studies confirming four surprising implications of the hypothesis: 1) No loss aversion in small to moderate risk levels 2) A positive effect of losses on autonomic arousal but no association between the contingent autonomic arousal and loss sensitivity, 3) A positive effect of losses on the consistency of risk taking levels within the individual across separate sessions and different decision tasks due to the activation of trait-relevant individual differences in risk taking, and 4) a negative effect of losses on the connection between tonic arousal level and risk taking (implied by personality theories, due to the tendency of low-arousal individuals to take more risk). Implications 2 through 4 are shown to exist simultaneously with the first implication. The LSR is thus a simple formally-expressable effect of losses that is

not consistent with loss aversion, and explains the rich effect that losses can have on different people. The ecological significance of the LSR effect is that individuals can tailor their behavioral choices to their preferred risk level without necessarily being forced to avoid risk.

(33)
Aug 02, 09:20–09:40
Lecture Hall C

Finding the Features that Represent Stimuli. Matthew Zeigenfuse, Michael Lee, *University of California, Irvine*. We develop a model for finding the features that represent a set of stimuli, and apply it to the Leuven Concept Database. The model combines the feature generation and similarity judgment task data, inferring whether each of the generated features is important for explaining the patterns of similarity between stimuli. Across four data sets, we show that features range from being very important to very unimportant, and that a small subset of important features is adequate to describe the similarities. We also show that the features inferred to be more important are intuitively reasonable, and present analyses showing that important features tend to focus on narrow sets of stimuli, providing information about the category structures that organize the stimuli into groups.

(34)
Aug 02, 09:40–10:00
Lecture Hall C

A Graph- Theoretic Approach to Statistical Semantics: Explaining both Similarity and Frequency Judgments. Jose Quesada, Lael Schooler, *Max Planck Institute*. LSA (Landauer and Dumais, 1997) started a trend in cognition by assuming that the usage pattern of words determines their mental representation. That is, the features that form the representation are contexts. Griffiths, Steyvers, and Tenenbaum (2007) propose that representation might be a language of discrete features and generative Bayesian models instead of continuous spaces. Jones and Mewhort (2007) propose methods to capture both syntax and semantics simultaneously in a single representation. Howard and Kahana (submitted) adhere to temporal context to explain the development of semantic representations, and Kwantes (2005) suggests that meaning might be computed 'in real time' when needed instead of being stored in LTM memory as static vectors. However, common to all models of meaning is the idea that using context patterns one can derive cognitive representations. All these models use a word by context matrix. This word by context matrix defines a weighted bipartite graph where term-document link weights are the word counts for each document (distributional graph). We compare several graph-based similarity and centrality measures on this graph. Pagerank –mathematically equivalent to a spreading activation mechanism– correlates with word frequency judgments, while Euclidian commute time correlates with semantic similarity judgments. We discuss how the added flexibility of graph theory may improve the range of effects statistical semantics can tackle. For example, in the 'bag of words' approach it is not easy to add structure such as an evolutionary tree relating animals. But any tree is a graph, and sharing vertices with the distributional

graph one can merge both and recompute measures.

(35)
Aug 02, 10:00–10:20
Lecture Hall C

Probabilistic Modeling of Human Choices and Preferences using Ratings Data. Tim Rubin, Mark Steyvers, *University of California, Irvine*. Recommendation systems provide an excellent opportunity for studying human choice and preferences. We present a probabilistic model that captures two closely related processes that underlie the human input to recommendation systems; the process by which individuals choose items to rate, and the process by which they select a rating for those items. Using movie-ratings data collected by Netflix, we demonstrate that this model can provide accurate predictions for missing data. Furthermore, we show that the implicit information that users reveal through their choice processes can be used to improve accuracy of rating predictions, even in the absence of explicit ratings data.

(36)
Aug 02, 10:20–10:40
Lecture Hall C

Pattern-Based Logical Probability Judgments. Momme von Sydow, *Georg-August Universität Göttingen*. Logical judgments like 'ravens are black and they can fly' are used ubiquitously. However, formal logic appears to be inappropriate to describe the truth conditions of such sentences. First, due to the deterministic interpretation of logical connectors, the empirical validity of a connector is falsified by single contradicting evidence. But since most rules have exceptions, a strict logical use of connectors would have almost no applicability. This problem may be ruled out by confining logical predication to high probability situations. Second, however, according to the standard (extensional) interpretation of probability a logical connector that refers to a larger set than another connector is always equally or more probable. But this implies that the hypothesis 'ravens are black or they can fly or both' is understood to be more probable than the above AND-judgment. An alternative, pattern-based notion of probability judgments is needed. A first formalization as Bayesian logic has been suggested (v. Sydow, 2007, 2008, in press). Although this model – reminiscent of pattern recognition algorithms – is formulated using standard probability theory, it does deviate in its predictions from a direct application of extensional probability theory. The model predicts several logical inclusion fallacies. Empirically, new data will be presented testing pattern-based probability judgments. In Experiment 1 logical probability judgments are investigated given a large number of observed frequency patterns, involving, for instance, contingencies tables with zero cells, identical marginals, or different sample sizes. Experiments 2 explores pattern-based probability judgments in a trial-by-trial setting.

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Aug 02, 11:00–11:20
Lecture Hall C

Subjective Complexity and the Language of Thought. Charles Kemp, *Carnegie Mellon University*. Many researchers have suggested that the psycho-

logical complexity of a concept is related to the length of its representation in a 'language of thought.' As yet, however, there are few concrete proposals about the nature of this language. I will discuss one such proposal: the language of thought allows first order quantification (quantification over objects) more readily than second-order quantification (quantification over features). To support this proposal I will present data and modeling results from a concept learning study inspired by the classic work of Shepard, Hovland and Jenkins.

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Aug 02, 11:20–11:40
Lecture Hall C

A Rational Model of Function Learning. Christopher Lucas, Thomas Griffiths, *University of California, Berkeley*, Michael Kalish, *University of Lafayette*, Joseph Williams, *University of California, Berkeley*. Most function learning research has been concerned with specifying representations and processes by which people understand the functional relationship between pairs of continuous variables. In this work, we take another tack, developing a rational model of function learning. This model characterizes human performance in terms of expectations about different kinds of functions, transparently identifying the inductive biases that a process model should capture. We treat the problem of function learning to be recovering a relationship between points $x \in \mathbb{R}^d$ and $y \in \mathbb{R}$ in an environment where certain kinds of relationships are more probable than others. A general solution to this problem is provided by Gaussian processes, a nonparametric Bayesian method for performing regression. Here we elaborate on our previous findings that Gaussian processes can be used to express both associative models and "rule-based" models that treat function learning like parametric regression. Our model describes the behavior of a rational agent who supposes that a single function relates a set of $(x; y)$ pairs but is uncertain as to what form that function takes. This model outperforms well-known alternatives in predicting the relative difficulty people have in learning different functions. We also consider an extension of that model, motivated by knowledge partitioning effects, in which people learn that multiple functional relationships apply when context is switched and produce bimodal predictions. Capturing these effects is an important part of adequately characterizing human inductive biases, since being able to partition values of x allows people to represent complex non-linear functions using several simpler functions.

(39)
Aug 02, 11:40–12:00
Lecture Hall C

When a Learning Theory Predicts the Wrong Response: Error of the Model or of the Learner? Martijn Meeter, *VU University Amsterdam*. In probabilistic categorization tasks various cues are probabilistically (but not perfectly) predictive of class membership. This means that a given combination of cues sometimes belongs to one class and sometimes to another. There are two alternative conceptualizations of learning in such tasks: as rule-based learning, or as incremental learning. Each conceptualization has links to a method of an-

alyzing performance: strategy analysis assumes rule-based learning, rolling regression analysis in most consistent with incremental learning. These two methods can be used to predict responses of categorizers from their responses on preceding trials. They turn out to predict responses about equally well - or equally badly, as both place a large number of trials in categories in which the response of the categorizer is a toss-up. Here, we investigate whether categorizers on such trials really produce a random or nearly random response, or whether there are regularities in such trials that are not yet captured by learning theories.

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Aug 02, 12:00–12:20
Lecture Hall C

Assessing Learning Processes by Assessing Learning Object Effects: A Probabilistic Skill Multimap Model. Pasquale Anselmi, Egidio Robusto, Luca Stefanutti, *University of Padua*. Let the knowledge state of a student be represented by the set of non directly observable skills possessed by him, and underlying his observable responses to a collection of problems. In our work, the learning process of a student is modelled as a function of the interaction between his knowledge state and the effect of a learning object. A probabilistic skill multimap model has been developed to assess the effect of learning objects on the attainment of skills required to solve problems in a given knowledge domain. Model parameters are the initial probabilities of the skills, the difficulties of attaining the skills, the learning object effects on attaining the skills, the careless error and lucky guess probabilities of the problems. The model has been applied to the responses provided by two groups of university students to 13 problems in elementary probability theory. To test the model, a 2 x 2 experimental design with two learning objects (effective vs. ineffective), and two assessment steps (pre-test and post-test) was planned. The effective learning object was supposed to be useful to learn the skills required to solve the problems, and it was given to the students of a first group. The ineffective learning object was supposed to be not useful, and it was given to the students of a second group. Results of the application are presented, and their implications for learning process assessment are discussed.

Keywords: learning object, learning process, skill map, knowledge structure

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Aug 02, 14:00–14:20
Lecture Hall C

Modes of Information Search in Active Learning. Doug Markant, Todd Gureckis, *New York University*. Effective learning often requires actively searching for information to reduce one's uncertainty about a concept. However, the ability to devise efficient queries–those that return the most information or are most useful in reaching the learning goal–has been shown to vary across task domains, such that people perform highly efficient search in perceptual tasks (Najemnik and Geisler, 2005) but exhibit biased search strategies in more abstract or conceptual tasks (Klayman and Ha, 1989). Using a novel search task based on the children's game Battleship, we studied how people make decisions about the value of future observations. We compare

human performance to a Bayesian "ideal learner" model of the task, along with a number of simple heuristic search models. We find that participants shift between two distinct search modes: slow, effortful exploitation of local information, and a faster, but less efficient pattern of exploration. We then evaluate how the costs of information collection, the complexity of the hypothesis space, and nature of prior beliefs influence search performance.

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Aug 02, 14:20–14:40
Lecture Hall C

Real-Time Attention in a Cross-Situational Learning Task: An Eye Tracking Analysis. Daniel Yurovsky, Chen Yu, *Indiana University*. In order to determine the meanings of words of their native languages, learners must extract information from noisy, complex environments. To be successful, they must direct their attention moment-by-moment to the most informative subset of this data. Using eye-tracking information from participants engaged in a cross-situational language learning task, we ask how attention and learning are dynamically coupled in real-time. In the cross-situational word-learning paradigm, learners are exposed to a series of trials containing multiple objects and multiple words each. While each trial is individually ambiguous (as it contains many potential word-object mappings), correct mappings can be determined over time by computing association frequencies between words and objects across the whole training set. Where previous work has assumed that all fixations are driven by word-item associations, we factor in online habituation processes, and show that these can account for much of what was previously treated as noise. A principled model of this process makes possible the use of fixation information as non-invasive, online index of learning. This allows us to move beyond the two stage train-test model, and to understand the dynamics of the cross-situational learning process.

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Aug 02, 14:40–15:00
Lecture Hall C

Cue Learning in a Changing Environment. Maarten Speekenbrink, David Shanks, *University College London*. Investigations of Multiple Cue Probability Learning (MCPL) typically focus on stationary environments where the predictive validity of cues is stable across time. Based on previous work, we present an experiment on MCPL where the relations between cues and outcome change over time. In a simulated environment, participants learned to predict share price on the basis of two market indicators (cues). In a between-subjects design, we varied the type (abrupt or gradual) and timing (synchronous or asynchronous) of change. We found no main effects of the type and timing of change on overall performance. A fine-grained analysis of the learning dynamics by a Kalman Filter showed that participants learned to track the changes quite well. In addition, there was evidence of a wide variation in individual strategies. To get more insight into the learning processes, we fitted a number of formal learning models to the data, including a dynamic Bayesian Filter, the Generalized Context Model, and an Associative Learning Model. We discuss results

in light of a main distinguishing feature of these models, namely whether they learn in a global or local manner.

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Aug 02, 15:00–15:20
Lecture Hall C

Sequential Learning Using Temporal Context. Karthik Shankar, Marc Howard, *Syracuse University*. The temporal context model (TCM) has been extensively applied to recall phenomena from episodic memory. Here we use the same formulation of temporal context to construct a sequential learning model called the predictive temporal context model (pTCM), which can extract the generating function of a language from sequentially presented words. In pTCM, temporal context is used to generate a prediction vector at each step of learning and these prediction vectors are in turn used to construct semantic representations of words on the fly. The semantic representation of a word is defined as the superposition of prediction vectors that occur prior to the presentation of the word in the sequence. Here we create a formal framework for pTCM and explore the effect of manipulating the parameters of the model on learning a sequence of words generated by a bi-gram generating function. In this simple case, we demonstrate that feeding back the constructed semantic representation into the temporal context during learning improves the performance of the model when trained with a finite training set from a language with equivalence classes among some words. We also describe pTCMA, a variant of the model, that has computational advantages in scaling-up to learn real languages. We show the results of training pTCMA over the TASA corpus and compare the resulting semantic representation to that constructed by LSA.

Reference: see http://memory.syr.edu/publications.html (submitted to J. Math. Psych.)

(45)
Aug 02, 15:40–16:00
Lecture Hall C

Reconciling Regular Minimality with Thurstonian-type Models. Janne Kujala, *University of Jyväskylä*, Ehtibar Dzhafarov, *Purdue University*. A Thurstonian-type model for pairwise discrimination is any model in which the response ("same" or "different") depends, deterministically or stochastically, on realizations of random variables $P(x)$ and $Q(y)$ (perceptual images) selectively depending on stimuli x and y. It has been shown that an unconstrained Thurstonian-type model can account for any discrimination probability function. However, it has also been shown that if the distribution of $P(x)$,$Q(y)$ depends on x, y in a "well-behaved" manner, then the model cannot simultaneously account for two empirically plausible basic properties of discrimination functions, Regular Minimality and nonconstancy of minima. Regular Minimality means that x is the stimulus least discriminable from y if and only if y is the stimulus least discriminable from x; nonconstancy of minima means that the discrimination probability generally varies across such pairs of corresponding x and y. We consider two ways of reconciling these two properties with Thurstonian-type models. The first one is to give up well-behavedness: we construct toy examples of

non-well-behaved Thurstonian-type models that can simultaneously account for both Regular Minimality and nonconstancy of minima. The second way is to consider Regular Minimality as only an approximate law: we demonstrate that well-behaved Thurstonian-type models can approximate certain types of discrimination functions satisfying Regular Minimality and nonconstancy of minima to an arbitrary degree of precision.

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Aug 02, 16:00–16:20
Lecture Hall C

Perceptual Discrimination of Two-dimensional Stimuli: a Test of Matching Regularity. Lacey Perry, Ehtibar Dzhafarov, *Purdue University*. Matching regularity (MR) is the adjustment-paradigm counterpart of the principles of Regular Minimality and Regular Mediality for, respectively, same-different and greater-less judgments. MR means that: (1) for every $x \in O_1$ (first observation area) there is a single matching value $y \in O_2$ (second observation area); (2) for every $y \in O_2$ there is a single matching value $x \in O_1$; (3) $y \in O_2$ matches $x \in O_1$ if and only if $x \in O_1$ matches $y \in O_2$. The present study employed a ping-pong matching procedure (Dzhafarov, 2006). Stimuli were two dots in two circles (observation areas). Participants were instructed to move one of the dots until its position matched that of the fixed dot in the other circle. The adjustable and fixed dots alternated between O_1 and O_2 from trial to trial, with the position adjusted in a trial serving as the fixed position in the next trial. Histograms of first-order differences of adjusted positions showed means and medians approximately equal to zero. Adjustment means across trials were relatively stable, so the adjustments did not progressively wander away from the initial positions. The means and medians of the first- through fifth-order differences did not change.

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Aug 02, 16:20–16:40
Lecture Hall C

Fechnerian Scaling in R. Thomas Kiefer, Ali Uenlue, *University of Augsburg*, Ehtibar Dzhafarov, *Purdue University*. R (http://www.r-project.org/; R Development Core Team, 2006) is a language and environment for statistical computing and graphics. R is free software and can easily be extended by user-contributed packages. In this talk we present the package fechner for performing Fechnerian scaling of object sets in R. Fechnerian scaling is a procedure for constructing a metric on a set of objects (e.g., colors, symbols, X-ray films, or even statistical models) to represent dissimilarities among the objects "from the point of view" of a system (e.g., person, technical device, or even computational algorithm) "perceiving" these objects. This metric, called Fechnerian, is computed from a data matrix of pairwise discrimination probabilities or any other pairwise measure which can be interpreted as the degree with which two objects within the set are discriminated from each other. We describe the functions of the package. Fechnerian scaling is demonstrated on real data sets accompanying the package.

Key words: R; Fechnerian scaling; Subjective metric; Psychophysics

References: Dzhafarov, E. N., & Colo-

nius, H. (2006). Reconstructing distances among objects from their discriminability. Psychometrika 71, 365-386. R Development Core Team (2006). R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing.

(48)
Aug 03, 09:00–09:20
Lecture Hall A

Hierarchical Bayesian Modeling in Cognitive Science. Michael Lee, *University of California, Irvine*. This talk will give an introduction to the Hierarchical Bayesian Modeling symposium. The goal is to explore some basic issues, ideas and challenges in using the Hierarchical Bayesian framework for modeling in the Cognitive Sciences. Besides giving some broad context for the specific research papers that form the symposium, some additional modeling work - probably including modeling developmental data from children learning numbers, and real world game show decision-making data - will be presented as concrete examples of the applicability and flexibility of Hierarchical Bayesian methods for helping understand human cognition.

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Aug 03, 09:20–09:40
Lecture Hall A

Modeling Episodic Memory Deficits in Alzheimer's Disease. James Pooley, Michael Lee, *University of California, Irvine*, William Shankle, *Medical Care Corporation*. Alzheimer's disease (AD) is characterized by a variety of episodic memory deficits. Fully understanding these deficits would prove useful for a variety of clinical problems related to AD, such as developing inexpensive methods for detecting AD early and assessing the efficacy of various drug treatments based on behavioral data. Using hierarchical Bayesian methods, we apply a variety of memory models from the psychological literature to a large clinical data set. Advantages of adopting the hierarchical Bayesian approach as well as using memory models in clinical settings will be discussed.

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Aug 03, 09:40–10:00
Lecture Hall A

A Hierarchical Bayesian Model for Assessing Working Memory Capacity. Richard Morey, *University of Groningen*, Jeffrey Rouder, *University of Missouri*. Working memory is thought to be a short-term, limited capacity buffer for the storage and manipulation of information. A model hierarchical Bayesian model for estimating the capacity of working memory is proposed. The model is based on Cowan et al. (2005) fixed capacity model, which fits visual array data well, with modifications. The hierarchical model has several novel elements, including Mass-at-chance and Mass-at-ceiling (Morey et al, 2008), and is estimated via Markov Chain Monte Carlo techniques. A graphical user interface is available for easy model estimation.

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Aug 03, 10:00–10:20
Lecture Hall A

A Single-Factor Model of Recognition Memory. Michael Pratte, Jeffrey Rouder, *University of Missouri*. Bayesian hierarchical models are of great benefit for separating latent psychological process from nuisance variability due to the selection of

people and items. We construct a parsimonious Bayesian hierarchical model of recognition memory which accounts for the effects of study, items, people, and conditions, with a single locus or factor. Recognition memory ROC curves are typically asymmetric about the negative diagonal. To account for this asymmetry most models place the effect of study in two or more parameters. For example, the unequal-variance signal detection model allows study to affect both the mean and variance of mnemonic strength. Likewise, Yonelinas' dual- process model posits that study affects both recollection and familiarity. We show that ROC curves across conditions and people have a surprising degree of structure which indicates that study affects a single factor or parameter. The current crop of models, however, miss this constraint and consequently posit too much flexibility. To account for asymmetry, we substitute a log-gamma parametric assumption for the more typical normal assumption. This model is highly constrained in that the effects of study, people, items, and conditions are shifts in strength distributions. Thus, the model imposes a great deal of structure on how ROC curves vary across people, items, and conditions. We show that this structure holds to a large degree across our data as well those data which have been used to support multiple memory systems.

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Aug 03, 10:20–10:40
Lecture Hall A

Bayesian State-Space Models for Affective Dynamics. Tom Lodewyckx, Francis Tuerlinckx, Peter Kuppens, *University of Leuven*, Nicholas Allen, *University of Melbourne*, Lisa Sheeber, *Research institute Oregon*. In the last years, emotion research has been focusing on the conceptualization of emotions as multicomponential, dynamical systems. This development created a new set of challenging research questions, concerning for instance autoregressive dependencies (related to concepts of emotional homeostasis) or cross-lagged relations (related to the mutual influence of emotion components). In a first part, we want to introduce a state-space approach for the dynamical modeling of emotion components. It will be shown how Markov chain Monte Carlo methods are used to estimate the model parameters. Various model extensions are discussed (e.g. external covariates, regime-switching). In a second part, we apply this framework to high resolution psychophysiological and behavioral data obtained during emotionally evocative adolescent-parent interactions and illustrate how it can be used to obtain new insights in the dynamical nature of emotions.

(53)
Aug 03, 11:00–11:20
Lecture Hall A

Hierarchical Bayesian Modeling in Category Learning. Wolf Vanpaemel, *University of Leuven*, Michael Lee, *University of California, Irvine*. We advocate hierarchical Bayesian methods to relate models and data in the cognitive sciences. We emphasize the advantages of hierarchical Bayesian modeling in converting model selection problems to parameter estimation problems, and providing one way of specifying theoretically-based priors for competing

models. We demonstrate the hierarchical Bayesian approach and its advantages using a worked example, considering an existing model of category learning, the Varying Abstraction Model (VAM). The VAM allows for a wide variety of category representations to be inferred from human behaviour in category learning tasks. We show how a hierarchical Bayesian analysis can provide a unifying explanation of the representational possibilities using two parameters. One parameter measures the degree of abstraction in category representations, and the other controls the emphasis on similarity in building these representations. Using 30 previously published data sets, we show how inferences about these parameters, and about the category representations they generate, can be used to evaluate data in terms of the ongoing exemplar versus prototype and similarity versus rules debates in the literature.

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Aug 03, 11:20–11:40
Lecture Hall A

Human Function Estimation: Balancing Fit and Complexity. Dan Little, Richard Shiffrin, *Indiana University*. Modern model selection methods all seek an appropriate balance of fit and complexity. We explore the way humans seek such a balance, and how this balance matches statistical methods, by asking humans to produce a best causal function to explain noisy data. We use a hierarchical Bayesian model of polynomials of different degrees to fit both the original set of noisy data and the observer's estimated functions. The results show a general human bias for simplicity, but with interesting individual differences that show deviations from the Bayesian best estimates.

(55)
Aug 03, 11:40–12:00
Lecture Hall A

Redundant Target or Focused Attention: Two Different Paradigms but the Same Crossmodal Integration Mechanism? A Modeling Account. Adele Diederich, *Jacobs University Bremen*, Hans Colonius, *Oldenburg University*. Two different experimental paradigms are used to measure reaction time (RT) to a crossmodal stimulus set. In the redundant target (aka divided-attention) paradigm, stimuli from different modalities are presented simultaneously or with certain stimulus onset asynchrony (SOA), and the participant is instructed to respond to the stimulus detected first. Typically, the time to respond in the crossmodal condition is faster than in either of the unimodal conditions. In the focused attention paradigm, crossmodal stimulus sets are presented in the same manner but now, participants are instructed to respond only to the onset of a stimulus from a specifically defined target modality, such as the visual, and to ignore the remaining non-target stimulus, the tactile or the auditory, say. In the latter setting, when a stimulus of a non-target modality, a tone, say, appears before the visual target, there is no overt response to the tone if the participant is following the task instructions. Nevertheless, the non-target stimulus has been shown to modulate the saccadic response to the target. The distinction between the redundant target and the focused attention paradigm is not only an interesting exper-

imental variation as such, but it may also provide an important theoretical perspective. In fact, since the stimulus setup can be chosen to be identical in both paradigms, any differences observed in the responses would have to be due to the instructions only. Here we show how the time-window-of-integration (TWIN) model developed by the authors (Colonius; Diederich & Colonius, BrainRes 2008) accounts for such results.

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Aug 03, 12:00–12:20
Lecture Hall A

The Optimal Time Window of Multisensory Integration. Hans Colonius, *University of Oldenburg*, Adele Diederich, *Jacobs University Bremen*. The notion of a spatiotemporal window of integration is a commonly accepted concept in multisensory research: crossmodal information falling within this window is integrated, whereas information falling outside of this window is not. It has been recognized, however, that integrating crossmodal information always involves a decision about whether or not two (or more) sensory cues originate from the same event, i.e., have a common cause [e.g., Koerding et al. PLoSONE, Sept. 2007]. Several research groups have shown by now that multisensory integration follows more or less closely rules based on optimal Bayesian estimation procedures. Here we extend this approach through determining the optimal width of a time window of integration: An infinitely large time window would lead to mandatory integration, a zero-width time window would rule out integration entirely. Computation of an optimal time window must be based, amongst others, on the a-priori probability of a common cause and the likelihood of observed temporal disparities between the unimodal signals. We demonstrate this approach within the framework of the time-window-of-integration (TWIN) model developed by the authors [Colonius Diederich & Colonius, BrainRes 2008].

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Aug 03, 14:00–14:20
Lecture Hall A

Identification of Complex Serial and Parallel Architectures Using the Systems Factorial Technology. Mario Fific, *Max Planck Institute*, James Townsend, *Indiana University*. A growing methodology, known as systems factorial technology (SFT), is being developed to diagnose the type of processing architecture that underlies performance in tasks of multidimensional perception, e.g., whether processing is serial or parallel, exhaustive or self-terminating. Systems factorial technology, a non-parametric method, also allows for a unique and fine-grained analysis of individual differences processing. The SFT diagnostic properties are achieved by utilization of a survivor interaction contrast (SIC) function, which uniquely identifies different architectures and stopping rules, based on the analysis of the distributions of choice reaction times. For the most part, however, applications of SFT have taken place in the context of simple two-process tasks. The purpose of the present research is to extend the application of SFT to multiple-process tasks ($n = 3, 4$). The results from a short-term memory experiment revealed striking individual

differences: some subjects were identified as relying on parallel processing while others primarily relied on serial processing. We also revealed a hybrid form of the serial and parallel processing, contingent on a searched item's position in a memory set. This finding is in contrast to many contemporary theories which assume purely serial or parallel architectures. The current experiments provide additional evidence on the utility and validity of SFT in the investigation of multiple processes tasks. The fine-grained assessment of individual differences, calls for SFT application in cognitive and clinical psychology, and potentially in cognitive neuroscience.

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Aug 03, 14:20–14:40
Lecture Hall A

Large-Scale Modeling of Reading Aloud in the Connectionist Dual Process (CDP) Model. Marco Zorzi, *University of Padova*, Conrad Perry, *Swinburne University*, Johannes Ziegler, *Aix-Marseille University*. We review the computational principles behind the Connectionist Dual Process (CDP) approach to modeling reading aloud (Zorzi, Houghton, & Butterworth, 1998) and discuss new analyses that investigate the factors behind the success of CDP+ (Perry, Ziegler, & Zorzi, 2007). We then present a new version of the model, CDP++, that simulates the reading aloud of mono- and disyllabic words and nonwords both in terms of pronunciation and stress assignment. With its lexicon of over 32,000 words, CDP++ is a notable example of the successful scaling-up of a connectionist model to a size that more realistically approximates the human lexical system.

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Aug 03, 14:40–15:00
Lecture Hall A

Learning Location Invariant Orthographic Representations for Printed Words. Frederic Dandurand, Jonathan Grainger, Stephane Dufau, *CNRS & Universite de Provence*. Neural networks were trained with back-propagation to map location-specific letter identities (letters coded as a function of their position in a horizontal array) onto location-invariant lexical representations. Networks were trained on a corpus of 1179 real words, and on artificial lexica in which the importance of letter order was systematically manipulated. Networks were tested with two benchmark phenomena - transposed-letter priming and relative-position priming - thought to reflect flexible orthographic processing in skilled readers. Networks were shown to exhibit the desired priming effects, and the sizes of the effects were shown to depend on the relative importance of letter order information for performing location invariant mapping. Presenting words at different locations was found to be critical for building flexible orthographic representations in these networks, since this flexibility was absent when stimulus location did not vary.

(60)
Aug 03, 15:00–15:20
Lecture Hall A

Holographic String Encoding: An Integrated Symbolic Connectionist Approach. Thomas Hannagan, Anne Christophe, Emmanuel Dupoux, *LSCP*. Following an integrated sym-

bolic/connectionist approach, we apply a special case of holographic representations to letter position coding. We translate different wellknown schemes into this format, which uses distributed representations and supports compositional structure. We show that in addition to these brain-like characteristics, performances on a standard benchmark of behavioural effects are improved in the holographic format relatively to the standard localist one. This notably occurs because of emerging properties in holographic codes, like transposition and edge effects, for which we give formal demonstrations. Finally we outline the limits of the approach as well as its possible future extensions.

(61)
Aug 03, 15:40–16:00
Lecture Hall A

Modeling Fixation Locations in the Overlap Model of Letter Position Coding. Pablo Gomez, *DePaul University*, Manuel Perea, *Universitat de Valencia*, Roger Ratcliff, *Ohio State University*. In a recent paper (Gomez, Ratcliff, & Perea, 2008, Psych.Review), we proposed the overlap model to account for the process of letter position coding. The last ten years of research has shown that letter identity and letter position are not integral perceptual dimensions (e.g., "jugde" activates JUDGE to a large degree). The basic assumption of the model is that letters in the visual stimulus have distributions over positions so that the representation of one letter will extend into adjacent letter positions. In this presentation we show data from experiments in which the fixation point was manipulated to coincide with different locations along the string of letters. Results showed that the location of the fixation had only marginal effects on subjects' performance, letter position coding was the most accurate for the first letter regardless of the location of the fixation. We examine the implication of this finding for the overlap model.

(62)
Aug 03, 16:00–16:20
Lecture Hall A

Performance Targets for Models of Word Naming. James Adelman, Gordon Brown, *University of Warwick*. I discuss the assessment of models of visual word recognition using item comparisons. Factorial techniques offer only first-pass testing of models. Simple regression comparisons with mega-studies are more stringent, but offer little insight into model problems. Error regressions are more stringent still, and highlight specific mispredictions. These points are illustrated with implementations of dual-route theories of word naming. An even more stringent target for models of word naming is set using a resampling technique on new mega-study data with replications.

(63)
Aug 03, 16:20–16:40
Lecture Hall A

Computational Modelling of Visual/Anatomical Factors Affecting Letter Position Coding. Colin Davis, *University of London, Royal Holloway*, Marc Brysbaert, Lise Van der Haegen, *University of Ghent*, Samantha McCormick, *University of London, Royal Holloway*. The flexibility with which readers code letter position has been studied

in recent years by investigating transposed letter (TL) priming effects (e.g., lexical decisions to the word JUDGE are faster following the TL prime 'jugde' than following the control prime 'jupte'; Perea & Lupker, 2003). In recent work (Van Haegen, Brysbaert, & Davis, 2009), we examined how TL priming varied as a function of fixation position. The anatomical split of the fovea suggests that the letters on either side of fixation are projected to different hemispheres. Projecting the transposed letters to different hemispheres didn't reduce TL priming effects relative to when the transposed letters were projected to the same hemisphere (contrary to the late hemispheric integration account proposed by Shillcock & Monaghan, 2000). However, priming increased markedly as a function of the distance of the transposed letters from fixation. In the present paper we examine the ability of computational models of visual word identification to capture this pattern of results.

(64)
Aug 03, 09:00–09:20
Lecture Hall B

The Neural Substrate of Decision Making with Prior Information: A Model-Based Analysis. Birte Forstmann, *University of Amsterdam*, Scott Brown, *University of Newcastle*, Gilles Dutilh, *University of Amsterdam*, Jane Neumann, *Max Planck Institute*, Eric-Jan Wagenmakers, *University of Amsterdam*. How does the human brain use prior information to guide subsequent decision making? To address this question we conducted an experiment in which people had to decide quickly whether a cloud of dots moved coherently to the left or to the right. Cues provided probabilistic information about the upcoming stimulus. Behavioral data were analyzed with the linear ballistic accumulator (LBA) model, confirming that people used the cue to bias their decisions. The fMRI data showed that presentation of the cue activated a corticosubcortical network consisting of RCZ, OFC, hippocampus, bilateral pre-PMd, bilateral thalamus, and bilateral putamen. Directional cues selectively activated the contralateral putamen. The fMRI analysis yielded results only when the LBA bias parameter was included as a covariate, highlighting the practical benefits of formal modeling. Together, our results suggest that the human brain uses prior information by increasing cortico-striatal activation to selectively disinhibit preferred responses.

(65)
Aug 03, 09:20–09:40
Lecture Hall B

Using Neurophysiology to Explore Discrete versus Continuous Flow Models of Perceptual Decision Making. Braden Purcell, Richard Heitz, Jeremiah Cohen, Gordon Logan, Jeffrey Schall, Thomas Palmeri, *Vanderbilt University*. Growing evidence supports an association of specific neural activity with the accumulation of perceptual evidence to a decision threshold as embodied in a broad class of psychological models. We explored the interactions between perceptual processing and evidence accumulation mechanisms and how these might be implemented in the brain. Two distinct populations of neurons in the primate frontal eye field (FEF) are identified with differ-

ent stages of decision making: FEF visual neurons modulate activity to visual stimuli according to the relevance of objects for a particular task, while FEF movement neurons trigger a saccade response when activity reaches a fixed threshold. To explore the relationship between perceptual processing (visual neurons) and evidence accumulation (movement neurons) we used random samples of recorded visual neuron activity as dynamic input to various accumulator models and tested how well the models accounted for observed saccade response time distributions. Two groups of models were able to predict observed behavioral data: models that assumed leaky integration with a continuous flow of information and models that imposed discrete stage-like constraints through the use of a gating mechanism. We show that the gated models provide the best account of observed movement neuron dynamics. More generally, this work highlights the efficacy of combining fits of models to behavioral data with the use of quantitative neurophysiological constraints as a model selection tool.

(66)
Aug 03, 09:40–10:00
Lecture Hall B

Does the Human Medial Temporal Lobe Maintain a Gradually-Changing Representation of Temporal Context? Marc Howard, *Syracuse University*, Indre Viskontas, *UCSF*, Karthik Shankar, *Syracuse University*. A fully satisfactory model of cognition will not only provide a concise and elegant model of cognitive performance, but also a description of the neural computations that underlie that cognition. The temporal context model (TCM) describes the behavior of a temporal context vector that is hypothesized to serve as the cue for episodic memory. We reanalyze neuronal data from a continuous recognition task performed by epileptic patients (Viskontas, et al., 2006). We measured the similarity among ensembles of simultaneously-recorded neurons. We find that the ensembles change gradually over time, both on the scale of seconds and on the scale of minutes. The ensembles distinguish categories of stimuli (faces vs places) as well as individual stimuli from a category to other members of a category. The tendency for ensembles to reinstate prior states when an item is repeated, i.e., retrieved temporal context, is examined. We compare our results to explicit simulations from TCM.

(67)
Aug 03, 10:00–10:20
Lecture Hall B

Reconstructing Stimulus- and Response-Related Components in Neural Recordings with Arbitrary Reaction Time Distributions. Jun Zhang, *University of Michigan*. When a neural signal (single neuron activity, ERP waveform, fMRI activation, etc) is being recorded as the animal/human subject performs a behavioral task, one need to ascertain the relative contributions towards such recorded signal from stimulus encoding/analysis, response preparation/execution, and the decision that translates a stimulus into a response. The presence of trial-by-trial variability in reaction time (RT) seems to add another level of complexity in data analysis, since often it is the ensemble average of neural recordings

that is behaviorally interpretable. Here, I describe a technique that takes advantage of the existent of an RT distribution to uniquely recover a stimulus-locked and a response-locked component in the recorded neural activity. Applying this technique to ERP data clarifies a long-standing debate in ERP literature concerning the so-called *P3 anteriorization* phenomenon for Go/Nogo tasks.

(68)
Aug 03, 10:20–10:40
Lecture Hall B

Random Effects Analysis of Graphical Models. LOURENS WALDORP, *University of Amsterdam*, INGRID CHRISTOFFELS, *Leiden University*, VINCENT VAN DE VEN, *Maastricht University*. Graphical models can be used to model interesting relationships in behavioral science: social interactions, brain areas, relations between symptoms in clinical psychology. Specifically, ancestral graphs are appealing to apply in the behavioral sciences because they allow different kinds of relationship within a single graph. An ancestral graph allows a directed connection, an undirected connection, and a bidirected connection. Furthermore, ancestral graphs allow for the possibility that some important variables are unmeasured. In many applications of ancestral graphs, however, there is interest in inference at both the individual and group level. For example, in functional MRI, data is available at the individual level but inference is often sought at the group level. We developed a method for fMRI data to determine an ancestral graph for each individual and then use a random effects analysis to infer graphical properties at the group level. For this to work we derived the limiting distribution of the estimated parameters of the ancestral graph at the level of the individual. Then we used these properties to devise a multivariate test on the connections of the ancestral graph at the group level. Monte Carlo simulations show that the statistical properties of the test are quite accurate. We have applied the method to fMRI data from an auditory task in which subjects were required to monitor their own speech while listening to varying degrees of noise.

(69)
Aug 03, 11:00–11:20
Lecture Hall B

Modeling Bistable Visual Illusions via Nonlinear Dynamics Principals. DANIEL REPPERGER, KATHERYN FARRIS, *Air Force Research Laboratory*. Visual illusions, which occur, for example, in the Necker Cube, are sometimes termed 'bistable' since the perception will be that an object may be in one of two possible visual scenarios. The Necker Cube sheds light on how the human visual system may work, indicating that two distinct and equally possible interchangeable states may exist. Correspondingly, in nonlinear dynamics, a class of certain problems can be characterized as a solution of the bipotential well problem containing two stable equilibrium points. One of the popular solutions of the bipotential well problem produces an effect termed Stochastic resonance (SR). Known in nonlinear dynamics, this principal can explain enhanced sensitivity not normally realized by linear systems and is ubiquitous in nature. In this paper, recent advances in the theory of SR have shown the relationship of solutions with this effect to a super crit-

ical pitchfork bifurcation. This indicates a dynamical solution on the brink of chaos. The two stable states of an SR system are interlaced between an unstable fixed point. Using the model of SR as an explanation of certain illusions which occur in the human visual system is explored both within a mathematical context and a visual perception paradigm. The interpretation of the model's responses can be related to some interesting analogs to the visual misperception problem in a physical sense.

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Aug 03, 11:20–11:40
Lecture Hall B

Complementarity in Bistable Perception: the Necker-Zeno Model. Harald Atmanspacher, Thomas Filk, *Institute for Frontier Areas of Psychology, Freiburg*. The concept of complementarity has been defined in an axiomatic framework generalizing the quantum mechanical axioms for states and observables to systems involving non-commutative operations. In this framework, a novel approach to understand the bistable perception of ambiguous stimuli has been achieved, where the dynamics of the switch between different representations of a stimulus (e.g., the Necker cube) is complementary to the process of observation of these representations. The corresponding Necker-Zeno model, referring to mental states and observables as well as their dynamics, is in agreement with experimental data for (1) the dwell time distributions (inverse reversal rates) in bistable perception and (2) the dependence of dwell times on off-times if stimuli are presented discontinuously. Finally, we speculate about the possibility to formulate temporal Bell inequalities for this scenario. Their violation would imply evidence for fundamentally *non-classical* behavior in mental systems.

(71)
Aug 03, 11:40–12:00
Lecture Hall B

Are Psychophysical Scales of Intensities the Same or Different when Stimuli Vary on Other Dimensions?: Theory. Duncan Luce, Louis Narens, Ragnar Steingrimsson, *University of California, Irvine*. Narens (1996) proposed a theory of loudness for a single frequency that made two predictions which were evaluated empirically by Ellermeir & Faulhammer (2000). One, a commutativity property, was confirmed, but the other a multiplicative prediction was not. Luce (2004) pointed out if one dropped the assumption that a signal is matched by a second signal of the same intensity generalized the theory sufficiently to account for the data. Steingrimsson & Luce (2005a,b, 2006, 2007) confirmed that account for loudness holds quite well. Narens (2006) raised a related issue: is it plausible to think of the loudness scales at different frequencies are all the same scale, and argued, using abstract algebraic reasoning, that for this to be true a certain cross frequency version of commutativity must be satisfied. This talk shows, using elementary algebra, the same prediction follows from Luce's representation. A second talk reports data on the topic.

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Aug 03, 12:00–12:20
Lecture Hall B

Are Psychophysical Scales of Intensities the Same or Different when

Stimuli Vary on Other Dimensions?: Experiments, Results, and Extensions. Ragnar Steingrimsson, Duncan Luce, Louis Narens, *University of California, Irvine*. Narens (2006) suggested that various subjective intensity scales might be viewed as deriving from a common ratio scale. We studied Naren's idea in the context of Luce's (2002, 2004) theory of global psychophysics in which testable behavioral properties are derived. These behavioral properties' holding is equivalent to different judgments being made on a common scale. (Luce describes this theory at the current meeting). The central property is a modified form of Narens' (1996) commutativity property. This talk reports an auditory evaluation of it in which respondents make magnitude productions of the loudness of tones varying in frequency (pitch). Data so far collected show that for 4/4 respondents, two intensity conditions, and two frequencies their judgments are consistent with the hypothesis that each individual has a common loudness scale independent of frequency. More complete results will be presented for several frequencies and intensities, as well as several empirical approaches, each providing supplementary information about respondents' behavior. We also review extensions of the work to brightness and hue, as well as evaluating judgment scales in a cross modal and interpersonal context.

(73)
Aug 03, 14:00–14:20
Lecture Hall B

On the Measurement of Latent Traits. Jürgen Heller, *University of Tübingen*. The assumption of the existence of a unidimensional scale measuring a latent trait is at the heart of many psychometric models. Measurement theory offers the means for justifying this assumption and for revealing the type of measurement of the latent trait they provide. The epistemological status of basing measurement on the solution probabilities is discussed. Elaborating on previous work concerning the representation and uniqueness of the Rasch Model and the Birnbaum Model new results are presented and their impact is illustrated. Issues covered include the dimensionality of the latent trait (as well as that of the item scales), and re-framing specific objectivity in terms of meaningfulness.

(74)
Aug 03, 14:20–14:40
Lecture Hall B

Why the Interval Level Unparadoxically Goes Poof in the Guttman-Rasch Paradox. Annemarie Zand Scholten, *University of Amsterdam*. Recently, quantitative measurement in Item Response Theory was questioned because it seems based on a paradox concerning error and precision (Michell, 2008). The Rasch model is said to ensure interval level measurement. Now if precision increases in Rasch items they become Guttman items, losing their quantitative properties. This means adding error improves precision. A paradoxical result which seems a good reason to doubt the claim of interval level measurement. However, this argument is invalid on three counts. We will present two simulations and an analysis of the adherence of both models to the axioms of additive conjoint measurement to support our objections, which are as follows. First, there are well-known sit-

uations where error, very unparadoxically, improves precision. Second, considering a change in precision misrepresents the paradox and unneccesarily complicates the issue. The relevant change concerns measurement level and not precision. Third, error is not the cause of change in measurement level, the jump from a discontinuous to a continuous model is. These three objections lead us to conclude that the Guttman-Rasch paradox cannot serve as an argument against the claim of interval level by the Rasch model, moreover, the paradox itself disappears when the relevant cause and effect are considered.

(75)
Aug 03, 14:40–15:00
Lecture Hall B

Integrating Jnds to Recover anAffine Representation for Discrimination Probabilities. Geoffrey Iverson, *University of California, Irvine*, Yung-Fong Hsu, *National Taiwan University*, Chris Doble, *Aleks Corporation USA*. The theory of psychophysical discrimination has its origins in Fechner's method of integrating jnds (just noticeable differences). In modern terminology and notation, if $P_{x,y} = F(u(x) - u(y))$ is a subtractive representation for discrimination probabilities $P_{x,y}$ and if $\xi_\pi(y) = y + \Delta_\pi(y)$ are the corresponding sensitivities [that is $P_{x,y} = \pi \iff x = \xi_\pi(y)$], then the function $u(x)$ can be recovered by integration:

$$u(x) - u(y) = \lim_{\pi \to 1/2} \int_y^x \frac{F^{-1}(\pi)}{\Delta_\pi(t)}\, dt$$

Data do not always support a subtractive representation however. Perhaps the simplest generalization of a subtractive representation is provided by an affine representation for the discrimination probabilities:

$$P_{x,y} = F\left(\frac{u(x) - u(y)}{\sigma(y)}\right)$$

We show that both scales $u(x)$, $\sigma(x)$ can be recovered by integrating jnds.

(76)
Aug 03, 15:00–15:20
Lecture Hall B

The Analytic Hierarchy Process and the Theory of Measurement. Michele Bernasconi, *Universita di Venezia*, Christine Choirat, *Universidad de Navarra*, Raffaello Seri, *Università degli Studi dell'Insubria*. The Analytic Hierarchy Process or AHP (Saaty 1977, 1980) is a decision-making procedure for establishing priorities in multi-criteria decision making. As often stated by its supporters, underlying the AHP is the theory of ratio-scale measures developed by psychophysicist Stanley S. Stevens (1946, 1951) in the middle of the last century. It is however well-known that Stevens' original model was flawed in various respects. We reconsider the AHP in light of the modern theory of measurement based on the so-called separable representations (Narens 1996, Luce 2002). We provide various theoretical and empirical results on the extent to which the AHP can be considered a reliable decision-making procedure in terms of the modern theory of subjective measurement. In particular, we propose some approximations of the distortion in Saaty's eigenvector as a function of the parameters of the separable representations and we apply them on data from an experiment with 69 individuals.

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Aug 03, 15:40–16:00

Lecture Hall B

On Unequal Variance and Mixture Extensions of Signal Detection Theory: Theoretical and Statistical Notes. Lawrence DeCarlo, *Columbia University*. Basic results for conditional means and variances, as well as distributional results, are used to clarify similarities and differences between the unequal variance extension of signal detection theory (SDT) and related extensions. It is shown that a recently presented motivation for the unequal variance SDT model (variable encoding) actually leads to a related, yet distinct, model; the related model has a random slope and is a generalized linear mixed model (GLMM). Some interesting conceptual and statistical results that follow from the GLMM version of the model are noted. Some well known results are shown to raise interpretive problems for both the unequal variance SDT model and the GLMM version of it. A mixture extension of SDT, on the other hand, offers a simple account of the results. Mixture SDT also unifies results found across several types of studies, such as simple recognition and source discrimination, whereas the results are problematical for both the unequal variance SDT model and the GLMM version of it. It is shown that the mixture SDT model can be viewed as a model with a random slope, but the slope parameter is categorical rather than continuous. The mixture model introduces a latent categorical variable that can be interpreted as reflecting a moderating effect of attention on perception.

(78)

Aug 03, 16:00–16:20

Lecture Hall B

Toward a Theory of Identification with Dimensional Face Spaces: Extended General Recognition Theory. Lei Pei, James Townsend, *Indiana University*. Most physical object spaces pertinent for human perception and cognition are of infinite dimension. Faces are a good example. Townsend and colleagues have developed infinite-dimensional Riemannian spaces and shown how to build metrics in such spaces. In face recognition, it might be the case that a perceived face with noise will be compared with the memory representations where the similarity between them is a random variable associated with a certain probability distribution. This paper seeks to extend previous work by building up the mathematical and psychological theoretical foundation to determine the distribution of the similarity random variable. While General Recognition Theory (GRT; Ashby & Townsend, 1986) has been developed to investigate the issue of independence between finite dimensions of perception by using probability distribution functions over signals and noise, it is the goal in this paper to assemble the minimal machinery required for perceptual identification (recognition) and thereby to extend GRT to infinite-dimensional face spaces.

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Aug 03, 16:20–16:40

Lecture Hall B

What Makes Face Recognition Holistic: Insight (or not) From Models and MSDA. Jennifer Richler, Michael Mack, Isabel Gauthier, Thomas Palmeri, *Vanderbilt University*.

General Recognition Theory (GRT; Ashby & Townsend, 1986) distinguishes holism in perceptual representations (violations of perceptual separability or perceptual independence) from holism in the decision process (violations of decisional separability). One method used to draw conclusions about GRT constructs is Multidimensional Signal Detection Analysis (MSDA; Kadlec & Townsend, 1992). Recent work using MSDA showed that holistic processing of faces is decisional, not perceptual (Richler et al., 2008; Wenger & Ingvalson, 2002). We analyzed predictions made by a model of face recognition (Dailey & Cottrell, 1999). MSDA does not report a perceptual violation, despite the fact that internal analyses of the perceptual space used by the model corresponds to a perceptual violation known as mean-shift integrality. By itself, this is not surprising, as mean-shift integrality is a special case that is known to be undetectable by MSDA (Maddox, 1992). However, what was unexpected is that MSDA erroneously concluded that there were decisional violations when the model explicitly assumes decisional separability. Not only did MSDA fail to detect the perceptual violation, but it misattributed a perceptual effect to a decisional source. Subsequent simulations tested the ability of MSDA to recover the appropriate GRT violations from simulated data where the perceptual space and decision bounds were known. While inferential limitations of MSDA are well known, we demonstrate several cases where MSDA does not simply fail to detect violations that are present, but draws erroneous conclusions about violations that are not present.

(80)
Aug 03, 09:00–09:20
Lecture Hall C

A Simple Stopping Rule for Cognitively Diagnostic Computer Adaptive Assessments. Alan Huebner, Xiang Wang, Sung Lee, *ACT Inc.* Cognitive diagnosis models are relatively new psychometric models that classify examinees as having mastered or not mastered a set of discretely defined skills. Though researchers have begun to apply this methodology to computerized adaptive testing (CAT) situations, one topic that has not been discussed is a stopping rule for cognitively diagnostic CAT. In the interest of test security, variable length CAT assessments generally aim to administer a minimal number of items to each examinee and terminate according to a predefined stopping rule. Standard item response theory CAT stopping rules such as the sequential probability ratio test do not apply to cognitive diagnosis where examinees are classified into latent classes representing the mastery status of a group of skills. We propose a simple stopping rule for cognitively diagnostic variable length CAT exams. After the administration of a predetermined number of items the examinee is classified into an interim skill mastery pattern, and Bayes factors are computed comparing the evidence in favor of the interim pattern to all other possible patterns. If the evidence in favor of the interim classification is below a predefined level B, another item is administered, and the process repeats until all Bayes factors are greater than B. The performance of the stopping rule, judged by its efficiency and correct classification rates compared to a fixed length

exam, is investigated for the Deterministic Input, Noisy-And (DINA) model through simulations programmed in the statistical software environment R.

(81)
Aug 03, 09:20–09:40
Lecture Hall C

The G-DINA Model: A General Framework for Cognitive Diagnosis Modeling. Jimmy de la Torre, *Rutgers, The State University of New Jersey*. The paper presents the G-DINA (generalized deterministic inputs, noisy and gate) model as generalization of the DINA model. As a general model, it has more relaxed assumptions and, in its saturated form, and is equivalent to other general cognitive diagnosis models (CDMs) formulated based on alternative link functions. When appropriate constraints are applied, several commonly used CDMs can be shown to be special cases of these general models. However, unlike other general CDMs, the G-DINA model is more than an alternative model specification, it is a general CDM framework that includes a component for model estimation based on design and weight matrices, and a component for hypothesis testing based on the likelihood-ratio (LR) and Wald tests. Simulated data are used to demonstrate the extent to which the expectation-maximization algorithm developed for the framework can accurately estimate the parameters of the G-DINA model, and several of its reduced models. In addition, the same data are used to document the power of the LR and Wald tests in rejecting differently specified models under various conditions. An illustration using real data is also presented. Finally, the paper concludes by discussing several potential applications and implications of the proposed framework.

(82)
Aug 03, 09:40–10:00
Lecture Hall C

Robustness and Power of the LRT to test the LLTM against the RM. Rainer Alexandrowicz, *Alpen-Adria-Universität Klagenfurt*. One important way to assess fit of the Linear Logistic Test Model (LLTM) is to test it against the Rasch Model (RM) by means of a Likelihood Ratio Test (LRT). But practical application shows this LRT to become significant rather easily. This raises the question of whether it either lacks robustness (i.e. fails to maintain the chosen niveau alpha) or is overly powerful to even slightest - and therefore irrelevant - deviations of model assumptions. By means of a simulation study (performed with R) we could identify situations where the LRT reproducibly showed non-robust results. Further, we assessed the power of the test to detect model deviations of varying degree and under several sample sizes.

(83)
Aug 03, 10:00–10:20
Lecture Hall C

The Partial Credit for the Rank of the Correct Alternative. Timo Bechger, Gunter Maris, *Cito*. Scoring the answer to a multiple-choice items by simply registering whether the chosen alternative was correct is wasteful of information. We obtain richer data when we change the instruction and ask respondents to rank order the alternatives. We will demonstrate that a partial credit model can be used for the po-

sition of the correct alternative. This result follows when it is assumed that the answer is found by a series of paired-comparison experiments. Independence between the comparisons lead to a special case of the partial credict model.

(84)
Aug 03, 10:20–10:40
Lecture Hall C

Classification Accuracy and Consistency of Decisions Based on Multiple Tests Using Item Response Theory. Peter van Rijn, Huub Verstralen, Anton Beguin, *Cito*. In psychological and educational testing, there are many situations in which important decisions are made on the basis of a person's scores on a multitude of tests. A decision rule is typically applied to the scores on relevant tests to produce a classification, e.g. a diagnosis, or pass or fail. In this paper, existing methods are extended and scrutinized to assess the accuracy and consistency of such classifications in the situation of multiple tests. That is, the extent to which observed classifications agree with true and repeated classifications (Lee, 2008). The investigation is performed by referring to item response theory (IRT). IRT provides a unified statistical framework of models and procedures to analyse psychological and educational tests at the level of items as well as tests, and both persons and populations. By making use of the partial credit model (Masters, 1982; Verhelst & Verstralen, 2008) in combination with the multivariate normal distribution, methods are described to establish classification accuracy and consistency. A study is performed to compare the classification accuracy and consistency of conjunctive, complementary and compensatory decision rules. The study is set up to resemble the system of final examinations in secondary education in the Netherlands. Preliminary findings indicate that compensatory decision rules outperform conjunctive and complementary decision rules, and that a resit leads to a substantial decrease of false negatives. Issues such as IRT model fit, the role of information, the effect of group differences, and test fairness are discussed.

(85)
Aug 03, 11:00–11:20
Lecture Hall C

Switch Costs in Working Memory Updating - A Tale of Two Foci. Ullrich Ecker, Stephan Lewandowsky, *University of Western Australia*, Klaus Oberauer, *University of Zurich*. Working memory updating refers to the ability to maintain accurate representations of information that changes over time. This comprises the online transformation of information. We investigated this ability in an updating task requiring the repeated transformation and ongoing memorisation of three single letters presented in individual frames. We orthogonally manipulated two factors across updating steps: (a) whether or not transformation initially required retrieval of the to-be-transformed information from memory and (b) whether or not the result of the transformation was used to substitute current memory content. Multilevel regression modelling suggested that the recurring transformation of multiple pieces of information concurrently held in working memory involves two distinct types of shifting. The *focus of attention* needs

to be shifted whenever there is a frame switch. That is, these switching costs arise whenever spatial attention needs to be moved to a different frame location between updating steps. In contrast, the *focus of memory* needs to be shifted whenever updating involves (a) the retrieval of to-be-transformed information or (b) the substitution of current memory content with the outcome of a transformation. That is, these switching costs only evolve if currently held memory content is being actively processed. Finally, a structural equation model will be presented that looks at interindividual covariation between these distinct types of switching costs and working memory capacity.

(86)
Aug 03, 11:20–11:40
Lecture Hall C

Models for Multi-Trial Free Recall. Donald Laming, *University of Cambridge*. Envisage that the same list of words is presented repeatedly with a free recall requested after each presentation. This paper proposes models for both the increase in number of words recalled and in the development of the serial position curve over successive iterations. The model for the number of words recalled is a simple development of the fundamental equation for the Total Time Hypothesis; briefly, m successive presentations of the same list of words increases the total time of presentation in strict proportion, and the increase in mean recall follows directly therefrom. The model for the development of the serial position curve supposes that each set of recalls is written into memory and is available for retrieval at the next recall. Word j is recalled at that next recall, either if it is retrieved from the record of the previous recall, or if it is retrieved from the intervening representation of the list. These models are embedded in the theory set out in Laming (2009) and are illustrated with data from Tulving (1962) and from Klein, Addis and Kahana (2005).

(87)
Aug 03, 11:40–12:00
Lecture Hall C

Bayesian Analysis of Retention Functions: What You See Depends on Where You View it From. Lee Averell, Andrew Heathcote, Scott Brown, *University of Newcastle*. The quantitative form of forgetting has been studied for over 100 year without adequate resolution. In fact the field is still so far from consensus that it has been suggested that no such lawful description exists (Rodiger, 2008). Another view is that consensus has been clouded by data analysis problems, particularly averaging data over participants, low power and accounting for differing degrees of flexibility amongst candidate functions. Recent advances in Bayesian analysis techniques (Shiffrin, Lee, Kim & Wagenmakers, 2008) allow these issues to be resolved. We analyse to two classic data sets Rubin, Hinton and Wenzel (1999) and Wixted and Ebbesen (1991) and two new data sets with large numbers of observations per retention interval for each participant at each of three levels, an individual participant level, a subject based hierarchical level and a population based hierarchical level (cf. Vaida & Blanchard, 2005). We show that the failure to resolve the question of

the most adequate quantitative form of forgetting may be because different levels of analysis could lead to differing conclusions.

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Aug 03, 12:00–12:20
Lecture Hall C

Mathematical Analysis of the Effects of Averaging Learning or Forgetting and Curves. Jaap Murre, *University of Amsterdam*. Learning performance improves with practice and some claim it follows the so-called 'Power Law of Learning'. Similarly, forgetting may follow a power function. It has been shown on the basis of extensive simulations that such power laws may emerge as artifacts through averaging functions with other shapes. We present mathematical proofs that power functions will indeed emerge as a result of averaging over exponential functions, if the distribution of learning rates follows a gamma, beta, normal distribution, or certain other distributions. Further analyses and computer simulations give insight into when this may be a problem in practice. Averaging over certain non-exponential functions will also be discussed. In most cases, averaging tends to transform the individual curves. Even if the shape is retained, the parameters tend to be altered. This work, thus, extends earlier computational research and may offer new ways to infer the true shape of learning and forgetting.

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Aug 03, 14:00–14:20
Lecture Hall C

Estimating Structural Equation Models with Non-normal Variables by Using Transformations. Kees Van Montfort, *VU University Amsterdam*. We discuss structural equation models for non-normal variables. In this situation the maximum likelihood and the generalized least-squares estimates of the model parameters can give incorrect estimates of the standard errors and the associated goodness-of-fit chi-square statistics. If the sample size is not large, for instance smaller than about 1000, asymptotic distribution free estimation methods are also not applicable. This paper assumes that the observed variables can be transformed to normally distributed variables. The non-normally distributed variables will be transformed with a Box-Cox function. Estimation of the model parameters and the transformation parameters will be done by the maximum likelihood method. Furthermore, the test statistics (i.e. standard deviations) of these parameters are derived. This makes it possible to show the importance of the transformations. Finally, an empirical example is presented.

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Aug 03, 14:20–14:40
Lecture Hall C

Cointegration Methodology - a Useful Multivariate Tool for Psychological Process Research? Esther Stroe-Kunold, Tetiana Stadnytska, *University of Heidelberg*. Time series analysis has gained an increasing scientific interest in social and behavioural sciences during the last decade. The systemic psychological perspective suggests that many processes are mutually interconnected forming a dynamic system. Multivariate methods appropriately modelling human dynamics are required. As a considerable number of psychological time

series is non-stationary, their mathematical pre-transformation into stationary series is usually necessary. This implies a loss of information inherent in the process. Engle and Granger (1987) introduced the cointegration approach where non-transformed non-stationary time series can be treated as a multivariate system. In cointegrated systems non-stationary processes are connected by a stationary long-run equilibrium relationship. Temporal deviations from this equilibrium due to developmental changes (i.e. stochastic trends) can be captured by means of error-correction models. These representations of cointegrated processes simultaneously model the long-run equilibrium and the short-term dynamic of adjustment, i.e. a part of the disequilibrium arising in one period is corrected in the next period. Thus, past disequilibrium serves as explanatory variable in the dynamic behaviour of current variables. Based on research by means of Monte Carlo simulations, the presentation aims at demonstrating in which way these models and their extensions (i.e. fractional cointegration) offer flexible techniques for analysing dynamic process-systems. Competing and related multivariate approaches are discussed. An empirical psychological example illustrates the performance of cointegration methods in a typical research situation.

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Aug 03, 14:40–15:00

Lecture Hall C

Additive Factors and Stages of Mental Processes. Richard Schweickert, *Purdue University*, Donald Fisher, *University of Massachusetts*, William Goldstein, *University of Chicago*. To perform a task a subject executes mental processes. An experimental manipulation, such as a change in response difficulty, is said to selectively influence a process if it changes the duration of that process leaving other process durations unchanged. A technique for analyzing reaction times, Sternberg's Additive Factor Method, assumes all the processes are in series. When all processes are in series, each process is called a stage. With the Additive Factor Method, if two experimental factors selectively influence two different stages, the factors will have additive effects on reaction time. An assumption of the Additive Factor Method is that if two experimental factors interact, then they influence the same stage. We consider processes in which some pairs of processes are sequential and some are concurrent (i. e., the processes are partially ordered). We propose a natural definition of a stage for such processes. For partially ordered processes, with our definition of a stage, if two experimental factors selectively influence two different processes, each within a different stage, then the factors have additive effects. If each selectively influenced process is in the same stage, then an interaction is possible, although not inevitable.

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Aug 03, 15:00–15:20

Lecture Hall C

Correct Statistical Inferences using Misspecified Models with Missing Data with Application to the Learner's Perceptions Survey. Richard Golden, *University of Texas, Dallas*, Steven Henley, *Martingale*

Research Corporation, HALBERT WHITE, *University of California, San Diego*, MICHAEL KASHNER, *Department of Veterans Affairs*. A unified asymptotic statistical theory is presented for making reliable statistical inferences for a large class of possibly misspecified regression models (e.g., linear, nonlinear, and categorical regression) with ignorable missing data mechanisms. The theory also handles misspecification of the missing data mechanism so that asymptotic inferences are reliable for non-ignorable response data (i.e., Missing Not At Random or MNAR) statistical environments. In this talk, we review new theorems establishing the consistency and asymptotic normality of maximum likelihood estimates for possibly misspecified probability models within MNAR missing data statistical environments. Simulation results are provided to illustrate the relevance of the large sample approximations. Next, the theory is applied to a current problem in health care resource allocation: The Learner's Perceptions Survey (Dept. of Veterans Affairs) which contains 18,000 survey records from sampled residents rotating through VA medical centers in 2001-2007.

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Aug 03, 15:40–16:00
Lecture Hall C

Mathematics, Perception and the Visual Arts: New Perspectives. DANIEL GRAHAM, DANIEL ROCKMORE, *Dartmouth College*. Mathematics has long informed visual art, from discovery of the Golden Ratio to the rise of linear perspective and beyond. Perceptual psychology, too, has influenced artwork, with ideas such as color opponency. Today, all three fields can be combined to advance the study of visual perception. In this paper, we survey an emerging body of techniques for mathematical analysis of art. We discuss results from analyses of diverse collections of paintings, and we describe implications for human visual coding and perception. Findings include: (1.) Spatial frequency spectra of paintings and natural scenes are similar, even for abstract painting. Given current understanding of efficient coding in the early visual system, this similarity can be seen as an influence of neural coding on the fundamental structure of human artwork. (2.) Statistics of features such as wavelets and sparse filters are useful discriminants of artistic style, and they can be used to assign likely dates to undated works (3.) Higher-order statistics of luminance distributions, along with spatial frequency spectra, can predict human judgments of similarity for art surprisingly well. This and other evidence suggests that variations in these statistics could be extracted in the visual stream in order to make such judgments. (4.) As in retinal coding, nonlinear functions are required to transform typical luminances in natural scenes into the smaller range available in paintings. For our tests of van Gogh works, this function is an inverted sigmoid. Together, this work shows how mathematical analysis of artwork can further our understanding of vision. These findings also have bearing on the worlds of art and mathematics.

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Aug 03, 16:00–16:20
Lecture Hall C

Compression of Natural Fourier Im-

ages. Thomas Wickens, Karen DeValois, *University of California, Berkeley*. A natural image $f(x, y)$ can be transformed to Fourier amplitude and phase components $A(f, \theta)$ and $\phi(f, \theta)$ with respect to an origin (x_0, y_0). We investigate schemes for compressing the information this image in perceptually plausible ways. We use the entire image, not arbitrary patches (e.g., JPEG compression). Examination of natural images has shown that the amplitude spectrum has roughly the form $A(f, \theta) \approx A(\theta) f^{\alpha(\theta)}$, where $\alpha(\theta) \approx -1$. We represent this tent-like function by giving $A(\theta)$ and $\alpha(\theta)$ simple polynomial or harmonic forms, thereby reducing this aspect of the image to a handful of parameters, and see how well the image can be reconstructed. The phase function $\phi(f, \theta)$ has no such simple functional form, but can be compressed by descretizing its values.

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Aug 03, 16:20–16:40
Lecture Hall C

Facial Perception as a Configural Process. Devin Burns, Lei Pei, Joseph Houpt, James Townsend, *Indiana University*. Configural or gestalt processing are general terms given to phenomena where the whole is different from the sum of its parts. Here we explore these phenomena through face perception, a known configural process. In this experiment, subjects are presented with a split face recognition task with manipulations on the presence or absence and the salience of each half, the famous 'composite face design'. It is one of a number of perceptual experimental designs based on selective attention and the presence or absence of interference expressed in RT or accuracy. We performed a replication of this task and then added a design based on divided attention. Systems factorial technology is employed to draw conclusions regarding architecture, stopping rule, capacity and independence.

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Aug 04, 09:00–09:20
Lecture Hall A

A Hierarchical Bayesian Account of 'Learning to Learn'. Charles Kemp, *Carnegie Mellon University*. Children face a seemingly endless string of learning tasks over the course of their cognitive development. Word learning, for example, can be viewed as a long sequence of problems where each problem requires an inference about the meaning of an individual word. Sequences of this kind provide an opportunity for 'transfer learning' or 'learning to learn', where inferences about each individual problem are accelerated by discovering and exploiting common elements across problems. I will suggest how a hierarchical Bayesian approach can help to account for transfer learning, and will include examples related to word learning, categorization and inductive reasoning.

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Aug 04, 09:20–09:40
Lecture Hall A

Connectionist Perspectives on the Development of Category Learning Abilities. Bradley Love, *University of Texas, Austin*. A variety of brain-inspired connectionist models successfully account for how infants and young children acquire categories. Some of these mechanistic models provide compelling accounts of what changes over development. However, one

major challenge in model evaluation is that a wide array of mechanisms account for the same basic findings. Although internally sound and well-motivated, key developmental studies lack sufficient structure for their findings to adjudicate among competing models. One possible way forward is to construe development broadly as a process that occurs from birth to death. According to this view, successful models of development do not simply account for the behavior of infants and young children, but also account for the behavior of adults and the elderly. Introducing these constraints rules out a number of possible models. Additionally, consideration of the relationship between model mechanisms and learning systems in the brain offers a wealth of constraints and suggests boundaries on the types of behaviors a model should and should not be expected to address. Finally, looking beyond connectionist models, I suggest that these same problems dog other approaches to addressing developmental change, such as Bayesian approaches to development (e.g., For a task, are people Bayesian, nearest neighbor, or both?). One possible advantage of mechanistic approaches (e.g., connectionist approaches) is the possibility of incorporating constraints related to performance and instantiation in the brain.

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Aug 04, 09:40–10:00
Lecture Hall A

Learning Models Show How Stimulus Similarity Differentially Affects the Learning Process. Maartje Raijmakers, *University of Amsterdam*. In this contribution we present a methodology to detect how the similarity structure of exemplars in a category-learning task affects the learning process. The main goal is to analyze qualitative differences between human children of different ages in comparison with human adults and infrahumans, in terms of stages that are underlying their learning process, thereby taking into account possible intra-individual and inter-individual differences within and between species and age groups. To this end, we apply a latent variable technique of latent Markov analysis to model the trial-by-trial time series of accuracy scores (Wickens, 1982). As opposed to more standard applications of latent Markov models, the defined Markov models take the sequence of learning stimuli into account. This makes it possible to distinguish all-or-none learning from paired-associative learning within the same model. The modeling approach is based on Batchelder (1970, JMP). The data includes pigeons (Columba livia; $N = 8$), human children (4 – 13 years of age; $N = 154$), and adults (17 – 41 years of age; $N = 22$). Only for pigeons, similarity hurts. Children mainly show paired associative learning. Older children and adults show, in addition, also concept formation on different levels of similarity.

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Aug 04, 10:00–10:20
Lecture Hall A

Modeling in Developmental Psychology. Michael Ramscar, Melody Dye, *Stanford University*. There are at least two ways in which response conflict can be handled in the mind: dynamic response conflict resolution, which enables conflicting

response demands to be resolved on-line, and discrimination learning, which reduces the amount of on-line response conflict that needs to be resolved in context. While under fours are perfectly capable of discrimination learning, they appear to lack the ability to resolve response conflict on-line. They can match their behavior to context in remarkably subtle and sensitive ways when they have learned to do so, but if they have not learned to match a response or a behavior to a context, their inability to handle on-line response conflict is their undoing (for example, in the dimensional change card sort task; DCCS). We present a formal analysis of how discrimination learning in context might aid children's performance in the dimensional change card sorting (DCCS) over time. In a training study in which three groups of age matched under fours attempt to complete the DCCS we find that, given appropriate discrimination learning, children are able to flexibly switch between the responses required by the DCCS. Without appropriate discrimination learning, children's performance is far worse, and when the task contexts are novel, children fail as expected. Why do under fours lack the ability to resolve response conflict on-line? We then use our learning model to show how cognitive control impedes convention learning, and argue that delayed prefrontal maturation is a necessary adaptation for human learning of social and linguistic conventions.

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Aug 04, 11:00–11:20
Lecture Hall A

State Trace Analysis of Recognition Memory Data. John Dunn, *University of Adelaide*, Andrew Heathcote, *University of Newcastle*. We have conducted a series of recognition memory experiments in each of which two factors is varied within subjects and within lists. For these data, we wish to contrast a one-dimensional (1D) and two-dimensional (2D) model. The 1D model may be considered as a generalization of the unequal variance single detection model in which the variance(s) is an unspecified monotonic function of d'. The 2D model is pretty much everything else. In particular, it subsumes a variety of dual process models, including Yonelinas' dual process signal detection model and DeCarlo's mixture model as well as the unconstrained unequal variance signal detection model. For the kind of data that we have collected, the 1D model predicts a set of non-intersecting ROC curves. This also corresponds to a configuration in a $(k-1)$-dimensional outcome space defined by the set of decision criteria corresponding to k response categories in which the hit rates for each condition lie on a single monotonically increasing curve. We show how to fit such a curve using constrained maximum likelihood estimation and report the results of monte carlo simulations on the distribution of the associated likelihood ratio test statistic. We then apply this procedure to data from item recognition and associative recognition paradigms and discuss the implication of the results for models of recognition memory as well as for wider application of the approach.

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Lecture Hall A

State Trace Analysis. Michael Kalish, *University of Louisiana*

at Lafayette, Ben Newell, *University of New South Wales*, John Dunn, *University of Adelaide*. A current debate in the field of category learning centers on the number of 'systems' required to explain people's behavior. Evidence in the debate takes the form of dissociations in the effect of various manipulations on the learning of two types of category structures. In this talk, I describe how we used state-trace analysis to investigate one of these manipulations: the effect of concurrent working memory load on perceptual category learning. Initial re-analysis of D. Zeithamova & W.T. Maddox (2006, Experiment 1) revealed an apparently two-dimensional state-trace plot consistent with the reported dissociation. Follow up analyses restricted to only those participants who had learned the category task and performed the concurrent working memory task adequately revealed only a one-dimensional plot, as did three modified replications of the original experiment. These results highlight the potential of state-trace analysis in furthering our understanding of the mechanisms underlying category learning. We suggest, however that the implications of high and low dimensional behavior for the discrimination of multiple cognitive systems remains only as clear as the notion of what comprises a 'system'.

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Aug 04, 11:40–12:00
Lecture Hall A

Bayesian State-Trace Analysis of Binomial Data. Melissa Prince, Andrew Heathcote, Scott Brown, *University of Newcastle*. One of the most fundamental questions in experimental psychology and neuroscience concerns determining whether a single psychological dimension (i.e., a single latent variable, model or process) can explain the joint effects of two or more experimental factors. State-trace analysis (Bamber, 1979), also called Dimensional analysis (Loftus, Oberg and Dillon, 2004), provides a method for answering this question of dimensionality. State-trace analysis makes minimal assumptions, is very generally applicable and avoids the caveats identified in traditional approaches to this question, such as dissociation methodologies. However, despite both its wide application and the importance of the question that it addresses, there is no agreement on appropriate inferential testing methods for state-trace analysis. We propose inferential tests based on Bayes factors for state-trace designs where performance is measured by a binary dependent variable. These tests can be used to refine experimental methodology and to estimate the probability that a one-dimensional or multi-dimensional model best describes performance.

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Aug 04, 12:00–12:20
Lecture Hall A

Generalized Bayesian Analysis of State-Trace. Andrew Heathcote, Beatrice Bora, Scott Brown, *University of Newcastle*, John Dunn, *University of Adelaide*. Heathcote, Prince and Brown (submitted) developed methods for inference about binary data in two-dimensional state-trace plots. Their analysis is based on Klugkist, Kato and Hoijtink's (2005) encompassing model approach to Bayes-factor estimation and assumes a binomial data-

generating model. We develop a generalization of this approach that is applicable to ordinal (e.g., confidence rating) and continuous (e.g., response time) data with an unknown distribution based on the work of Dunn and James (2003) and Dunn (2008). The generalization is non-parametric in that it approximates the unknown data distribution using empirical cumulative distribution functions with S levels. Each of the S levels is assumed to correspond to an axis in a multi-dimensional state-trace plot. We explore the implementation of this analysis using confidence and accuracy data from Heathcote, Freeman, Etherington, Tonkin and Bora (in press) and Heathcote, Bora and Freeman (submitted).

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Aug 04, 14:00–14:20
Lecture Hall A

Model Selection for Dummies (and experts). Richard Shiffrin, Woojae Kim, *Indiana University*. In part one we present a conceptual overview that shows the close connection between Minimum Description Length and Bayesian Model Selection, and the ways in which each balances fit and complexity. In part two we extend the methods to incorporate prior knowledge about likely data patterns. Time permitting, we will discuss a number of large issues that are critical for reasonable model selection.

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Aug 04, 14:40–15:00
Lecture Hall A

The Catch-Up Phenomenon in Model Selection and Prediction. Tim van Erven, Peter Grunwald, *Centrum Wiskunde Informatica*, Steven de Rooij, *University of Cambridge*. We resolve a long-standing debate in statistics, known as the AIC-BIC dilemma: model selection/averaging methods like BIC, Bayes factors, and MDL are consistent (they eventually infer the correct model) but, when used for prediction, the rate at which predictions improve can be suboptimal. Methods like AIC and leave-one-out cross-validation, which penalize less for complexity, are inconsistent but typically converge at the optimal rate. We give a novel analysis of the slow convergence of the BIC/Bayesian-type methods. Based on this analysis, we propose the switching method, a modification of Bayesian model averaging that achieves both consistency and minimax optimal convergence rates. The method has run time complexity comparable to Bayes. Experiments with nonparametric density estimation confirm that our large-sample theoretical results also hold in practice in small samples.

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Aug 04, 15:00–15:20
Lecture Hall A

Decoupling Strength of Evidence from Uncertainty in Model Selection. Charles Liu, *Boston University*, Murray Aitkin, *University of Melbourne*. Almost all model selection criteria (such as the AIC, BIC, DIC, and Bayes factor) compare models using single-value summaries. These summaries can be misleading because they disguise the uncertainty associated with model parameters. In this talk, I will discuss the posterior likelihood approach, which is a fully Bayesian method that provides a measure of the uncertainty associated with the strength of evidence for

each model. The advantages of this method will be discussed in a comparison of retention functions.

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Aug 04, 15:40–16:00
Lecture Hall A

Bayesian Model Selection for Informative Hypotheses. Irene Klugkist, *Utrecht University*. Null-hypothesis significance testing (NHST) basically investigates the two competing statements 'nothing is going on' (H_0) versus 'something is going on but I don't know what' (H_A). The null hypothesis is not realistic (there is usually something going on) and the alternative is not informative (it does not tell you what is going on). The investigation of specific theories or expectations in a NHST approach usually leads to multiple testing, with several related complications, like, for instance, inflated Type I errors, choosing one of the many correction methods, and sometimes inconsistent results. Model selection, however, can be a very useful tool for the evaluation of specific, informative hypotheses.

We consider hypotheses specified using inequality constraints (e.g. $\mu_1 < \mu_2 < \mu_3$) and hypotheses testing for relevant differences (e.g. $\mu_1 \simeq \mu_2 \simeq \mu_3$, where $\simeq$ denotes that the difference between parameters is less than a (user-specified) minimal relevant effect size). In the Bayesian model selection approach that is developed for these types of hypotheses, the constraints are incorporated in an otherwise relatively uninformative prior distribution. The performance of the approach will be demonstrated, with special attention for prior sensitivity and some other issues that require further investigation.

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Aug 04, 16:00–16:20
Lecture Hall A

Parameters, Prediction and Evidence in Computational Modeling: A Statistical View Informed by ACT-R. Rhiannon Weaver, *Carnegie Mellon University*. Computational models in typical cognitive experiments often contain multiple, plausible sources of variation arising from human subjects and from stochastic cognitive theories. But standard model validation techniques based purely on a "model fixed, data variable" measurement paradigm can obscure these sources of variation, making it difficult to interpret model predictions and to account for individual differences. In this talk I discuss the impact of multiple sources of variation on model validation based on comparisons between experimental data and model simulations, and I propose likelihood-based modeling as a framework for exploring the functional relationship between these two populations. I show how to express a simple class of ACT-R models as stochastic processes, as a motivating example for generalizing from deterministic to stochastic model validation in the face of probabilistic theories and random subject-to-subject variation.

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Aug 04, 16:20–16:40
Lecture Hall A

An Encompassing Prior Generalization of the Savage-Dickey Density Ratio Test. Eric-Jan Wagenmakers, Ruud Wetzels, Raoul Grasman, *University of Amsterdam*. Hoijtink, Klugkist, and colleagues introduced an encompassing prior (EP) approach to facilitate Bayesian

model selection in nested models with inequality constraints. In this approach, samples are drawn from the prior and posterior distributions for an encompassing model that contains an inequality restricted version as a special case. The evidence in favor of the inequality restriction (i.e., the Bayes factor) simplifies to the ratio of the proportions of posterior and prior samples consistent with the inequality restriction. Up to now, this elegant formalism has been applied almost exclusively to models with inequality or "about equality" constraints. Here we prove that the EP approach naturally extends to exact equality constraints by considering the ratio of the heights for the posterior and prior distributions at the point that is subject to test (i.e., the Savage-Dickey density ratio test). Therefore, the EP approach generalizes the Savage-Dickey test and can account for both inequality and equality constraints. The general EP approach is an elegant and computationally efficient procedure to calculate Bayes factors for nested models.

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Aug 04, 09:00–09:20
Lecture Hall B

Multinomial Processing Tree Models of Paired-comparisons. William Batchelder, *University of California, Irvine*, Xiangen Hu, *University of Memphis*, Jared Smith, *University of California, Irvine*. This paper shows how to develop new multinomial processing tree (MPT) models for discrete choice, and in particular binary choice. First it reviews the Bradley-Terry-Luce (BTL) paired-comparison model which is the basis of logit models of discrete choice used throughout the social and behavioral sciences. It is shown that a reparameterization of the BTL model is represented by choice probabilities generated from a finite state Markov chain, and this representation is closely related to the rooted tree structure of MPT models. New MPT models of binary choice, including one's that can handle ties, can be obtained by placing restrictions on this representation of the BTL model. Several of these new MPT models are described, compared to the BTL model, and applied to data from a replicated round-robin data structure.

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Aug 04, 09:20–09:40
Lecture Hall B

On the Minimum Description Length Complexity and Selection of Multinomial Processing Tree (MPT) Models. Hao Wu, Jay Myung, *Ohio State University*, William Batchelder, *University of California, Irvine*. Multinomial processing tree (MPT) models have been widely and successfully applied as a statistical tool for various experimental paradigms. A prominent feature of MPT models is that models with the same number of parameters may vary greatly in their tree structures. In addition, inequality constraints imposed to represent hypothesized treatment ef fects, though leaving the dimension of a model unchanged, may change its complexity. Given the above sources of variability and the importance of model complexity in model evaluation and selection, it is important to evaluate complexity of MPT models and fully account for its effect in model complexity. In this work, I will present theorems that link complexity of an MPT model to that

of its building components, a general purpose computer program that calculate the complexity of MPT models, and an example with pair clustering data. The theorems show that the complexity of an MPT model depends not only on that of its building blocks, but also on how those building blocks are combined: the tree structure e ffect. Our example shows that structural complexity, especially those due to the presence of inequality constraints, may change the complexity significantly.

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Aug 04, 09:40–10:00
Lecture Hall B

Multinomial Processing Tree (MPT) Models Analysis For Quasi-Independence Contingency Tables. Xiangen Hu, *University of Memphis*, Yuan You, *Huazhong University of Science and Technology*, William Batchelder, *University of California, Irvine*. Multinomial processing tree (MPT) models constitute a family of nonlinear models for categorical data. The particular nonlinearity of MPT models makes it especially easy to analyze contingency tables that do not satisfy log-linear properties. In this talk we focus on the MPT model analysis of quasi-independence of contingence tables. We provide a general framework for testing quasi-independence with dominant observations in the diagonal cells. We claim that the MPT model approach is more appropriate than log-linear models for the analysis of contingency tables because it allows the formulation of a greater variety of statistical hypotheses about their structure. Our presentation will include a MPT model analysis of social mobility data collected from China. The analyses reveal some interesting phenomena in Chinese society before 1980 and after 1980.

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Aug 04, 10:00–10:20
Lecture Hall B

Multiplicatively Interacting Factors in Multiple Response Class Processing Trees. Richard Schweickert, Zhuangzhuang Xi, *Purdue University*. Suppose the processes required for a task are in a rooted tree. A probability is associated with each edge. The probability on an edge denotes the probability with which it is selected when its starting vertex is reached. Such trees are used as models in perception, memory and social cognition, for example, as models of source memory. Processing begins at the root. An edge descending from the root is selected and the ending vertex of this edge is reached. An edge descending from this ending vertex is selected. Processing continues until a terminal vertex of the tree is reached. Each terminal vertex is associated with a class of responses; when a terminal vertex is reached the response associated with it is made. Suppose each of two experimental factor changes probabilities on a subset of edges, and the subsets are mutually exclusive. Necessary and sufficient conditions are given for the factors to have a multiplicative interaction on the probability each response is made. If the factors have a multiplicative interaction, the underlying processing tree is equivalent to a processing tree having a simple form. Analogous trees with rates rather than probabilities on the edges have been used to model rates of behaviors such as bar pressing, and analogous results apply to them.

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Aug 04, 10:20–10:40
Lecture Hall B

Mixed Ideal Point Models for Longitudinal Multinomial Outcomes. Mark de Rooij, *Leiden University*. In psychology and other social sciences often multinomial longitudinal data are gathered. Maximum likelihood estimation of mixed effect models for such data can be prohibitive due to the integral dimension of the random effects distribution. We propose to use multidimensional scaling methodology to reduce the dimensionality of the response variable and thereby the dimensionality of the random effects. As a by product readily interpretable graphical displays representing change are obtained. Several examples will be used to illustrate the methodology.

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Aug 04, 11:00–11:20
Lecture Hall B

Firing Patterns of Single Neurons Contain Information About Task Context. Christoph Weidemann, Alec Solway, Michael Kahana, *University of Pennsylvania*, Itzhak Fried, *University of California, Los Angeles*. We recorded single unit activity from neurons in the brains of human participants while they navigated through a large and unconstrained virtual environment towards previously learned goal locations. We identified neurons that responded significantly to participants location in a manner that suggests a special encoding of task relevant locations even in the absence of sensory cues marking these locations. These results demonstrate a strong and exible dependence of neural ?ring patterns on current task context. This result is most apparent in an analysis of the information content of the ?ring patterns rather than in raw rate of neural discharge.

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Aug 04, 11:20–11:40
Lecture Hall B

Modelling of the Action Potential Propagation in Nerve Fibre. Kanad Ray, *Icfai University*. Modelling of the action potential propagation in nerve fibre is important in neuro physiology. An analytic solution for a myelinated axon excitation is crucially important for applications involving vertebrates. In the calculations involving myelinated fibre lossless transmission line model is used without taking into account the myelin resistance. We are developing a lossy, distributive parameter transmission line model[1] and applying it to study behaviour of the fibre for an understanding of the analysis of neural propagation.

[1]"Nerve conduction using a myelinated nerve fibre modelled as a lossy transmission line" by Kanad Ray(accepted for talk presentation)-Conference on Recent Development in Applied Mathematical Science and Engineering(20-22Feb,2009) at Jalpaigudi Government Engineering College, Jalpaigudi,West Bengal,India

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Aug 04, 11:40–12:00
Lecture Hall B

Contextual Emergence of Mental States from Their Neural Correlates. Peter beim Graben, *University of Reading*, Harald Atmanspacher, *Institute for Frontier Areas of Psychology, Freiburg*. The concept of contextual emergence has

been proposed as a non-reductive, yet well-defined relation between different levels of description of physical and other systems [1]. Stability conditions are crucial for a rigorous implementation of "higher-level" contingent contexts that are required to understand the emergence of higher-level properties from an underlying "lower-level" description [2]. An important question of cognitive neuroscience, how neurobiological and mental states are related to one another, can be addressed within this framework. We argue that Chalmer's "phenomenal families" [3], which partition the space of phenomenal experiences, provide contingent contexts for the emergence of conscious mental states. They induce a partitioning of the underlying neural state space [4] which is stable under the neurodynamics, if sequences of such states form an ergodic Markov chain. In the special case of a generating partition, conscious states are faithful representations of the neurodynamics.

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[3] Chalmers, D. (2000): What Is a Neural Correlate of Consciousness?, in T. Metzinger (ed.), Neural Correlates of Consciousness, Cambridge: MIT Press, pp. 17-39.

[5] Atmanspacher, beim Graben (2007): Contextual Emergence of Mental States from Neurodynamics, Chaos Compl. Lett. 2(2), 151-168.

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Aug 04, 12:00–12:20
Lecture Hall B

Linear Discriminant and Workload Capacity Analyses of the Neural Correlates of Configural Learning.
Leslie Blaha, James Townsend, Thomas Busey, *Indiana University*.
The purpose of our current study is to employ linear discriminant analysis (LDA; Philiastides & Sajda, 2006) to characterize the changes in ERPs over the entire course of a perceptual learning task. Configural learning is the perceptual learning process by which participants develop configural processing strategies or representations characterized by extremely efficient parallel information processing (Blaha & Townsend, under revision). Participants performed a perceptual unitization task in which they learned to categorize novel images. Correct categorization responses required exhaustive feature identification, which encouraged unitization of images into whole-object percepts. Linear discriminator accuracy, measured by Az, increased each day of training, showing significant differences in neural signals between categories on and after training day 3 or 4 for all participants. Additionally, the LDA training window starting time resulting in discriminator performance of 65% accuracy or better shifted from 450-500ms to 300ms after stimulus onset at the completion of training. LDA results are consistent with our earlier report (Blaha & Busey, VSS 2007) of peak ERP amplitude differences between categories after training at approximately 170ms and 250ms after stimulus onset. The shift in discriminator performance parallels the shift from limited to super capacity, as indexed by Townsend's capacity coefficient.

We explore ways in which the distribution of ERP component times may be analyzed together with response times to develop a measure of neural workload capacity.

(119)
Aug 04, 14:00–14:20
Lecture Hall B

Information Integration in Perceptual Decision Making. Jared Hotaling, *Indiana University*, Andrew Cohen, *University of Massechusetts*, Jerome Busemeyer, Richard Shiffrin, *Indiana University*. In cognitive science there is a seeming paradox: On the one hand researchers studying judgment and decision making (JDM) have repeatedly shown that people employ simple and often sub-optimal strategies when integrating information from multiple sources. On the other hand another set of researchers has had great success using Bayesian optimal models to explain information integration in fields such as categorization, perception, and memory. One impediment to reconciling this paradox lies in the different experimental methods each group has used. A decision making experiment was designed to test whether the sub-optimal integration found in verbal problems stated in terms of probabilities may also appear in perceptual tasks. We investigated two classic JDM findings: the conjunction fallacy and the dilution effect. The best known example of the former is the 'Linda Problem', in which the probability that 'Linda is a feminist and a bank teller' ($P(A\&B)$) is judged greater than the probability that 'Linda is a bank teller' ($P(B)$), thus violating the law of total probability. The dilution effect has been demonstrated in various situations where participants are given strong evidence X favoring A over B, and weak evidence Y also favoring A over B. Rather than multiplying the odds in favor of A, as Bayesian analysis proscribes, the odds are averaged. In effect the weak evidence dilutes the strong evidence. I present data from a perceptual decision making experiment investigating the conditions giving rise to these non-normative behaviors.

(120)
Aug 04, 14:20–14:40
Lecture Hall B

Decision Field Theory for Intertemporal Choice. Sébastien Houde, Jerker Denrell, *Stanford University*. This paper extends Decision Field Theory (DFT), a computational model of decision-making proposed by Busemeyer and Townsend (1992), to intertemporal choice. We propose to use DFT to investigate the process of attention allocation for choices between temporally distance outcomes. To extend the theory, we make two important assumptions. First, we assume that time is an explicit attribute in intertemporal choice tasks. In the context of DFT, deliberations then consist to sample alternatives by stochastically allocating attention to both the money and time dimensions. Second, we assume that the regime of weights determining the attention allocation process varies with the nature of the choice tasks. We posit that particular choice tasks give raise to specific and systematic patterns of weights. To test our theory, we apply three concepts of model selection. First, we simulate the model and replicate a number of known anomalies in intertemporal choice, such as decreasing impatience, the magnitude effect and the gain-loss asymmetry

(Lowenstein and Prelec, 1992). Second, we estimate the model using experimental data from various published studies and perform out-of-sample forecasting. We found that the estimated models have the ability to predict choices across studies. Third, we perform lab experiments to test new predictions of DFT in the context of intertemporal choice.

(121)
Aug 04, 14:40–15:00
Lecture Hall B

Testing Learning Models of Sequential Decision Making. Jörg Rieskamp, *University of Basel*, Jerome Busemeyer, *Indiana University*. Decisions are frequently made on the basis of past experience. How experience changes people's decisions can often be accurately described by learning models. However, past research has predominantly focused on decision situations where decisions' outcomes are independent of each other. On the contrary, the present work examines how people make decisions in situations in which decisions' outcomes depend on previous decisions. More specifically we conducted an experiment in which the participants faced a situation where they made three decisions and the outcome of the last two decisions depended on their previous decisions. Thus, the decision problem consisted of finding the best sequence of decisions, that is decision path. The outcome of each decision was a payoff drawn from a normal distribution. To provide the opportunity of learning the decision situation was repeated one hundred times. The experiment results show that most participants learned the optimum sequence of decisions. This learning process was described with two learning models. The first reinforcement learning model assumes that the object of reinforcement are the complete paths that can be taken. The second temporal difference learning model assumes that the object of reinforcement are the possible decisions that can be made given the state of previous decisions. When testing the models against each other the temporal difference model predicted the observed learning process best. These results show that people apparently do not plan ahead the whole sequence of decisions, but instead try to make the best decisions given the situation they are in.

(122)
Aug 04, 15:00–15:20
Lecture Hall B

An Introduction to the Quantum Inference Model with an Application to Legal Inferences. Jennifer Trueblood, Jerome Busemeyer, *Indiana University*. Cognitive models based upon the principles of quantum probability have the potential to provide a cohesive framework for understanding paradoxical observations in human decision making. Specifically, the quantum inference model accounts for interference effects arising from incompatible measurements based upon human judgments. These interference effects occur when more than one measurement is taken from an individual and an earlier measurement disturbs a later measurement. As an illustration, we apply the quantum inference model to the task of inferring the guilt of a defendant after hearing two sides of a case. Experimental results show that a weak argument for one side of a

case increases confidence in the opposing side. If we assume measurements are conditionally independent, then the Bayesian inference model fails to explain these results. McKenzie, et al. (2002) explained this phenomena with an anchor-and-adjust model using a case's minimum acceptable strength. We discuss the weaknesses of the anchor-and-adjust and compare it to the quantum inference model. We conclude by mentioning other examples of order effects arising in the social and behavioral sciences and discuss possible future applications of the quantum inference model.

(123)
Aug 04, 15:40–16:00
Lecture Hall B

Optimal Experimental Design for Bandit Problems. Shunan Zhang, Michael Lee, *University of California, Irvine*. In bandit problems, a decision-maker must choose between a set of alternatives – each of which has a fixed but unknown rate of reward – to maximize their total number of rewards over a sequence of trials. There are many existing quantitative models, developed in the reinforcement learning and cognitive science literature, for decision-making in bandit problems. A major goal of conducting experiments with people completing bandit problems is to discriminate between these different models as accounts of human decision-making. This raises a questions of experimental design: How should a set of bandit problems be designed to maximize our ability to discriminate between the models? We use a previously developed design optimization framework for statistical experiments, and apply it to the problem of finding good bandit problem experiments. The approach involves maximizing a utility function over the design space, with respect to the prior distributions of model parameters. Statistical methods including prior simulation Monte Carlo and MCMC sampling are adopted to search for the mode of the utility, thus finding the optimal design. As a preliminary study, we concentrate on finding the optimal distributions of reward rates to discriminate between some simple models, including variants of the win-stay lose-shift model, for two-armed bandit problems. Our results show that the optimal designs vary, in systematic and interpretable ways, according to different prior beliefs about the parameters of the models to be discriminated.

(124)
Aug 04, 16:00–16:20
Lecture Hall B

Confirmation Bias is Rational when Hypotheses are Sparse. Amy Perfors, Daniel Navarro, *University of Adelaide*. We consider the common situation in which a reasoner must induce the rule that explains an observed sequence of data, but the hypothesis space of possible rules is not explicitly enumerated or identified; an example of this situation is the number game (Wason, 1960), or *twenty questions*. We present mathematical optimality results showing that as long as the hypotheses in the hypothesis space are not explicitly enumerated and as long as they tend to be sparse – that is, as long as rules, on average, tend to be true only for a small proportion of entities in the world – then confirmation bias is a near-optimal strategy. The intuition underlying these results is built

on basic information theory, which holds that when all hypotheses can be enumerated, the optimal strategy is that of bifurcation: choosing the query for which precisely half of the hypotheses are true and half are false. When hypotheses are not enumerated, the bifurcation strategy is not possible, since one cannot identify which queries would exactly divide the space; if hypotheses are sparse, a random query will likely lead to a *no* response. The best way to overcome this tendency is to choose queries that one knows will lead to a *yes* response for at least some hypotheses (namely, those hypotheses being considered): this positive-test strategy is closely related to the confirmation bias. Additional considerations suggest that in a variety of realistic situations, the sparsity assumption is reasonable.

(125)
Aug 04, 16:20–16:40
Lecture Hall B

Scale Invariance and Models for the Iowa Gambling Task. Chung-Ping Cheng, *National Chengchi University*, Ching-Fan Sheu, *National Cheng Kung University*. The Iowa gambling task (IGT) is a laboratory task designed to simulate real-life decision making under uncertainty. IGT is often used to assess decision making deficit of neurological patients. Ahn et al. (2008) proposed eight cognitive models including expectancy-valence model (Busemeyer & Stout, 2002) to characterize performance of the IGT and compare them according to BIC and other criteria. Here, we propose a general framework to include these eight models. Within the general framework, we investigate the scale invariance issue. A model is said to be scale invariant, if we change the units, there will be a different set of values of parameters results in the same prediction. A parameter in a scale invariant model is scale independent if change of units does not affect its value. For models which are not scale invariant, it may be not proper to compare them based on model-data discrepancy because discrepancy is a function of prediction which in turn, is a function of unit selected. We should also avoid directly comparing parameters from experiments with different units when the parameters are scale dependent. We found only models with trial-independent choice rule are scale invariant. Since some of eight models are not scale invariant, comparison based on BIC may be not proper. All parameters except sensitivity parameter in the models with trial-independent choice rule are scale independent. Comparison of sensitivity parameters across studies in different monetary currencies should be made with caution. We also provide a sufficient condition of scale invariance for IGT models.

(126)
Aug 04, 09:00–09:20
Lecture Hall C

On the Size Principle for Similarity. Daniel Navarro, Amy Perfors, *University of Adelaide*. In this paper we consider the notion of a 1size principle' for featural similarity, which states that rare features should be weighted more heavily than common features in people's beliefs about the similarity between two entities. Specifically, it predicts that if a feature is possessed by N objects, the expected weight scales according to a $1/N$ law. The size

principle emerges from a Bayesian analysis of simple induction problems (Tenenbaum & Griffiths 2001), and is closely related to work by Shepard (1987) proposing universal laws for inductive generalization. In this article, we (1) show that the size principle can be also be derived as an expression of a form of communicative or representational optimality, and (2) present analyses suggesting that across 11 different data sets in the domains of 'animals' and 'artifacts', human judgments are in agreement with this law. A number of implications of this law are discussed.

(127)
Aug 04, 09:20–09:40
Lecture Hall C

The Wisdom of Individuals or Crowds in Everyday Cognition: Is it Really That Simple? Ralf Mayrhofer, *University of Goettingen*. Griffiths and Tenenbaum (2006) reported that subjects' predictions about the duration of events (e.g., cake baking times) are nearly optimal and account for prior knowledge as presumed by Bayesian inference. In response to these findings, it has been argued (Mozer, Pashler, and Homaei, 2008) that this can simply be explained by a wisdom-of-crowds effect (i.e., a consequence of aggregating across individuals). On an individual level not optimal Bayesian inference, but only a simple memory-based heuristic, the Min-k heuristic, would be necessary to explain human performance. Using a mathematically equivalent statistics-textbook task, the estimation of the number of taxi cabs in town, we will show that peoples' judgments systematically depend on several aspects of the task that alter the likelihood function of the inference problem. This is not consistent with a memory-based heuristic, which is blind to these task characteristics.

(128)
Aug 04, 09:40–10:00
Lecture Hall C

Making the Locally Bayesian Model More Rational. Adam Sanborn, Ricardo Silva, *University College London*. Highlighting, a conditioning effect, is notoriously difficult for Bayesian models to predict. This effect can be predicted by the Locally Bayesian model (LBM), which approximates a full Bayesian model by partitioning the model into regions and passing messages between these regions. It is unclear how this local approximation compares to other approximations used in Bayesian models, and what behaviors this approximations will predict in other paradigms. Our contribution is to show the Locally Bayesian model is closely related to the statistical algorithms of Assumed Density Filtering, which simplifies calculations by assuming independence, and Belief Propagation, which identifies how to make these calculations through message passing. We propose a conditioning model based on Assumed Density Filtering itself (ADFM) and show how this model can produce highlighting behavior. In addition, we demonstrate how the degrees of approximation used in the LBM and ADFM cause the models to make very different predictions in a proposed experimental design.

(129)
Aug 04, 10:00–10:20
Lecture Hall C

Converting a Fuzzy Set Based Suicide Risk Assessment Model into a Bayesian Belief Network.

Olufunmilayo Obembe, Christopher Buckingham, *Aston University*. The loss of life that ensues from completed suicide attempts by mental health patients makes the need for reliable assessments of suicide risk, a crucial issue in mental health services. Using risk factors such as 'family history of suicide', 'current intention of committing suicide', 'depression' and 'serious mental illness', we investigate the development of Bayesian Networks from the knowledge representation of the Galatean Risk Screening Tool (GRiST) to model and assess suicide risk. GRiST (Buckingham, 2002) is a psychological model for risk assessment based on fuzzy sets. In this paper we discuss a reformulation of the fuzzy set based GRiST model into probability based Bayesian Networks for suicide risk assessments.

(130)
Aug 04, 10:20–10:40
Lecture Hall C

A Bayesian Approach to Aggregation in Rank-Order Tasks. Brent Miller, Pernille Hemmer, Mark Steyvers, Michael Lee, *University of California, Irvine*. When averaging the estimates across individuals, the aggregate can often come surprisingly close to the true answer, as demonstrated by Galton's famous Ox survey and game shows such as 'Who Wants to be a Millionaire'. We are interested in extending this wisdom of crowds phenomenon to more complex situations where a simple strategy of taking the modal or average response is inappropriate or might lead to bad predictions. We report the performance of individuals in a series of ranking tasks where the goal is to reconstruct from memory the order of time-based events or the magnitude of physical properties. We introduce a Bayesian version of a Thurstonian model that aggregates rank-orders across individuals. We apply MCMC techniques to estimate the distribution over all rank-orderings and take modal response in this space as the proposed answer. We compare this approach against heuristic aggregation techniques such as taking the empirical modal response and a variety of other methods inspired by social choice and voting theory. We show that the model performs as good as or better than all heuristics in reconstructing the true ordering. In addition, we show that the model is calibrated and gives confident responses about answers that turn out to be correct.

(131)
Aug 04, 11:00–11:20
Lecture Hall C

Informative Hypotheses for Repeated Measurements: A Bayesian Approach. Joris Mulder, *University of Utrecht*, Herbert Hoijtink, Irene Klugkist, Rens van de Schoot, Wim Meeus, Maarten Selfhout, *Utrecht University*. When analyzing repeated measurements data, researchers often have expectations about the relations between the measurement means. Such expectations can be formalized into so-called informative hypotheses with equality (=) and inequality (<,>) constraints between measurement means over time, measurement means between groups, means adjusted for time-invariant covariates, and means adjusted for time-varying covariates. These informative hypotheses may differ substantially from the standard null and alternative hypothesis,

e.g., the measurement means are constant in the beginning of the experiment but increase exponentially from a certain point in time, or the difference between the measurement means of group 1 and group 2 decrease over time. Subsequently, the goal is to select the best of a set of informative hypotheses based on the data. In this paper, we use the Bayes factor as selection criterion. A pivotal element in the Bayesian framework is the specification of the prior. To avoid subjective or ad hoc prior specification, training data in combination with restrictions on the measurement means are used to obtain so-called constrained posterior priors. It is shown that the resulting Bayes factors appropriately balance between fit and complexity of the informative hypotheses, and therefore, can effectively be used to select the best of a set of informative hypotheses. This is illustrated with a simulation study and an empirical example from developmental psychology.

(132)
Aug 04, 11:20–11:40
Lecture Hall C

Confidence Intervals Versus Probability Intervals in Adaptive Bayesian Estimation of Sensory Thresholds.
Miguel Angel García-Pérez, Rocío Alcalá-Quintana, *Complutense University of Madrid*. Detection or discrimination thresholds are widely used as summary measures of psychophysical performance, and they are often estimated with adaptive Bayesian procedures. Editorial policies demand that confidence intervals (CIs) accompany these measures, but the typical experiment obtains a single estimate per participant and condition and CIs for the mean cannot be obtained. Moreover, threshold represents a single point on a psychometric function which has additional parameters that are rarely estimated concurrently. Bayesian procedures must assume values for these additional parameters, and results presented elsewhere[1,2] show that Bayesian procedures can provide unbiased threshold estimates within a practically feasible number of trials despite the unknown parameters. Here we investigate the extent to which frequentist CIs and Bayesian probability intervals (PIs) faithfully indicate estimation accuracy. Sampling distributions of Bayesian estimates and Bayesian PIs were obtained by simulation under various sets of assumptions on the values of the unknown parameters of the psychometric function. Results show that CIs accurately keep their nominal coverage probability regardless of discrepancies between actual and assumed values for the additional parameters, and that the width of these CIs varies only with the number of trials. On the contrary, the probability coverage of Bayesian PIs is wildly unstable and only attains its nominal level when the assumed value of each additional parameter is within a narrow vicinity of its actual value. These results advise against the use of Bayesian PIs as measures of accuracy in adaptive Bayesian estimation of sensory thresholds.

[1] Alcalá-Quintana, R. and García-Pérez, M.A. (2004). The role of parametric assumptions in adaptive Bayesian estimation. Psychological Methods, 9, 250-271.

[2] García-Pérez, M.A. and Alcalá-Quintana, R. (2007). Bayesian adaptive estimation of arbitrary points on a psychometric function. British Journal of Mathemat-

ical and Statistical Psychology, 60, 147-174.

(133)
Aug 04, 11:40–12:00
Lecture Hall C

Adding Some Color to Data Analysis. Geoffrey Iverson, *University of California, Irvine*. An experimenter using the simple independent two-groups design has three hypotheses in mind: H_0: treatment has no effect, H_+: treatment has a positive effect and H_-: treatment has a negative effect. The prior probabilities of these hypotheses satisfy $P(H_0)+P(H_+)+P(H_-) = 1$ and accordingly the triple of prior probabilities provides chromaticity coordinates that define a color (e.g. $P(H_0) = P(H_+) = P(H_-) = \frac{1}{3}$ is the white point). Likewise, after the data are allowed to update the prior probabilities, the resulting posterior probabilities are identified with a different color. The "motion" in chromaticity coordinates from a prior color to a posterior color is determined by the model used to account for the data. The transition from prior to posterior probabilities is mediated by Bayes factors. We discuss how these arise from a study of the p-values associated with the standard t-tests of H_0 vs H_+ and H_0 vs. H_-.

(134)
Aug 04, 12:00–12:20
Lecture Hall C

Adaptive Design Optimization: A Mutual Information Based Approach to Model Discrimination. Daniel Cavagnaro, Jay Myung, Mark Pitt, *Ohio State University*, Janne Kujala, *University of Jyväskylä*. Discriminating among competing statistical models is a pressing issue for many experimentalists in the field of cognitive science. Resolving this issue begins with designing maximally informative experiments. To this end, the problem to be solved in adaptive design optimization is identifying experimental designs under which one can infer the underlying model in the fewest possible steps. When the models under consideration are nonlinear, this problem can be impossible to solve analytically without simplifying assumptions. However, a full solution can be found numerically with the help of a Bayesian computational trick derived from the statistics literature. We apply an information theoretic optimality criterion and show how this criterion connects intuitively with Bayesian inference. To demonstrate the approach, we offer a simple application to an experiment on memory retention.

(135)
Aug 04, 14:00–14:20
Lecture Hall C

The Derivation of Item Response Models from Sequential Sampling Models of Choice. Han van der Maas, *University of Amsterdam*. We discuss the work of Tuerlinckx en De Boeck (2005), who derived the popular two parameter logistic model (2PLM) for item responses from the diffusion model, a stochastic sequential sampling model for simple two choice decisions. Other derivations of IRT models are based on desirable statistical or measurement properties but have no bearing on the processes that generate the data. However, we contend that the derivation of Tuerlinckx en De Boeck is only valid when the 2PLM is used for items with two response options. We extend their work by presenting a formal extension of

the 2PLM and the diffusion model to allow for more than two choices (MC2PLM). The behavior of this simple multiple choice diffusion model is consistent with Hick's law. Another limitation of Tuerlinckx en De Boeck's derivation is that it does handle guessing by subjects for whom the item is too difficult. This frequently occurs in multiple choice high stake ability testing as in exams. We propose a new restricted 2PLM that handles guessing in IRT. This new model implies new interpretations of the standard parameters of IRT models.

(136)
Aug 04, 14:20–14:40
Lecture Hall C

On the Relation Between Different Stochastic Process Models for Two-Alternative Forced Choice Data. Gunter Maris, *Cito*. The general setup we consider here involves two people running against each other in a competition. The behaviour of the first person is described by a stochastic process that indicates the distance he has run after t time units. Similarly, the behaviour of the second person is described by a stochastic process as well. We assume that persons generally run forward, and hence our stochastic processes are non-decreasing with time. As with any competition the purpose is to name a winner. It is shown that different stochastic process models for two-alternative forced choice data can be derived by considering different ways to determine when the competition ends, and whoever has covered the largest distance at that moment is the winner. Formally, the competition ends when a criterion function reaches a set value for the first time. The types of models considered here relate to a competition that end when a) one runner has covered a set distance, b) one runner is a set distance ahead of the other one, and c) two runners running towards each other meet. The first and second of these are shown to correspond to race models and diffusion models, respectively. After having derived the different process models, their optimality is considered. It is found that each of the three types to organize a running competition is optimal, in a different sense however.

(137)
Aug 04, 14:40–15:00
Lecture Hall C

Adaptive Performance in Two-Alternative Decision Making. Patrick Simen, *Princeton University*, David Contreras, *University of Granada*, Philip Holmes, Jonathan Cohen, *Princeton University*. Bogacz et al. (2006) analyzed a reduced drift-diffusion model of two-alternative decision making to identify parameters (starting point and decision threshold) that maximize reward rate. Results of a motion discrimination experiment support quantitative optimal-performance predictions made by this model for tasks with fixed durations. Qualitatively, these are: 1) as average response-stimulus interval (RSI) decreases, speed-accuracy tradeoff (SAT) shifts toward speed; 2) as one response becomes more likely or more rewarded, an RSI-dependent bias toward that response develops; 3) for a given stimulus probability, fast-guessing exclusively in favor of the biased response should occur at short, but not long, RSIs. Constrained fits of Ratcliff's diffusion model (in which the

reduced model is nested) imply that performance was quantitatively optimal, while unconstrained fits imply a suboptimal accuracy emphasis. (Simulations suggest that non-uniform contaminant RTs may account for this discrepancy, suggesting general advantages to constrained fitting.) Simen et al. (2006) proposed a fast algorithm to learn these optimal parameterizations by accumulating reward feedback across trials with exponentially weighted moving averages. The distance between starting point and each threshold is a decreasing function of these averages, so that as reward rate increases, thresholds decrease. As predicted by this algorithm, RTs in the motion task were both autocorrelated and negatively correlated with estimated values of the moving average at the time of each response, and RT variance decreased as the reward average increased. Thus, optimal performance in some tasks appears both computationally feasible and empirically supported.

(138)
Aug 04, 15:00–15:20
Lecture Hall C

Cognitive Control and Reaction Time Distributions. Eddy Davelaar, *University of London*. The conflict-monitoring hypothesis of attentional control assumes that conflict is monitored during one trial and affects the attentional focus on the subsequent trial. Recently, this hypothesis has been challenged on the grounds of data showing that the sequential dependencies observed in studies using the Eriksen flanker task may be in part due to stimulus or response priming. I will present new data regarding response time distributions that falsifies some possible resolutions to the debate (and produces new questions). The critical analysis of the data involves the use of delta-plots, which are piece-wise linear functions of the interference effect against the response speed. RT delta-plots typically show a less-than-linear profile, which has been interpreted as reflecting the operations of a fast-acting, unconditional, automatic channel and a slow-acting, conditional, controlled channel. Both the dual-process model and the conflict-monitoring hypothesis are global models in the sense that the action of control is not directed to a specific stimulus or response. Through simulations, I will illustrate the predictions of these models and show how to extend them to capture the sequential dependencies observed in the experimental data. As the use of delta-plots in accessing cognitive control in clinical populations has increased over recent years, implications for research and potential reinterpretations of existing findings will be addressed.

(139)
Aug 04, 15:40–16:00
Lecture Hall C

Logical-Rule Models of Classification Response Times. Robert Nosofsky, *Indiana University*, Mario Fific, *Max Planck Institute*. We formalize and provide tests of a set of logical-rule models for predicting perceptual classification response times (RTs) and choice probabilities. The models are developed by synthesizing mental-architecture, random-walk, and decision-bound approaches. According to the models, people make independent decisions about the locations of stimuli along a set of component dimensions. Those in-

dependent decisions are then combined via logical rules to determine the overall categorization response. The time course of the independent decisions is modeled via random-walk processes operating along individual dimensions. Alternative mental architectures are used as mechanisms for combining the independent decisions to implement the logical rules. We derive fundamental qualitative contrasts for distinguishing among the predictions of the rule models and major alternative models of classification RT. We also use the models to predict detailed RT distribution data associated with individual stimuli in tasks of speeded perceptual classification.

(140)
Aug 04, 16:00–16:20
Lecture Hall C

Testing Response Time and Accuracy Predictions of a Large Class of Parallel Models within OR and AND Redundant Signals Paradigms. Ami Eidels, *University of Newcastle*, James Townsend, *Indiana University*. This study investigates visual detection of dot signals from two spatial locations within a class of stochastic process models that permits a unified treatment of both accuracy and response times. With respect to the accuracy measure, we point out potential mimicries between parallel and serial models, as well as between time-based and completion-based models. The tests of architecture (response times and accuracy), decisional stopping rule, and capacity (response times only) were strengthened by using both an OR (disjunctive) task as well as an AND (conjunctive) task. The results of four experiments supported parallel processing, generally with a decisional stopping rule appropriate to the OR vs. AND conditions. Capacity was generally quite limited but with flashes of super capacity in the AND case. Specific types of integration models (coactive, weighted integration) were falsified by both response time and accuracy data.

(141)
Aug 04, 16:20–16:40
Lecture Hall C

Direct Measurement of Cognitive Processing from Response Latencies. Fermin Moscoso del Prado, *CNRS*. Human response latencies are informative as to the amount of information that is elicited by a certain task or experimental condition. In a recent study has reported that, independently of the task or condition, the distribution of human response latencies in behavioral tasks has a common baseline level which corresponds to the responses that one would expect to occur merely by chance. This level is described power-law with fixed a scaling parameter value of exactly two (Moscoso del Prado, 2009a; 2009b). From this perspective, cognitive processing corresponds to a process of energy dissipation in the strict thermodynamical sense: Presentation of stimuli disturbs the cognitive system, increasing its complexity, and cognitive processing consist in returning to the critical state. In this study, we demonstrate that the amount of information processing involved in linguistic processing has a one-to-one correspondence with the amount of information conveyed by the linguistic stimuli. For this we compare the magnitude of the decrease of complexity in the distribution of eye fixation dura-

tions in reading, naming latencies and visual lexical decision reaction times to words with different properties. The increase in the (estimated) entropy of the distributions is, in each case, predicted by the linguistic informativity of the word measured in terms of entropy (cf., Milin, NAME, Moscoso del Prado, NAME, & Baayen, 2004). This findings opens the possibility of directly quantifying cognitive processing by plain observation of the distribution of responses, without actual reference to the stimuli or tasks.

Abstracts For Posters

(P1)
Aug 03, 18:00–19:30
Poster session

Strong Knowledge in Psychology and Artificial Intelligence. Carlos Pelta, *Complutense University of Madrid*. In this contribution it is introduced a formal system (Ks) expressing the notion of strong knowledge. An agent has strong knowledge of that expressed by the formula A if and only if all the possible worlds in which A is applicable for the agent, can be finitely determined by the same. We find applications in the Psychology of planning and in AI (simple movement automatons). For instance, in classical tasks of planning like (TOL), the participants manage only a small subset of possible states whilst solving those puzzles. They are situations of *closed* knowledge imposed by the restrictions of the proper task. They can be analysed using our formal system.

(P2)
Aug 03, 18:00–19:30
Poster session

AIC and BIC in Model Selection and Inference from Psychological Data. Caterina Primi, Silvia Galli, Francesca Chiesi, *University of Florence*. Despite the widespread use of the AIC and BIC in the model selection, they are still rarely used with psychology data. A recent paper (Wagenmakers, 2007) presented these methods as an alternative for inference that could replace the p-value procedure. Although, both methods are model selection methods that select the best model comparing different ones, some differences between them have been described (Burnham, Kass & Raftery, 1995). In this work, we presented different examples of model selection with psychological data (in the cases of Structural Equation Modeling and Item Response Theory) to make a comparison between AIC and BIC. The comparison was conducted also between AIC weights and the BIC weights (or 'Schwarz weights') transformations that measure the probability of each models. Merits and debts are presented for each methods. Burnham, K.P., & Anderson, D.R. (2002). Model selection and multimodel inference: A practical information-theoretic approach. New York: Springer-Verlag. Kass, R.E., & Raftery, A.E. (1995). Bayes factors. Journal of the American Statistical Association, 90, 773–795. Wagenmakers, E.J. (2007). A practical solution to the Pervasive Problems of p-value. Psychonomic Bulletin & Review, 14, 779–804.

(P3)
Aug 03, 18:00–19:30
Poster session

Investigation of Independent Variables within Gestalt Displays via Hazard Functions. Daniel Repperger,

Air Force Research Laboratory, James Townsend, *Indiana University*, Paul Havig, Katheryn Farris, *Air Force Research Laboratory*. Hazard functions can be employed in visual search tasks with multidimensional displays to characterize response time distributions and have a well defined theoretical development. Their advantages include being 'distribution free' and producing higher sensitivity in statistical testing as compared to a typical probability density function. A further advantage of this framework of analysis of experimental variables is in the optimization of performance for visual search tasks when dealing with displays that produce the situation called 'super capacity'. The term capacity is borrowed from reliability theory which is a dimensionless quantity representing efficiency. Gestalt Displays produce this requisite 'pop out' effect and when studied within the framework of hazard functions for visual search tasks and will generate super capacity. Certain signatures occur in the survivor functions of the experimental variables that do not appear when super capacity is not demonstrated. In this paper we analyze the Gestalt Display situation and the requisite signatures of the survivor functions of the independent variables of interest. Once the characteristics of this signature are identified, this allows more intelligent selection of the independent variables a priori that may be combined in the synthesis of a display that would induce higher capacity. Also, from the signatures of the experimental variables obtained, possible architectures of sensory processing are discussed for visual search tasks that may exhibit the super capacity efficiency measures.

(P4)

Aug 03, 18:00–19:30

Poster session

Modelling Positive and Negative Recency Effects with Dynamically Changing Bias. Giorgio Gronchi, *University of Florence*, Marco Raglianti, *Universita di Pisa*. In this work we employed the dynamically changing bias process proposed by Nickerson (2002) to formalize the negative and positive recency effects. Nickerson's model is aimed at formalizing the negative recency effect (gambler's fallacy). Given a sequence of binary events (X and O), the probability of the events are determined by the previous outcomes of the preceding tosses. Specifically, letting $p_k(E)$ represents the probability of the outcome E on the kth toss, we have $p_k(E) = ap_{k-1}(E)$ with $0 < a < 1$. In this study, positive recency was formalized modifying this model in order to make the probability of observing an X (or O) higher if an X (or O) was already observed, $p_k(X) = 1 - bp_{k-1}(O)$ with $0 < b < 1$. Participants were asked to predict the next element of twelve 8-elements binary sequences in two different scenarios (Gronchi & Sloman, 2008). One scenario was associated with negative recency and the other with positive recency. Four sequences were employed in order to estimate the parameters of the models and we tested the predictions on the others. We obtained good results in terms of predictions with a mean error of about 6%. Results suggest how this kind of model can be used in formalizing recency effects where previous works had often employed models that take into account only the last

outcome.

(P5)
Aug 03, 18:00–19:30
Poster session

Improvement of Fisher Information Approximation to Normalized Maximum Likelihood (NML). Hao Wu, *Ohio State University*. The normalized maximum likelihood (NML) is a well-studied model selection criterion. As an implementation of the minimum description length principle, it minimizes the maximum expected redundancy in code-length of a predictive distribution. The numerical evaluation of NML involves an integral of maximum likelihood (ML) over all possible data of a given sample size. Because of the dimension of the integration and the lack of analytical form of the ML for most models, it is hard to compute. Instead, a large sample approximation involving Fisher information matrix is usually employed. Studies have shown that this method, though successful for large samples, may not give desired accuracy when sample size is small or moderate. In this work, I present my work to improve the approximation by considering the effect of boundary of the parameter space. Some examples with multinomial processing tree (MPT) models will be given. These examples show that the method is effective in improving the accuracy of approximation in small samples.

(P6)
Aug 03, 18:00–19:30
Poster session

Preschoolers' Performance on a Causal Reasoning Task: The Development of Response Strategies. Tessa van Schijndel , Kim Huijpen , Maartje Raijmakers, *University of Amsterdam*. How do young children respond to cause-effect problems? Several studies showed that preschoolers are capable of causal reasoning (e.g. Gopnik, Sobel, Schulz & Glymour, 2001). This conclusion is generally based on the behavior of the majority of children within an age group. However, children show considerable variance in their responses to cause-effect problems (e.g. Gopnik et al., 2001). This variance can arise from a) children using different strategies, b) children making errors in applying a strategy. In the present study, we investigated individual differences in 2- to 5-year-olds' performance on a causal reasoning task. For this purpose we used a statistical technique, Latent Class Analysis, which enables describing children's performance with models that account for both sources of variance: different strategies as well as errors. 78 Preschoolers participated in 4 successive items of the blicket detector task (Gopnik & Sobel, 2000). The items were selected from the literature so that the response patterns distinguished optimally between the expected strategies. By means of Latent Class Analysis we distinguished three strategies: causal reasoning, associative reasoning (Sobel, Tenenbaum & Gopnik, 2004) and a third strategy possibly resulting from the design of the task: imitation of the test leader. As the majority of 2-year-olds used the associative strategy, while the majority of 3-, 4- and 5-year-olds used the causal strategy, it can be concluded that strategy use is age related. These findings show the importance of paying attention to individual differences when investigating

children's causal reasoning skills.

(P7)

Aug 03, 18:00–19:30

Poster session

Absolute Identification: Testing A Truism. Pennie Dodds, Chris Donkin, Scott Brown, Andrew Heathcote, *University of Newcastle*. In a typical absolute identification task, the participant is first presented with a series of unidimensional stimuli, where each is given a unique label. Usually this is a number from 1 to n. In the test phase, one stimulus is presented at a time and the participant is asked to try and remember the label that was previously associated with it. Despite its seeming simplicity, AI presents some complex issues. For example, it was assumed for over 50 years that people cannot improve their performance in these tasks, even when given significant practice. Miller's (1956) famous review described this phenomenon, showing that even when given a small number of stimuli to learn, participants still failed to improve their performance beyond 72 items. This fundamental limit on human information processing capacity has been widely accepted by the field. In a series of experiments, however, we have shown that people are not only capable of improving their performance, but they are able to do so considerably with only moderate practice. Through a series of follow-up experiments, we also investigated whether this learning effect is apparent for different stimuli, and how this process might be occurring. We showed that stimulus modality, and to some extent, set size, affect the rate of learning.

(P8)

Aug 03, 18:00–19:30

Poster session

No Rules, No exceptions: A Proposal of an Adaptive Mixture of Experts Algorithm. Shin-ichi Asakawa, *Tokyo Woman's Christian University*. All rules have, more or less, exceptions. If we can automatically extract general rules from a majority of examples, and if we find a few exceptions from special cases, then we would obtain a general inferential tool to deal with complex phenomena. Here, we propose an adaptive algorithm for dealing with such situations. When the world can be divided into several sub-spaces to which we can apply general rules, and when there are some singular points to where we must apply exceptional rules, we would employ a divide-and-conquer strategy. Jordan and Jacobs (1994) proposed such kind of algorithm, a mixture of experts. In their model, the problem space was divided into subspaces, and local experts were applied to deal with such sub-problems to acquire the total solutions. We could extend their algorithm to deal with more specific cases. The algorithm begins with a minimal network, then automatically trains and adds new exceptions to deal with exceptions. If it is able to find the exceptions, then we can deal with these exceptions as small value of dispersion parameter. This parameter approximates to Dirac's delta function as the limitation to zero. We propose a gradient descent algorithm to learn this situation. we applied this algorithm to pronouncing English words, where there are general grapheme-to-phoneme corresponding rules to pronounce regular words, and there also are special rules to pronounce exception words. The proposed algorithm can be regarded as one

of neural network implementations to the Dual Route Cascaded model proposed by Coltheart et al.(2001).

(P9)
Aug 03, 18:00–19:30
Poster session

Frequency Analysis Method for General Brain Behavior Prediction by Electrical Modeling of Stimulus and Nervous-System. Koralur Muniyappa Mahendra Gowda, *Airvana Networks India Pvt Ltd*. The motive behind the work is that individual differences have less significance in many practically important scenarios. Most individuals respond in similar manner to same stimulus if internal and external conditions are kept same.

Method and Model: Frequency analysis method treats stimulus as generator of electrical signal comprising of various complex frequencies (called as stimulus spectrum) having different amplitude and phase for each frequency; entire Nervous Subsystem (Ex: visual system) as frequency filter (called as Nervous Subsystem Filter NSF) which manipulates the amplitude and phase of stimulus spectrum. We have modeled NSF as Second order filter by explaining its suitability, since it is best fit model to mimic Nervous Subsystem. Now multiply the stimulus spectrum by the frequency response of NSF to obtain Nervous Subsystem Response (NSR) which is nothing but the brain behavior that may be applied to target organs or environment in general.

(P10)
Aug 03, 18:00–19:30
Poster session

An Analytical and Mechanical Statistical approach to Perception & Psychophysics. Stefano Noventa, Giulio Vidotto, *University of Padua*. People expectations and believes are generally based on subjective models of the world. This is especially true in naive physics where, almost everyone, possesses a model of a falling weight, of the motion of a pendulum or of two crashing objects. The mathematical tools of Analytical Mechanics allow to describe exactly, by means of Lagrangian or Hamiltonian equations, the behavior of a physical system. Statistical Mechanics, instead, combines Probability Theory and Analytical Mechanics, allowing to describe complex systems in terms of thermodynamic properties like entropy and energy. An application of those two frameworks to the fields of Perception and Psychophysics is suggested, analyzing the possibility of building, at least locally, Lagrangian and Hamiltonian equations that models the representation of a phenomenon. Hence, psychophysical law becomes the solution of an Eulero-Lagrange's equation and the Hamiltonian can be used to build the statistical mechanics of the system: i.e free energy and entropy.

(P11)
Aug 03, 18:00–19:30
Poster session

Contrasting Computational Models of Preference Reversal in Multi-Attribute Choice. Konstantinos Tsetsos, *University College London*, Marius Usher, *Tel-Aviv University*, Nick Chater, *University College London*. A central puzzle for theories of choice is that people's preferences between options can be reversed by the presence

of 'decoy' options that are not chosen. Three types of decoy effects reported in the literature, the attraction, compromise and similarity effects have been explained by a number of theories. Yet a major theoretical challenge is to capture all three effects simultaneously. We review the number of mechanisms that have been proposed to account for decoy effects and analyze in detail two dynamic- neurocomputational models, Decision Field Theory (Roe, Busemeyer & Townsend, 2001) and Leaky Competing Accumulators (Usher & McClelland, 2004), that aim to combine several such mechanisms into an integrated account. Simulations show that, while DFT can capture all three decoy effects simultaneously, it does so for a limited set of parameters. We argue that the LCA framework provides a more robust account and suggests also that common mechanisms may be involved in both high-level decision making and perceptual choice, for which LCA was originally developed.

(P12)
Aug 03, 18:00–19:30
Poster session

A Poisson Race Model Analysis of the Implicit Association Test. Michelangelo Vianello, Luca Stefanutti, Pasquale Anselmi, Egidio Robusto, *University of Padua*. The Implicit Association Test (IAT) is a computerized two-choice discrimination task in which stimuli have to be categorized as belonging to target concepts (e.g., 'flowers' and 'insects') or attribute concepts (e.g. 'positive' and 'negative') by pressing, as quickly and accurately as possible, one of two response keys. In test blocks, target and attribute concepts are mapped onto the same response keys in different combinations. A Poisson race model analysis of the IAT is presented. Four parallel and independent Poisson processes, each of which concerns a specific concept, have been considered. Each response is associated with two processes. Information related to specific characteristics of the stimulus that has been displayed accumulates on the counter of each process. Model parameters are the rates of incoming information to the counters, and the thresholds of the counters. The process that reaches its threshold first wins and determines the response. Both latency and accuracy of the responses are taken into account. Latencies are determined by the time at which a process wins. The accuracy depends on the winning process, the category of the displayed stimulus, and the test block. The model parameters separate automatic and controlled processes involved in the IAT effect. Results of an empirical application are presented and discussed. Comparisons with other models for the analysis of the IAT are presented as well.

(P13)
Aug 03, 18:00–19:30
Poster session

Judgements of Relative Order: Bridging Findings from Subspan to Suprapan Lists. Yang Liu, Michelle Chan, Jeremy Caplan, *University of Alberta*. Judging the relative order of materials is a core function of human memory. In short, subspan consonant lists with immediate judgments of relative recency (JOR), instruction wording ("which item was presented earlier?" versus "which item was presented later?") could flip around memory search direction (Chan et al., SMP 2008).

We wondered whether instruction wording could have an analogous influence on the JOR judgement in supraspan lists. However, supraspan lists typically show a very different behavioural pattern - distance effects (e.g., Yntema & Trask, 1963). Our participants performed JOR judgements on "short" (LL=8) supraspan noun lists. We evaluate whether it is possible to reconcile the subspan and supraspan data by assuming that the judgement in both sub- and supra-span regimes are influenced by the same factors, positional discriminability and attentional bias across serial positions, and that speed-accuracy tradeoffs combined with ceiling in subspan lists account for the observed qualitative differences in behaviour.

(P14)
Aug 03, 18:00–19:30
Poster session

Influence of Single-Item Properties on Cued Recall in Distributed Memory Models. Christopher Madan, Jeremy Caplan, *University of Alberta*. Madan, Glaholt, & Caplan (in prep) demonstrated that properties of items (word frequency and imageability) can modulate cued recall performance by acting purely on the effectiveness of the probe item or the retrievability of the target item (item-level effects) or by affecting learning and access to the association based on the composition of the pair (relational effects). Evidence for these alternative mechanisms was based on the pattern of memory accuracy in a paired-associates procedure with the following design, based on manipulating an item property between HIGH and LOW levels for constituent pairs. Each studied pair could be pure (HIGH-HIGH or LOW-LOW) or mixed (HIGH-LOW or LOW-HIGH) and was tested either in the forward ($A \leftarrow$) or backward ($\rightarrow B$) direction. With a simple probabilistic model we could disentangle item-property enhancement of item-level versus relation-dependent memory processes. Here we characterize the range of possible loci of item-property influence within distributed memory models in terms of whether they will produce probe-dependent, target-dependent, and relation-dependent effects, respectively. This represents an interpretational framework for a range of effects that have already been reported as well as predicting as-yet unobserved patterns.

(P15)
Aug 03, 18:00–19:30
Poster session

Why Don't Psychology Students Like Statistics? Carlo Chiorri, *University of Genoa*, Silvia Galli, Francesca Chiesi, *University of Florence*, Sara Piattino, *University of Genoa*, Caterina Primi, *University of Florence*. Psychology students experience difficulties when dealing with introductory statistics and data analysis courses. They usually report negative attitudes, worry and anxiety toward the subject, this having a negative effect on achievement and eventually leading to early drop-out. This research investigated the association of achievement in Psychometrics courses with a number of potential predictors. In Study 1, a measure of statistics anxiety, the Statistical Anxiety Rating Scale, and a self-report measure of cognitive style, the Object-Spatial-Verbal Imagery Questionnaire, were administered

to 268 first-year psychology students. Results showed that participants reported a high anxiety toward the exam (with females being more anxious than males) and a cognitive style characterized by an holistic encoding and processing of information, as a single perceptual unit. Lower anxiety scores and analytic (part-by-part) processing of information were associated with higher achievement scores. In Study 2, a measure of math ability (Prerequisiti di Matematica per la Psicometria) and a measure of math self-efficacy, the Mathematics Problems Scale-Revised, together with measures of attitude, learning style and anxiety, were administered to 313 first-year students. Higher math ability and higher math self-efficacy were found to be related to higher achievement scores; both ability and self-efficacy were related with attitude and learning style, but self-efficacy was also negatively associated with anxiety. Results suggest that statistics teaching methods in psychology courses should take into account that the prevailing cognitive style of students may be inconsistent with that required by statistics, and that math self-efficacy also plays a fundamental role, independent of math ability.

(P16)
Aug 03, 18:00–19:30
Poster session

Modeling Choice-Similarity Effects in Episodic Recognition. Beatrice Bora, Emily Freeman, Andrew Heathcote, *University of Newcastle*. We used a quantitative model based approach to investigate the processes underlying recognition memory for faces in paradigms developed by Tulving (1981; the choice-similarity paradigm) and Tulving (1985; the remember-know paradigm). To do so, we extended two existing explanations of the confidence-accuracy inversion that is produced by a manipulation of choice-similarity. First, we enabled Clark's (1997) quantitative single-process model to address remember-know data by adding a variable recollection criterion. Second, we implemented aspects of Dobbins, Kroll and Liu's (1998) verbally specified dual-process explanation by incorporating quantitative assumptions from two other dual-process models (Yonelinas, 1994; Wixted, 2007). Both models provided an accurate account of all aspects of accuracy and confidence for both remember and know judgements, both for an experiment using faces reported here, and for data from Dobbins et al.'s experiment using natural scene stimuli. The single process model provided the most parsimonious account in both cases.

(P17)
Aug 03, 18:00–19:30
Poster session

Concept Associations: A Complex Networks' Perspective. Arun Rajkumar, Suresh Venkatasubramaniyan, Veni Madhavan Conjeevaram Ekambaram, *Indian Institute of Science*. We study the properties of concept associations from a complex networks perspective. We compute various network properties of human-concept associations (generated from standard databases) and are able to arrive at rational explanations for their distributions. First we observe that concepts with high degrees are the same irrespective of the database considered. Top degree nodes are always

associated with entities that are salient for life (food, money, love etc.). More importantly, concept associations are significantly disassortative with respect to fundamental network parameters like degree, betweenness and page-rank. This is also observed as low clustering-coefficients not mixing. These imply that salient concepts do not have direct interactions. This is a property observed in Protein-Interaction-Networks (PIN) and is understood in the context of the cell's robustness to cascading failures. We conjecture that disassortativity endows concept associations with similar indispensable benefits: clarity of thoughts and ability to dwell on one concept without getting lost. Extending this, we hypothesize that psychological conditions like thought-disorders and fetishes result from assortative mixing of concept associations. Understanding the dynamics of PIN through its network properties has given raise to models for its evolution and methods for predicting missing interactions. Likewise there is scope for building models for concept associations utilizing its similarities with PIN topology for better understanding for evolution of concepts and languages in general. In addition, Concept Association Networks (CANs) can serve as mathematical tools to model the human working memory (WM) and thereby explain empirical evidence obtained from various psychology experiments.

(P18)
Aug 03, 18:00–19:30
Poster session

Identification and Categorization of Faces in Congenital Prosopagnosia: Curse and Blessing of Dimensionality.

Rainer Stollhoff, Juergen Jost, *Max Planck Institute*. Congenital prosopagnosia (CP) refers to a lifelong deficit in the identification of faces that is present from birth. Although the deficit in identification can be severe, categorization of faces e.g. gender is mostly spared. CP can thus serve as a prime example and benchmark for models of task dependent differences in cortical processing of visual information. Whereas most models of Perceptual Categorization theory share the assumption of a multidimensional object space, differences abound w.r.t. the representation of object categories, e.g. decision-boundaries or exemplar-based. We propose to focus on properties of the object space itself and introduce an abstract framework to analyse requirements on the dimension of the object space posed by categorization and identification. For any given assignment of objects to categories the dimensions of the object space can and should be selected to include only properties in which the categories differ. This category-specific reduction of the dimensionality is necessary for estimation and generalization ("curse of dimensionality"). The focus of identification is the separation of an individual from its population. As most individuals will be typical samples of the population, there are no universal identity-specific properties. However, we show that a high dimensionality can be sufficient to achieve separation of individuals from the population: A "blessing of dimensionality". Based on this abstract formulation of differences between categorization and identification we motivate a novel viewpoint on "holistic" processing in face recognition and derive a computational model relating the deficits in CP to

sparse network connectivity.

(P19)
Aug 03, 18:00–19:30
Poster session

Adaptive Design Optimization for Developmental Psychology Experiments. Yun Tang, Daniel Cavagnaro, Jay Myung, *Ohio State University*. We explore a Bayesian approach for adaptively optimizing experimental designs to discriminate mathematical models in psychology. Specifically, we apply Adaptive Design Optimization (ADO) on a numerical estimation problem in the field of developmental psychology. Several researchers (e.g. Dehaene et al., 1998, Siegler & Opfer, 2003) claim that the abstract representation of numbers takes a logarithmic form, whereas other claim that the numerical estimation becomes linear as children grow up, or as a result of learning (Opfer & Siegler, 2007). This leads to the problem of discriminating between the two models. Typical experiments designed to elicit such numerical representations use a Number-to-Position Task, in which children are shown a number between 0-1000 and are asked to estimate its position on a line. Hence, choosing appropriate numbers to show (i.e. designs) in order to quickly and reliably discriminate linear and log models could be seen as a design optimization problem. In the current study, we approach the aforementioned problem through simulated experiments. The simulations show that using ADO to find the optimal set of numbers to show in each trial, the experimenter could correctly locate the data-generating model and recover the parameter estimates in the fewest trials possible. Results from sensitivity analysis indicate that the performance of ADO is consistent under different priors.

(P20)
Aug 03, 18:00–19:30
Poster session

An Experimental Investigation of the Role of Best and Worst Elements in Choice under Complete Uncertainty. Amélie Vrijdags, *University of Ghent*. A decision under complete uncertainty' or 'ignorance' is one where the decision maker knows the set of possible outcomes for each decision, but cannot assign probabilities to those outcomes. This way, the problem of ranking decisions is reduced to a problem of ranking sets of outcomes. Most rankings that have emerged in the literature in this domain are based on best and worst outcomes. They depart from a theorem which asserts that every set A is indifferent to the set consisting of the best and the worst element in A. This theorem can be deduced from various combinations of plausible and appealing behavioral axioms. In the current study, we aimed to verify the descriptive validity of the theorem by testing its characterizing axioms in a pairwise comparison experiment. We also tested two axioms characterizing the Uniform Expected Utility (UEU) criterion (Gravel, Marchant, & Sen, 2007), a model according to which decisions are ranked on the basis of the expected utility of their outcomes, under the assumption that the decision maker assigns to every outcome of a decision an equal probability of occurrence. A substantial number of violations was observed for three axioms, which are essential for the above mentioned theorem to hold. Neither of both axioms characterizing UEU could be convincingly

refuted. The results suggest that in a situation of complete uncertainty, a decision maker does not merely look at the best and the worst outcomes of each decision. As a consequence, the central role of best and worst outcomes in designing set-based rankings seems unjustified.

Gravel, N., Marchant, T., & Sen, A. (2007, July). Ranking completely uncertain decisions by the uniform expected utility criterion (IDEP Working Papers No. 0705). Institut d'economie publique (IDEP), Marseille, France. Available from http://ideas.repec.org/p/iep/wpidep/0705.html

(P21)

Aug 03, 18:00–19:30

Poster session

Integrating Episodic and Semantic Information in Memory for Natural Scenes. Pernille Hemmer, Mark Steyvers, *University of California, Irvine*. Recall of objects in natural scenes can be influenced not only by episodic but also by semantic memory. To model the statistical regularities that might be encoded in semantic memory, we applied a topic model to a large database of labeled images. We then incorporated the learned topics in a dual-route topic model for recall that explains how and why episodic memories are combined with semantic memories. The dual-route model was applied to an empirical study in which people recall objects from scenes under varying amounts of study time. The dual route model explains how the trade-off between episodic and semantic memory is affected by study time, output position, and also congruity of the object with the scene context.

(P22)

Aug 03, 18:00–19:30

Poster session

The Neural Representation of Context and its Role in Free Recall. Jeremy Manning, *University of Pennsylvania*, Sean Polyn, *Vanderbilt University*, Michael Kahana, *University of Pennsylvania*. Models of the encoding and recall of episodic (i.e., contextually-mediated) memories often posit the existence of a cognitive representation of the context in which events are experienced. Polyn & Kahana (2008) suggest that context can be thought of as a neural representation which integrates incoming information with a long time scale, such that context uniquely defines the spatiotemporal surroundings of each event. Manns et al. (2007) found a pattern of results consistent with the predictions of context-based models, where changes in patterns of neural activity in the rodent hippocampus predicted behavior in a temporal judgment task on a series of odor presentations. Here we take an analogous approach by recording intracranially from human neurosurgical patients who perform a variant of an episodic memory task, free recall, in which participants are asked to study lists of words and later recall them in any order they wish. We probe the neural recordings for patterns consistent with a representation of context. By using context-based models (e.g. Howard & Kahana, 2002) to interpret changes in the context representation, we will be able to gain a deeper understanding of the neural mechanisms underlying the encoding and recall of episodic memories.

(P23)

Aug 03, 18:00–19:30

Poster session

Modeling Frequency and Context Effects in Statistical Word Learning. George Kachergis, Chen Yu, Richard Shiffrin, *Indiana University*. Previous work has shown that humans often learn an impressive number of word-referent pairings solely from their co-occurrences across short sequences of individually ambiguous trials. The difficulty of learning a given stimulus pairing is a function of, among other factors, the frequency of that pairing during training and the number of times that pairing appeared with (and could thus be confused with) particular other pairings (i.e., contextual diversity). Our recent empirical work, which varied stimulus frequency and contextual diversity, found main effects of both factors, as well as interesting interactions. For example, high frequency pairings that co-occurred often with low frequency pairings increased learning of the low frequency pairs. To account for these results, several associative learning and decision-making mechanisms are compared in a number of simple computational models.

(P24)

Aug 03, 18:00–19:30

Poster session

The Role of Information Ecology in Judgment: A Computational Account of Expertise Bias. Gregory Cox, *University of Maryland / Indiana University*, Michael Dougherty, *University of Maryland*. Experts in many specialized domains are known to make judgments that are biased toward coming from their area of expertise. We investigate this 'expertise bias' within the HyGene model [Thomas, R.P., Dougherty, M.R., Sprenger, A.M., & Harbison, J.I. (2008) Diagnostic hypothesis generation and human judgment. Psychological Review, 115 (1), 155-185.], taking medical diagnostic data from Hashem, Chi & Friedman [2003. Medical errors as a result of specialization. Journal of Biomedical Informatics, 36, 61-69] as a concrete example. We model diagnoses of partially-representative symptom sets when the diagnostician must diagnose from a set of diseases comprised of multiple clusters-the "information ecology". Diagnosticians may specialize in one cluster or be "generalists". Expertise bias is modeled within HyGene by different amounts of experience of each cluster and the interaction of this experience with retrieval dynamics and hypothesis-guided information search. HyGene is able to reproduce the patterns of bias reported in Hashem, et al. (2003). The standard HyGene model's predictions are contrasted with those of both a simple application of Bayes' theorem and an "ideal observer" version of HyGene. While the predictions of the standard and "ideal" versions of HyGene contrast primarily quantitatively (the ideal version has better performance in all cases), both HyGene versions contrast qualitatively with Bayes' theorem, which is over-sensitive to differences in the amount of experience of each cluster (equivalent to prior probability). HyGene provides an account of expertise bias purely in terms of memory processes and contents. The present work suggests further avenues of research to determine the effects of different amounts and types of training, different information search strategies, and more complex information ecologies.

(P25)
Aug 03, 18:00–19:30
Poster session

Algebraic Models for Measuring Knowledge Creation in Organizational Contexts. Kian Abolfazlian, *Kian Abolfazlian Inc*. We develop an Algebraic model for conversion of sets of organizational mediators (such as Implicit/Explicit Rules, Beliefs, Roles, Instruments) as well as processes to Measurable Spaces. This will be used to quantify the organizational context in the form of an inner-product metric space. Using a pseudo-norm (reminiscent of Minkowski norm), we define an organizational space, which readily can be used to measure organizational processes, such as Team-synergies and Knowledge Creation. The model can be normalized in order to make it possible to compare both intra and inter organizational settings. The work can be used to bridge the Qualitative research models and their findings within psychology and the organizational sciences to Quantitative models.

(P26)
Aug 03, 18:00–19:30
Poster session

A Neurocomputational Model of Response Inhibition in the Frontal Cortex and Basal Ganglia. Thomas Wiecki, Michael Frank, *Brown University*. Inhibitory control is a key element in executive functioning which can be measured by tasks like the antisaccade task (AST) and the stop signal task (SST). Converging evidence implicates frontal-basal ganglia circuits as key players in response inhibition and cognitive control. Abstract, theoretical models of these tasks currently do not take the underlying neuronal mechanisms into account and are limited in their ability to account for a broader range of behaviors in different scenarios. To address these issues, we extended the mechanistic model of the basal ganglia (BG) by Frank (2006) to provide an account of the AST and SST. At the system level, the model comprises of an input layer that projects to two routes that modulate the selection of motor commands in the presupplementary motor area (preSMA): a prepotent BG-based mechanism selecting habitualized actions which learns via dopaminergic reinforcement mechanisms, and a prefrontal-based mechanism modulating the preSMA according the task rules. A cricital part in this interplay between these two routes are the subthalamic nucleus (STN) and right inferior frontal gyrus (rIFG), areas involved in response inhibition as shown by various studies. Our model captures many of the behaviors observed in studies of inhibitory control. Graded rIFG or STN lesions produce deficits in inhibitory control in the SST. The network also exhibits sequential effects, responding slower in trials following a stop signal trial (modeled by a working-memory-like hysteresis current in the rIFG) or following errors to inhibit (modeled by increased 'conflict'-related activity in the preSMA).

(P27)
Aug 03, 18:00–19:30
Poster session

Mutual Constraint in Learning of Word Reference and Word Order. Luke Maurits, Amy Perfors , Daniel

Navarro, *University of Adelaide*. We use computational models based on Bayesian inference to explore two related sub-problems in language acquisition. The first sub-problem is cross-situational word learning. Learning mappings from words to objects or actions is unintuitively difficult. Much of the difficulty arises from the ambiguity – for example, in many situations, perceived words may each refer to any one of a potentially large number of salient objects, or any component or property of those objects. Previous research has used computational modelling to demonstrate strategies by which infants may effectively overcome these ambiguities, such as by learning and exploiting social cues such as pointing, gazing and prosody. The second sub-problem is word order learning. Many languages possess a fixed word order for certain kinds of sentences, e.g. the English active voice uses a "ubject Verb Object" word order. Experimental evidence suggests that children are able to interpret the importance of word meaning from a very early age, which raises the question of how they learn it. We investigate the extent to which these two problems are easier to solve if they are considered as one joint acquisition problem rather than two separate ones - partial knowledge about one problem may provide some knowledge about the other, and vice versa, so that semantic and syntactic learning mutually constrain one another to facilitate quicker learning. Our models are designed to allow an easy extension toward incorporating extra-linguistic, relational knowledge about the physical world into the language acquisition process, providing further constraint.

(P28)

Aug 03, 18:00–19:30

Poster session

A Latent Semantic Analysis of "Reversible" Chinese Words. Yuhtsuen Tzeng, *National Chung Cheng University*, Minglei Chen, *National Central University*. Latent semantic analysis (LSA) has become a new approach of meaning representation by applying Singular Value Decomposition (SVD) to extract underlying semantic relations among words that occur in related contexts regardless their order. It has been successful in accounting many psycholinguistic phenomena across several "Indo-European" languages yet remains to be tested in more distant languages such as Chinese. Most Chinese words have two-character and one of particular types can be termed as 'reversible' in which the physical order of its constituent characters is inter-changeable and remains meaningful legal words. For example, 'lien dai' means 'necktie' but its reversible counterpart 'dai lien' means 'to lead'. We explore whether Chinese LSA systems can compute the semantic relations between 'reversible word' and its constituent characters. Two semantic spaces were created within a Chinese LSA system: character-base and word-base spaces respectively. A comprehensive list of 750 reversible Chinese word pairs were extracted from a large corpus and semantic relations (cosine values) between two constituent characters and their corresponding reversible word pair were computed for both character and word-base semantic space respectively. Patterns of cosine values between constituent characters and each of reversible word pair were identical

for character base LSA, indicating been unable to distinguish the possible meaning differences between each reversible word pair due to the ignorance of character order. In contrast, such semantic relations are distinguishable for word base LSA. It appears that, with the proper unit of analysis, the power of SVD is applicable to Chinese language.

(P29)

Aug 03, 18:00–19:30

Poster session

Cognitive Modeling Repository. Jay Myung, Mark Pitt, *Ohio State University*. Quantitative modeling has contributed substantially to the advancement of the cognitive sciences. Papers introducing and testing cognitive models regularly appear in the top journals. For instance, during the 2006-2007 period, Psychological Review published a total of 70 regular articles, of which 45 were cognitive modeling papers (64.5%). The growth and success of cognitive modeling demonstrate why modeling itself should be a primary quantitative method in the researcher's toolbox. Yet this method of scientific investigation remains under-utilized by the research community at large because of the hassles in obtaining data sets to model and the difficulties in implementing models. The goal of this project is to assist scientists in their cognitive modeling efforts by creating an online repository containing data sets that can be modeled and the cognitive models themselves. The current state of the project and future plans will be presented. Funded by Air Force Office of Scientific Research.

(P30)

Aug 03, 18:00–19:30

Poster session

Modeling the IAT. Pablo Gomez, Christine Reyna, Christopher Cox, *DePaul University*. In this presentation we discuss recent progress on modeling the IAT (Implicit Association / Attitude Task) with an accumulator/diffusion model. The IAT is an ubiquitous task in Social Psychology. Based on IAT results, researchers often make claims about participants' implicit attitudes towards a particular concept (arts vs. sciences) or group of people (European vs African descent). The IAT scores are computed by comparing latency data from a series of two-choice tasks, which is the type of tasks that diffusion models have been very successful in accounting for the last 20 years. Here, we present data from IAT experiments in which we manipulated some of the well known variables in the diffusion modeling literature (speed/accuracy instructions, payoffs, discriminability, go/no-go vs 2-choice). This manipulations were performed to better constrain the model in order to obtain more reliable parameter estimates. Our findings indicate that IAT results emerge from many different decisional mechanisms, and that the fits of the diffusion model allow us to identify groups of subjects that produce IAT effects for very different reasons.

(P31)

Aug 03, 18:00–19:30

Poster session

Comparing Saccade Sequences. Sebastiaan Mathot, *Free University of Amsterdam*, Filipe Cristino, Iain Gilchrist, *University of Bristol*, Jan Theeuwes, *Free University of Amster-*

dam. Performing a quantitative comparison of two saccade sequences poses a considerable challenge for eye movement researchers. Not only are there many dimensions which should be taken into account, there is also no clear definition of what constitutes similarity. E.g., in some situations two saccade sequences may be considered similar if the same stimuli are fixated, regardless of fixation order. In contrast, a different situation may dictate a measure of similarity in which fixation order is crucial. The aim of the current project is to develop an algorithm which provides a measure of the similarity between two saccade sequences. The algorithm is generic and may therefore be readily applied to a wide range of research problems. However, there is enough flexibility to allow for users to define a task-specific measure of similarity. In the algorithm, each fixation is identified by an arbitrary number of values. Commonly, location (x, y) and time are among these values, but more exotic measures (say, the distance to the initial fixation point) may be included as needed. Conceptually, a saccade sequence is therefore represented by a set of points in a multidimensional space. Points in one sequence are mapped onto points in the other sequence. This mapping is such that the sum of the distance between all mapped points (which is also used as the measure of similarity) is minimal. By applying the algorithm to experimental data, we show that the algorithm provides a sensible measure of the similarity between two saccade sequences.

(P32)
Aug 03, 18:00–19:30

Poster session

On Null Categories in Constructed Response Scoring: A View from a Latent Class Signal Detection Model.
Yoon Soo Park, Lawrence DeCarlo, *Columbia University*. This study examines the effects of null categories in constructed response (CR) scoring and offers strategies to overcome problems that they raise. A null category occurs when a rater does not use a response category given in the scoring rubric (Wilson & Masters, 1993). Null categories occur quite often in large scale assessments, yet to date there has been very little research on this topic. Furthermore, most IRT software automatically downcodes responses (e.g., responses of 2 to 6 are recoded as 1 to 5) and so researchers may not be aware of problems raised by null categories. The present study examines the effects of null categories in the context of latent class signal detection theory (SDT) (DeCarlo, 2002, 2005), which has previously been shown to be a useful model for analyzing and scoring CR items. In the SDT approach, null categories can be produced by setting the raters' response criteria to low or high values, and/or by using small sample sizes. Simulations are used to examine different strategies for dealing with null categories. The strategies are evaluated by examining the effects of null categories on classification accuracy. Analyses of real world data are used to obtain information about the prevalence and patterns of null categories that appear in practice. Approaches to dealing with null categories are examined. For example, one approach is to augment the data by including cases to eliminate the null categories.

(P33)
Aug 03, 18:00–19:30
Poster session

The Stop Signal Paradigm and the Diffusion Model. Annika Boldt, Florian Schmiedek, *Humboldt-University Berlin*. The stop signal paradigm is a commonly used approach to investigate response inhibition. It consists of a choice task that is – on some proportion of trials – followed by a signal that tells people to withhold their reaction. Race models are used to estimate the amount of time needed for the stopping process. The Ratcliff diffusion model is another influential model in cognitive psychology, it is used to describe the distribution of reaction times in two-choice tasks. Here we seek to combine both models and to locate the inhibition process within the decision process described from a diffusion model perspective. A parity-judgement task was conducted by 16 young (18 – 25 years) and 16 old (70 – 81 years) participants. Number stimuli were presented and then masked. The onset of the mask was experimentaly manipulated randomly on each trial. The mask also turned red in some trials, indicating that people ought to stop their reactions. We show that inhibition could take place after the drift process of the diffusion model was completed. Moreover we will investigate age differences in the diffusion and stopping processes.

(P34)
Aug 03, 18:00–19:30
Poster session

Bayesian Inference for Rating Based Receiver Operating Characteristics. Ingo Früund, *Berlin Institute of Technology*. Signal detection theory provides a simple yet flexible way to describe decision making in psychological tasks. A common way to describe the decision process is by means of a receiver operating characteristic (ROC). These ROCs can be derived from confidence ratings: on every trial, the decision maker rates his or her confidence about the presence of the signal on a scale with n levels. The cumulative distributions for these rating responses given signal or noise stimuli define an empirical ROC curve. The decision process that leads to these confidence ratings can be modeled as follows: on every trial, the decision maker compares the stimulus' strength to a set of $n-1$ ordered criteria. The confidence rating of the decision maker is the number of criteria that are exceeded by the stimulus. An extension of this model assumes that the decision maker misses some signals and performs on the noise distribution in these trials. For this extended model, numerical maximization of the likelihood can become very unstable and confidence limits for parameters of ROCs can be difficult to obtain. We used Markov Chain Monte Carlo to draw samples from the posterior distribution of decision parameters given the data. Parameters of the decision process could be recovered with reasonable accuracy, even for moderately large data sets. In conclusion, Bayesian inference can estimate signal detection models that are difficult to assess using traditional statistics. A Python extension to perform the required calculations is available.

(P35)
Aug 03, 18:00–19:30
Poster session

Average Mutual Information: Algorithms and Applications. Robin Thomas, Adam Strang, Nathan Moses, *Miami University*. Average mutual information (AMI) measures the degree to which two series of data are statistically independent. It generalizes the notion of cross-correlation to signals of nonlinear origin. One application of this quantity is to determine an appropriate time-delay to use for a state-space reconstruction of a nonlinear time series, an important concept in the analysis of motor coordination, EEG, and other behavior that can be described by such dynamics. In almost all versions of AMI computation available for researchers, the requisite density functions are estimated with some variant of the traditional histogram. In the density estimation literature, a plethora of arguments exist in favor of kernel density estimation over the construction of histograms. We offer a set of AMI Matlab functions that employ kernel density estimation rather than the histogram. In the present study, we explore the virtues of this adaptation in the cases of two separate signals and in the selection of an appropriate time delay for a phase space reconstruction. We examine known cases and generalize to the situation of noisy data from unknown dynamics.

(P36)
Aug 03, 18:00–19:30
Poster session

Psychological Interpretation of the Ex-Gaussian and Shifted Wald Parameters: A Diffusion Model Analysis. Dora Matzke, Eric-Jan Wagenmakers, *University of Amsterdam*. A growing number of researchers use descriptive distributions such as the ex-Gaussian and the shifted Wald to summarize response time data for speeded two-choice tasks. Some of these researchers also assume that the parameters of these distributions uniquely correspond to specific cognitive processes. We studied the validity of this cognitive interpretation by relating the parameters of the ex-Gaussian and shifted Wald distributions to those of the Ratcliff diffusion model, a successful model whose parameters have well-established cognitive interpretations. In a simulation study, we fitted the ex-Gaussian and shifted Wald distributions to data that were generated from the diffusion model by systematically varying its parameters across a wide range of plausible values. In an empirical study, the two descriptive distributions were fitted to published data that featured manipulations of task difficulty, response caution, and a priori bias. The results clearly demonstrate that the ex-Gaussian and shifted Wald parameters do not correspond uniquely to parameters of the diffusion model. We conclude that researchers should resist temptation to interpret changes in the ex-Gaussian and shifted Wald parameters in terms of cognitive processes.

(P37)
Aug 03, 18:00–19:30
Poster session

Are Researchers Egoistic When They Write an Abstract? A Bayesian Hierarchical Test of the Name-Letter Effect. Oliver Dyjas, *University of Tuebingen*, Raoul Grasman, Ruud Wetzels, Han van der Maas, Eric-Jan Wagenmakers, *University of Amsterdam*.

People generally prefer their initials to the other letters of the alphabet, a phenomenon known as the name-letter effect (NLE). This effect, researchers have argued, makes people move to certain cities, buy particular brands of consumer products, and choose particular professions (e.g., Angela moves to Los Angeles, Phil buys a Philips TV, and Dennis is a dentist). In order to establish such associations between people's initials and their behavior, researchers typically carry out statistical analyses of large databases. Unfortunately, the standard p-value procedures ignore the hierarchical structure of the data and do not allow one to confirm the null hypothesis. Here we propose a Bayesian hierarchical hypothesis test that avoids these limitations. We illustrate the method with examples that involve the use of author initials in scientific abstracts. The NLE for each letter is governed by a group-level Normal distribution, and inference concerns the posterior distribution of the group-level effect size. The conclusions from our Bayesian hypothesis test are sometimes in radical opposition to those based on p-value procedures. We believe that the Bayesian hierarchical hypothesis test is a useful alternative to the procedures that are currently standard in the field.

Puzzles

Sudoku

	5	7			3			2
4								
	6				7		3	
1				9		3		
7		2				6		5
		4		2				1
	7		3				6	
								4
9			8			7	1	

Horse Frenzy

Three horses are standing in a triangular field, which is exactly 100 yards on each side. One horse stands at each corner; and simultaneously all three set off running. Each horse runs after the horse in the adjacent corner on his left, thus following a curved course, which terminates in the middle of the field, all three horses arriving there together. The horses obviously ran at the same speed, but just how far did they run?

The Distance Problem

Jerry is returning home from the conference venue. Half the distance he rode by subway – fifteen times as fast as he would go on foot. The second half he went by cab, but due to unruly traffic, he would have walked that distance

twice as fast. Would Jerry have saved time if he had gone all the way on foot? How much?

Freedom

Michael is convicted for indecent exposure; he gets the death penalty. The judge allows him to make a final statement in order to determine the way the penalty will be carried out. If Michael lies, he will be hanged. If he speaks the truth, he will be beheaded. He makes his statement and to everybody's surprise some minutes later he is set free, because the judge could not determine his penalty. What did Michael say?

Signs

1 2 3 4 5 6 7 8 9=100
Can you make the equation correct by inserting 3 plus or minus signs?

Soccer Congrats

The Dutch soccer team has just become World Champion. The players on the field would like to congratulate each other by shaking hands. Assuming that each player shook hands with every other player only once, how many handshakes were there in total?

The Puzzled Driver

Roger is looking at the odometer of his family car; it shows 15,951 miles. He notices that this number is palindromic: it reads the same backward as forward. "Curious," Roger said to himself, "It will be a long time before that happens again." But, two hours later, the odometer showed a new palindromic number. How fast was Roger driving in those two hours?

Lockers

Irvine has a strange graduate school director. On the first day, he has his students perform an odd opening day ceremony:

There are one thousand lockers and one thousand students in the college building. The director asks the first student to go to every locker and open it. Then he has the second student go to every *second* locker and close it.

The third goes to every *third* locker and, if it is closed, he opens it, and if it is open, he closes it. The fourth student does this to every *fourth* locker, and so on. After the process is completed with the thousandth student, how many lockers are open?

Self Referring Number

Find a number ABCDEFGHIJ such that A is the count of how many 0's are in the number, B is the number of 1's, and so on.

Author Index

(stevenh@martingale-research.com), 50
Hochman, Guy
(hochmang@tx.technion.ac.il), 24
Hockemeyer, Cord
(cord.hockemeyer@uni-graz.at), 20
Hoijtink, Herbert
(h.hoijtink@uu.nl), 67
Holmes, Philip
(pholmes@math.princeton.edu), 10, 70
Hotaling, Jared
(jaredhotaling@gmail.com), 62
Houde, Sébastien
(shoude@stanford.edu), 62
Houpt, Joseph
(jhoupt@indiana.edu), 52
Howard, Marc
(marc@memory.syr.edu), 30, 39
Hsu, Yung-Fong
(yfhsu@ntu.edu.tw), 43
Hu, Xiangen
(xhu@memphis.edu), 58, 59
Huber, David
(dhuber@ucsd.edu), 16
Huebner, Alan
(huebster79@gmail.com), 45
Huijpen, Kim
(kimhuijpen@gmail.com), 76

Iverson, Geoffrey
(giverson@uci.edu), 43, 69

Jang, Yoonhee
(yhjang@ucsd.edu), 16
Johnson, Joe
(johnsojg@muohio.edu), 14
Jones, Matt
(mcj@colorado.edu), 22
Jost, Juergen
(jost@mis.mpg.de), 82

Kachergis, George
(gkacherg@indiana.edu), 85
Kahana, Michael
(kahana@psych.upenn.edu), 60, 84
Kalish, Michael
(kalish@louisiana.edu), 27, 54
Kashner, Michael
(michael.kashner@va.gov), 51
Katsikopoulos, Konstantinos
(katsikop@mpib-berlin.mpg.de), 16
Kemp, Charles
(ckemp@cmu.edu), 26, 52
Kiefer, Thomas
(thomas.kiefer@student.uni-augsburg.de), 31
Kim, Woojae
(kim292@indiana.edu), 56
Klugkist, Irene
(i.klugkist@uu.nl), 57, 67
Kujala, Janne
(jvk@iki.fi), 30, 69
Kuppens, Peter
(peter.kuppens@psy.kuleuven.be), 33

Laming, Donald
(drjl@hermes.cam.ac.uk), 48
Lee, Michael
(mdlee@uci.edu), 25, 32, 33, 64, 67
Lee, Sung
(sung.lee@act.org), 45
Lewandowsky, Stephan
(lewan@psy.uwa.edu.au), 19, 47
Little, Dan
(drlittle@indiana.edu), 34
Liu, Charles
(ccyliu@gmail.com), 56
Liu, Yang
(ly6@ualberta.ca), 79
Lodewyckx, Tom
(tom.lodewyckx@psy.kuleuven.be), 33
Logan, Gordon
(gordon.logan@vanderbilt.edu), 38
Love, Bradley
(brad_love@mail.utexas.edu), 52

Perea, Manuel
(mperea@uv.es), 37
Perfors, Amy
(amy.perfors@adelaide.edu.au), 64, 65, 86
Perry, Conrad
(conradperry@gmail.com), 36
Perry, Lacey
(laperry@purdue.edu), 31
Piattino, Sara
(spiattino@fastwebnet.it), 80
Pitt, Mark
(pitt.2@osu.edu), 69, 88
Polyn, Sean
(polyn@psych.upenn.edu), 84
Pooley, James
(jpooley@uci.edu), 32
Pratte, Michael
(mspn69@missouri.edu), 32
Primi, Caterina
(primi@unifi.it), 74, 80
Prince, Melissa
(melissa.prince@newcastle.edu.au), 55
Purcell, Braden
(braden.a.purcell@vanderbilt.edu), 38

Quesada, Jose
(quesada@gmail.com), 25

Raab, Markus
(raab@dshs-koeln.de), 14
Raglianti, Marco
(m.raglianti.work@gmail.com), 75
Raijmakers, Maartje
(m.e.j.raijmakers@uva.nl), 53, 76
Rajkumar, Arun
(arun_r@csa.iisc.ernet.in), 81
Ramscar, Michael
(ramscar@stanford.edu), 53
Ratcliff, Roger
(ratcliff.22@osu.edu), 21, 23, 37
Ray, Kanad
(kanadray@yahoo.co.in), 60
Repperger, Daniel
(daniel.repperger@wpafb.af.mil), 40, 74
Reyna, Christine
(creyna@depaul.edu), 88
Richler, Jennifer
(jennifer.j.richler@vanderbilt.edu), 44
Rieskamp, Jörg
(joerg.rieskamp@unibas.ch), 63
Robusto, Egidio
(egidio.robusto@unipd.it), 28, 79
Rockmore, Daniel
(rockmore@cs.dartmouth.edu), 51
Rouder, Jeffrey
(rouderj@missouri.edu), 32
Rubin, Tim
(tim.rubin@gmail.com), 26

Sanborn, Adam
(asanborn@gatsby.ucl.ac.uk), 66
Schall, Jeffrey
(jeffrey.d.schall@vanderbilt.edu), 38
Schmiedek, Florian
(florian.schmiedek@psychologie.hu-berlin.de), 90
Schooler, Lael
(schooler@mpib-mpg.de), 25
Schweickert, Richard
(swike@psych.purdue.edu), 50, 59
Selfhout, Maarten
(m.selfhout@uu.nl), 67
Seri, Raffaello
(raffaello.seri@hotmail.com), 43
Shankar, Karthik
(karthik@memory.syr.edu), 30, 39
Shankle, William
(rshankle@mccare.com), 32
Shanks, David
(d.shanks@ucl.ac.uk), 29
Sheeber, Lisa
(lsheeber@ori.org), 33
Sheu, Ching-Fan

(csheu@mail.ncku.edu.tw), 65
Shiffrin, Richard
(shiffrin@indiana.edu), 34, 56, 62, 85
Silva, Ricardo
(ricardo@stats.ucl.ac.uk), 66
Simen, Patrick
(psimen@math.princeton.edu), 70
Smith, Jared
(smithjb@uci.edu), 58
Smith, Philip
(hod-psych@unimelb.edu.au), 21
Smithson, Michael
(michael.smithson@anu.edu.au), 12, 13
Solway, Alec
(asolway@seas.upenn.edu), 60
Speekenbrink, Maarten
(m.speekenbrink@ucl.ac.uk), 29
Spoto, Andrea
(andrea.spoto@unipd.it), 19
Stadnytska, Tetiana
(tstadnit@hotmail.com), 49
Stefanutti, Luca
(luca.stefanutti@unipd.it), 19, 28, 79
Steingrimsson, Ragnar
(ragnar@uci.edu), 41, 42
Steyvers, Mark
(mark.steyvers@uci.edu), 26, 67, 84
Stollhoff, Rainer
(rainer.stollhoff@mis.mpg.de), 82
Strang, Adam
(strangaj@muohio.edu), 91
Stroe-Kunold, Esther
(esther.stroe-kunold@psychologie.uni-heidelberg.de), 49
Suck, Reinhard
(rsuck@uos.de), 20

Tang, Yun
(tangyuncn@gmail.com), 83
Telpaz, Ariel
(arielt@tx.technion.ac.il), 24
Teodorescu, Andrei
(andrei_bigchief@hotmail.com), 10
Theeuwes, Jan
(j.theeuwes@psy.vu.nl), 88
Thomas, Robin
(thomasrd@muohio.edu), 91
Townsend, James
(jtownsen@indiana.edu), 35, 44, 52, 61, 72, 75
Trueblood, Jennifer
(jstruebl@indiana.edu), 63
Tsetsos, Konstantinos
(k.tsetsos@ucl.ac.uk), 10, 78
Tuerlinckx, Francis
(francis.tuerlinckx@psy.kuleuven.be), 33
Turner, Brandon
(turner.826@osu.edu), 16
Tzeng, Yuhtsuen
(ttcytt@ccu.edu.tw), 87

Uenlue, Ali
(ali.uenlue@math.uni-augsburg.de), 20, 31
Usher, Marius
(marius@post.tau.ac.il), 10, 78

van de Schoot, Rens
(r.vandeschoot@uu.nl), 67
van de Ven, Vincent
(v.vandeven@psychology.um.nl), 40
Van der Haegen, Lise
(lise.vanderhaegen@ugent.be), 37
van der Maas, Han
(h.l.j.vandermaas@uva.nl), 69, 91
van Erven, Tim
(tim.van.erven@cwi.nl), 56
Van Montfort, Kees
(kvmontfort@feweb.vu.nl), 49
Van Ravenzwaaij, Don
(e-mailaddress), 21
van Rijn, Peter
(peter.vanrijn@cito.nl), 47

van Schijndel, Tessa
(t.j.p.vanschijndel@uva.nl), 76
Van Zandt, Trish
(van-zandt.2@osu.edu), 16
Vanpaemel, Wolf
(wolf.vanpaemel@psy.kuleuven.be), 33
Venkatasubramaniyan, Suresh
(suresh.venkatasubramanian@gmail.com), 81
Verkuilen, Jay
(jverkuilen@gc.cuny.edu), 12, 13
Verstralen, Huub
(huub.verstralen@cito.nl), 47
Vianello, Michelangelo
(michelangelo.vianello@unipd.it), 79
Vidotto, Giulio
(giulio.vidotto@unipd.it), 19, 78
Vincze, Markus
(vincze@acin.tuwien.ac.at), 18
Viskontas, Indre
(indre.viskontas@gmail.com), 39
Visser, Ingmar
(i.visser@uva.nl), 24
von Sydow, Momme
(momme@von-sydow.de), 26
Vrijdags, Amélie
(amelie.vrijdags@ugent.be), 83

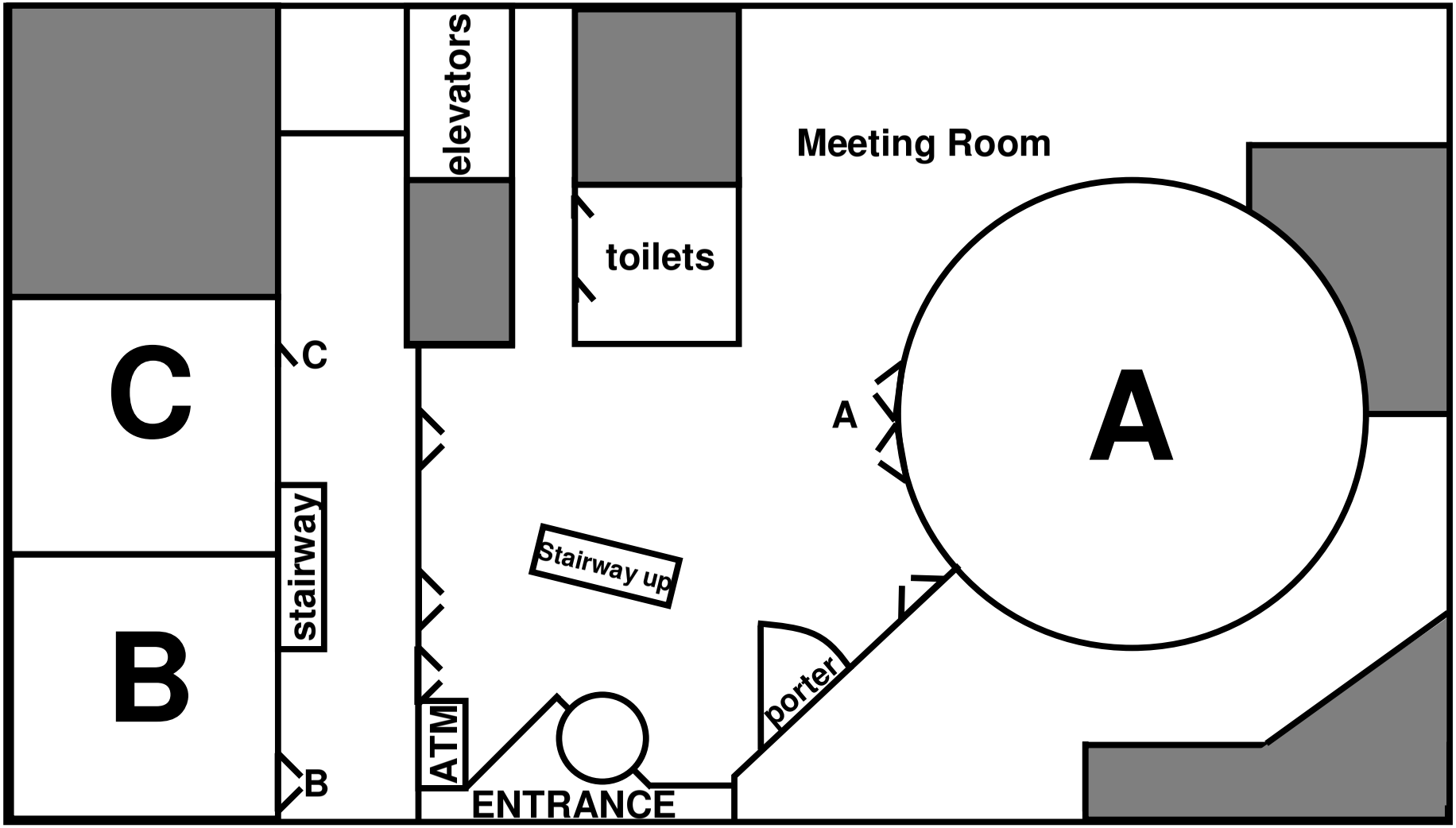
Wagenmakers, Eric-Jan
(ej.wagenmakers@gmail.com), 21, 38, 57, 91
Waldorp, Lourens
(waldorp@uva.nl), 40
Wallsten, Thomas
(twallsten@psyc.umd.edu), 16
Wang, Xiang
(bo.wang@act.org), 45
Weaver, Rhiannon
(rlweaver@stat.cmu.edu), 57
Weidemann, Christoph
(ctw@cogsci.info), 60
Wetzels, Ruud
(wetzels.ruud@gmail.com), 57, 91
White, Corey
(white.1198@osu.edu), 23
White, Halbert
(hwhite@weber.ucsd.edu), 51
Wickens, Thomas
(twickens@berkeley.edu), 52
Wiecki, Thomas
(thomas_wiecki@brown.edu), 86
Williams, Joseph
(joseph_williams@berkeley.edu), 27
Wu, Hao
(wu.498@osu.edu), 58, 76

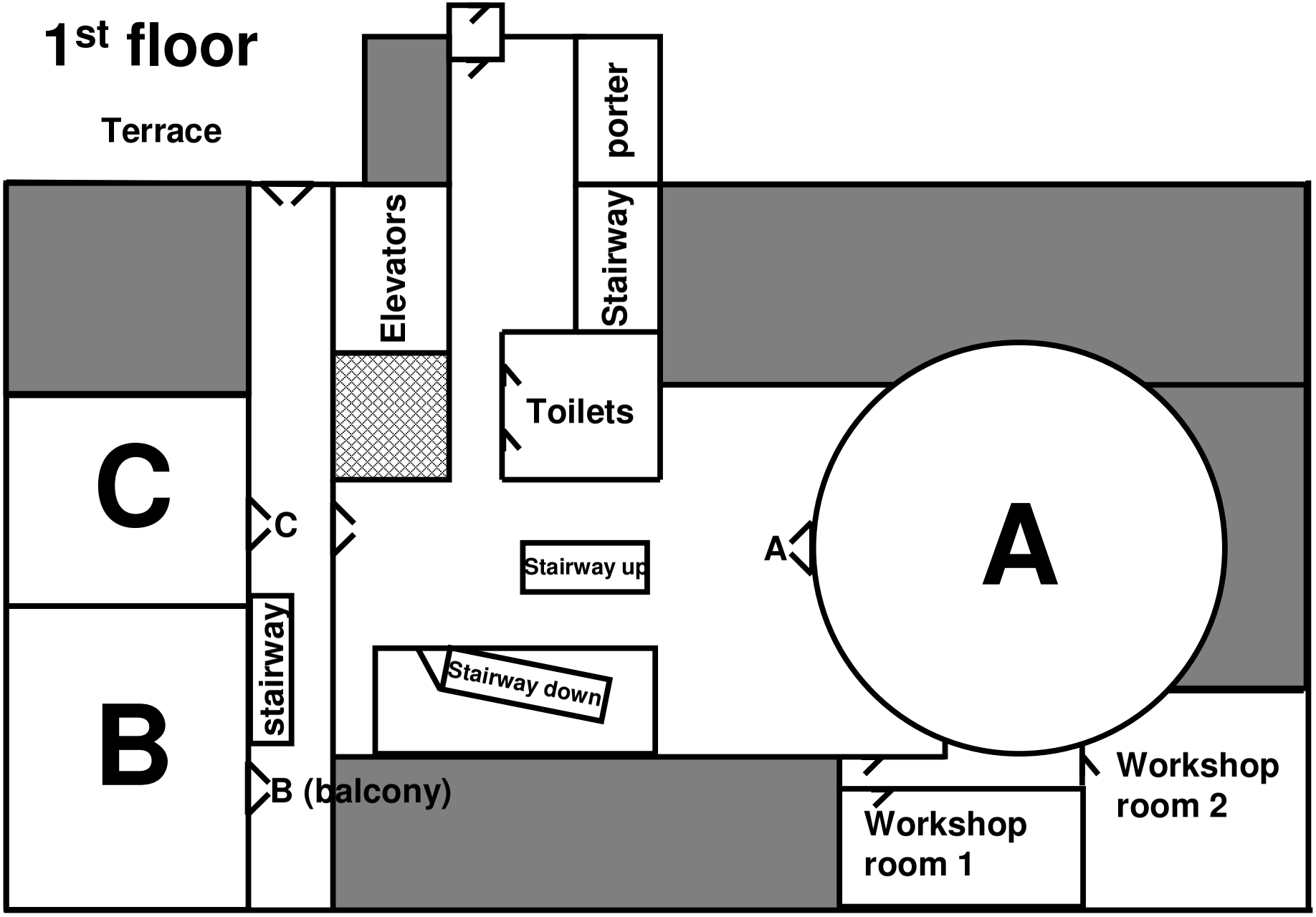
Xi, Zhuangzhuang
(zxi@purdue.edu), 59

Yechiam, Eldad
(yeldad@tx.technion.ac.il), 24
You, Yuan
(yyster514@gmail.com), 59
Yu, Chen
(chenyu@indiana.edu), 29, 85
Yurovsky, Daniel
(dyurovsky@gmail.com), 29

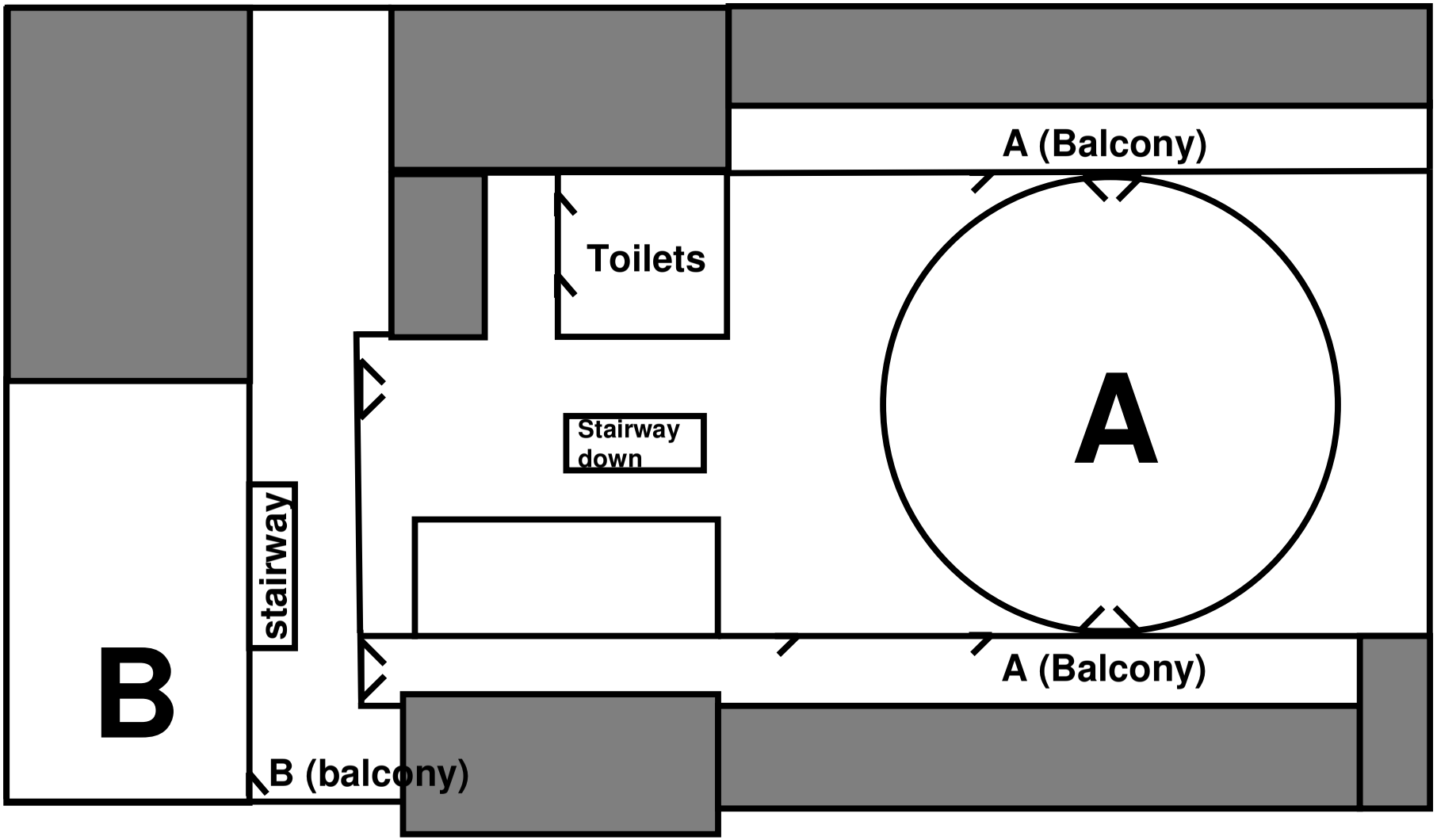
Zacksenhouse, Miriam
(mermz@techunix.technion.ac.il), 10
Zand Scholten, Annemarie
(a.zandscholten@uva.nl), 42
Zeigenfuse, Matthew
(mzeigenf@uci.edu), 25
Zhang, Jun
(junz@umich.edu), 39
Zhang, Shunan
(szhang@uci.edu), 64
Ziegler, Johannes
(johannes.ziegler@univ-provence.fr), 36
Zorzi, Marco
(marco.zorzi@unipd.it), 36

ground floor




1st floor
Terrace
porter
Elevators
Stairway
Toilets
C
C
A
A
Stairway up
stairway
Stairway down
B
B (balcony)
Workshop room 1
Workshop room 2

2nd floor


A (Balcony)
Toilets
A
Stairway down
stairway
B
A (Balcony)
B (balcony)

MathPsych 2009 Schedule

August 1	Lecture Hall A, Computer rooms: 106 and 107
10:00-18:00	**Workshop Bayesian Modeling for Cognitive Science**
18:00-21:00	**Welcome, Registration and Reception** *(Main Hall)*

August 2	Stream A: Lecture Hall A	Stream B: Lecture Hall B	Stream C: Lecture Hall C
09:00-10:40	**Symposium: Neuro-computational Models of Speeded Decision Making**	**Memory 1**	**Judgement**
coffee			
11:00-12:20	**Symposium: Modeling Response Styles on Bounded Scales**	**Knowledge Space Theory**	**Learning**
lunch			
14:00-15:20	**Symposium: Applied Dynamic Modeling: Behavior in Sports**	**Reaction Times 1**	**Learning**
coffee			
15:40-16:40	**Signal Detection 1**	**Reaction Times 1**	**Perceptual Discrimination & Scaling**
coffee			
17:00-18:00	**Keynote Address by Michael Frank**		

August 3	Stream A: Lecture Hall A	Stream B: Lecture Hall B	Stream C: Lecture Hall C
09:00-10:40	**Symposium: Bayesian Hierarchical Models**	**Neuro 1**	**IRT 1**
coffee			
11:00-11:40		**Perception**	**Memory 2**
11:40-12:20	**Multisensory Integration**	**Measurement Theory**	
lunch			
14:00-14:20			**Multivariate Methods**
14:20-15:20	**Symposium: Visual Word Recognition**		
coffee			
15:40-16:40		**Signal Detection 2**	**Perception 2**
coffee			
17:00-18:00	**Keynote Address by Gordon Logan**		
18:00-19:30	Poster Session		

August 4	Stream A: Lecture Hall A	Stream B: Lecture Hall B	Stream C: Lecture Hall C
09:00-10:40	**Symposium: Modeling in Developmental Psychology**	**Multinomial Modeling**	**Bayesian Modeling**
coffee			
11:00-12:20	**Symposium: State - Trace Analysis**	**Neuro 2**	
lunch			
14:00-14:20	**Symposium: Model Selection**	**Decision Making**	**IRT 2**
14:20-15:20			**Reaction Times 2**
coffee			
15:40-16:40			
coffee			
17:00-18:00	**New Investigator Address by Scott Brown**		
18:00-23:00	Conference Dinner		